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Oak Ridge Reservation Environmental Report for 1989

Volume 1: Narrative, Summary, and Conclusions

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FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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OAK RIDGE RESERVATION ENVIRONMENTAL REPORT FOR 1989

VOLUME 1: NARRATIVE, SUMMARY, AND CONCLUSIONS

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EXECUTIVE SUMMARY

OVERVIEW OF 1989 ENVIRONMENTAL REPORT

This two-volume report, the *Oak Ridge Reservation Environmental Report for 1989,* is the nineteenth in an annual series that began in 1971. It reports the results of a comprehensive, year-round program to monitor the impact of operations at the three major U.S. Department of Energy (DOE) production and research installations in Oak Ridge on the immediate areas' and surrounding region's groundwater and surface waters; soil; air quality; vegetation and wildlife; and, through these multiple and varied pathways, the resident human population. Information is presented for the environmental monitoring Quality Assurance (QA) Program, audits and reviews, waste management activities, and special environmental studies.

Data are included for the

- **Oak Ridge Y-12 Plant,** which fabricates nuclear weapons components and conducts research and development (R&D) activities in support of that national defense mission;
- **Oak Ridge National Laboratory** (ORNL), a multipurpose center for R&D in the biomedical, environmental, and physical sciences; nuclear and engineering technologies; and advanced energy systems; and the
- **Oak Ridge Gaseous Diffusion Plant** (ORGDP), where production operations in uranium enrichment are shut down, but active R&D, supporting, and waste storage activities continue.

Volume 1 presents narratives, summaries, and conclusions based on environmental monitoring at the three DOE installations and in the surrounding environs during calendar year (CY) 1989. Volume 1 is intended to be a "stand-alone" report about the Oak Ridge Reservation (ORR) for the reader who does not want an in-depth review of 1989 data. Volume 2 presents the detailed data from which these conclusions have been drawn and should be used in conjunction with Vol. 1.

Scope and Purpose

While the report documents effluents and emissions, both at the source and as monitored in the external environment, its ultimate concern is with potential pathways to humans and with the resulting consequences for human health and environmental quality. To this end, contaminant levels are reported in absolute terms and in relation to discharge limits established by state and federal regulatory bodies and to existing national and international guidelines and standards designed to protect human health and the environment.

The primary purpose of the Oak Ridge monitoring program is to provide a thorough and systematic ongoing assessment that is fully responsive to the needs for ensuring compliance with state and federal regulations for safe industrial operations. An additional objective of the monitoring program is to provide a standard for measuring progress in implementing improved environmental management practices and in taking remedial actions to correct deficiencies in past practice. This includes efforts to develop and demonstrate more effective means to isolate and/or treat the hazardous and radioactive wastes that are

inevitable by-products of nuclear and other energy-related production and research operations. The stated goal of the environmental management programs at DOE Oak Ridge installations is to reduce environmental releases from current and past operations to levels that are demonstrably and consistently "as low as reasonably achievable."

From this perspective, the aim of the effluent and environmental monitoring program is two-fold: (1) to serve as an effective *indicator* that detects and provides the data required to assess potentially adverse discharges and impacts and (2) to provide for continuing, regular *verification of compliance* with applicable state and federal permits and regulations.

Therefore, routine monitoring and sampling for radiation, radioactive materials, and chemical substances on and off the ORR are important as tools to document compliance with appropriate standards, to identify undesirable trends, to provide information to the public in Oak Ridge and surrounding communities, and to contribute to general environmental knowledge.

Monitoring Networks

The approximately 1.9 million individual items of data reported in these two volumes come from a growing complex of monitoring stations and a routine sampling program, supplemented by special measurements, which involves these principal components:

- 8 air monitoring networks, consisting of 50 stations located within and on the perimeters of each installation; throughout the ORR; in residential and community areas; and at distances up to 120 km (77 miles) from Oak Ridge;
- 6 meteorological towers;
- Over 400 National Pollutant Discharge Elimination System (NPDES) and surface-water-sampling stations;
- Over 850 on-site groundwater-monitoring wells of which over 330 were sampled this year;
- 96 on-site exhaust-stack monitors for detecting radionuclide releases;
- 3 river and stream points where fish are sampled;
- 22 locations where vegetation samples are taken;
- 22 locations where soil samples are taken;
- 8 stream sediment monitoring points;
- 5 milk-sampling locations; and
- 17 locations for measuring external radiation.

State and Federal Regulations

The regulatory environment that applies to the Oak Ridge operations is itself multifaceted and complex. A major effort by DOE and its operating contractor, Martin Marietta Energy Systems, Inc., has been to put in place complementary monitoring and reporting systems that are capable of responding to all applicable regulatory requirements. Modifications to improve these systems continue.

An example of regulations and guidelines used as measures of safe operations at the installations include NPDES; National Emission Standards for Hazardous Air Pollutants (NESHAP); National Primary and Secondary Drinking Water Regulations; Tennessee Hazardous Waste Regulations; and the derived concentration guides in DOE Order 5400.5, entitled "Radiation Protection of the Public and the Environment."

Summary Conclusion

Efforts to clean up contaminated storage and disposal areas and to close disposal sites that do not meet current standards are now the focus of long-term, large-scale remedial action efforts. Likewise, new and improved treatment and isolation systems for gaseous, liquid, and solid wastes contribute annually to continuing reductions in potentially harmful emissions and effluents from current operations. This measurable evidence provides a degree of confidence and assurance that the aggressive, long-term program of corrective actions and waste management improvements now under way will be successful in restoring and enhancing environmental quality in the future and in reducing the potential for any deleterious

impacts on human health or the environment from current or past Oak Ridge operations.

Outline of Findings

The 1989 environmental surveillance report gives particular attention to several primary areas of health and environmental concern: airborne discharges of radionuclides and hazardous chemicals and air and meteorological measurements; waterborne discharges and surface water monitoring; groundwater monitoring; external gamma exposure levels; monitoring of biological systems (fish, milk, vegetation, and deer); soil and sediment sampling; and potential chemical and radiation exposures to the surrounding public.

Key results in each of these areas are highlighted in the sections that follow. This summary then concludes with accounts of major environmental actions and activities on the ORR and surrounding areas during CY 1989.

One environmental reporting goal is to ensure that the annual site environmental reports include all known quantities of radiological and nonradiological materials in effluents to all environmental media. This includes routine and accidental releases and those that can be quantified through material balance calculations. All known radiological effluent quantities are reported in this document.

Appendix C includes the information from the Superfund Amendments Reauthorization Act (SARA) Title III, Section 313, Toxic Chemical Release Inventory report on quantities of nonradiological chemical emissions. The complete SARA report, to be issued on July 1, 1990, provides the community with the opportunity to learn about estimated quantities of certain toxic chemicals used at a facility that are routinely or could potentially be released into the environment. This appendix includes some additional "large quantity" chemicals used or stored at the facilities that are not required to be reported by SARA Title III but are known to be emitted from the facilities. Appendix C is not all inclusive but provides emissions information on the major chemical emissions to the air, water, or land from processes at the facilities.

SUMMARY OF 1989 ENVIRONMENTAL SURVEILLANCE DATA

AIRBORNE DISCHARGES AND AIR AND METEOROLOGICAL MEASUREMENTS

Permitting Status

About 780 air emission sources are now permitted by the TDHE for the three Oak Ridge installations. No notices of violation were received on air emission sources in 1989.

Radioactive Discharges to the Atmosphere

During 1989, 123,000 Ci of radionuclides were released to the atmosphere from Oak Ridge installations (see Fig. 1). The difference from year to year can be accounted for almost totally by two inert gases, xenon and krypton. These gases have little or no interaction with the terrestrial biosphere, including humans. The total curie discharges of tritium, xenon, and krypton are shown in Figs. 2, 3, and 4.

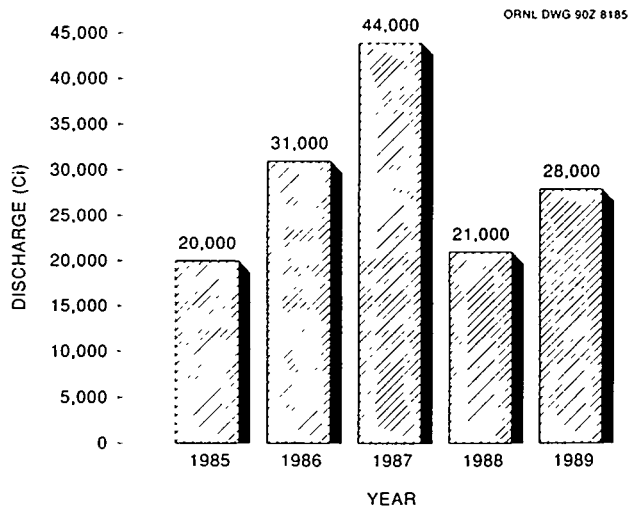

Fig. 2. Total discharges of tritium from ORNL to the atmosphere, 1985–1989.

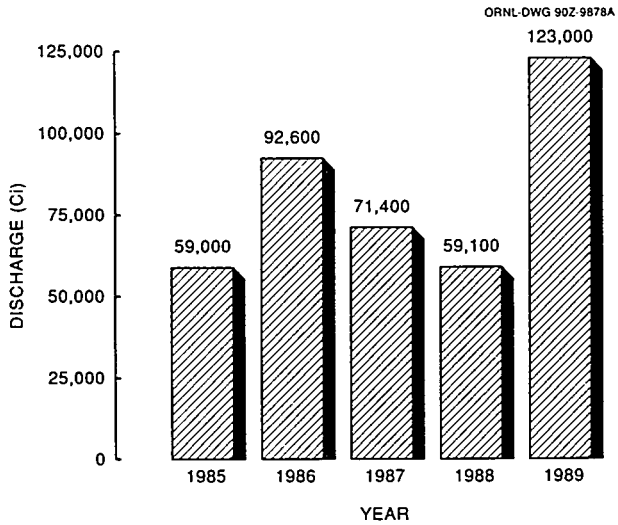

Fig. 1. Total curie discharges from the Oak Ridge Reservation to the atmosphere, 1985–1989.

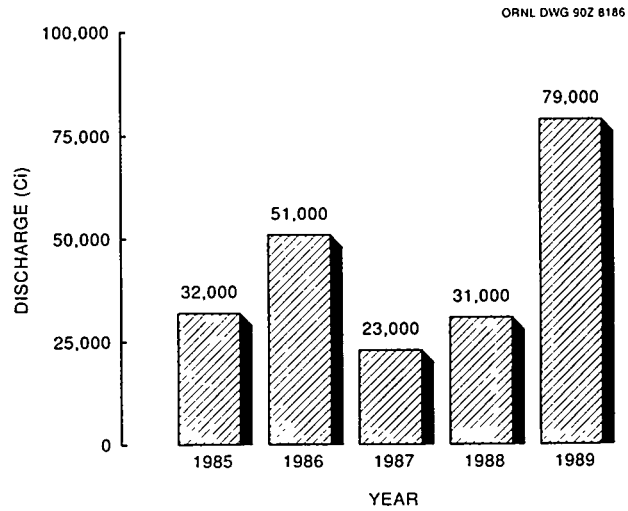

Fig. 3. Total discharges of ^{133}Xe from ORNL to the atmosphere, 1985–1989.

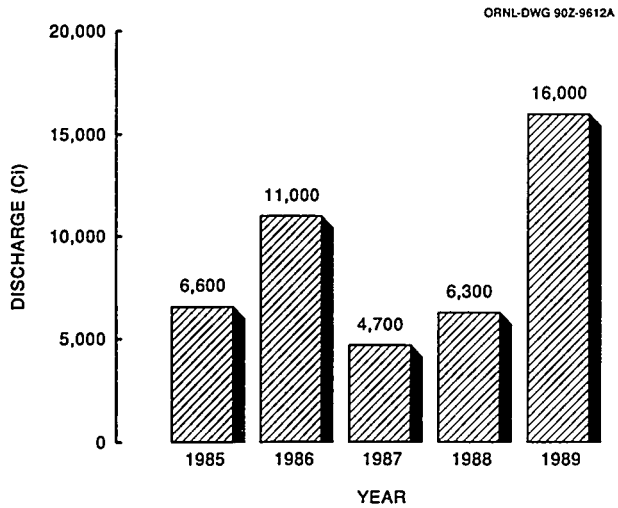

Fig. 4. Total discharges of ^{85m}Kr from ORNL to the atmosphere, 1985–1989.

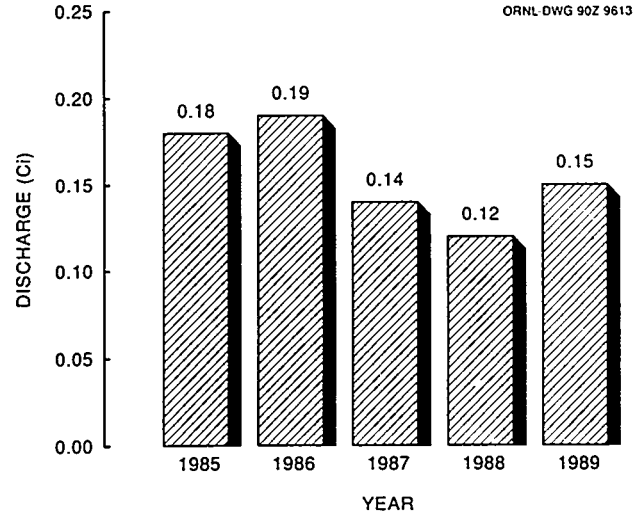

Fig. 5. Total discharges of uranium from the Y-12 Plant to the atmosphere, 1985–1989.

Uranium is the primary radioactive element of concern at the Y-12 Plant. Uranium emissions have remained relatively consistent in recent years at the plant. During 1989, 0.15 Ci of uranium was discharged from the Y-12 Plant in comparison with 0.12 Ci in 1988 and 0.14 Ci in 1987. After uranium isotope differences are considered, this correlates to 44.3 kg (97.5 lb) and 47.4 kg (104.3 lb) of uranium discharged in 1989 and 1988, respectively, as compared with 116 kg (255.7 lb) in 1987 and 211 kg (465.2 lb) in 1986. Figure 5 shows the total curies discharge of uranium emitted into the atmosphere from the Y-12 Plant from 1985 through 1989. Figure 6 shows the comparable total mass of uranium emitted from the Y-12 Plant for the same years. This reduction in 1987, 1988 and 1989 compared to 1985 and 1986 was due in part to improved uranium emissions monitoring in 1987 and the installation of new exhaust gas filtration systems, especially in the depleted uranium areas of the plant. Twenty-seven stacks with the greatest potential to emit significant amounts of uranium are equipped with "breakthrough monitors." These monitors measure the rate of increase of radiation on the trapping media and alert operations personnel if filtration system efficiencies decline.

Discharges, as well as meteorological data, are input into dose models to predict the radiation dose

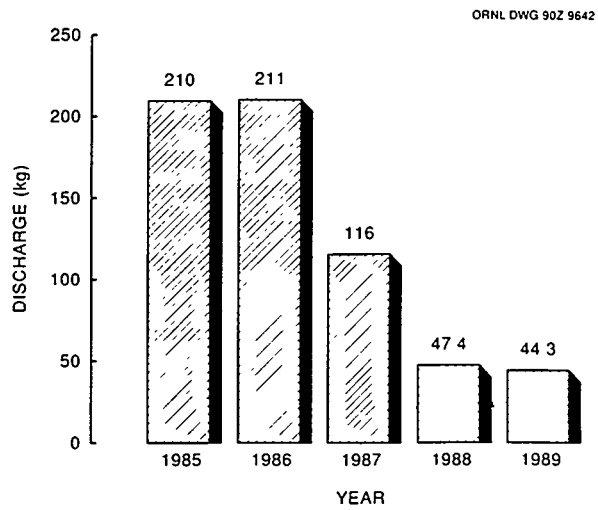

Fig. 6. Total kilograms of uranium discharged from the Y-12 Plant to the atmosphere, 1985–1989.

to the maximally exposed individual and to the population within 80 km (50 miles) of the DOE Oak Ridge facilities. The calculated 50-year committed effective dose equivalent to the maximally exposed off-site individual from airborne effluents from the entire ORR is 1 mrem, well within the federal standard. The estimated collective committed effective dose equivalent to the approximately 940,000 persons living within 80 km (50 miles) of the ORR is 35 person-rem

for 1989 airborne emissions. This represents about 0.01% of the 2.85×10^5 person-rem that the surrounding population would receive from all sources of background radiation.

Radionuclide Concentrations in Air

Atmospheric radionuclide concentrations occurring in the general environment around ORNL, the ORR, and the general region are monitored or sampled continuously by an air-monitoring network of 18 stations. The stations are divided into three groups. The ORNL perimeter air monitors are designed to evaluate the specific impact of ORNL on the local air quality. The reservation perimeter air monitors assess the impact of the entire ORR on air quality. Comparing these two sets of data provides us with insight into the relative contribution of ORNL as compared with other facilities such as the Y-12 Plant and the ORGDP on the Reservation. The remote air monitors provide information on reference concentrations of isotopes and gross parameters for the region. By comparing the ORNL data and ORR data with the remote air monitor data, the net impact of the ORR and ORNL upon the regional air quality can be assessed.

Measurements are taken of air concentrations of the following parameters: gross alpha, gross beta, ^{131}I, ^{3}H, ^{60}Co, ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{228}Th, ^{230}Th, ^{232}Th, total radioactive strontium, ^{234}U, ^{235}U, and ^{238}U.

Five isotopes exhibited elevated concentrations at the ORR perimeter, as compared with the remote station data. They are ^{228}Th, ^{234}U, ^{235}U, ^{238}U and total radioactive strontium. Uranium-234 made the largest contribution to inhaled dose with an annual average of 0.22% of the Derived Concentration Guide (DCG), a guideline for protection of the public. All the elevated values are associated with ORR perimeter stations. The most likely sources of these increased concentrations are fugitive dusts associated with remedial action activities on the ORR.

A comparison of ORNL perimeter air-sampling data with the remote air-sampling data shows that ORNL does not have a statistically significant impact on the local air quality. A similar comparison for the ORR perimeter air-sampling data shows that operations on the ORR are increasing local airborne concentrations of radionuclides. These range from <0.01% to 0.22% of the DCGs. No significant changes in the concentrations of these radionuclides were detected between 1988 and 1989 data for the remote stations. Therefore, based on these data, ORR operations are not significantly impacting the regional air quality.

Chemical Discharges to the Atmosphere

Ambient Fluoride Monitoring

Ambient fluoride sampling was not conducted at ORGDP in 1988 or 1989 because the fluoride emission sources were shut down. Of the approximately 590 ambient air fluoride measurements taken at the Y-12 Plant, all were less than 5% of the 7-d (1.6 mg/m^3) or 30-d (1.2 mg/m^3) Tennessee Air Pollution Control Standard (TAPCS).

Suspended Particulate Monitoring

Of the 340 suspended particulate measurements taken at ORGDP, all were within primary and secondary Tennessee air pollution control standards. Particulate concentrations reached only 24% of the amount allowed by the primary standard and 42% of emissions allowed by the secondary standard.

Similarly, at the Y-12 Plant, 51 samples were collected, which met the sample collection protocol for total suspended particulates. All of these values were within the primary and secondary Tennessee Air Pollution Control Standards.

Sulfur Dioxide Measurements

Continuous sulfur dioxide samples were taken and recorded hourly at the Y-12 Plant. All were within both 24- and 3-h standards. The highest 24-h average concentration measurement was 45% of the Tennessee air quality standard. The highest 3-h average concentration measurement was 25% of the Tennessee air quality standard.

WATERBORNE DISCHARGES AND SURFACE WATER MONITORING

Each of the Oak Ridge installations has an NPDES permit. More than 400 NPDES stations were sampled, requiring more than 65,000 water analyses. During 1989, the Y-12 Plant, with 247 noncompliances, was 98.0% in compliance with NPDES standards. ORNL had 133 noncompliances and was 96.1% in compliance. With 64 noncompliances, ORGDP was 99.7% in compliance.

The primary surface water areas monitored by all three installations include the Tennessee and Clinch rivers, White Oak Creek (WOC), Bear Creek, East Fork Poplar Creek, and Poplar Creek, all of which could be affected by operations at the DOE installations. Progress was made on several projects to minimize the release of pollutants to surface waters. At the Y-12 Plant, these projects included process improvements at Central Pollution Control Facility (CPCF), West End Treatment Facility (WETF), Plating Rinsewater Treatment Facility (PRTF), and the startup of the Steam Plant Wastewater Treatment Facility (SPWTF). With the completion of CPCF in late 1987 and the completion of WETF in early 1988, all nitrate wastewaters produced at the Y-12 Plant are now treated on-site and no longer transported to ORGDP for partial treatment and then back to the Y-12 Plant for final treatment. In 1989, the PRTF treated over 38 million liters (10 million gallons) of plating rinsewaters. During 1989, the SPWTF treated about 213 million liters/year (55 million gallons/year) of acidic and caustic discharges from the Y-12 Plant coal yard and steam plant operations.

Construction on the ORNL Nonradiological Wastewater Treatment Plant (NRWTP) continued throughout 1989. The NRWTP, which will treat numerous waste streams for removal of metals and organics, is scheduled to begin operation in April 1990.

The NPDES Compliance Program at ORNL was audited by the Tennessee Department of Health and Environment (TDHE) as well as the Environmental Protection Agency (EPA) in 1989. The TDHE audit resulted in no findings, and the EPA audit identified two findings, which have been corrected.

The EPA audited the ORGDP NPDES program in 1989 and reported no findings.

Radionuclide Discharges to Surface Streams

At the Y-12 Plant, ORNL, and ORGDP, radiological effluents were well within limits at all effluent locations. The radioactivity discharges to surface waters, which had declined over the previous 5 years, increased in 1989. Radionuclide discharges to surface streams are mainly emitted from ORNL to the Clinch River via White Oak Dam (WOD). Figures 7 through 10 pictorially represent the 5-year trend at the WOD monitoring station. This increase is associated in part with increased precipitation in 1989. The total flow at WOD for 1989 was twice the flow for 1988. Other factors that may be affecting the discharge of radionuclides at WOD are currently under investigation.

GROUNDWATER

In 1989, 58 new on-site groundwater wells were installed on the ORR. A total of 339 wells was sampled as part of an ongoing effort under RCRA to determine whether hazardous wastes have entered the groundwater and, if so, to define

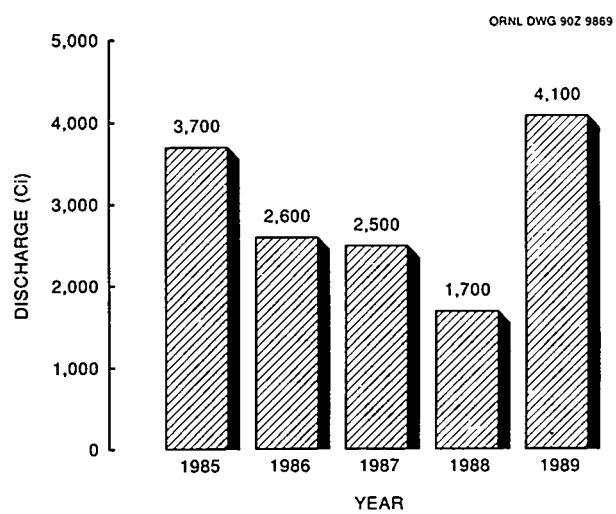

Fig. 7. Total discharges of tritium to surface waters, 1985 through 1989 (White Oak Dam).

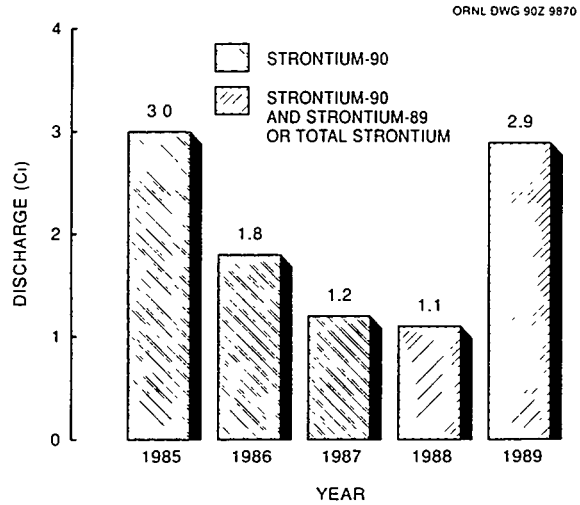

Fig. 8. Total discharges of radioactive strontium to surface waters, 1985 through 1989 (White Oak Dam).

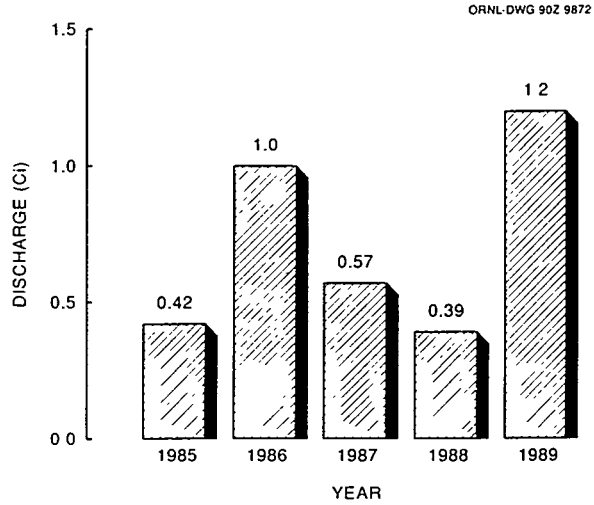

Fig. 10. Total discharges of ^{137}Cs to surface waters, 1985 through 1989 (White Oak Dam).

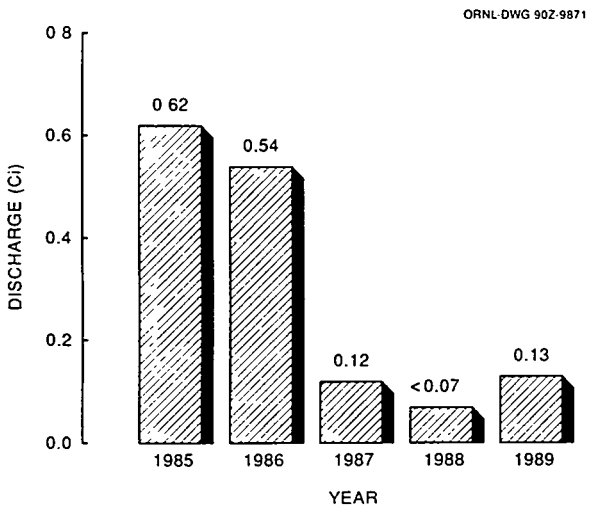

Fig. 9. Total discharges of ^{60}Co to surface waters, 1985 through 1989 (White Oak Dam).

the extent of the problems. Over 150,000 laboratory analyses of groundwater samples were conducted during 1989. Groundwater detection and assessment monitoring is under way at RCRA sites, and problem areas are being identified.

At the Y-12 Plant, 29 additional groundwater-monitoring wells were installed in 1989. Four additional wells were installed to supplement existing monitoring programs and to fill previously identified gaps in data.

Seven land-based waste disposal sites at the Y-12 Plant are RCRA Interim Status facilities and, as such, require groundwater monitoring. Currently, groundwater monitoring at five of the sites has detected volatile organics, nitrates, heavy metals, and radioactivity that exceed applicable standards. The focus of the assessment monitoring program is to gather data to define rate of migration of the contaminants, their concentration, and to better define contaminant plume boundaries. Although it is too early to determine accurately the quantitative rate and extent of migration, data indicate contamination remains relatively close to its source. For instance, at the S-3 Pond site the highest concentrations are within 150 m (500 ft) of the site, whereas nitrate, the most widespread groundwater contaminant, has been detected in wells as far as 920 m (3000 ft) southwest. Additional wells and continued monitoring are needed to draw further conclusions.

At ORNL, about 250 known potential waste sites are grouped into 20 Waste Area Groupings (WAGs), of which at present 11 are being or are to be monitored along their boundaries for groundwater quality. In 1989, four sets of analytical results were available for WAG 6 from quarterly samples from 22 boundary groundwater quality monitoring (GQM) wells. Tritium is the most commonly detected contaminant in WAG 6,

but only five wells, all of which are along the eastern boundary, consistently exceeded the drinking water standard of 19,980 pCi/L. Two of these same wells showed volatile organic compounds (VOCs), including trichloroethene, carbon tetrachloride, chloroform, 1,2-dichloroethane, and 1,2-dichloroethene. Trichloroethene, with a maximum concentration of 0.51 mg/L, is the VOC that has been detected at the highest concentrations. All GQM well water quality has met applicable primary drinking water standards for total and dissolved metals; no semivolatile organic compounds have been found in these wells. Two wells showed elevated gross alpha or beta activity, but the levels are below the EPA primary drinking water limit of 15.12 pCi/L. None of the GQM wells exceeded the allowable 4-mrem dose level of 40.5 pCi/L for total radioactive strontium when calculated according to the most recent DOE guidance. Based on the findings and interpretations of these results, a Groundwater Quality Assessment Plan was prepared by ORNL staff and submitted to DOE in December 1989 for transmission to regulatory authorities.

Three sets of analytical results were available by the end of 1989 for the 25 GQM wells at WAG 1 (main plant area). These show levels of cadmium above the primary drinking water standard in three wells, barium in one well, and chromium in another. Two wells exceeded the Tennessee standard for fluoride but were within the EPA standard. Low levels of radionuclides were detected in several wells, including tritium, total radioactive strontium, total radium, and gross alpha and beta activity. The volatile organic compounds trichloroethene and vinyl chloride were detected in three wells at concentrations exceeding the primary drinking water standards.

Drilling of remaining GQM wells at the remaining WAGs resumed in June 1989 and by December, 28 new wells had been installed. The total number of GQM wells projected for all WAGs is 172. Installation is to be complete by June 1990.

The ORGDP Groundwater Protection Program currently includes 191 monitoring wells at 40 remedial action and 2 RCRA sites. Fifty-one of these wells were installed at 27 remedial action sites during 1989. At all 42 sites, 188 wells were actively monitored for groundwater contamination during 1989, involving 122,682 laboratory analyses.

The 11 wells at the 2 RCRA sites (K-1407-B and C Ponds) continued under modified interim status detection monitoring during 1989 as approved by TDHE. Sixty-nine wells at the first 13 remedial sites were monitored for site-specific parameters at site-specific frequencies during 1989 as part of continued remedial action monitoring. The parameters and frequencies for continued monitoring were determined through evaluation of the baseline monitoring results for the sites. The 108 wells at the remaining 27 remedial action sites underwent one or two quarters of baseline monitoring during 1989, depending on when they were installed. Baseline monitoring involves four consecutive quarters of sampling for an extended list of constituents, including field parameters, indicator parameters, water quality parameters, volatile organics, semivolatile organics, metals, radioactivity, PCB/pesticides, and herbicides. All new wells undergo baseline monitoring during their first year of service.

Evaluations of hydrogeologic and groundwater quality data that were conducted by ORGDP during 1989 led to a realization that the approach to groundwater monitoring for remedial actions required modification. Because of the potential for intermingling of groundwaters contaminated by individual sites within the same groundwater drainage basins, it became obvious that the most efficient, cost-effective, and technically defensible approach to remedial action groundwater monitoring at ORGDP would be to divide the plant into hydrogeologically defined Waste Area Groupings (WAGs). Thirteen WAGs, encompassing from 1 to more than 10 individual sites, have been identified. The ORGDP Groundwater Protection Program will be completing a transition to the WAG approach for remedial action monitoring during 1990.

OTHER MONITORING

Biological Monitoring

Contaminant concentrations in fish samples during 1989 are comparable to, or are generally lower than, concentrations found in previous years (see Figs. 11 through 15). Samples were collected

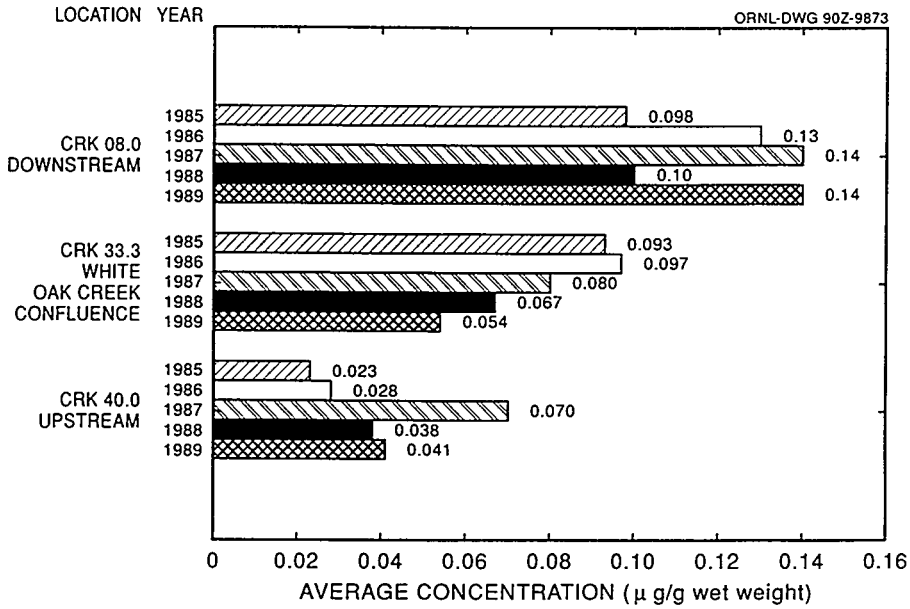

Fig. 11. Annual average mercury concentrations in bluegill at three Clinch River locations, 1985 through 1989.

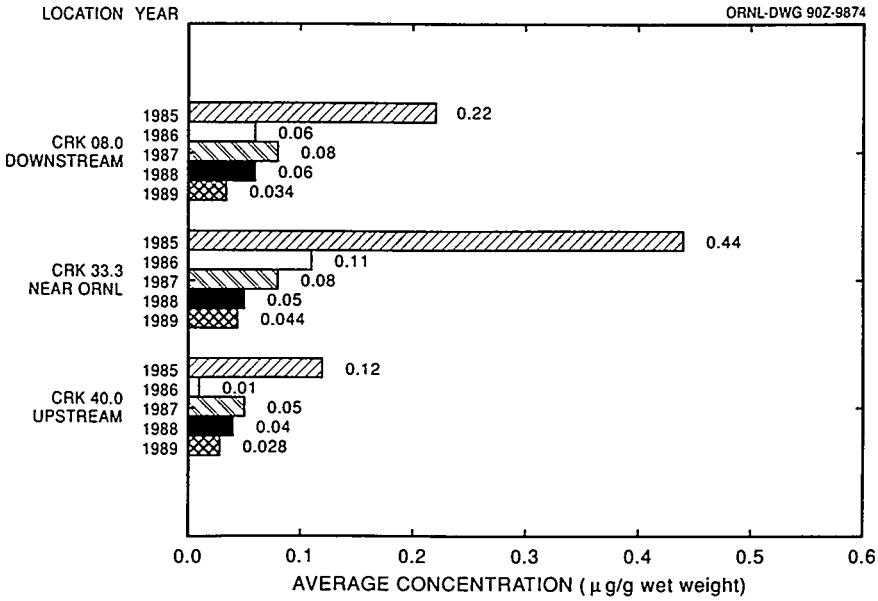

Fig. 12. Annual average PCB concentrations in bluegill at three Clinch River locations, 1985 through 1989.

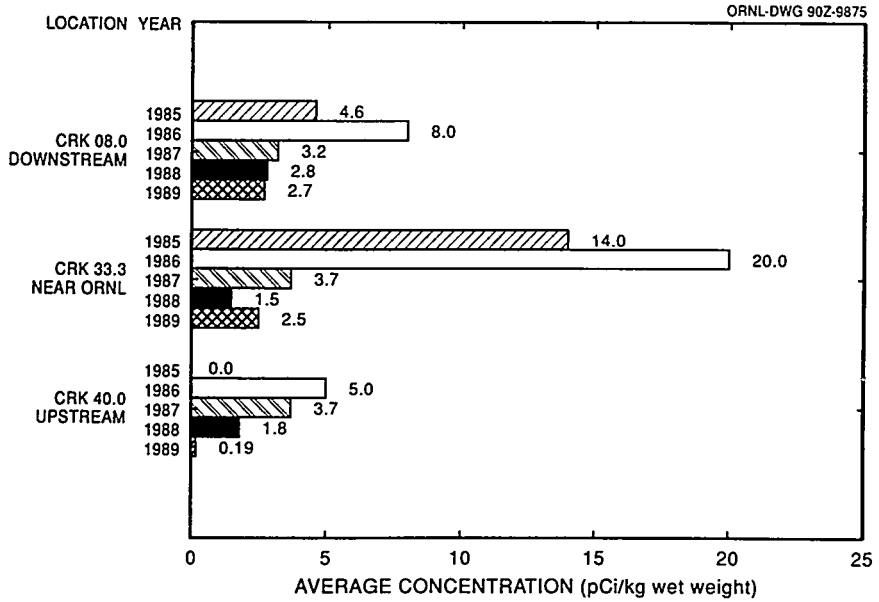

Fig. 13. Annual average ^{60}Co concentrations in bluegill at three Clinch River locations, 1985 through 1989.

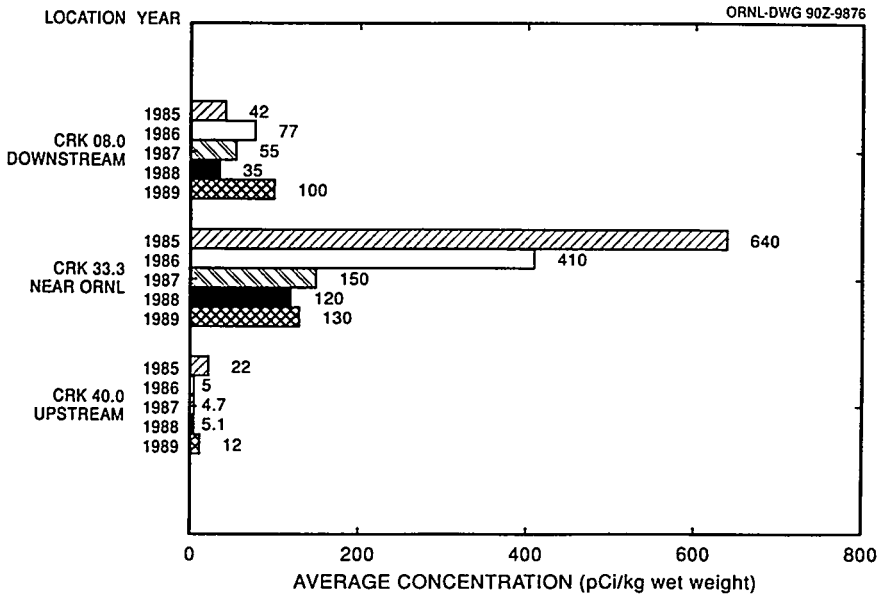

Fig. 14. Annual average ^{137}Cs concentrations in bluegill at three Clinch River locations, 1985 through 1989.

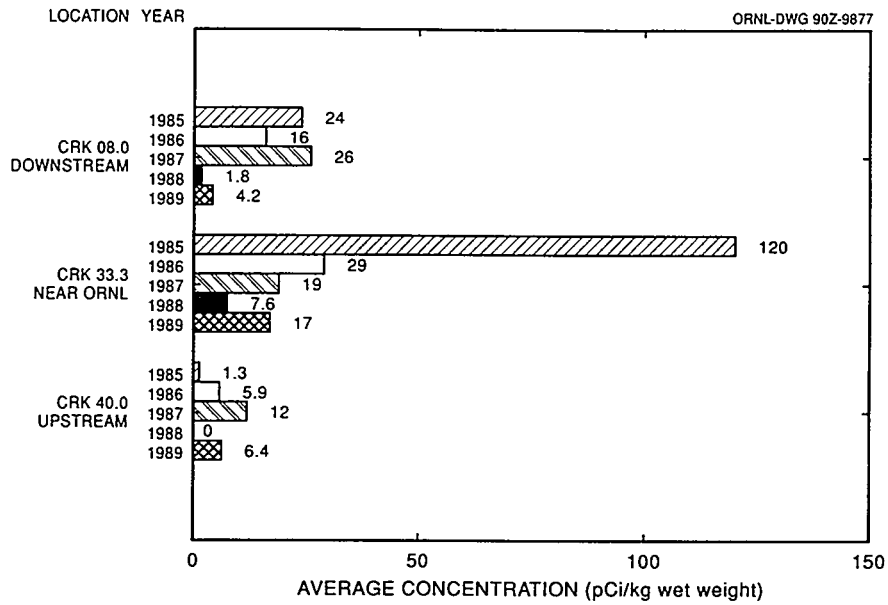

Fig. 15. Annual average total strontium concentration in bluegill at three Clinch River locations, 1985 through 1989.

to measure concentrations of mercury, polychlorinated biphenyls (PCBs), ^{60}Co, ^{137}Cs, and total radioactive strontium in bluegill from the Clinch River. The average mercury concentration for 1989 was 6.9% of the U.S. Food and Drug Administration (FDA) guideline. For the PCBs, the percentage of the guideline in 1989 was 2.5%. No guidelines exist for radionuclide concentrations in fish. However, dose calculations were based on concentrations of radionuclides in fish and assumed consumption rates. These calculations are described in Sect. 3.1 of this report. To put doses from waterborne radionuclides into perspective, a person who eats fish and drinks water from Kingston could add ~0.1% to his or her annual dose from background radiation.

Milk samples were collected from five locations in the 80-km area around the ORR and were analyzed for ^{131}I and total radioactive strontium. All the results were less than 40% of the applicable Range I Federal Radiation Council Guidelines.

Stream Sediment Sampling

The stream-sediment-sampling program consists of six sampling locations on Poplar Creek and two locations on the Clinch River. These samples were collected in the fall and analyzed for concentrations of mercury, lead, nickel, copper, zinc, chromium, manganese, aluminum, thorium, cadmium, and total uranium.

The sampling locations are shown in Fig. 2.5.2 of this report. Bar graphs indicating trends since 1985 are shown in Figs. 16–21 for six of the most prominent metals: uranium, mercury, lead, nickel, chromium, and aluminum. In most locations, the concentrations have been decreasing since 1985. Samples taken at the mouth of Mitchell Branch (SS4) in 1989 showed concentration decreases of all metals except aluminum and manganese. Samples taken on the Clinch River (SS7 and SS8) continue to have the lowest concentrations of the sampling stations.

RADIATION DOSE TO THE PUBLIC

Collective Committed Effective Dose Equivalent to the Population Within 80 km (50 miles) of Oak Ridge Installations

The collective lifetime effective dose equivalent to the entire population (~940,000 persons) residing within 80 km (50 miles) of the

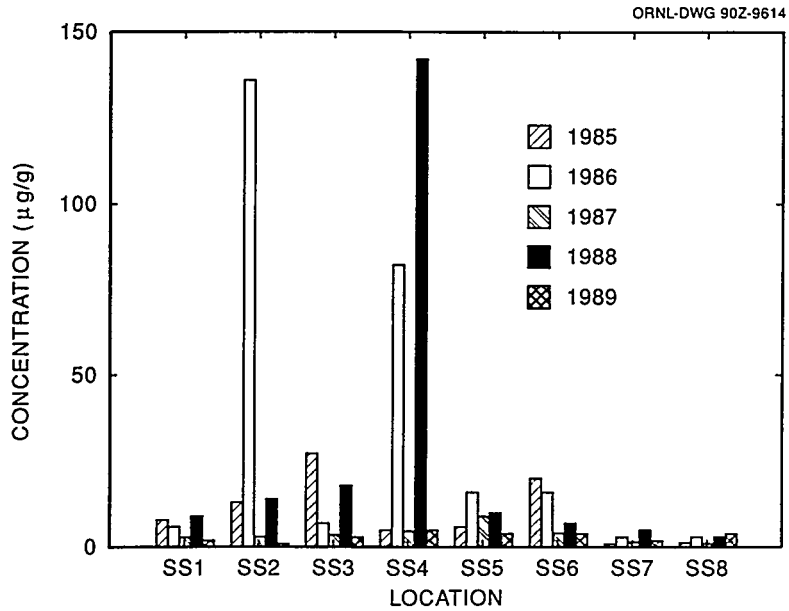

Fig. 16. Average uranium concentrations (μg/g dry weight) in sediment.

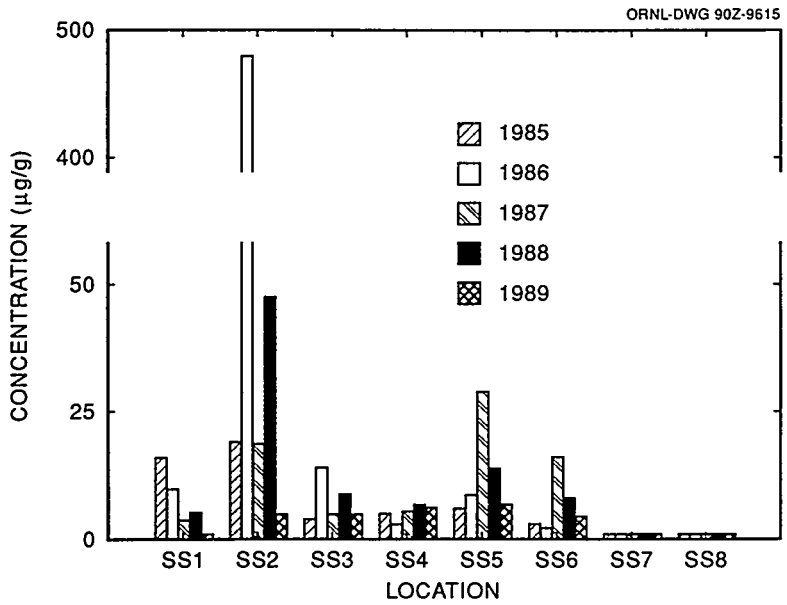

Fig. 17. Average mercury concentrations (μg/g dry weight) in sediment.

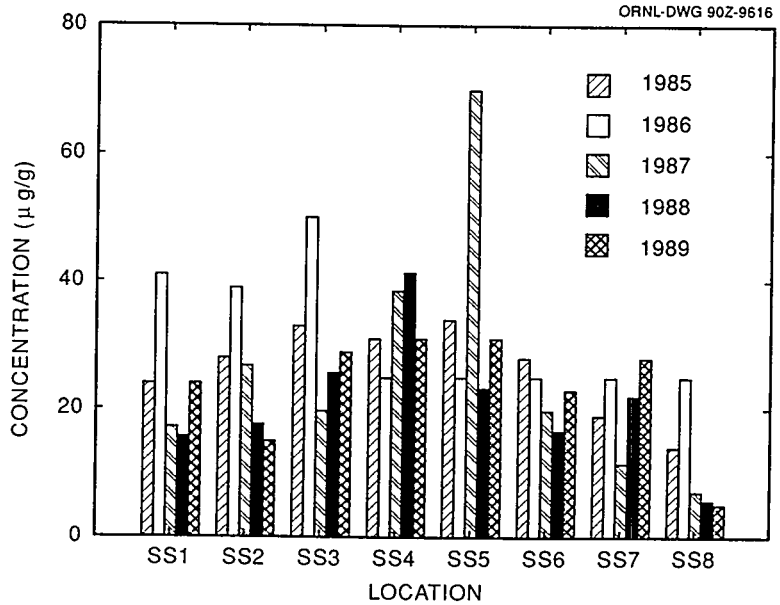

Fig. 18. Average lead concentrations (μg/g dry weight) in sediment.

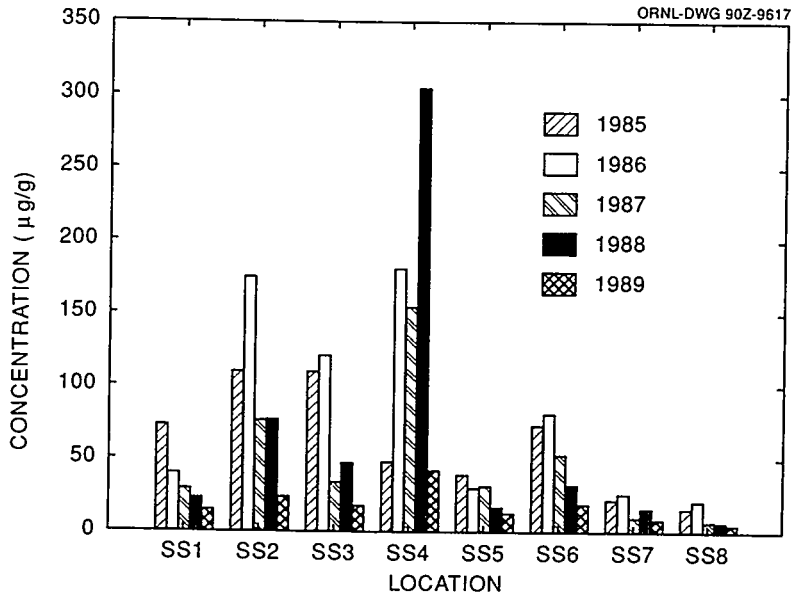

Fig. 19. Average nickel concentrations (μg/g dry weight) in sediment.

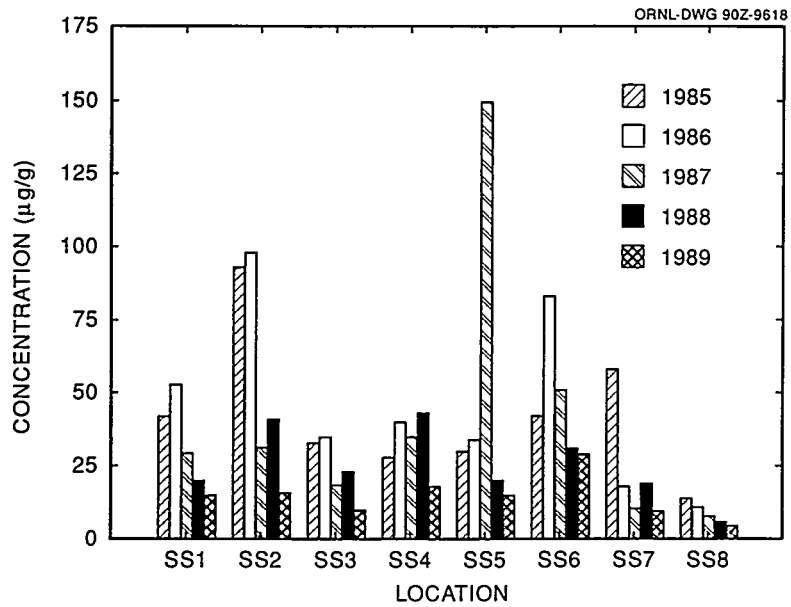

Fig. 20. Average chromium concentrations (µg/g dry weight) in sediment.

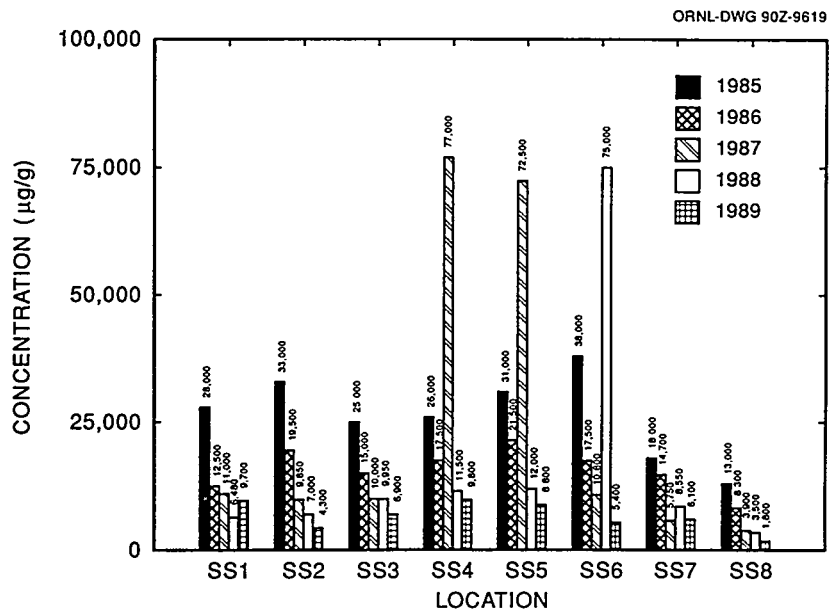

Fig. 21. Average aluminum concentrations (µg/g dry weight) in sediment.

ORR during 1989 is estimated to be 35 person-rem from releases of radionuclides from the ORR to the atmosphere. This dose equivalent is about 0.01% of the collective dose equivalent to the entire population from one year of exposure to natural radiation (see Fig. 22). A fatal cancer risk from reception of such doses can be calculated using a risk factor of 0.0004 per rem of effective dose equivalent, even though there is no conclusive evidence to support the existence of a risk from reception of such a low dose at such a low dose rate (i.e., the actual risk factor could be 0). The calculated fatal cancer risk associated with the 35-person-rem effective dose equivalent is ~0.01. This means that it would take, on average, ~100 years of such exposures for a fatal cancer to have a chance of developing in the entire population. The chance that an individual who receives the average effective dose equivalent (0.03 mrem) might develop a fatal cancer over a lifetime is 1 in 94,000,000. Effective dose equivalents from various exposure pathways are shown in Fig. 23.

REMEDIAL ACTION PROGRAM

Past ORR practices in the storage, treatment, and disposal of hazardous materials and wastes have resulted in the release of hazardous wastes to the environment. A remedial action program has been established at all three plants to identify and assess hazardous waste sites that may contaminate the environment and to develop and implement remedial actions to control and minimize the release of these contaminants from the sites. To date, 321 sites have been identified as requiring investigation: 42 at the Y-12 Plant, 169 at ORNL, and 110 at ORGDP. The sites include burial grounds, storage facilities, process ponds, underground tanks, treatment facilities, low-level-waste process lines and leak sites, and radioactive waste facilities.

To determine the need for, extent of, and priority of corrective actions at the sites identified, a remedial investigation/feasibility study (RI/FS) program has been implemented. The first step is to identify sites that have potential for releasing hazardous wastes to the environment. Next, an assessment or investigation is performed to determine if the groundwater, surface water, air, or soil influenced by the facility contains hazardous contaminants. If the investigation indicates that environmental media are not contaminated, the environment adjacent to the site is declared clean, and the investigation work is documented. If the

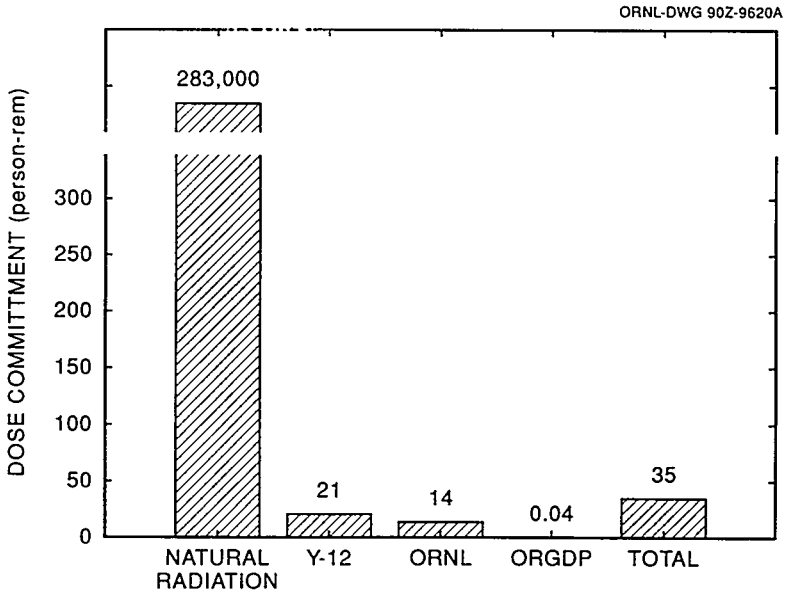

Fig. 22. The collective 50-year committed effective dose equivalent of the entire population within 80 km (50 miles) of the three installations.

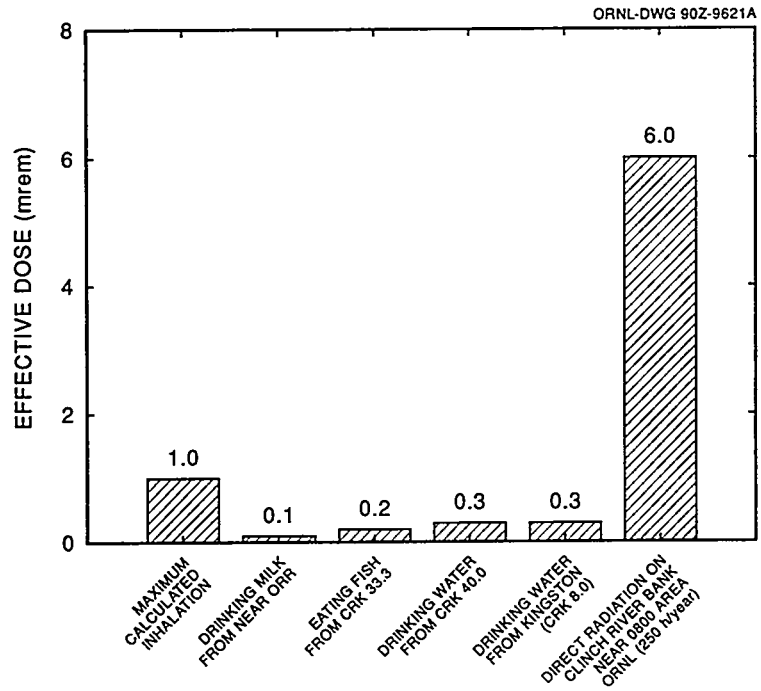

Fig. 23. The 50-year committed effective dose equivalent from various pathways from ORR discharges during 1989.

investigation indicates that the environmental media at the facility are contaminated, appropriate remedial actions are developed and implemented. After site remediation, maintenance and surveillance are performed to ensure the effectiveness of remediation.

High-priority sites will be addressed earlier, through near-term remedial actions; lower priority areas will continue to be maintained while awaiting final closure efforts. Many of the current groundwater monitoring efforts now under way on the ORR are being conducted to assess the groundwater near these hazardous waste sites.

From 1986 through 1989, the following RCRA closures were completed at the Y-12 Plant in accordance with TDHE-approved closure plans:

- the Salvage Yard Oil/Solvent Drum Storage Area,
- the hazardous waste storage area in the Old Steam Plant (Building 9401-1),
- the Prenco Incinerator Facility,
- the southern portion of the Interim Drum Storage Yards,
- the ACN Drum Yard, and
- the Waste Machine Coolant Biodegradation Facility (WMCBF).

RCRA closure activities of the following four major facilities at the Y-12 Plant have been completed as of the end of 1989:

- Oil Landfarm
- Bear Creek Burial Ground A,
- Chestnut Ridge Sediment Disposal Basin, and
- Chestnut Ridge Security Pits.

In addition, closure activities at the following facilities are under way:

- S-3 Ponds,
- Oil Retention Ponds 1 and 2,
- New Hope Pond,
- Bear Creek Burial Ground C, and
- Kerr Hollow Quarry.

The first phase of RCRA 3004 (u) and (v) corrective actions, the RCRA Facility Assessment (RFA), was conducted in 1987. Of the 187 Solid

Waste Management Units (SWMUs) identified at the Y-12 Plant at the time, approximately 127 were determined to be uncontaminated and therefore needed no further investigation. The remaining 42 sites will be addressed in the second-phase Remedial Facility Investigation (RFI) or are still undergoing assessment to determine the need for an RFI. During 1987, general documents and RFI plans for 9 of these 42 sites were developed and submitted to EPA and TDHE for review and approval. In 1988, ten additional RFI plans were submitted to EPA and TDHE for review and approval. In 1989, five additional RFI plans were submitted to EPA and TDHE for review and approval. Two RCRA RFIs were initiated in 1989, with the sampling phase completed.

At ORNL, the largest single Remedial Action Program (RAP) activity currently is the implementation of the comprehensive Remedial Investigation/Feasibility Study, initiated in 1986. Thirteen Waste Area Groupings are scheduled for characterization and assessment of remedial alternatives. A major support-subcontractor team was procured in 1987, and major documents related to areas such as QA, health and safety, data-base management, and waste management have been completed. Draft plans for 10 WAG RIs have been completed and submitted for regulatory review; the remainder will be completed by the end of 1993. Plans completed, to date, cover the main plant area of ORNL, all solid waste storage areas (SWSAs), the low-level waste (LLW) pits and trenches area, and hydrofracture sites. The RFI schedule for WAG 6 is tied to commitments in the SWSA-6 Closure Plan approved by TDHE and EPA; the WAG-6 RFI was formally implemented in late 1988. Work was initiated in WAG 1 (main plant area) in late 1989; other WAGs will be addressed according to established priorities. The overall RI/FS phase of the ORNL RAP was originally foreseen to require a 5-year effort. With a better understanding of the magnitude of the problem and experience with budget reductions, it now appears that 10 years will be a realistic, perhaps optimistic, expectation.

Three disposal sites are considered to have priority in the RAP at ORGDP. The facilities include the K-1070-A contaminated burial ground, the K-1070-B old classified burial ground, and the K-1070-C/D classified burial ground. Groundwater wells have been installed, and these facilities are being characterized for groundwater contamination to determine if buried materials are leaching. Overall, ORGDP has identified 110 sites requiring investigation. The preparation of RCRA Facility Investigation Plans is under way.

AUDITS AND REVIEWS

The three major Oak Ridge installations experienced numerous audits or inspections and reviews during 1989 related to environmental sampling and data management, sample analysis, waste management, and quality assurance. These audits and reviews consisted of external audits by outside regulatory agencies, such as the EPA and TDHE; audits and reviews by DOE-Headquarters (HQ) in Washington or the DOE-Oak Ridge Operations (ORO) office; and internal audits by Energy Systems. A representative listing is shown below.

- TDHE RCRA Inspections
- DOE-ORO Environmental Appraisals
- TDHE Inspection of West Borrow Area at the Y-12 Plant
- TDHE Compliance Evaluation Inspection
- TDHE Inspection of Site Clearing North of Bear Creek Road near the Y-12 Plant
- TDHE/EPA RCRA Inspection
- Martin Marietta Energy Systems Environmental Appraisal
- National Academy of Science Interim Oversight of DOE's Non-Reactor Nuclear Facilities
- DOE-Headquarters Environmental Survey
- Technical Safety Appraisal
- DOE-Headquarters Y-12 Plant Compliance Assessment
- TDHE Air Permits and Sources Inspection
- EPA NPDES Performance Audit Inspection Follow Up
- Audit of NPDES sampling and chain-of-custody procedures by DOE-ORO and Peer Consultants

Identified deficiencies associated with these audits and reviews were recorded and corrective action plans were developed to ensure follow-up.

1989 SUMMARY ASSESSMENT
ENVIRONMENTAL COMPLIANCE ACTIVITY
U.S. DEPARTMENT OF ENERGY

OAK RIDGE Y-12 PLANT

BACKGROUND AND OVERVIEW

The Oak Ridge Y-12 Plant (Y-12) must operate in conformance with environmental (and other) requirements established by a number of federal and state statutes and regulations, Executive Orders, U.S. Department of Energy (DOE) Orders, and Compliance and Settlement Agreements. Compliance status with major environmental statutes is summarized below.

Clean Air Act (CAA) and National Emission Standards for Hazardous Air Pollutants (NESHAP)

Y-12 has approximately 120 state air permits; more than 500 air emission sources are permitted by the Tennessee Department of Health and Environment (TDHE). Eighty-five radiological stacks are equipped with continuous stack samplers to monitor uranium emissions. Some unpermitted sources and procedures were identified and addressed immediately on a case by case basis. Current efforts are focusing on ensuring that all sources are permitted and are operating in accordance with those permits.

Clean Water Act (CWA)

The Y-12 National Pollutant Discharge Elimination System (NPDES) permit encompasses 240 point discharges that require compliance monitoring and results in 12,500 samples per year. Five major wastewater treatment plants have been constructed and brought on-line since 1983. NPDES excursions and spills have occurred; however, progress continues in minimizing these incidents and their effects on receiving streams. An application of renewal of the Y-12 NPDES permit was provided to the TDHE in November 1989. The current NPDES permit expires May 23, 1990.

Resource Conservation and Recovery Act (RCRA)

Y-12 operates 37 interim status RCRA units; 11 of these units recently received final Part B permits (of these, 10 are under appeal). Five additional permits are in draft form, and three units have permits-by-rule in place. The balance are undergoing or are targeted for closure. More than 200 RCRA waste streams are generated at the Y-12 site; it has over 48 90-day waste accumulation areas and 49 underground storage tanks. Eight-three on-site solid waste management units are identified for further study under the 3004(u) Remedial Action Program. RCRA violations have occurred, and citations have been received in the past; however, recent improvements in the program have been noted as exemplary by both the TDHE and the U.S. Environmental Protection Agency (EPA), Region IV.

Toxic Substances Control Act (TSCA)

Polychlorinated biphenyls (PCBs) are used, and PCB waste is generated at Y-12. The storage, control, and disposal of these are regulated by the TSCA. A compliance issue does exist regarding the storage of uranium-contaminated PCB wastes beyond the TSCA 1-year limit (see Current Issues below for details).

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

The Oak Ridge Reservation was placed on the National Priorities List in November 1989. The TDHE, the EPA, and DOE are negotiating a Federal Facility Agreement (FFA) that is now in final draft form. It is anticipated that the FFA will be signed in the summer of 1990. This FFA will address the remediation of inactive waste sites and waste storage areas.

CURRENT ISSUES

A number of specific compliance issues have been identified as a result of recent intensive efforts to attain full compliance. The significant issues are discussed below.

Air Permits

An investigation identified a number of air emission sources that had been modified or constructed without proper permits, that had expired air permits, or that were unpermitted. These problems have been resolved for the most part; however, the development of procedures and systems to prevent recurrence is ongoing.

Unsampled NPDES Discharges

A field investigation of outfalls discharging to East Fork Poplar Creek identified several discharges that are not listed on the current NPDES permit. The outfalls have been incorporated into a Miscellaneous Discharge Sampling Plan and will be permitted in the new NPDES permit currently being negotiated for Y-12.

Discharges of Toxic Pollutants to Surface Water

Y-12 has been listed by the EPA and the TDHE as a point source discharger of toxic priority pollutants under CWA Sect. 304(l). Activities to reduce discharges of priority pollutants as well as other toxic agents such as chlorine and high temperature may be required.

Steam Plant Ash Disposal

The discharge of ash sluice water from the steam plant currently results in some parameters exceeding TDHE water quality criteria in McCoy Branch. Both interim and long-term projects have been identified and initiated to address this issue.

Uranium Disposal in Bear Creek Burial Grounds (BCBG)

Pyrophoric uranium chips, along with machining coolants, have been disposed by placing them in earthen trenches in BCBG. The machining coolants may have been released to surface streams or groundwater. This disposal activity has now been eliminated as standard practice; however, it may continue on an emergency basis. These materials (not including "saw fines") are thermally converted to uranium oxide at the Uranium Chip Oxidizer Facility, and the uranium oxide is stored in vaults. The saw fines will be blended with uranium oxide and stored in the vaults. This processing will begin as soon as environmental and safety documentation has been approved.

Land Disposal Restricted Waste

RCRA mixed, radioactive land ban waste (including some nonradiological classified land ban waste) has been stored in some areas at Y-12 for longer than 1 year. These wastes are currently subject to the land ban that permits storage only for accumulation of sufficient quantities to facilitate proper treatment, recycle, or disposal. This waste is being stored because of the nationwide shortage of treatment and disposal facilities for these types of waste. Private sector technology demonstrations are being conducted that involve uranium extractions from sludge. In addition, technology demonstrations are being planned for FY 1991 that will involve the removal of uranium and other metals from oils and solvents. DOE and the EPA are continuing to discuss the issue, and the inventory of such waste is reported to the regulators on an annual basis. DOE's Oak Ridge Operations Office expects to negotiate an FFA that would detail the steps needed to attain compliance.

Mixed TSCA Waste Storage

Uranium-contaminated PCB wastes (i.e., mixed wastes) are being stored in excess of the 1-year limit imposed by the TSCA because of the lack of treatment and disposal capabilities. A compliance agreement with the EPA is being pursued.

PCB Contamination Investigation in BCBG

On January 5, 1990, accumulations of dense, nonaqueous phase liquids (DNAPLs) were discovered at depths of approximately 83.5 m (274 ft) below ground surface in newly installed well GW-625 located along the southern border of Burial Ground A-South within the BCBG Hazardous Waste Disposal Unit. Subsequent to this discovery, a preliminary investigation was initiated to obtain information on the mode of occurrence and distribution of the DNAPLs and to obtain expert technical advice on DNAPL behavior in fractured rock such as that underlying BCBG. The investigation included installation and sampling of two additional groundwater monitoring wells, resampling of existing wells in the vicinity of the discovery well, evaluation of existing groundwater quality data, and technical review of available information and site conditions by an independent consultant expert in the behavior of DNAPLs.

Because of the complex behavior of DNAPLs in fractured rocks, direct determination of the extent of their occurrences within the subsurface is not feasible. However, accumulations of DNAPLs in the subsurface generate dissolved contaminant plumes within groundwater. Detection and characterization of such plumes typically provide the only reliable means of determining the extent of DNAPL contamination at a site. Samples obtained from wells GW-625 (i.e., the discovery well) and GW-628 (i.e., the preliminary investigation well) provide direct evidence for the occurrence of DNAPLs at depths of at least 82.3 m (270 ft) below ground surface in the vicinity of BCBG. Groundwater from existing intermediate and deep wells have a suite of volatile organic compound contaminants suggesting that these wells may indicate dissolved contaminant plumes associated with subsurface DNAPL occurrences.

As long as the hydrogeologic system in the immediate vicinity of the DNAPL occurrences is not disturbed, DNAPL migration is not likely to advance. However, if the system is disturbed, DNAPL accumulations could become remobilized. The static nature of the system and the occurrence of DNAPL pools in the subsurface, combined with the complex hydrogeology of the site, require that future characterization and remediation activities at the site be undertaken with care and understanding of all factors that can influence DNAPL migration.

Future investigations will focus on defining the deep and intermediate groundwater flow system within the BCBG vicinity and determining the extent of the dissolved plume from the outside inward. If conditions warrant, hydraulic control of the dissolved plume by creating a capture zone will be undertaken.

DOE Environmental Assessment (Tiger Team)

In September and October 1989, a team of DOE environmental specialists conducted a comprehensive assessment of environmental practices at Y-12. The assessment covered the CWA, the CAA, the RCRA, the TSCA, Remedial Action Programs, radioactive emissions, the National Environmental Policy Act (NEPA), underground storage tanks, and environmental monitoring and surveillance. The assessment expressed concern over 24 compliance issues: 1 for the CAA, 4 for the CWA, 1 for hydrogeology, 6 for waste management, 3 for toxic materials management, 4 for radioactive emissions, and 5 for NEPA. Other practices relating to Best Management Practices were also examined. Copies of the draft report were made available to the U.S. Congress, the state of Tennessee, and the EPA. Copies of the final report will be made available to the public on request.

CERCLA Reporting Requirements

A compliance assessment is needed to determine if continuous releases of hazardous substances reportable under 40 CFR 302.6(a) of CERCLA are occurring.

Deficiencies in the NEPA Program

In the past the NEPA Program at Y-12 has been loosely structured with informal guidelines used for NEPA determinations. As such, it has been rated as marginal by a recent DOE Tiger Team Compliance Assessment. Personnel are being added to upgrade the NEPA Program. Y-12 is also developing a NEPA implementation procedure that outlines steps to ensure NEPA compliance for projects involving construction.

OAK RIDGE NATIONAL LABORATORY

BACKGROUND AND OVERVIEW

The Oak Ridge National Laboratory (ORNL) must operate in conformance with environmental (and other) requirements established by a number of federal and state statutes and regulations, Executive Orders, U.S. Department of Energy (DOE) Orders, and Compliance and Settlement Agreements. Compliance status with major environmental statutes is summarized below.

Clean Air Act (CAA) and National Emission Standards for Hazardous Air Pollutants (NESHAP)

Some unpermitted sources and procedural violations have been reported. Current efforts are focusing on ensuring that all sources are permitted and are operating in accordance with those permits. Currently, ORNL has 106 state air permits; an additional 2 are in review or preparation. Of the ten major stacks, nine are either monitored or sampled for radiological emissions (the steam plant is not sampled or monitored for radiological emissions). The measured radiological emissions provided the basis for calculations of the ORNL annual radiological effective dose equivalent and conformance with NESHAP requirements. On December 15, 1989, the EPA issued new NESHAP regulations. Compliance with these requirements was required by March 15, 1990. A Monitoring Compliance Plan for all DOE facilities on the Oak Ridge Reservation was submitted to EPA Region IV. A proposal was prepared according to the requirements of the new NESHAP regulations and is under review by EPA Region IV.

Clean Water Act (CWA)

The ORNL National Pollutant Discharge Elimination System (NPDES) permit, renewed in 1986, has over 190 point source discharges that require compliance monitoring. The majority of these are storm drains, roof drains, parking lot drains, and storage area drains. Three major wastewater treatment facilities have been constructed since 1985: the Sewage Treatment Plant, the Coal Yard Runoff Treatment Plant, and the Non-Radiological Wastewater Treatment Plant (NRWTP). Occasional spills, excursions, and precipitation runoff from storm and parking lot drains have resulted in NPDES permit effluent limits being exceeded for certain parameters. Progress continues toward minimizing or eliminating these occurrences.

Because of numerous construction activities throughout the ORNL site that may impact the local surface streams, ORNL has applied for and received nine approvals for such projects from the U.S. Army Corps of Engineers. The projects are approved and permitted under the requirements of 33 CFR Pt. 330.5, "U.S. Army Corps of Engineers Nationwide Permits."

Five water quality permits, aquatic resource alterations, have been issued to ORNL by the Tennessee Department of Health and Environment (TDHE).

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

The Oak Ridge Reservation was placed on the National Priorities List in November 1989. The

TDHE, the U.S. Environmental Protection Agency (EPA), and DOE are negotiating a Federal Facility Agreement (FFA) that is now in final draft form. Signing of the FFA is anticipated in the summer of 1990. This FFA will address the remediation of inactive waste sites and waste storage areas.

National Environmental Policy Act (NEPA)

ORNL is in compliance with NEPA. This compliance is achieved and maintained through the efforts of the Environmental Review and Documentation Program, which reviews and documents all new programs and projects for any potential environmental impact.

Resource Conservation and Recovery Act (RCRA)

ORNL generates both RCRA hazardous waste and RCRA hazardous waste mixed with radionuclides (i.e., "mixed" hazardous waste). The hazardous waste is accumulated at several satellite accumulation areas by individual generators where it is picked up by waste management personnel and stored in permitted storage facilities until it is shipped off-site for treatment and/or disposal at an RCRA-permitted facility. ORNL has one RCRA-permitted hazardous waste storage facility and several others that operate under RCRA interim status. Mixed waste must be stored on-site because no facilities are currently available for treatment and/or disposal. Part B permit applications for nine mixed waste storage facilities are in various stages of preparation. Several mixed waste facilities that currently operate under interim status will not be permitted. They are undergoing or are targeted for closure.

The most recent RCRA inspection by the TDHE (i.e., February 1990) resulted in no violations, and the regulators remarked that ORNL RCRA facilities were very well managed and were maintained in an exemplary manner.

Toxic Substances Control Act (TSCA)

Polychlorinated biphenyls (PCBs) are used, and PCB waste is generated at ORNL. The storage, control, and disposal of these are regulated by the TSCA. A compliance issue does exist regarding the storage of PCB wastes that are also contaminated with radionuclides beyond the 1-year TSCA limit (see Current Issues below for details). The EPA has been informed of this activity, and an agreement between the EPA and DOE that will allow continued storage of mixed PCB waste until it can be incinerated in the new TSCA-RCRA incinerator at Oak Ridge Gaseous Diffusion Plant is being pursued. The EPA conducted a TSCA inspection of ORNL facilities in February 1990, and no nonconformances with regulatory requirements were cited.

Underground Storage Tanks (USTs)

The UST regulations (40 CFR Pt. 280—referred to as Subtitle I) require that all underground tanks storing petroleum products or hazardous substances be in compliance with specific technical standards within a period of 10 years from the date of adoption of the final regulations. Tanks that were in existence prior to the issuance of the regulations are required to be upgraded during this 10-year period to meet the standards or are taken out of service. The TDHE has also promulgated state UST regulations that attempt to mirror the federal regulations.

ORNL has developed a UST Management Program that includes implementation of leak detection, corrosion protection, spill and overflow protection, annual tightness testing, operational controls, record keeping, reporting, and replacement of certain UST systems that cannot be upgraded by 1998. The program also addresses the immediate removal from service and remediation of tank sites from tanks found to be leaking as well as implements any required closures, corrective actions, and any upgrading and/or replacement of affected USTs in accordance with the program plan. Additionally, the program also ensures that the installation of new USTs meets the minimum design standards. To date, eight USTs have been removed from the ground, and several upgrade and remediation projects are currently under way.

CURRENT ISSUES

A number of specific compliance issues have been identified. Some of the most significant issues are discussed below.

Land Disposal Restricted Waste

Currently, ORNL is storing liquid, low-level radioactive waste that also contains RCRA hazardous waste (mixed waste) subject to the Land Disposal Restrictions that allow storage only for accumulating sufficient quantities for treatment. This waste is being stored because of the lack of treatment or disposal facilities for this type of mixed waste. DOE and the EPA are continuing to discuss the issue, and the inventory of such materials is reported to the EPA on an annual basis. DOE expects to negotiate with the EPA an FFA that would detail the steps needed to attain compliance.

Contaminants Resulting from Storm Runoff

Precipitation runoff has resulted in total suspended solids (TSS) and oil and grease (O&G) values that persistently exceed NPDES effluent limits at storm drain and parking lot drain outfalls. Studies have been initiated to identify potential corrective measures along with the feasibility of implementation. Based on evidence that the NPDES exceedences of TSS and O&G experienced over the past 2 years do not appear to have a significant impact on the water quality of the White Oak Creek watershed and exemptions from NPDES permitting requirements provided by the EPA's proposed regulations governing stormwater runoff from parking lots, a request for a modification to ORNL's NPDES permit has been submitted to the TDHE.

Ethylene Glycol Spills

It is suspected that slow releases of ethylene glycol to surface streams are occurring from the Central Chilled Water Facility in the main plant complex at ORNL. Occasional ethylene glycol spills also occur that enter surface waters. Although ethylene glycol is not a toxic pollutant, it results in the generation of an oxygen demand on the receiving stream that can be detrimental to aquatic organisms. An action plan has been developed by ORNL for replacement of ethylene glycol with water coolant.

In instances where major ethylene glycol spills occur, containment is provided as soon as practicable to minimize releases to surface waters. Agreements are being negotiated with the TDHE to allow treatment of these contained wastes through on-site conventional wastewater treatment facilities for subsequent discharge through NPDES-permitted outfalls.

Mixed TSCA Waste Storage

Radioactively contaminated PCB wastes (i.e., mixed wastes) are being stored in excess of the 1-year limit imposed by the TSCA because of the lack of treatment and disposal capabilities. A compliance agreement with the EPA is being pursued.

Releases from Burial Grounds and Waste Disposal Areas

Radionuclides and chemical constituents due to releases from inactive burial grounds and other waste disposal areas have been found in groundwater and surface water in the Bethel and Melton Valley areas of ORNL. Major known releases include strontium, cesium, cobalt, and tritium as well as chemical, organic, and metal constituents. ORNL has established a Remedial Action Program to provide comprehensive management and remediation of those areas where past research, development, and waste management activities have been conducted and have resulted in residual contamination of facilities or releases to the environment. The FFA will address selections of corrective measures and schedules for implementation.

Discharges of Toxic Pollutants to Surface Water

ORNL was originally considered for listing by the EPA and the TDHE as a point source discharger of toxic priority pollutants under CWA Sect. 304(1) because of effluents from four outfalls. Three of the four effluent points have been addressed using individual control strategies. The fourth effluent point has been addressed through a proposed modification to the NPDES permit.

OAK RIDGE GASEOUS DIFFUSION PLANT

BACKGROUND AND OVERVIEW

The Oak Ridge Gaseous Diffusion Plant (ORGDP) must operate in conformance with environmental (and other) requirements established by a number of federal and state statutes and regulations, Executive Orders, U.S. Department of Energy (DOE) Orders, and Compliance and Settlement Agreements. Compliance status with major environmental statutes is summarized below.

Clean Water Act (CWA)

The compliance activity issue associated with CWA regulations includes excursions outside the National Pollutant Discharge Elimination System (NPDES) permit discharge limits. ORGDP has one NPDES permit that was issued by the Tennessee Department of Health and Environment (TDHE) pertaining to eight discharge locations. Approximately 22,000 analyses are performed annually as required by the existing NPDES permit. Even though a 99%-plus compliance rate is experienced, occasional excursions occur outside the NPDES discharge limits. Each time an excursion is experienced, a quality investigation is conducted to identify causes and corrective actions to prevent future occurrences. Approximately half of the excursions experienced are for aluminum at the Mitchell Branch sampling station and chemical oxygen demand (COD) at the K-1007-B pond outfall. These excursions are believed to be the result of natural occurrences during periods of heavy rainfall and not process related. DOE has requested variances from the TDHE for aluminum and COD at these locations.

Corrective actions relating to the NPDES Program include identifying projects to treat and/or remove nonpoint source discharges. These projects include the rehabilitation of sanitary sewer lines to prevent infiltration, the removal and/or treatment of effluents to storm drains to remove residual chlorine, and the remediation of sites that may be contributing to surface water contamination.

Clean Air Act (CAA)

At present, there are approximately 125 air permits for operations existing at ORGDP. The compliance activity issues associated with CAA regulations include (1) asbestos abatement under the National Emission Standards for Hazardous Air Pollutants (NESHAP) requirements, (2) the opacity excursions that occur when coal is used during peak power demands as a supplemental fuel source at the steam plant, and (3) new regulatory requirements under NESHAP for radionuclide emissions. The asbestos abatement issue has been addressed using an aggressive program for the removal and/or encapsulation of deteriorating asbestos in identified areas and for the formalization of all procedures for asbestos work. Current efforts are focusing on ensuring that all sources are permitted and are operating (1) in accordance with those permits, (2) in compliance with the new NESHAP regulations for radionuclide emissions, and (3) in accord with ongoing work to eliminate opacity excursions.

Resource Conservation and Recovery Act (RCRA)

ORGDP has 22 storage/treatment units for which RCRA Part B applications have been submitted to the TDHE. Nine other storage areas have been added to the Part A application but have not been approved for use because of the operator signature issue between DOE and Martin Marietta Energy Systems, Inc. Once the issue is resolved, 10 of the 22 units should be permitted, and the remaining 12 will come under interim status. The nine other units will also come under interim status after the Part A application has been approved.

Toxic Substances Control Act (TSCA)

Polychlorinated biphenyls (PCBs) are used, and PCB waste is generated at ORGDP. In addition, PCB-contaminated wastes generated at other DOE Oak Ridge Operations (ORO) sites are

stored at ORGDP pending treatment at the K-1435 TSCA incinerator. The storage, control, and disposal of these are regulated by the TSCA. Compliance issues do exist regarding PCB leaks from ventilation system gaskets and the storage of uranium-contaminated PCB wastes beyond the TSCA 1-year limit (see Current Issues below for details).

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

The Oak Ridge Reservation was placed on the National Priorities List in November 1989. The TDHE, the U.S. Environmental Protection Agency (EPA), and DOE are negotiating a Federal Facility Agreement (FFA) that is now in final draft form. Signing of the FFA is anticipated in the summer of 1990. This FFA will address the remediation of inactive waste sites and waste storage areas.

CURRENT ISSUES

A number of specific compliance issues have been identified as a result of recent intensive efforts to attain full compliance. The significant issues are discussed below.

PCB-Contaminated Ventilation System Gaskets

Oil drips from PCB ventilation gaskets are considered PCB spills. The TSCA requires documentation and immediate cleanup action and verification after discovery. New drips from ventilation gaskets are cleaned in general accordance with the EPA Spill Cleanup Policy as contained in the TSCA. This includes periodic inspections to identify leaks and initiation of cleanup within 24 h. Sampling to verify cleanup, however, is performed only on a representative basis rather than for each spill as required by TSCA policy. Drip collection troughs are installed when leaks are discovered. DOE and the EPA are negotiating an FFA to bring the facility into compliance with TSCA regulations for use, storage, and disposal of PCBs.

Land Disposal Restricted Waste

Currently, ORGDP is storing liquid, low-level radioactive waste that also contains RCRA hazardous waste subject to the land ban that allows storage only for accumulating sufficient quantities for treatment. This waste is being stored because of the lack of treatment or disposal facilities for the materials. DOE and the EPA are continuing to discuss the issue, and the inventory of such materials is reported to the regulators on an annual basis. DOE expects to negotiate with the EPA an FFA that would detail the steps needed to attain compliance.

Liquid RCRA Wastes

Free liquids exist in an unknown number of drums of the concrete-stabilized sludge. Actions taken to resolve this issue include the preparation of a sampling plan to identify the effected drums and a method for removing the free liquid. The drums were divided into four populations according to process variations. The inspection of the drums began with the population that appeared most likely to contain liquid. Ten percent of the total number of drums were inspected in 1989, and approximately 18% of these contained free liquids. The liquid was drained and treated in the Central Neutralization Facility.

Mixed TSCA Waste Storage

Uranium-contaminated PCB wastes (i.e., mixed wastes) are being stored in excess of the 1-year limit imposed by the TSCA because of the lack of treatment and disposal capabilities. A compliance agreement with the EPA is being pursued.

Discharges of Toxic Pollutants to Surface Waters

ORGDP has been listed by the EPA and the TDHE as a point source discharger of toxic priority pollutants under CWA Sect. 304(l). Activities to reduce discharges of priority pollutants as well as other toxic agents such as chlorine and high temperature will be required. FY 1990 projects to address toxic contributors have been approved.

Steam Plant Opacity Problems

The opacity problem at the ORGDP Steam Plant is being resolved by replacing coal-fired boilers with gas-fired boilers. The engineering

design for the project to replace the coal-fired boilers has been completed, and the procurement of the gas-fired boilers has been initiated. Actions have been taken to eliminate the use of coal except when peak power demands are experienced during the winter months. DOE has also submitted a request for a formal agreement with the TDHE to commit to boiler installation and operation schedules.

CERCLA Reporting Requirements

A compliance assessment is needed to determine if continuous releases of hazardous substances reportable under 40 CFR 302.6(a) are occurring.

National Environmental Policy Act (NEPA) Program Deficiencies

In the past, the NEPA program at ORGDP has been loosely structured with informal guidelines used for NEPA determinations. Corrective actions for the program shortcomings have been recently implemented as part of a new emphasis by ORGDP on NEPA requirements. These actions include proposals for addition of new dedicated personnel and the development of an ORGDP-specific NEPA implementation procedure. As a result of the DOE SEN 15-90 guidance, DOE-ORO has developed a procedure for NEPA compliance. ORGDP will structure their site-specific NEPA Program to reflect the DOE-ORO procedure.

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ACRONYMS AND INITIALISMS

ACD	Analytical Chemistry Division
ACN	acetonitrile
AEA	Atomic Energy Act
AESG	Analytical Environmental Support Group
ALARA	as low as reasonably achievable
Am	americium
AMS	Aerial Measuring System
APG	Analytical Products Group, Inc.
As	arsenic
ASTM	American Society for Testing and Materials
ATLC	Atomic Trades and Labor Council
AVLIS	atomic vapor laser isotopic separation
BAT	best available technology
BCBG	Bear Creek Burial Grounds
BCK	Bear Creek kilometer
Bq	becquerel
BMAP	Biological Monitoring and Abatement Programs
BMP	best management practices
BOD	biological oxygen demand
BRC	Below Regulatory Concern
BTM	breakthrough monitors
CAA	Clean Air Act
CAPCA	Closure and Post Closure Activities
CARL	Comparative Animal Research Laboratory
CAS	Chemical Abstracts Service
CC	Copper Creek
CEI	Compliance Evaluation Inspection
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	cubic feet per minute
CH	contact-handled
Ci	curie
CLP	Contract Laboratory Program
Cm	curium
CNF	Central Neutralization Facility
Co	cobalt
COD	chemical oxygen demand
CPCF	Central Pollution Control Facility

CRK	Clinch River kilometer
CRSDP	Chestnut Ridge Sediment Disposal Basin
CRSP	Chestnut Ridge Security Pits
Cs	cesium
CSS	continuous stack samplers
CWA	Clean Water Act
CYRTF	coal yard runoff treatment facility
d	day
DARA	disposal area remedial action
DCG	derived concentration guide
D&D	decontamination and decommissioning
diam	diameter
DMR	Discharge Monitoring Report
DNA	deoxyribonucleic acid
DNAPL	dense nonaqueous phase liquid
DOE	U. S. Department of Energy
DOT	U. S. Department of Transportation
DWL	drinking water limits
EA	Environmental Assessment
EAP	Environmental Assessment Plan
EFK	East Fork Poplar Creek kilometer
EFPC	East Fork Poplar Creek
EIS	Environmental Impact Statement
EMC	Environmental Monitoring and Compliance
EMD	Environmental Management Department
EML	Environmental Measurements Laboratory
EMSL-LV	Environmental Monitoring System Laboratory at Las Vegas
EP	extraction procedure
EPA	Environmental Protection Agency
E&SA	Environmental and Safety Activities
ESD	Environmental Sciences Division
ERBC	Environmental Restoration Budget Category
ERD	Environmental Restoration Division
ET&I	Equipment Testing and Inspection
FAC	free available chlorine
FDA	Food and Drug Administration
FFA	Federal Facility Agreement
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FS	feasibility study
FWPLA	Federal Water Pollution Control Act
g	gram
GQM	groundwater quality monitoring
GC/MS	gas chromatography/mass spectrometry
GUT	Garage Underground Tanks

GW	groundwater
GWQAP	groundwater quality assessment plans
GWQAR	groundwater quality assessment reports
GWTF	Groundwater Treatment Facility
h	hour
H	hydrogen
ha	hectare
HAZWDDD	Hazardous Waste Development, Demonstration, and Disposal
HEPA	high-efficiency particulate air
HFIR	High Flux Isotope Reactor
Hg	mercury
HHMS	hydraulic head measuring stations
HSEA	Health, Safety, Environment, and Accountability
HSWA	Hazardous and Solid Waste Amendments
HWDU	hazardous waste disposal unit
HWOG	Hazardous Waste Operations Group
I	iodine
IAG	interagency agreement
IBI	Index of Biotic Integrity
ILSF	Interim Liquid Storage Facility
ISV	in situ vitrification
IWC	instream waste concentration
K	Kingston
kg	kilogram
KHQ	Kerr Hollow Quarry
km	kilometer
Kr	krypton
L	liter
LAM	local air monitor
LCR	lowest concentration reported
LLW	low-level waste
LLWDDD	Low-level Waste Disposal Development and Demonstration
LSF	Liquid Storage Facility
m	meter
MAA	material access area
MB	Melton Branch
MCL	maximum contaminant level
MDL	method detection limits
MEP	Maintenance Engineering Procedures
Mgd	million gallons per day
MHD	Melton Hill Dam
min	minute
mm	millimeter

mrem	millirem
M&S	maintenance and surveillance
NAS	National Academy of Sciences
ND	not detected
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHP	New Hope Pond
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
NOEC	no-observed-effect concentration
Np	neptunium
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
OLF	Oil Landfarm Area
ORAU	Oak Ridge Associated Universities
ORGDP	Oak Ridge Gaseous Diffusion Plant
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations
ORP	Oil Retention Ponds
ORR	Oak Ridge Reservation
ORRER	Oak Ridge Reservation Environmental Report
Pa	protactinium
P&A	plugging and abandonment
PAM	perimeter air monitor
Pb	lead
PC	Pond Closure
PCB	polychlorinated biphenyl
pCi	picocurie
PCP	pentachlorophenol
PE	performance evaluation
PET	Proficiency Environmental Testing
PGDP	Paducah Gaseous Diffusion Plant
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
PRTF	Plating Rinsewater Treatment Facility
Pu	plutonium
PWTP	process waste treatment plant
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
Ra	radium
RAM	remote air monitor
RAP	Remedial Action Program

RCRA	Resource Conservation and Recovery Act
RCW	recirculating cooling water
R&D	research and development
REDAC	radiation and environmental data analyzer and computer
REDAR	radiation and environmental data acquisition and Recorder
REDC	Radiochemical Engineering Development Center
RFA	RCRA Facility Assessment
RFI	RCRA facility investigation
RH	remote-handled
RI	remedial investigation
RMA	Rocky Mountain Arsenal
ROV	remote-operated vehicle
RWMD	Reservation Waste Management Division
S-3	S-3 Site
S&A	sampling and analysis
SARA	Superfund Amendments and Reauthorization Act
Se	selenium
SIM	selected ion monitoring
SE	standard error of the mean
SF	Support Facilities
SGS	soil gas survey
SO_2	sulfur dioxide
SOP	standard operating procedure
SPWTF	Steam Plant Wastewater Treatment Facility
Sr	strontium
SSF	Solids Storage Facility
STP	sewage treatment plant
SWMUs	solid waste management units
SWSA	solid waste storage areas
TARA	test area for remedial actions
TC	technetium
TCMP	toxicity control and monitoring program
TDHE	Tennessee Department of Health and Environment
Th	thorium
THWMR	Tennessee Hazardous Waste Management Regulations
TOC	total organic carbon
TOX	total organic halides
TRK	Tennessee River kilometer
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal
TSF	Tower Shielding Facility
TSP	total suspended particulates
TSS	total suspended solids
TSWMA	Tennessee Solid Waste Management Act
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency

U	uranium
UCOF	Uranium Chip Oxidation Facility
UEFPC	Upper East Fork Poplar Creek
UEFPCHR	Upper East Fork Poplar Creek Hydrogeologic Regime
UF_6	uranium hexafluoride
UNC	United Nuclear Corporation
UST	underground storage tank
VC7002	Vehicle Cleaning Facility
VOA	volatile organic aromatics
VOC	volatile organic compound
WAC	waste acceptance criteria
WAG	waste area grouping
WCPF	Waste Coolant Processing Facility
WETF	West End Treatment Facility
WIPP	Waste Isolation Pilot Plant
WMA	Waste Management Area
WMCBF	Waste Machine Coolant Biodegradation Facility
WOC	White Oak Creek
WOD	White Oak Dam
WOL	White Oak Lake
WOM	White Oak Mountain
Xe	xenon

1. INTRODUCTION AND GENERAL INFORMATION

1. INTRODUCTION AND GENERAL INFORMATION

The purpose of this report is to provide information to the public about the impact of the U.S. Department of Energy's (DOE's) Oak Ridge facilities on the public and the environment. It describes the environmental surveillance and monitoring activities conducted at and around the DOE facilities operated by Martin Marietta Energy Systems, Inc. Preparation and publication of this report is in accordance with DOE Order 5400.1. The order specifies a publication deadline of June of the following year for each calendar year of data.

One environmental reporting goal is to ensure that the annual site environmental reports include summaries of all known quantities of radiological and nonradiological materials in effluents to significant environmental media. This includes routine and accidental releases and those that can be quantified through material balance calculations. All known radiological effluent quantities are reported in this document. Chemicals covered by the Superfund Amendments and Reauthorization Act (SARA) Title III 313 Report on gaseous emissions are also included.

The scope of the environmental surveillance programs at the DOE facilities has increased significantly during the years since the plants' startup. This change is reflected in annual reports. Prior to the early 1980s, the focus of the reports was on radiological monitoring. Since that time, the reports have included increased amounts of nonradiological monitoring data as those programs have increased.

Volume 1 of the report summarizes environmental surveillance and monitoring activities at the three DOE facilities located on the Oak Ridge Reservation (ORR) and for the surrounding environment. It contains key figures and summary tables. Volume 2 contains the detailed data tables and figures for individual stations or locations and is not considered a stand-alone report.

In addition to providing information for the past calendar year, this report shows trend analyses over several years, when possible, to indicate increases and decreases in concentrations, discharges, or doses from the DOE facilities. It also provides radiation and chemical dose estimates to the surrounding populations and describes how the estimates are derived. A major effort at all the DOE facilities during the past year has been the implementation of a remedial action program to evaluate potential waste areas, assign priorities to them, and determine how to clean them up. Remedial action program activities during 1989 are described in this report, as are the ongoing programs for managing the solid waste generated by the plants' operations. Summary tables are provided that describe the quantities of solid waste treated or disposed of on-site, shipped off-site, or placed in storage. Special projects or studies that are ongoing in support of environmental protection or surveillance are also included. The final section of the report describes some of the quality assurance activities that are related to the generation of valid and reliable environmental data.

1.1 OPERATIONS ON THE OAK RIDGE RESERVATION

The ORR is located within the corporate limits of the city of Oak Ridge in eastern Tennessee. The ORR consists of about 14,300 ha (35,300 acres) of federally owned lands. The location of Oak Ridge and the ORR is shown on the map of Tennessee in Fig. 1.1.1. The ORR site is predominantly to the west and south of the

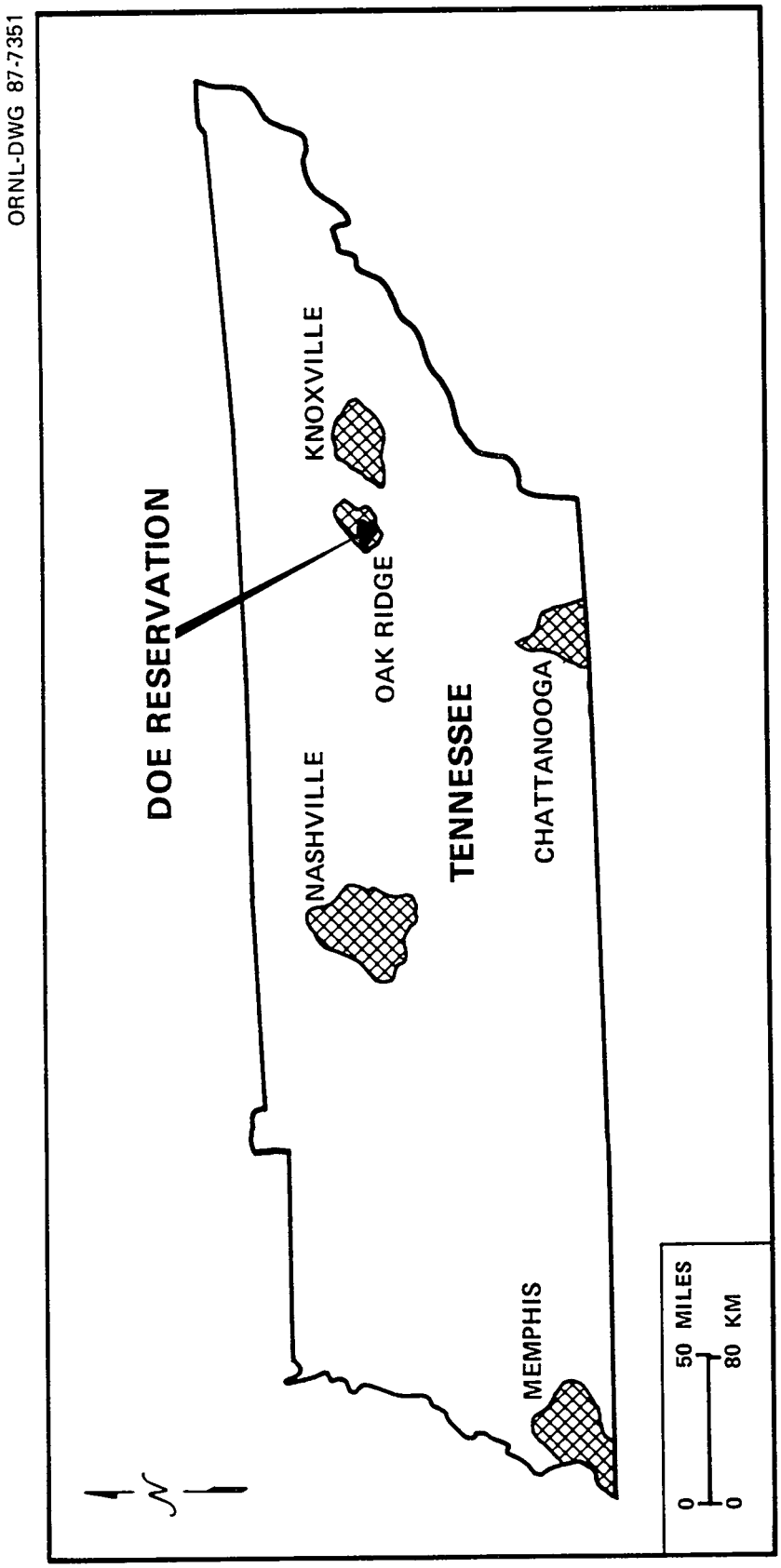

Fig. 1.1.1. Map showing the location of the Department of Energy's Oak Ridge Reservation in the state of Tennessee.

population center of the city, which has a population of 28,000. Oak Ridge lies in a valley between the Cumberland and southern Appalachian mountain ranges and is bordered on one side by the Clinch River. The Cumberlands are about 16 km (10 miles) northwest; 113 km (70 miles) to the southeast are the Great Smoky Mountains, as shown in Fig. 1.1.2.

The ORR contains three major operating facilities: Oak Ridge Y-12 Plant (Y-12 Plant), Oak Ridge National Laboratory (ORNL), and Oak Ridge Gaseous Diffusion Plant (ORGDP). The locations of these three facilities are shown on the map of the ORR (Fig. 1.1.3). The on-site DOE buildings and structures outside the major plant sites consist of the Scarboro Facility, Clark Center Recreational Park, Central Training Facility, and the Transportation Safeguards Division maintenance facility. The off-site DOE buildings and structures consist of the Federal Office Building, Office of Scientific and Technical Information, Oak Ridge Associated Universities (ORAU), Atmospheric Turbulence and Diffusion Division-National Oceanographic and Atmospheric Administration, the American Museum of Science and Energy, Energy Systems administrative support office buildings, and the former museum building. The administrative units (units managed by a major installation or by central Energy Systems) on the ORR are shown in Table 1.1.1. in Vol. 2.

The Y-12 Plant (Fig. 1.1.4), which is immediately adjacent to the city of Oak Ridge, has five major responsibilities: (1) to fabricate nuclear weapons components, (2) to process source and special nuclear materials, (3) to provide support to the weapons design laboratories, (4) to provide support to other Martin Marietta Energy Systems, Inc., installations, and (5) to provide support to other government agencies. Activities associated with these functions include production of lithium compounds, recovery of enriched uranium from scrap material, and fabrication of uranium and other materials into finished parts and assemblies. Fabrication operations include vacuum casting, arc melting, powder compaction, rolling, forming, heat treating, machining, inspection, and testing.

ORNL (Fig. 1.1.5), located toward the west end of Bethel Valley, is a large, multipurpose research laboratory whose basic mission is to expand knowledge, both basic and applied, in areas related to energy. To accomplish this mission, ORNL conducts research in fields of modern science and technology. ORNL's facilities include nuclear reactors, chemical pilot plants, research laboratories, radioisotope production laboratories, accelerators, fusion test devices, and support facilities. The Oak Ridge National Environmental Research Park is managed by ORNL. All of ORNL's reactors were shut down in 1986 while efforts were under way to improve operating procedures and safety standards for the facilities. The High Flux Isotope Reactor (HFIR) and the Tower Shielding Facility (TSF) operated to a very limited extent in 1989. In addition to the main ORNL complex, the ORNL Biology and Fusion Energy divisions and staff from other ORNL divisions are located at the Y-12 Plant, and the Applied Technology Division is located at the ORGDP site.

Until the summer of 1985, the primary mission of ORGDP (Fig. 1.1.6) was enrichment of uranium hexafluoride (UF_6) in the ^{235}U isotope for use as a fuel in nuclear reactors. The gaseous diffusion process was utilized to produce the enrichment services. In August 1985, the gaseous diffusion process at ORGDP was placed in a "ready standby" mode because of declining demands for enriched uranium. The decision to permanently shut down the gaseous diffusion cascade was made in December 1987.

In addition to operating the gaseous diffusion process, ORGDP personnel were involved in developing and demonstrating more energy-efficient and cost-effective methods for uranium enrichment. Two such methods under development at ORGDP were the gas centrifuge process and the atomic vapor laser isotopic separation (AVLIS) system. In 1985 the gas centrifuge process was shut down, and in 1986 the AVLIS work at ORGDP was significantly reduced.

Major changes in the role of ORGDP began evolving during 1986 and 1987. A significant increase in work for agencies other than DOE is projected in the future. The unique technologies,

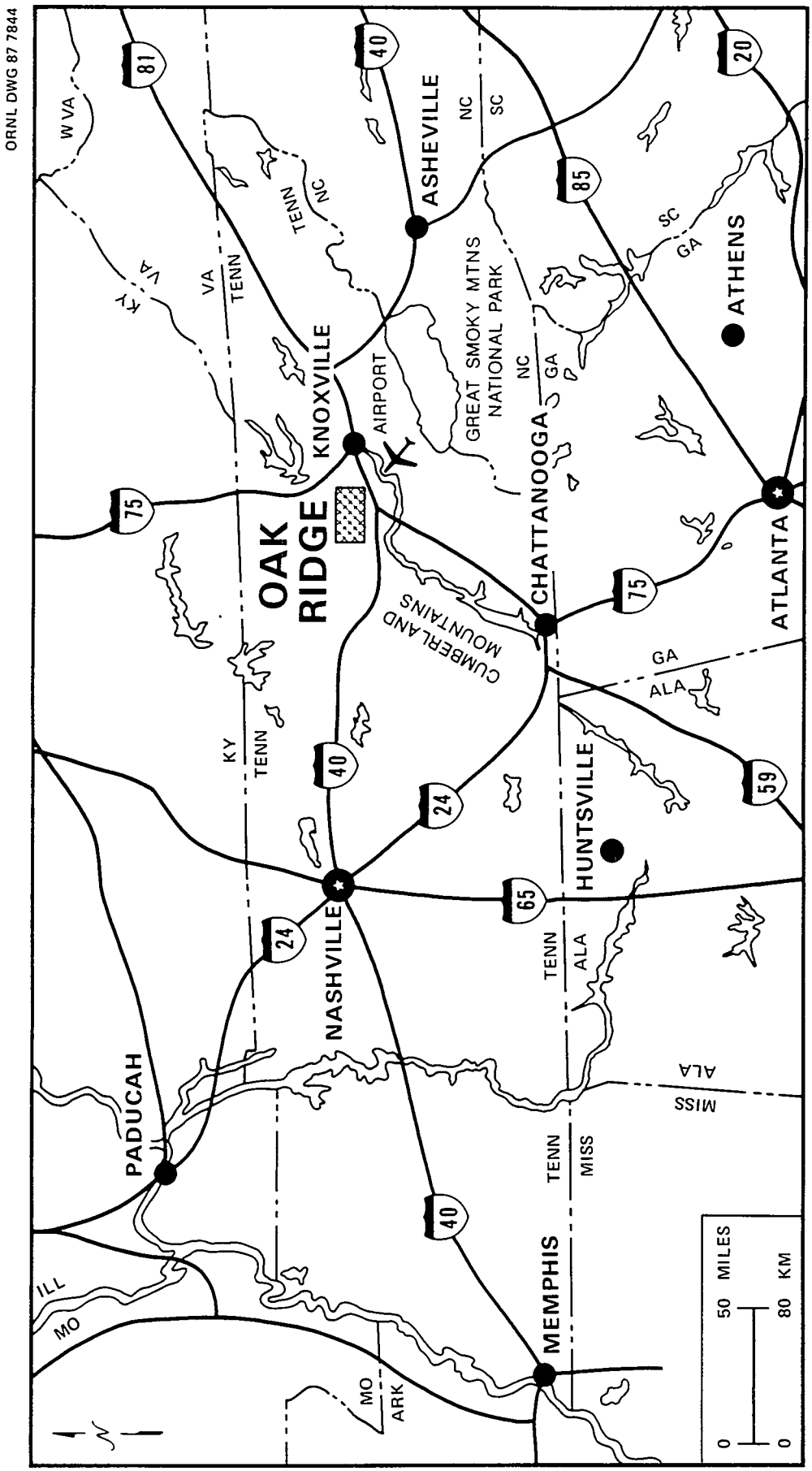

Fig. 1.1.2. Map showing location of Oak Ridge in relationship to geographic region.

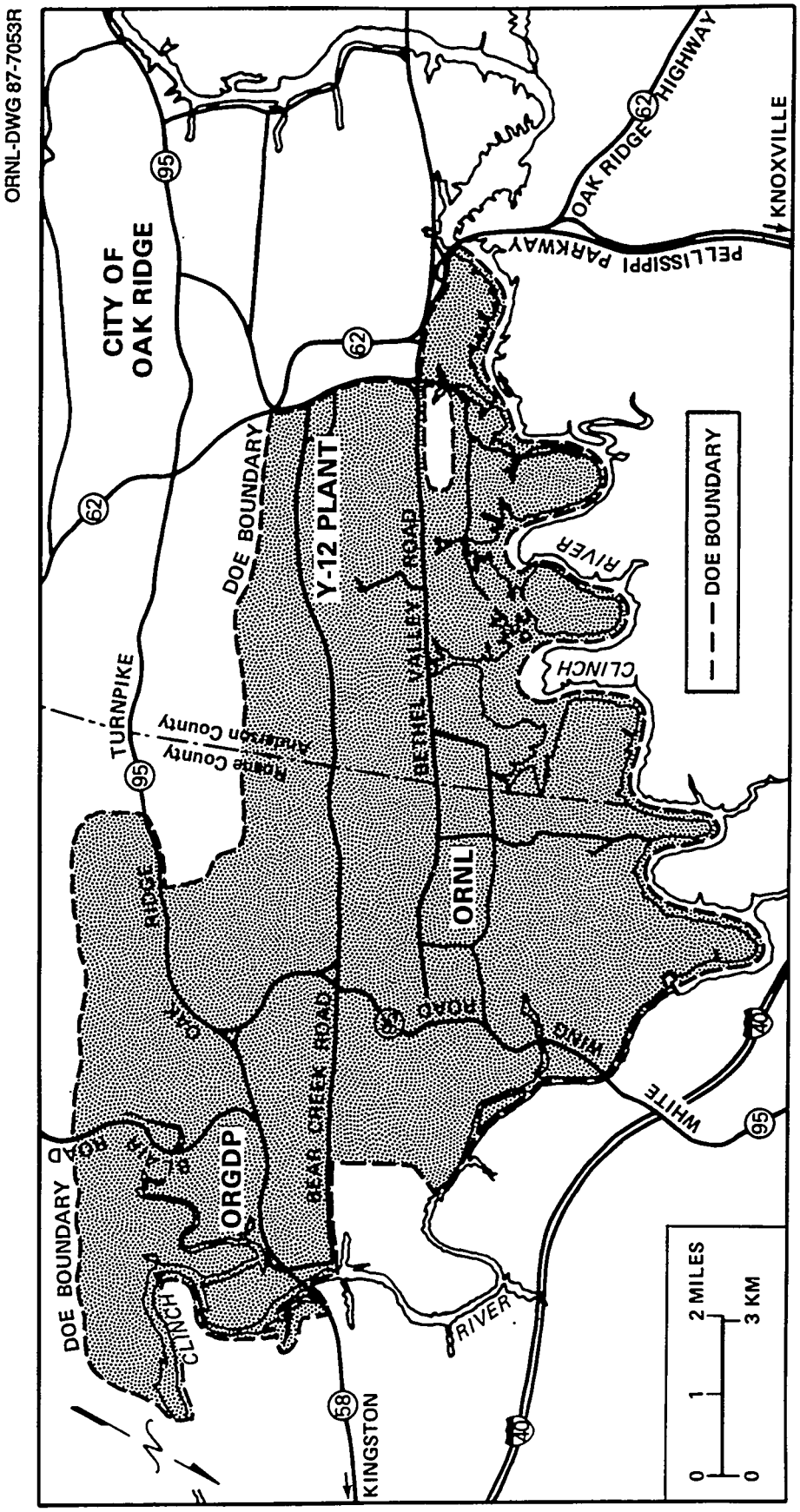

Fig. 1.1.3. Map showing the Department of Energy's Oak Ridge Reservation and the location of the three major installations.

Y-12 PHOTO 253352

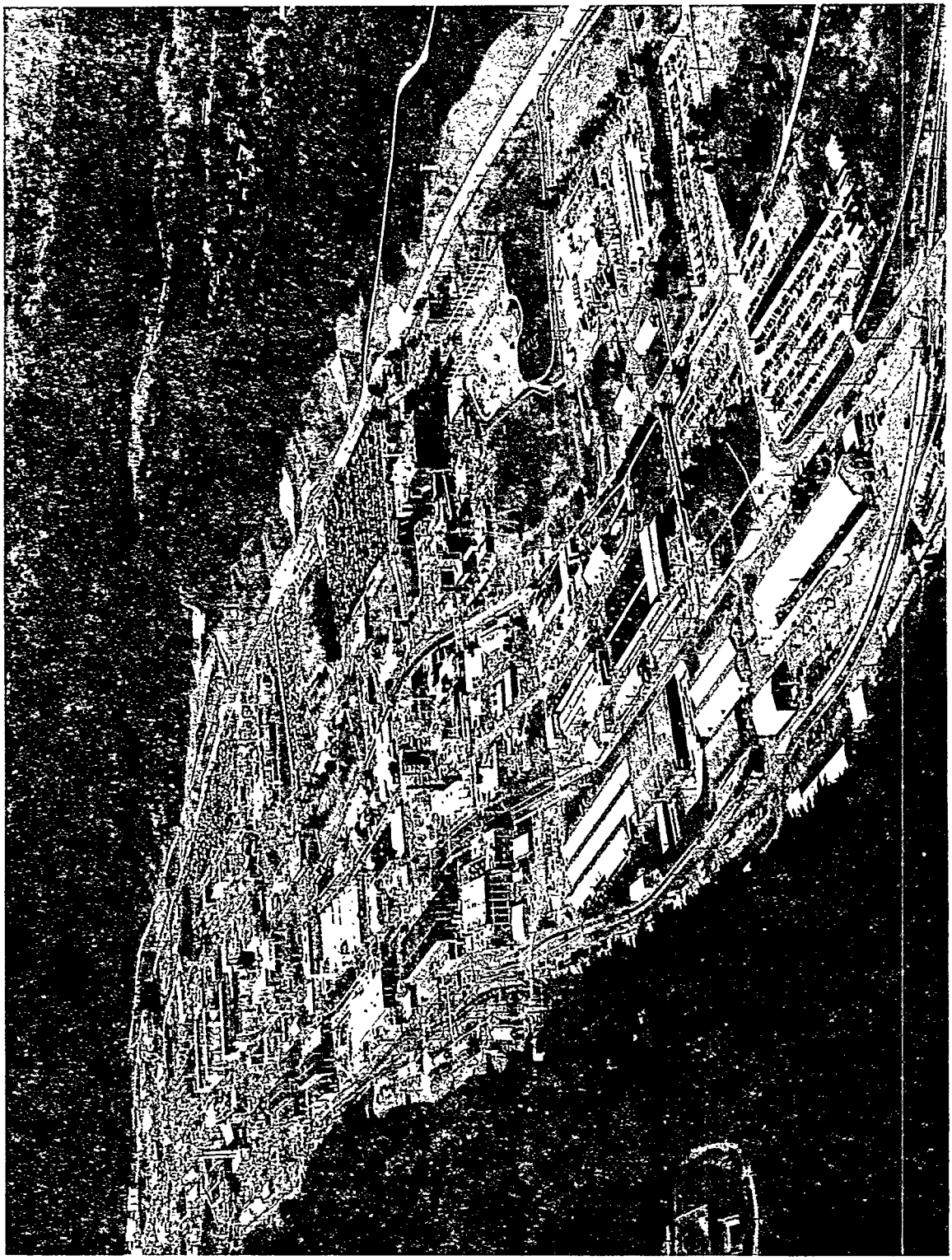

Fig. 1.1.4. Oak Ridge Y-12 Plant (view looking northwest).

ORNL PHOTO 2220-86

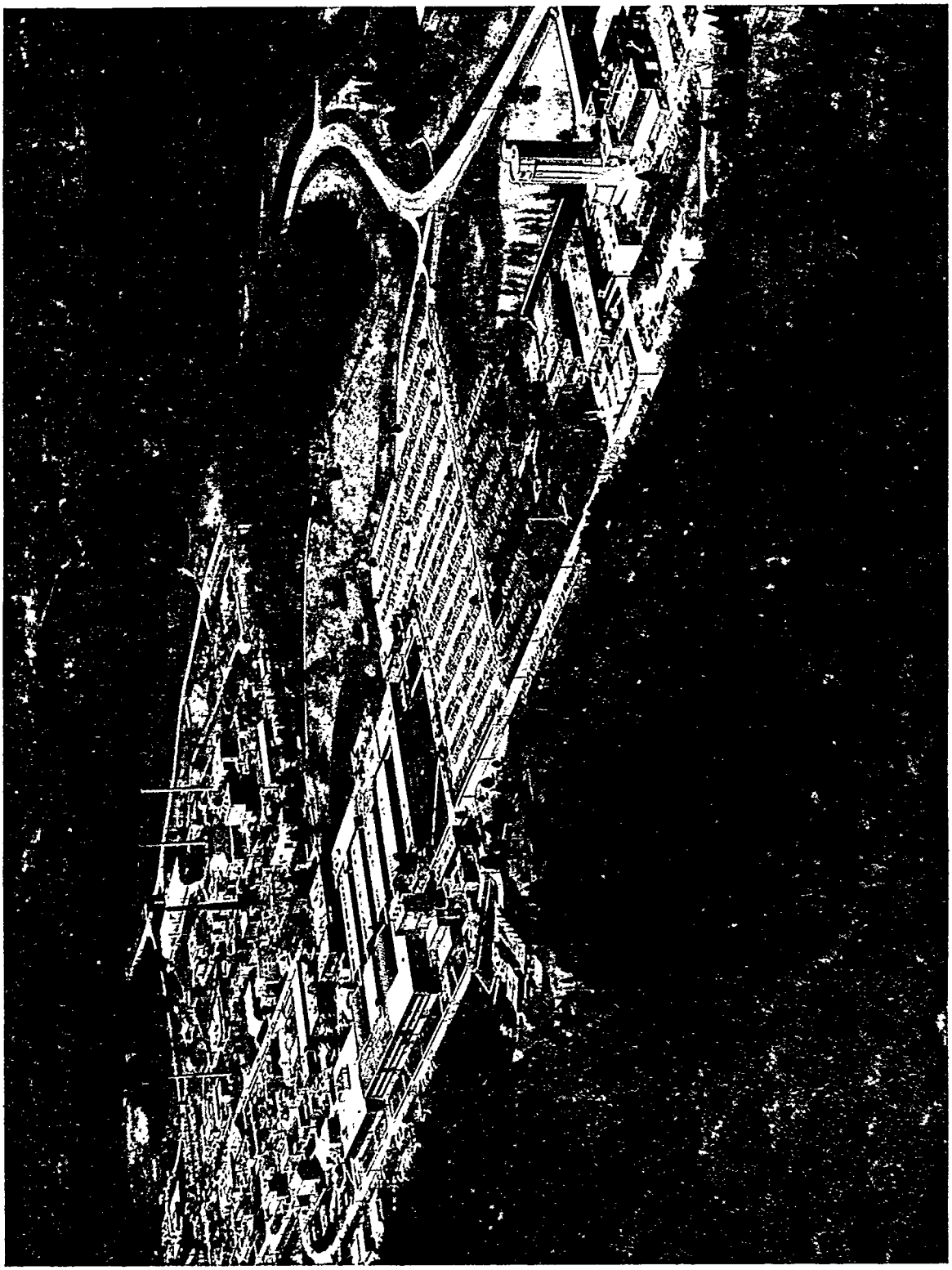

Fig. 1.1.5. ORNL (view looking west).

ORNL PHOTO 2219-86

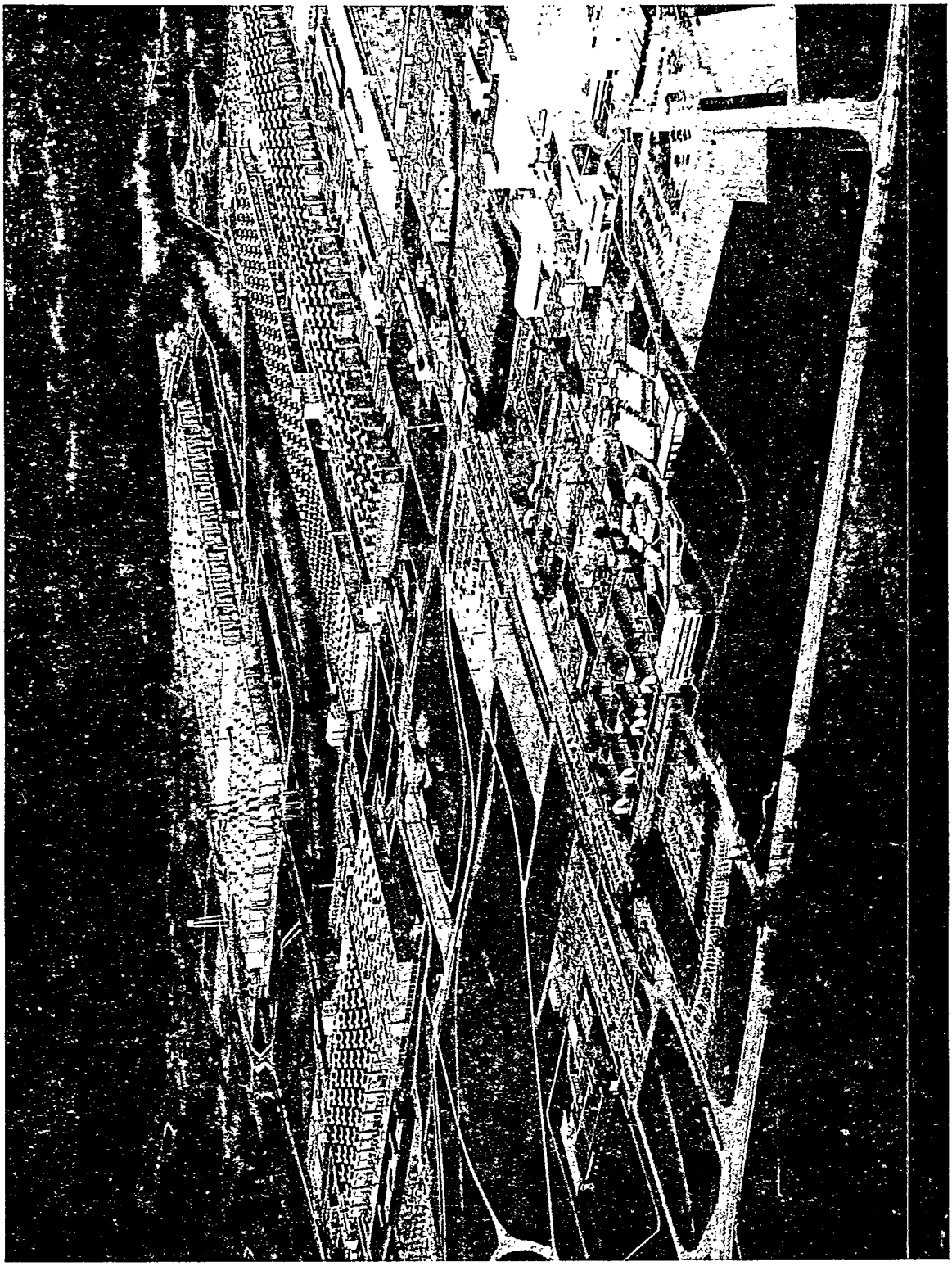

Fig. 1.1.6. ORGDP (view looking northwest).

expertise, and facilities at ORGDP constitute a national resource that can effectively be used to solve problems of national importance in areas that complement the ongoing DOE missions. Although enrichment operations at ORGDP are shut down, some waste streams are being generated, and wastes now in storage will require disposal in the future.

Waste management activities at ORGDP are increasing. Low-level radioactive wastes from other DOE-Oak Ridge Operations (ORO) sites are now being placed in interim storage facilities in the K-25 Building vaults until the final disposition strategy is identified. Also, polychlorinated biphenyl (PCB) wastes contaminated with uranium began arriving from other DOE-ORO sites in 1987 for incineration in the K-1435 Toxic Substances Control Act (TSCA) Incinerator.

Other remaining missions at ORGDP include advanced enrichment technology research and development, analytical laboratory programs, engineering and computer support, and waste treatment services.

Operations associated with the DOE research and production facilities in Oak Ridge produce several types of waste materials. Radioactive wastes are generated from nuclear research activities, weapons production, reactor operations, pilot plant operations involving radioactive materials, isotope separation processes, and uranium processing operations. Nonradioactive (including hazardous) wastes are generated by normal industrial-type support facilities and operations that include water demineralizers, air conditioning, cooling towers, acid disposal, sewage plants, and steam plants.

Nonradioactive, nonhazardous solid wastes are buried in the Tennessee Department of Health and Environment (TDHE)-permitted Centralized Sanitary Landfill II, operated by the Y-12 Plant, or in other designated burial areas. Hazardous wastes are shipped to approved disposal sites off the ORR or are stored on site. Radioactive solid wastes are managed on-site and placed in retrievable storage units either above or below ground, depending on the type and quantity of radioactive material present.

Gaseous wastes generally are treated by filtration, electrostatic precipitation, and/or chemical scrubbing techniques before they are released to the atmosphere.

Liquid radioactive wastes are not released but are contained in tanks for ultimate disposal. After treatment, process water is discharged under National Pollutant Discharge Elimination System (NPDES) permits to White Oak Creek, Poplar Creek, and upper East Fork Poplar Creek, which are small tributaries of the Clinch River.

1.2 REGIONAL DEMOGRAPHY

Except for the city of Oak Ridge, the land within 8 km (5 miles) of the ORR is predominantly rural, used largely for residences, small farms, and cattle pasture. Fishing, boating, water skiing, and swimming are favorite recreational activities in the area. The approximate location and population (1980 census data) of the towns nearest the ORR are Oliver Springs (pop. 3600), 11 km (6.8 miles) to the northwest; Clinton (pop. 5200), 16 km (10 miles) to the northeast; Lenoir City (pop. 5400), 11 km (6.8 miles) to the southeast; Kingston (pop. 4400), 11 km (6.8 miles) to the southwest; and Harriman (pop. 8300), 13 km (8 miles) to the west. Figure 1.2.1 shows the locations of these towns. Knoxville, the major metropolitan area nearest Oak Ridge, is located about 40 km (25 miles) to the east and has a population of approximately 183,000. Table 1.2.1 in Vol. 2 lists cities and population centers within an 80-km (50-mile) radius of the ORR. Directional 80-km-radius population distribution maps are shown in Figs. 1.2.2 and 1.2.3. It should be noted that the center of these figures is the center of the ORR and that most of the area within a 10-km (6.2-mile) radius is part of the ORR. Fewer than 5000 people live within those 10 km of the ORR center. The Tennessee Valley Authority's (TVA) Melton Hill and Watts Bar reservoirs on the Clinch River form the southern, eastern, and western boundaries of the ORR, and the residential sector of the City of Oak Ridge forms the northern boundary. The ORR is within the Oak Ridge city limits.

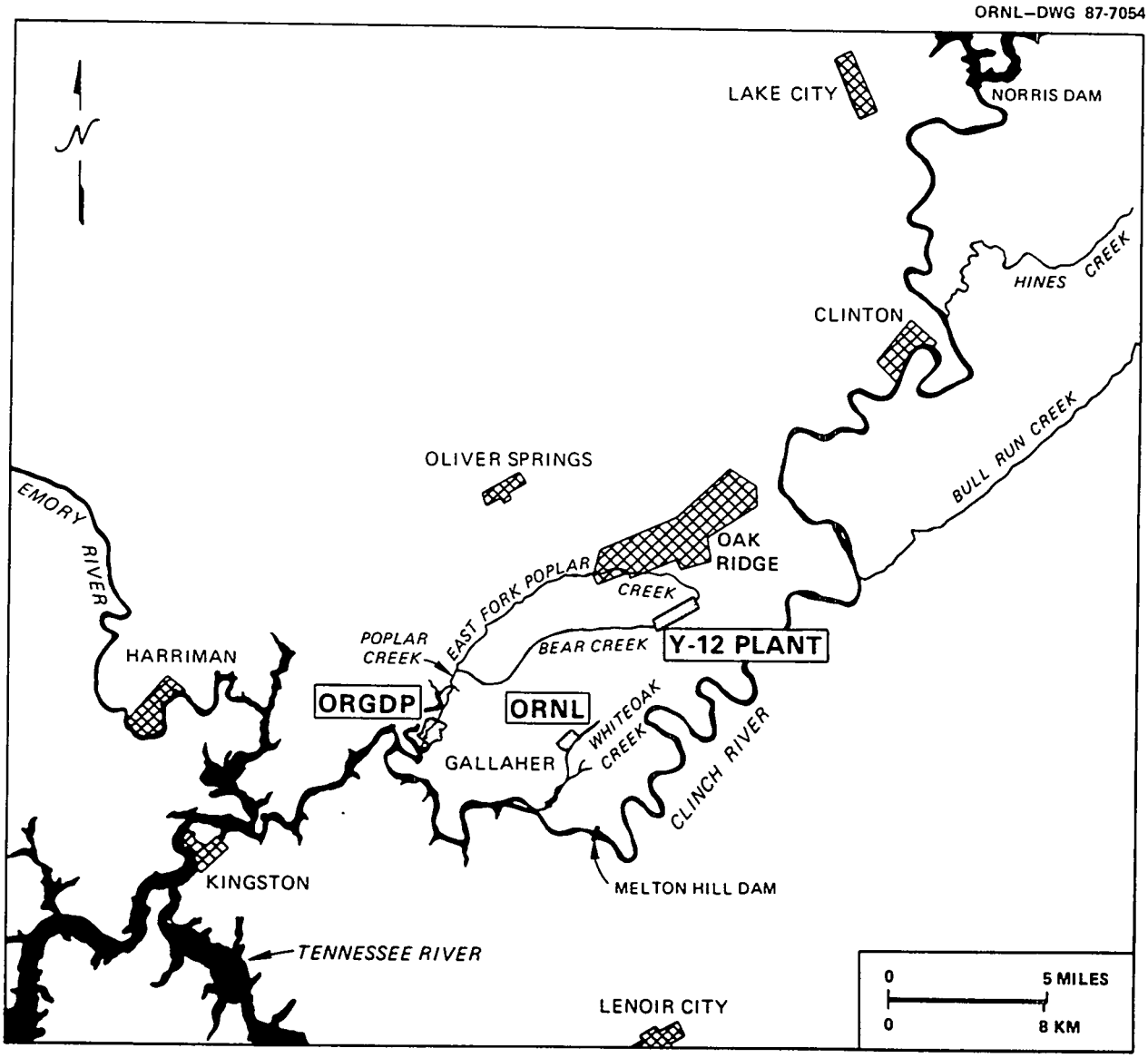

Fig. 1.2.1. Location map of towns nearest the ORR.

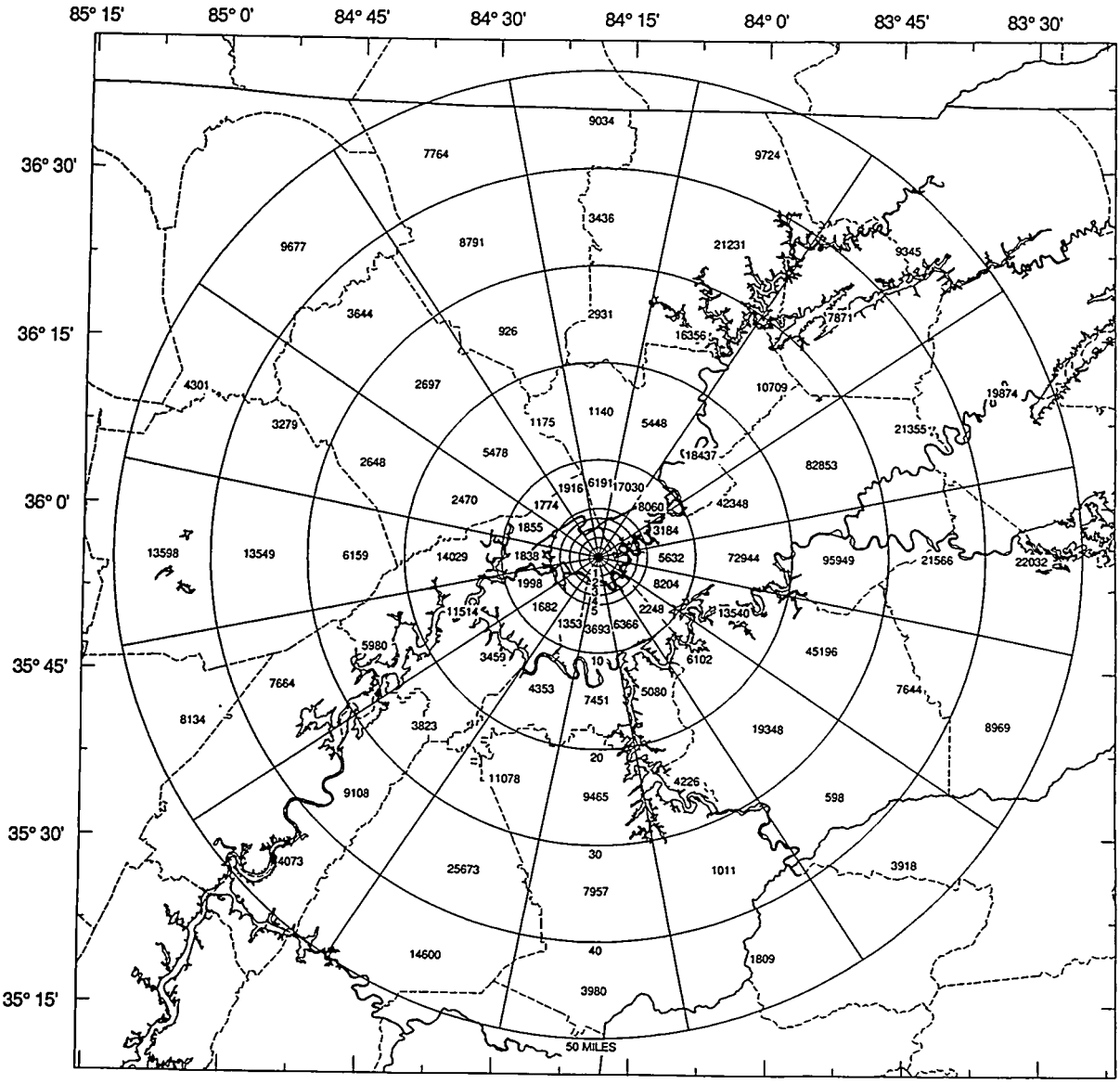

Fig. 1.2.2. Projected 1989 population by sector from the center of the Oak Ridge Reservation, based on 1980 census data.

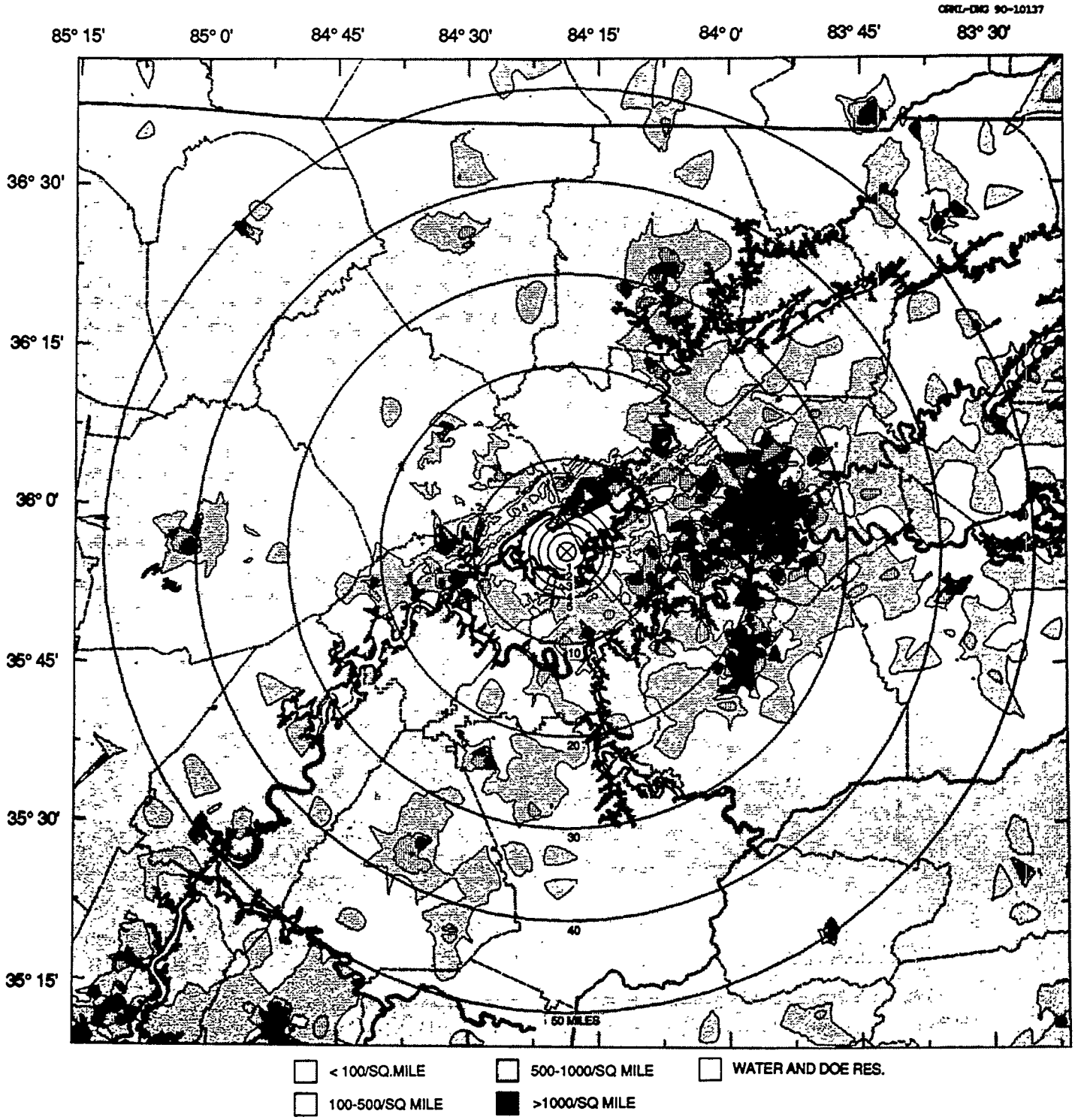

Fig. 1.2.3. Projected 1989 population densities by 10-km (6.2-miles) section of East Tennessee area, based on 1980 census data.

1.3 GEOLOGY

The geologic characteristics of the ORR affect air and water flow and stability of emplaced wastes. The ORR is located in the Tennessee Valley and Ridge Province, part of the Southern Appalachian fold and thrust belt [Fig. 1.3.1 (and Fig. 1.3.1 in Vol. 2)]. The area is characterized by a succession of northeast-trending thrust faults that structurally stack and duplicate the Paleozoic rocks of this area (Fig. 1.3.2; Fig. 1.3.2 in Vol. 2; and Fig. 1.3.3). As a result of thrusting and subsequent differential erosion, a series of valleys and ridges have formed that parallel the thrust faults. In general, the more-resistant siltstone, sandstone, and dolomite units are ridge-formers, and the less-resistant shales and shale-rich carbonates underlie the valleys of the region.

1.3.1 Stratigraphy

The stratigraphy of the area, in ascending order, includes the Lower Cambrian Rome Formation, the Cambrian Conasauga Group, the Cambro-Ordovician Knox Group, and the Middle Ordovician Chickamauga Group. Younger Upper Ordovician to Mississipian rocks are exposed locally in the cores of two synclines north of the White Oak Mountain (WOM) Thrust Fault (Fig. 1.3.2). (Refer to Appendix A for further description.)

1.3.2 Structure

The ORR is located in a foreland fold and thrust belt. As a result, its geology is strongly influenced by structural features at all scales, including regional thrust faults, local thrust faults and tear faults, local folding of relatively weak units, and widespread fracture development. The large-scale structures formed during the Permian-Pennsylvanian Alleghanian Orogeny and have not been historically active. Although fracture formation has occurred at times from the Ordovician (from burial processes) to the present (from erosion and unroofing processes), the Alleghanian Orogeny was probably the strongest influence on fracture formation. (Refer to Appendix A for further description.)

1.4 SURFACE WATER

Potable water from most nonrural areas comes from surface water. This section includes discussions of stream classification, surface water hydrology, watershed characteristics, and water use.

1.4.1 Stream Classification

The Clinch River is the major surface water source that receives discharges from the Oak Ridge installations. Four TVA reservoirs influence the flow and/or water levels of the lower Clinch: Norris and Melton Hill on the Clinch River and Watts Bar and Fort Loudon on the Tennessee River.

The area on and around the ORR has no streams classified as scenic rivers (DOE 1982). Most of the streams on the ORR are classified for fish and aquatic life, irrigation, and livestock watering and wildlife. Table 1.4.1 in Vol. 2 gives the State of Tennessee stream use classifications for the Clinch River and its tributaries on or near the ORR. Classifications are based on water quality, designated uses, and resident aquatic biota. For each designated water-use classification, specific water quality criteria are applied.

1.4.2 Surface Water Hydrology

Figure 1.4.1 shows the location of surface water bodies in the vicinity of the ORR. The ORR is bounded on the south and west by a 63-km stretch of the Clinch River. Melton Hill Dam is located at Clinch River kilometer (CRK) 37.2 (river mile 23), forming the Melton Hill Reservoir. Several major embayments bound the ORR; the largest is the Bearden Creek embayment, with an approximate surface area of 48 ha (120 acres). Other embayments include Walker Branch, McCoy Branch, and Scarboro Creek.

Both groundwater and surface water are drained from the ORR by a network of small tributaries of the Clinch River, as shown in Fig. 1.4.1. At Kingston, Tennessee, the Clinch flows into the Tennessee River, which is the seventh largest river in the United States. Water levels in the Clinch River in the vicinity of the

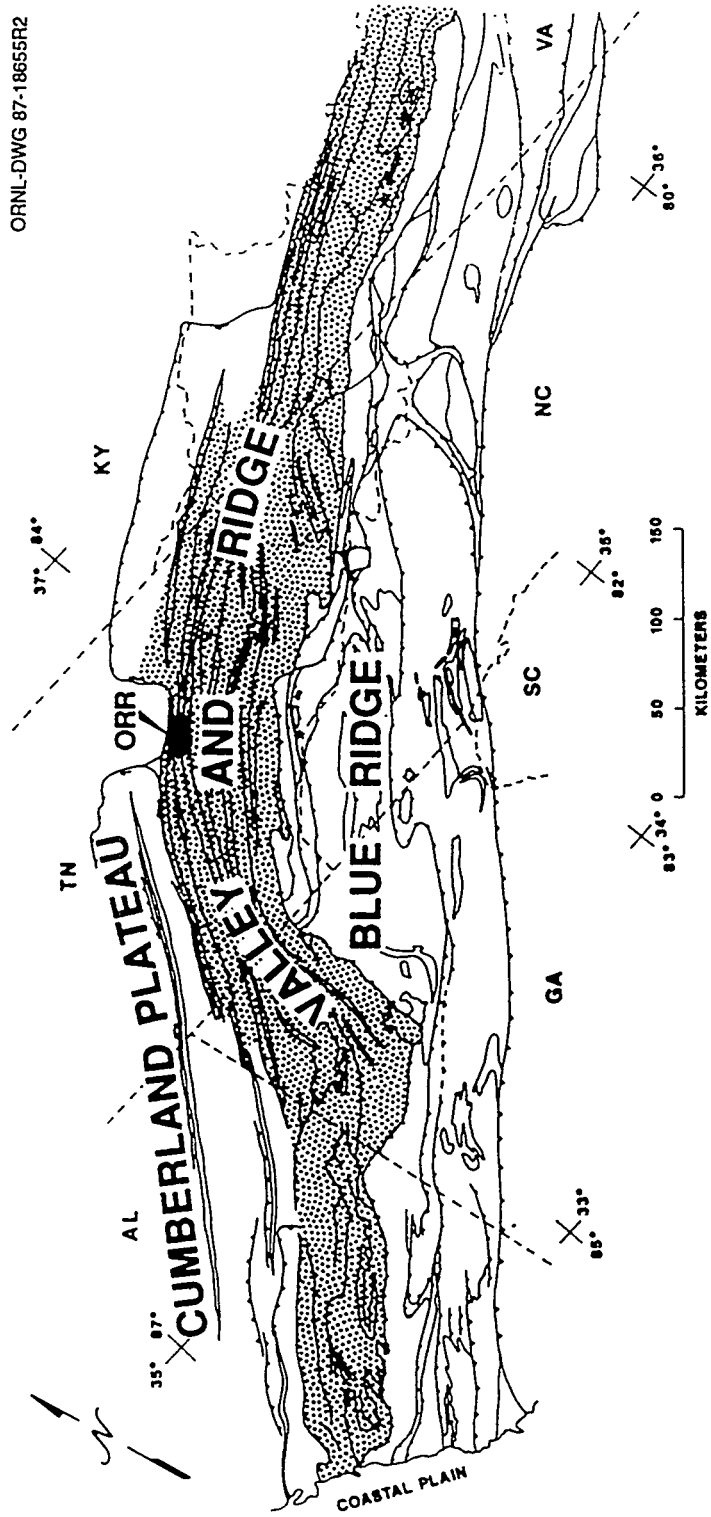

Fig. 1.3.1. Geology of the Southern Appalachians.

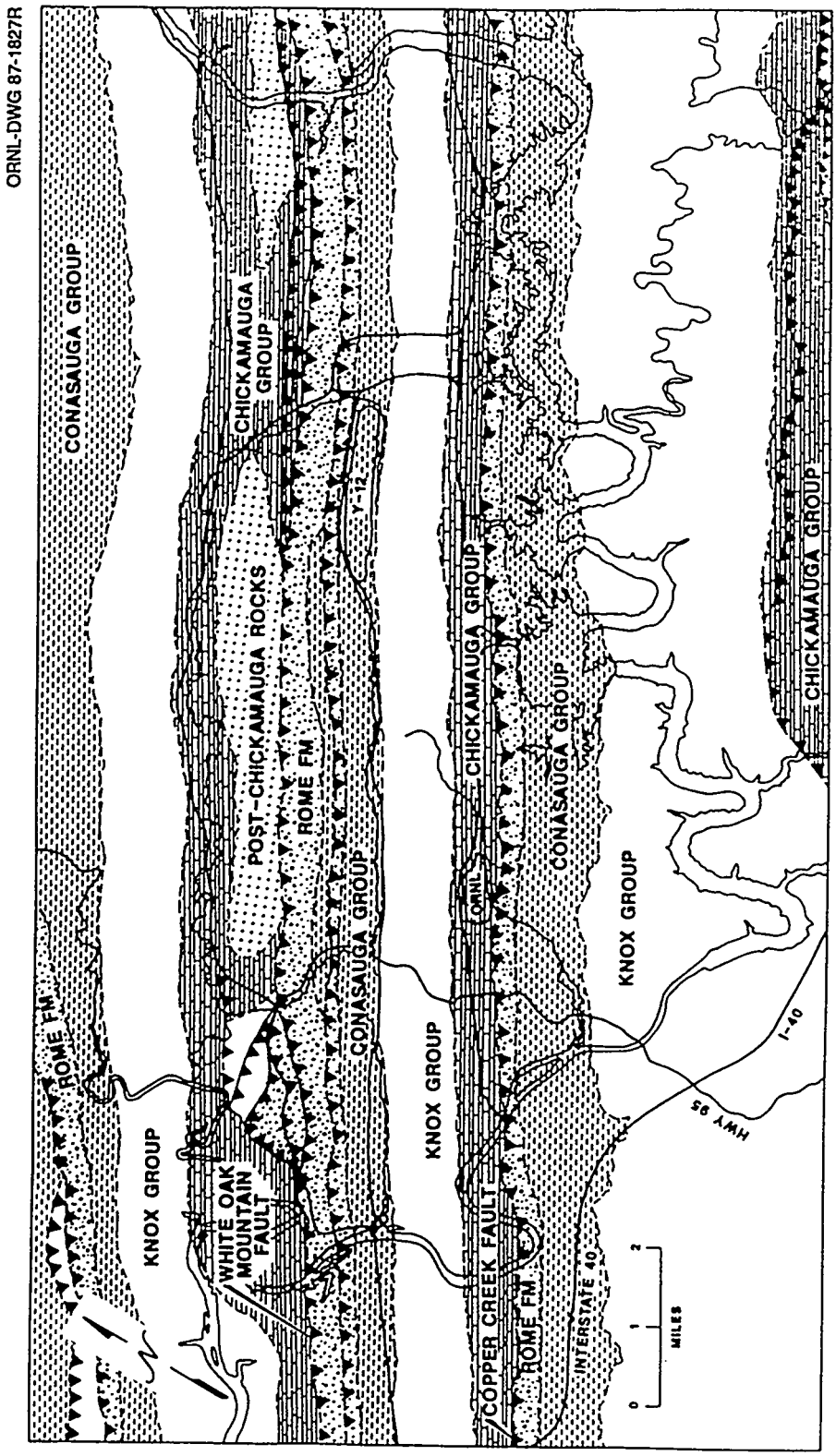

Fig. 1.3.2. Geologic map of the Oak Ridge Reservation.

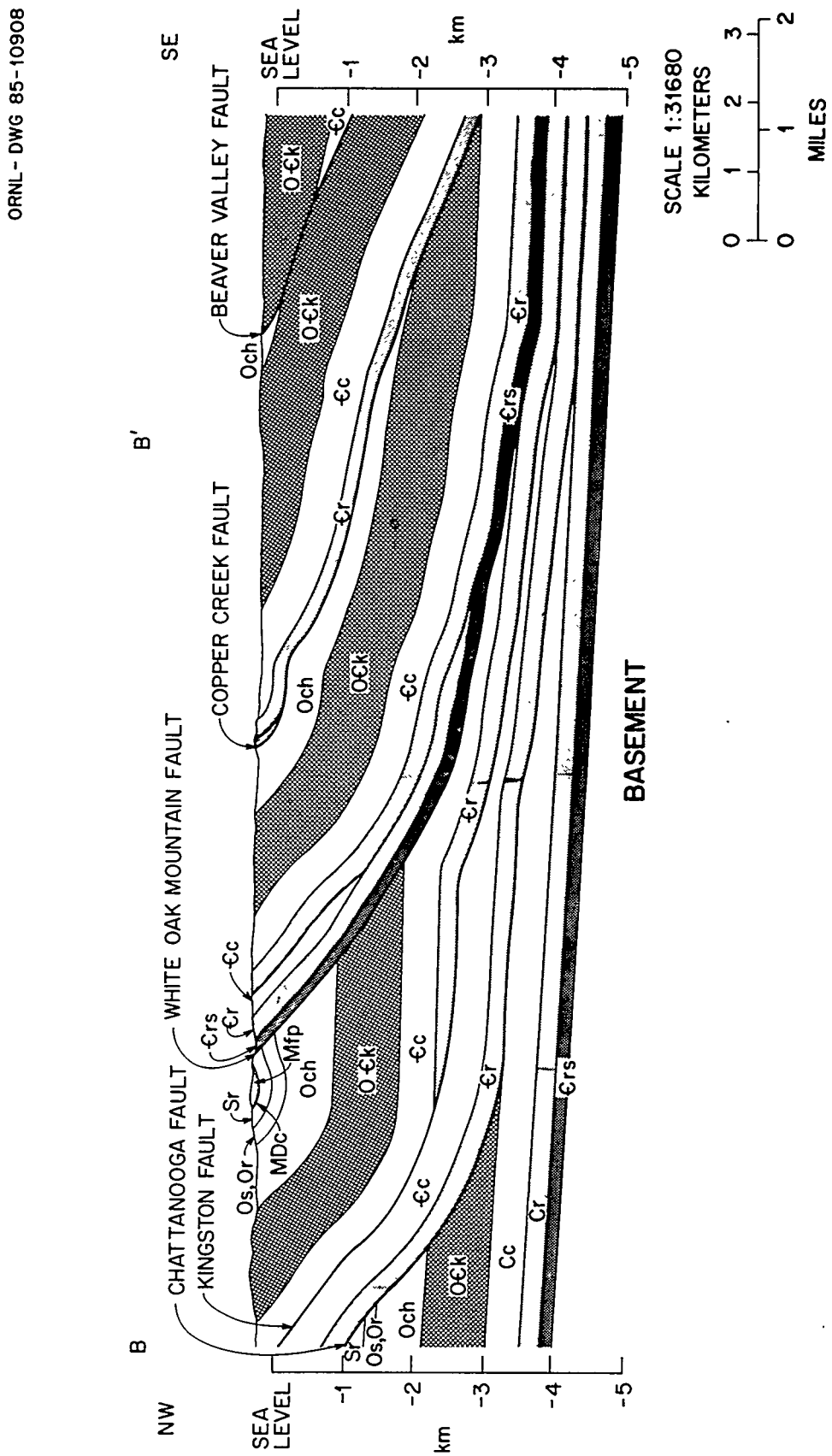

Fig. 1.3.3. Geologic cross-section of the Oak Ridge Reservation.

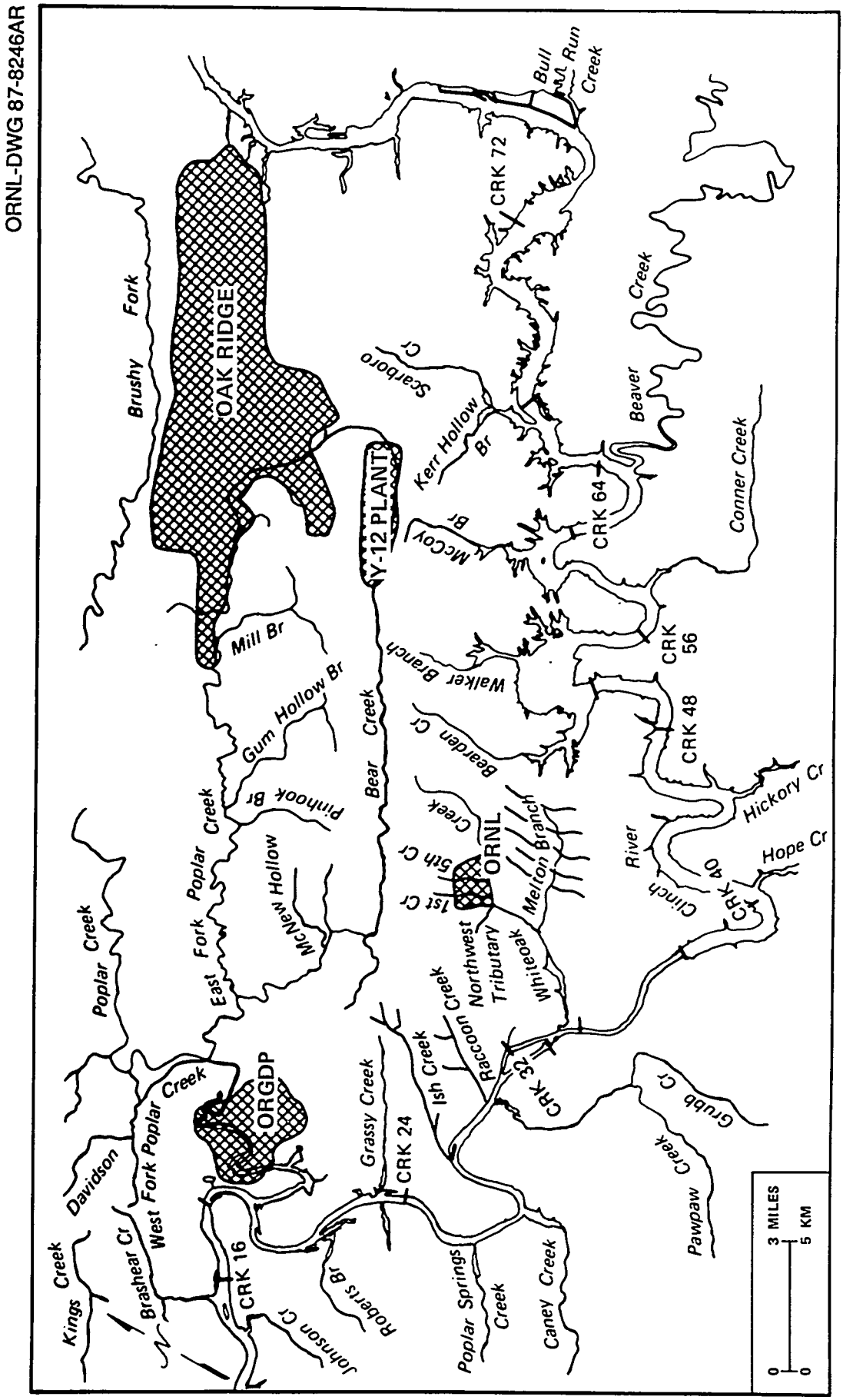

Fig. 1.4.1. Location map of Oak Ridge Reservation tributaries.

ORR are regulated by TVA, and fluctuations of the river have an impact on the tributary steams draining the ORR.

Each of the three DOE facilities affects a different subbasin of the Clinch River. Drainage from the Y-12 Plant enters both Bear Creek and East Fork Poplar Creek; ORGDP drains predominantly into Poplar Creek and Mitchell Branch, a small tributary; and ORNL drains into White Oak Creek and several tributaries. Hydrologic data are extensive for these streams because of their size and relationship to DOE facilities. Walker Branch has also been intensely studied as an undisturbed watershed.

1.4.3 Watershed Characteristics

The Clinch River has its headwaters near Tazewell, Virginia, and empties into the Tennessee River near Kingston, Tennessee, at Tennessee River kilometer (TRK) 914 (river mile 568). The Clinch watershed comprises about 11% of the Tennessee River watershed. Three dams operated by TVA control the flow of the Clinch River. Norris Dam, constructed in 1936, is approximately 50 km (31 miles) upstream from the ORR. Melton Hill Dam, completed in 1963, controls the flow of the river near the ORR. Its primary function is not flood control but power generation (Boyle et al. 1982). Watts Bar Dam is on the Tennessee River near the lower end of the Clinch.

1.4.4 Water Use

Nine public water supply systems serve about 91,500 people that withdraw surface water within a 32-km (20-mile) radius of the ORR. Of these nine supply systems, only the city of Kingston and the ORGDP Water Treatment Plant are downstream of the ORR. The intake for Kingston is located at TRK 914.2 (river mile 566.8), about 0.6 km (0.37 mile) above the confluence of the Clinch and Tennessee rivers and 34.1 km (21.1 miles) below the mouth of Poplar Creek. (This location is monitored because it is in the area of backflow of Clinch River water in the Tennessee.) Kingston withdraws approximately 9% of its average daily supply from the Tennessee River. The ORGDP Water Treatment Plant intake is located 4 km (2.5 mi) above the mouth of Poplar Creek and provides all of the water for ORGDP.

1.5 GROUNDWATER

Groundwater in the Tennessee Valley region supplies water to many rural residences, industries, public water supplies, and sustains base flow in streams and rivers. Most farm use is for livestock watering and washing. This section includes discussion of groundwater occurrence in the region and local groundwater use.

1.5.1 Geohydrology and Groundwater Occurrence

In the Valley and Ridge Province of Tennessee, groundwater occurs in bedrock, in the regolith, and in a few alluvial aquifers along the largest rivers. Groundwater flow in the shale and carbonate rock that dominate the region's bedrock occurs in fractures and solution cavities.

1.5.2 Groundwater Use

The objective of groundwater classification is to provide a systematic approach for designating the use of and water quality goal for the groundwater resource. More than 50% of the population of Tennessee relies on groundwater for drinking water supplies (Henry et al. 1986). Twenty-one percent of water consumed in the state (exclusive of thermoelectric use) is groundwater. Of this, about 55% is withdrawn for public and domestic supplies, 42% for self-supplied industrial use, and 1% for irrigation (Bradley and Hollyday 1985; Henry et al. 1986). Nine principal aquifiers have been identified in Tennessee, as illustrated in Fig. 1.5.1. The major portion of the industrial and drinking water supply in the Oak Ridge area is taken from surface water sources. However, single-family wells are common in adjacent rural areas not served by public water supply systems. As in most of East Tennessee, usable groundwater on the ORR and in areas adjacent to the ORR occurs primarily in solution cavities or in fractures in the rocks. Other than those adjacent to the city of Oak Ridge, most of the residential wells in the immediate area are south of the Clinch River.

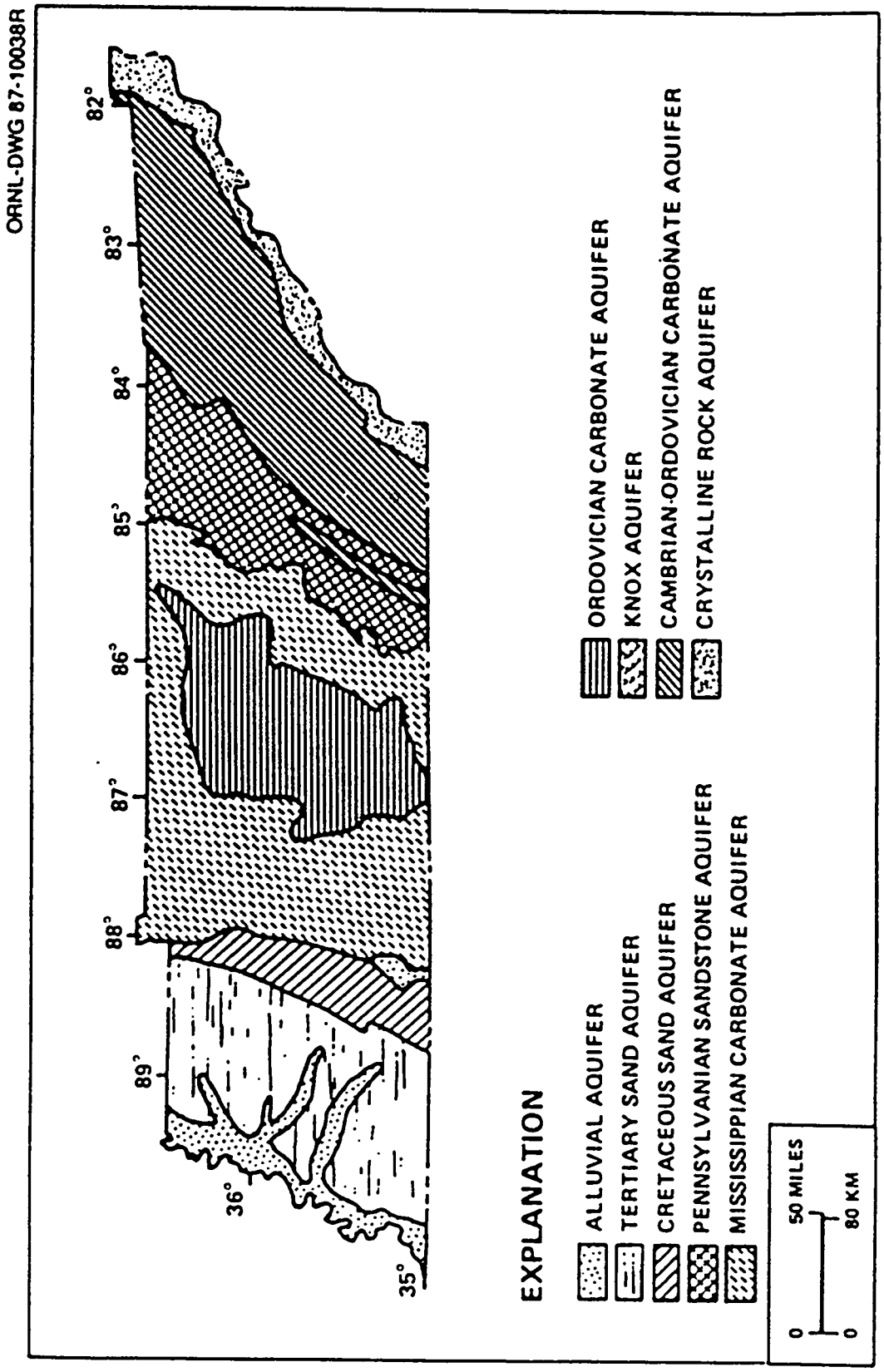

Fig. 1.5.1. Principal aquifers in Tennessee.

1.6 CLIMATE AND ATMOSPHERIC PROCESSES

Oak Ridge has a temperate climate with warm, humid summers and cool winters. No extreme conditions prevail in temperature, precipitation, or winds. Spring and fall are usually long, and the weather is normally sunny with mild temperatures. Severe storms such as tornadoes or high-velocity winds are rare. The mountains frequently divert hot, southeasterly winds that develop along the southern Atlantic coast.

Oak Ridge is one of the country's calmest wind areas. Because of this, providing relief from the summer's humidity through ventilation is difficult. The atmosphere can be considered to be in an inversion status about 36% of the time. The daily up- and down-valley winds, however, provide some diurnal exchange. The prevailing wind directions are northeasterly (up-valley) and southwesterly (down-valley).

1.7 PRECIPITATION

Precipitation varies both within and between years, as shown in Fig. 1.7.1. The 39-year annual average precipitation (water equivalent) is 1.36 m (53.5 in.), including approximately 0.25 m (9.8 in.) of snowfall, with monthly precipitation peaking in January and February. Winter storms are generally of low intensity and long duration. Another peak in rainfall occurs in July when short, heavy rains associated with thunderstorms are common. Typically in October, slow-moving high-pressure cells suppress rain and, while remaining nearly stationary for many days, provide mild, clear, dry weather. Poor air dilution (and thus the primary air pollution episodes) occurs with the greatest frequency and severity during this period. Precipitation in 1989 was 168 cm (66 in.), about 29 cm (11.25 in.) above the annual average.

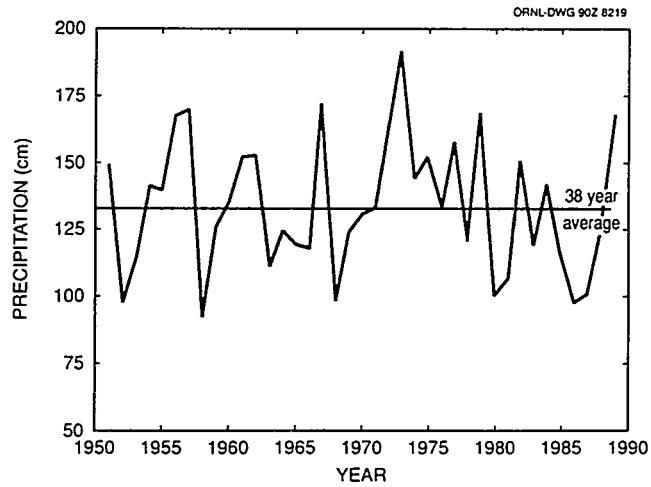

Fig. 1.7.1. Annual precipitation history of the Oak Ridge area.

From 1986 to 1988, drought conditions prevailed in the Tennessee Valley, reducing stream flows and groundwater table levels to 100-year record lows. Fall precipitation began to bring relief in 1988, and the above-average 1989 precipitation returned stream flows to normal levels.

2. ENVIRONMENTAL MONITORING SUMMARY

2. ENVIRONMENTAL MONITORING SUMMARY

Published environmental summary reports for the DOE ORR have been issued for each year since 1971. The current environmental program is designed primarily to meet various regulatory requirements and DOE directives and to provide a continuity of data on environmental media at unregulated locations. The federal legislative framework that establishes standards and regulates environmental releases consists mainly of the following: Clean Air Act; Clean Water Act; Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as "Superfund"; Resource Conservation and Recovery Act (RCRA); Toxic Substances Control Act (TSCA); Superfund Amendments and Reauthorization Act (SARA); the Atomic Energy Act; and FIFRA. Administrative bodies principally concerned with implementation and enforcement on the federal level are the U.S. Environmental Protection Agency (EPA) and DOE and, on the state level, the Tennessee Department of Health and Environment (TDHE).

Environmental monitoring consists of two major activities: effluent monitoring and environmental surveillance. Effluent monitoring is the collection and analysis of samples, or measurements of liquid and gaseous effluents. Environmental surveillance is the collection and analysis of samples, or direct measurements, of air, water, soil, foodstuff, biota, and other media from DOE sites and their environs. Environmental monitoring is performed by each site for the purpose of characterizing and quantifying contaminants, assessing radiation exposures of members of the public, demonstrating compliance with applicable standards and permit requirements, and assessing the effects, if any, on the local environment.

The samples are analyzed for various radioactive, physical, and chemical parameters. In some cases, such as liquid effluent outfalls, the discharge permit may require the analysis of up to 20 different parameters.

Annual summaries are presented in this section for each of the media sampled. The summary tables generally give the number of samples collected and the maximum, minimum, average, and standard error of the mean (SE) values of parameters for which determinations were made. This value is based on multiple samples collected throughout the year. It includes the random uncertainty over time and space associated with sampling, analysis, and the intrinsic variability of media. The random uncertainty is a statement of precision (or imprecision), a measure of the reproducibility or scatter in a set of successive measurements, and an indication of the stability of the average value for a parameter. When differences in the magnitudes of the observations are small, the SE is small, and the precision is said to be high; when the differences are large, the SE is large, and the precision is low. Random uncertainties are assessed and propagated by statistical methods (see Appendix B for calculations). Average values have been compared where possible with applicable guidelines, criteria, or standards as a means of evaluating the impact of effluent releases or environmental concentrations.

In some of the tables, radionuclide concentrations are compared with derived concentration guides (DCGs) as published in DOE Order 5400.5. These concentration guides were established for drinking water and inhaled air and are guidelines for the protection of the public. DOE Order 5400.5 defines a DCG as the

concentration of a radionuclide in air or water from which, under conditions of continuous exposure by one exposure pathway (i.e., drinking water, inhaling air, submersion) for 1 year, a "reference person" would receive an effective dose equivalent of 100 mrem. A reference person is a hypothetical human who is assumed to inhale 8400 m^3 (296,700 ft^3) of air in a year and to drink 730 L (190 gal) of water in a year. When there are multiple DCGs for a given isotope, the most restrictive value is used. When the percent of the DCG is less than 0.010, the percent is reported as less then 0.01. When total radioactive Sr is measured, it is compared to the DCG for ^{90}Sr, which is the most restrictive value.

The current convention for radioactivity data at the instrument detection limit is to treat it in the same manner as instrument responses above the detection limit. The instrument background is subtracted from the actual instrument signal, and the result is reported. Because of the intrinsic uncertainties associated with making radiation measurements, it is possible to subtract a background value from a sample result and get a negative number. The advantage to this approach is that no bias is introduced in calculating statistical summaries of the data.

Measurements of nonradioactive analytes at or below the instrument detection limit are expressed as "less than" (<) the detection limit value. In computing summary statistics, the less than results are assigned the detection limit value. When a statistic includes one or more "less than" results, the computed value is also expressed as a less than quantity.

2.1 AIRBORNE DISCHARGES, AMBIENT AIR MONITORING, AND METEOROLOGICAL MONITORING

The DOE Oak Ridge facilities are subject to regulations issued by the TDHE Air Pollution Control Board, the EPA for the control of air pollution sources, and DOE Orders. Nonradioactive emission sources are regulated by TDHE, and radioactive emission sources are regulated by EPA under the National Emission Standards for Hazardous Air Pollutants (NESHAP). The authority for these regulations is derived from the Clean Air Act and the Tennessee Air Quality Control Act.

The TDHE air pollution control rules regulate pollution sources to protect the public health and welfare and the environment. These rules include regulations for maximum allowable ambient air concentrations of certain pollutants, open burning, pollution sources such as coal-fired boilers and processes, fugitive emission sources, performance standards for new sources, and hazardous air pollutants. State-issued permits are required for air pollution sources.

The rules for radioactive emission sources, issued by EPA, limit the amount of exposure to radioactivity to the nearest or the most affected member of the public. EPA sets the limit on exposure to radioactivity by first determining a safe exposure level and then adding a margin of safety. The most affected member of the public is determined by EPA-approved radioactive emissions dose modeling. The NESHAP rules were reissued in December 1989, and efforts are under way to implement these new requirements for the Oak Ridge facilities.

2.1.1 Airborne Discharges

Each 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 the exhaust gases before release to the atmosphere. In addition, administrative controls play a role in regulating emissions. Each installation has developed a stack monitoring program to measure pollutants that are not removed by the air pollution control equipment. Ambient air monitoring is also conducted around the facilities and within the surrounding East Tennessee communities to assess the impacts of operations within the three Oak Ridge facilities on the ambient air quality of the region.

The following three sections describe airborne pollutants emitted from the Oak Ridge facilities during 1989. These sections also describe the emissions monitoring performed at each facility and present data on measured pollutant concentrations within the surrounding communities. A brief section is also included on meteorological measurements conducted during 1989 at each facility. A discussion of atmospheric dispersion modeling and atmospheric radiological dose modeling is included in Sect. 3.

2.1.1.1 Oak Ridge Y-12 Plant

Description

The release of contaminants into the atmosphere at the Oak Ridge Y-12 Plant occurs almost exclusively as a result of plant fabrication and steam generation operations. There are several hundred point sources of building ventilation exhaust within the facility. Most processes are served by process ventilation systems that remove air contaminants from the workplace. More than 700 of these are permitted. Approximately 85 of these exhausts serve areas where depleted or enriched uranium is processed, and these are monitored continuously for radioactive emissions. Additionally, there are several hundred process ventilation exhaust points (Table 2.1.11, Vol. 2).

As illustrated in Figs. 2.1.1 and 2.1.2, atmospheric discharges from Y-12 Plant production operations are minimized through the extensive use of air pollution control equipment. High-efficiency particulate air (HEPA) filters are used to essentially eliminate particulate emissions (including uranium) from numerous production shops. HEPA filters remove more than 99% of the particulates from the exhaust gases. Exhaust gas scrubbers, baghouses, and other emission control equipment are used to reduce airborne discharges of other pollutants. Although Y-12 Plant airborne discharges are within regulatory guidelines, improvements continue to be made to the plant's exhaust ventilation systems to further reduce emissions. While many of these improvements involve the installation of new air pollution control equipment, material substitution, and process modification, projects are also being examined to reduce plant emissions and to comply with waste minimization strategies currently being pursued by plant operations.

Summary

Y-12 Plant radiological emission estimates are further broken down in Table 2.1.1. Y-12 Plant uranium stack emission totals were made using stack sampling data obtained from sampling equipment installed in March 1987 under the Stack Radiological Monitoring Project. Uranium stack losses are continuously measured on 85 process exhaust stacks by extracting a representative sample of stack gas through a multipoint sampling probe. Particulate matter (including uranium) is removed from the stack sample through filtration by a 47-mm-diam filter paper. Sample filter papers are changed routinely at each location an average of three times per week and analyzed in the Y-12 Plant laboratory to determine uranium stack emissions.

Engineering analysis was also used to obtain a conservative estimate of uranium emissions into the atmosphere from room exhaust ventilation systems within the plant. These emission estimates are included in plant uranium emission totals listed in Table 2.1.1.

In 1988 a study was conducted to better estimate depleted uranium emissions through unmonitored room exhaust ventilation systems. This study took into account the current information on ventilation systems and Health Physics data from the depleted uranium processing areas. The 1988 estimate of 34.9 kg is still considered to be conservative and was used in estimating 1989 emissions. All known significant sources of enriched uranium are monitored; therefore, no estimate is made for enriched uranium room exhausts. Radionuclides other than uranium are handled in millicurie quantities as a part of ORNL research activities at facilities in the Y-12 Plant. The releases from these activities are minimal and have a negligible impact on the total Y-12 Plant dose; therefore, only Y-12 Plant uranium discharges are shown in Table 2.1.1.

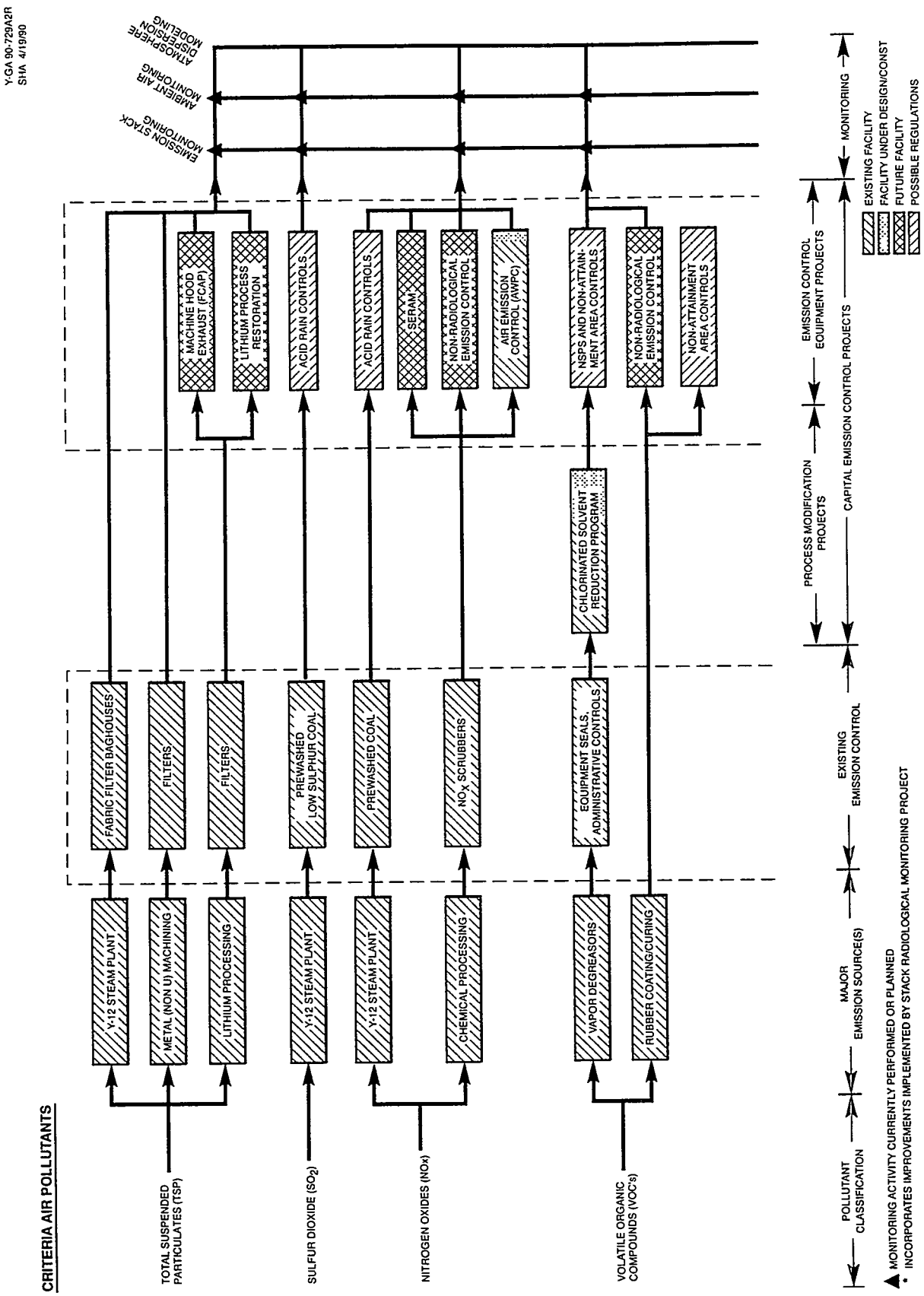

Fig. 2.1.1. Air pollution control program at the Y-12 Plant (criteria air pollutants).

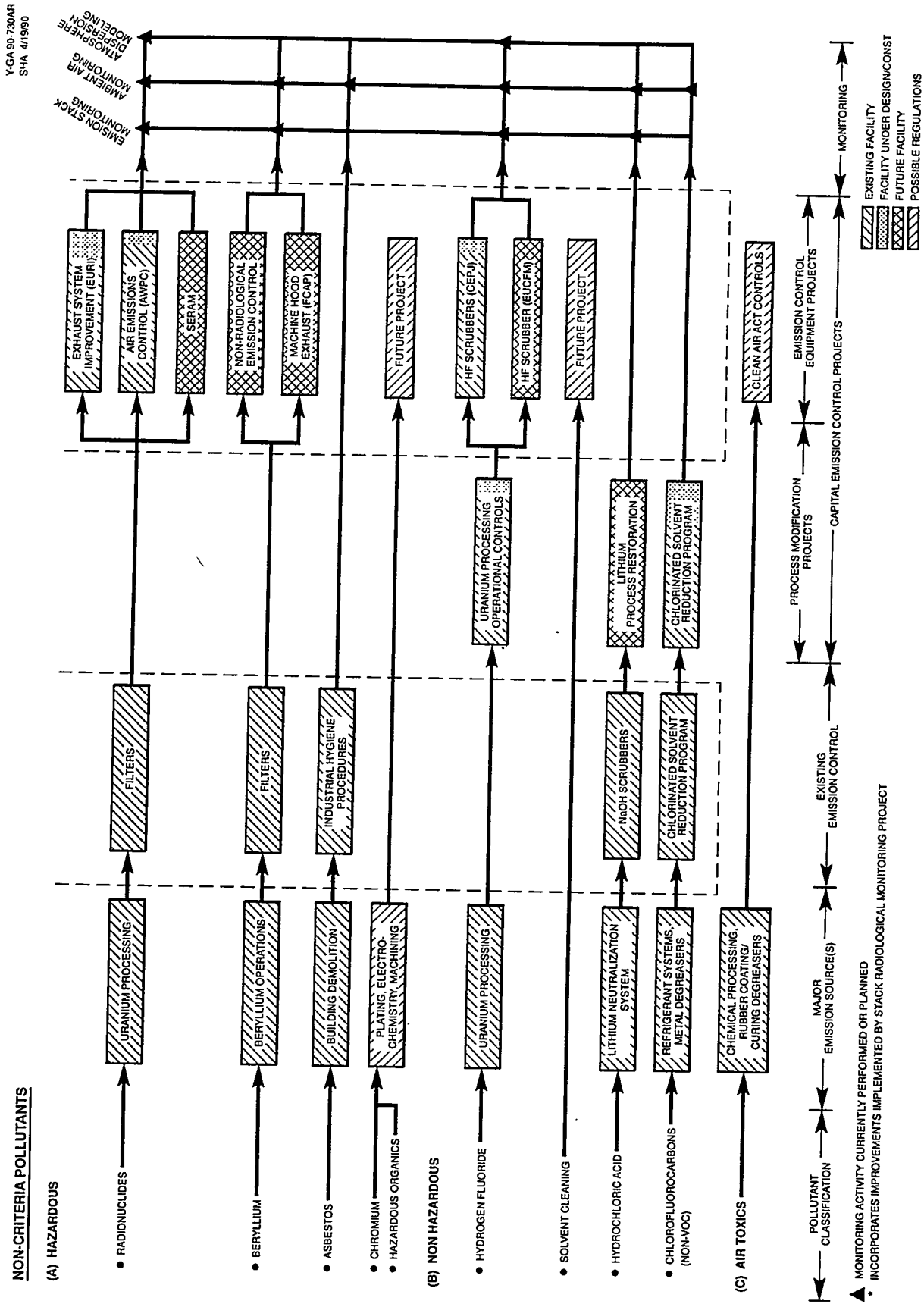

Fig. 2.1.2. Air pollution control program at the Y-12 Plant (noncriteria pollutants).

Table 2.1.1. 1989 Y-12 Plant airborne uranium emissions estimates[a]

Source of emissions	Quantity emitted	
	(kg)	(Ci)
Enriched uranium process exhaust	1.9	0.131
Depleted uranium process exhaust	7.5	0.003
Enriched uranium room exhaust	0.0	0.0
Depleted uranium room exhaust	34.9	0.013
Total	44.3	0.147

[a]See Table 3.1.5 for off-site committed dose equivalents resulting from Y-12 Plant uranium emissions.

Chemical emissions

Emission estimates have been made for a number of major pollutant categories. These are itemized in Appendix C (see Table C.1), which addresses chemical releases and SARA Title III, Section 313. Special studies are under way at the Y-12 Plant to characterize emissions resulting from fugitive (nonpoint) sources (see Sect. 6). The fugitive source of highest priority to the Y-12 Plant is that of mercury emissions from the former Lithium Isotope Separation Facility (Building 9201-4). As closure activities began at New Hope Pond in 1988, special air sampling at that site was initiated to characterize fugitive emissions. This special sampling was terminated in 1989 when the clean cover was put in place. Similar sampling activities were conducted in the summer and fall of 1989 at the Bear Creek Burial Grounds for closure of the Oil Ponds and adjacent areas.

Discussion

It is estimated that a total of 0.15 Ci (44.3 kg) of uranium was released into the atmosphere in 1989 as a result of Y-12 Plant processing operations (Figs. 2.1.3 and 2.1.4). Because of the significantly higher specific activity of enriched uranium over that of depleted uranium, approximately 89% of the curie release was from emissions of enriched uranium particulates, whereas only 4% of the total mass of uranium released was from enriched uranium losses. The increase in curies emitted in 1989 was the result of a slight increase from an enriched uranium process (see Sect. 6).

As illustrated in Fig. 2.1.4, 1989 Y-12 Plant uranium emissions estimates were lower than in recent years. This reduction was in part the result of improvements made during 1987 in uranium emissions monitoring and the installation of new exhaust gas filtration systems in 1987 and 1988, especially in the depleted uranium areas of the plant. In 1989, the reduction was primarily the result of improved administrative controls, including better testing and changeout procedures for process filters and closer control of the procedures themselves. Twenty-seven stacks with the greatest potential to emit significant amounts of uranium are equipped with "breakthrough monitors." These monitors measure the rate of increase of radiation on the trapping media and alert operations personnel if filtration system efficiencies decline.

2.1.1.2 Oak Ridge National Laboratory

Description

The gaseous emission point sources for ORNL consist of the following nine stacks located in Bethel and Melton valleys (Fig. 2.1.5):

Building	Description
2026	Radioactive Materials Analytical Laboratory
3020	Radioactive Processing Plant
3039	3500 and 4500 areas cell ventilation systems
	Central off-gas and scrubber system
	Isotope solid state ventilation system
	3025 and 3026 area cell ventilation system
7025	Tritium Target Fabrication Facility
7830	Hydrofracture Facility
7911	Melton Valley complex (High Flux Isotope Reactor, Radiochemical Engineering Development Center)
7512	Molten Salt Reactor Facility
7877	Emergency Avoidance Solidification Project
6010	Electron Linear Accelerator Facility

Discharges from each stack are unique because of the wide variety of research activities performed at ORNL. Radiological gaseous emissions from ORNL typically consist of solid particulates, adsorbable gases (e.g., iodine), tritium, and nonadsorbable gases.

Gaseous waste streams at ORNL consist mainly of ventilation air from contaminated or potentially contaminated areas, vents from tanks and processes, and ventilation for reactor facilities. Many sources, mostly nonradioactive, are permitted with the TDHE, Air Pollution Control Board. A table listing air permits issued by the TDHE for ORNL emission sources is presented in Table 2.1.12 of Vol. 2. All gaseous emissions are treated and filtered before discharge to the atmosphere. Typically, contaminated and potentially contaminated gaseous wastes are treated, then filtered with HEPA and charcoal filters before discharge to ensure that any radioactivity released is within acceptable levels.

Airborne emissions sampling

Each of the previously listed point sources is provided 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. The other equipment does not provide data of sufficient accuracy and precision to support the quantitation

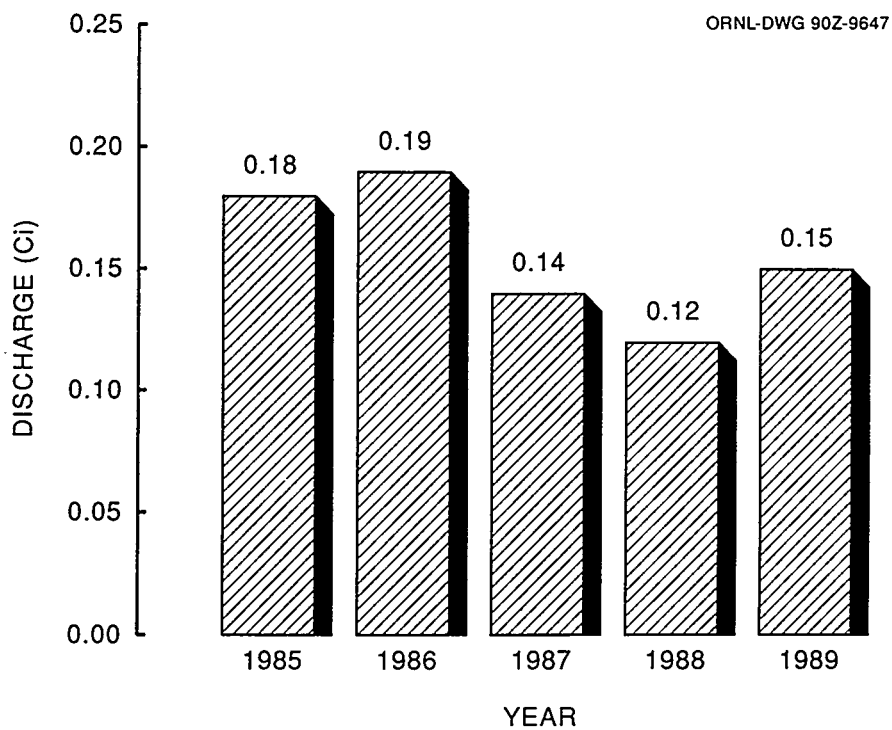

Fig. 2.1.3. Total curie discharges of uranium from the Y-12 Plant to the atmosphere, 1985–1989.

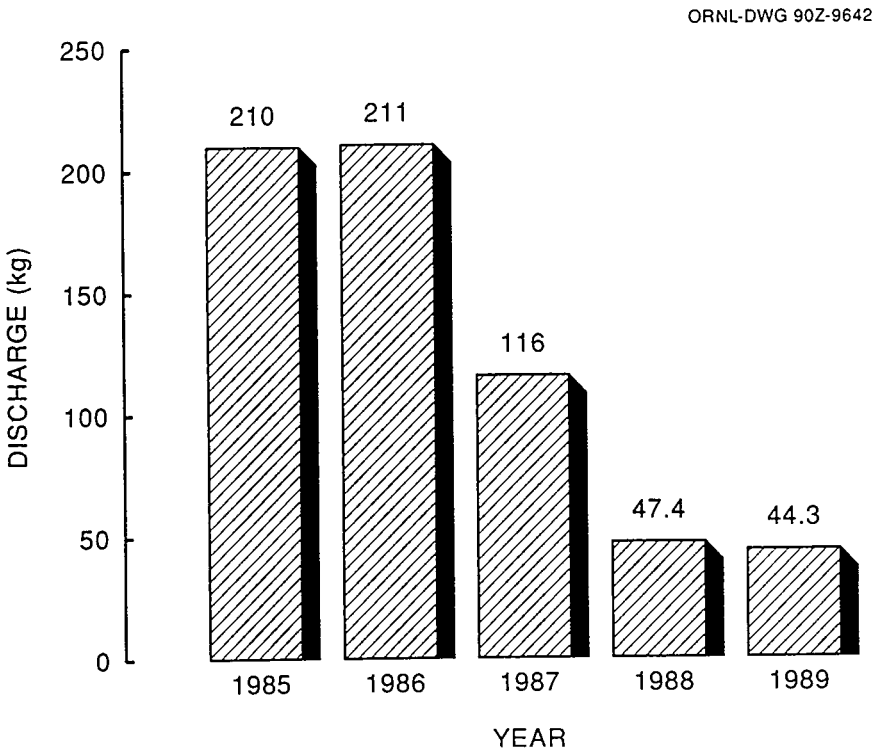

Fig. 2.1.4. Total kilograms of uranium discharged from the Y-12 Plant to the atmosphere, 1985–1989.

of emission source terms. The single exception is for noble gases, which must be evaluated with a monitoring chamber because those radionuclides cannot be quantitatively captured on a sampling medium.

Data are presented for all areas except the Electron Linear Accelerator Facility (Building 6010), where continuous sampling equipment is not presently installed, and the Emergency Avoidance Solidification Project, which was not operated in 1989. The Electron Linear Accelerator Facility exhibits extremely low concentrations of very short half-lived isotopes. Consequently, this stack has virtually no impact on the radiation dose associated with the operation of ORNL.

The sampling systems generally consist of in-stack sampling probes, sample transport piping, a particulate filter, an activated charcoal canister, a silica-gel tritium trap, flow measurement and totalizing instruments, a sampling pump, and return piping to the stack. The sampling system for the Tritium Target Fabrication Facility is configured with a tritium trap only. The sampling systems at 2026, 3020, and 7512 have not been upgraded and do not have tritium traps.

Data sources for the various isotopes identified in the 1989 airborne emission source term are shown in Table 2.1.2 and are further discussed in the summary. Tritium data were generated by inventory for 3039 and by sampling for 7911 and 7025. Consequently, there is a double entry for tritium in the table. Other double entries are for isotopes that are captured by more than one sampling media.

Summary

The 1989 radioactive airborne emissions data included 35 isotopes and five gross parameters captured from five data sources. Table 2.1.2 provides a listing of isotopes and gross parameters and the media from which they were captured.

The charcoal filters, particulate filters, and silica-gel traps (as described above) were collected

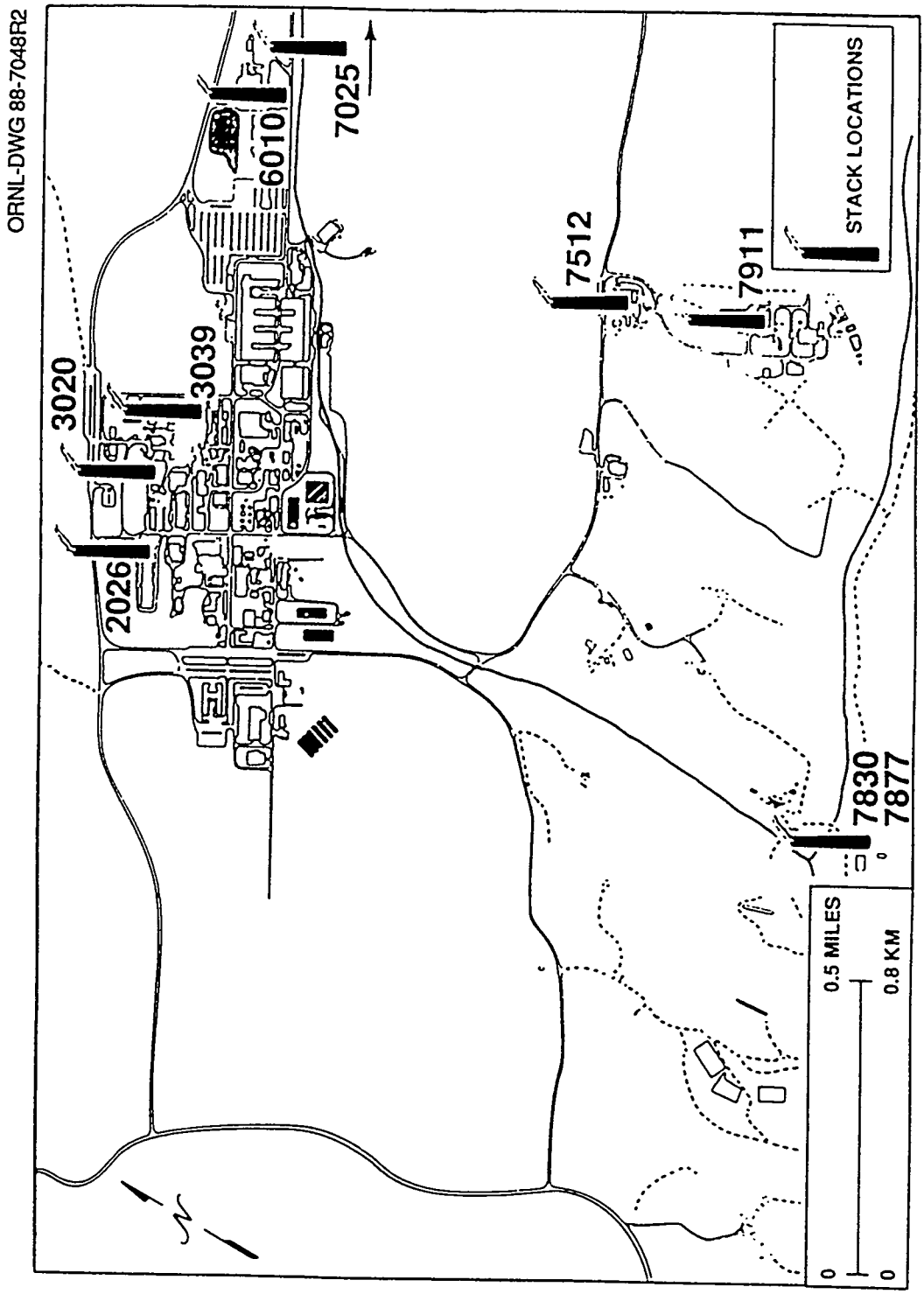

Fig. 2.1.5. Locations of major stacks (emission points) at ORNL.

Table 2.1.2. ORNL radioactive airborne emissions data sources, 1989

Isotope	Charcoal filter	Weekly particulate filter	Particulate composite	Monitoring or inventory	Silica gel
^{241}Am			X		
^{194}Au	X				
^{140}Ba			X		
^{7}Be			X		
^{82}Br	X				
^{244}Cm			X		
^{60}Co	X		X		
^{137}Cs	X		X		
^{152}Eu			X		
^{154}Eu			X		
^{155}Eu			X		
Gross alpha		X			
Gross beta		X			
^{125}I	X				
^{129}I	X				
^{131}I	X		X		
^{132}I	X				
^{133}I	X				
^{134}I	X				
^{135}I	X				
^{140}La			X		
^{191}Os	X		X		
^{212}Pb	X				
^{238}Pu			X		
^{239}Pu			X		
^{228}Ra			X		
Total radium			X		
^{106}Ru	X				
^{125}Sb	X				
^{75}Se	X		X		
Total Sr			X		
^{228}Th			X		
^{230}Th			X		
^{232}Th			X		
^{234}U			X		
^{235}U			X		
^{238}U			X		
Total uranium			X		
^{65}Zn			X		
Noble gas				X	
Tritium				X	X

weekly. Starting in May 1989, the weekly tritium samples were composited biweekly for analysis. The 3039 area is sampled in each of the four main ducts feeding into the 3039 stack, resulting in four sets of data for that stack. For the purposes of this report, the 3039 area data were weighted proportionally according to each duct's contribution to the total stack flow and summed.

Charcoal filters are a standard method for capturing and quantifying radioactive iodines in airborne emissions. Gamma spectrometric analysis

of the charcoal traps identified nine additional noniodine isotopes, as shown in Table 2.1.2.

Particulate filters were held for 8 days prior to analysis to minimize the contribution from short-lived isotopes. A study conducted during 1989 (Tardiff and Wolf, in preparation) showed the short-lived gross alpha and gross beta signature of the stacks to be primarily associated with ^{220}Rn and its daughter products. This decay series is quantified through measurements of ^{212}Pb on the activated charcoal filter. By including the short-lived gross alpha and beta, these emissions would be counted. These samples were analyzed for gross alpha and gross beta, because radioactive particulates are typically alpha and beta emitters. These data are not used in dose calculations because an assumption about the contributing isotope would be necessary. Instead, the particulate filters are composited quarterly and analyzed for alpha and beta emitting isotopes, and these data are used for dose assessment.

Compositing provides an opportunity to evaluate the lower specific activity radionuclides in the emissions. Identification and quantification of this group is initially confounded by the presence of short-lived isotopes.

Noble gas emissions from stacks 3039 and 7911 were derived from real-time monitoring data. Noble gases are chemically inert and, consequently, cannot be trapped on a collecting media for analysis. Instead, after the monitoring system gas stream has passed through the particulate filter and charcoal trap, a part of the stream is pumped through a lead-shielded chamber that is equipped with a beta-gamma detecting monitor. The implicit assumption is that the upstream collecting media have removed all but the noble gases. The noble gas monitor data are accrued as 10-min and 1-h averages of counts per minute in the real-time monitoring system. Each of the chambers has been calibrated with ^{85}Kr at two concentrations. The calibration results can be used to convert counts per minute into noble gas activity as ^{85}Kr. The 1989 noble gas emissions are based on the median counts-per-minute value for January through December 1989. The median counts per minute was then converted to an annual noble gas emission as ^{85}Kr by using the calibration data.

Data from silica-gel traps were used to calculate tritium emissions from stacks 7025 and 7911. Tritium emissions from the 3039 stack area were based upon monthly inventory data of incoming and outgoing shipments and calculated net losses.

Radioactive emissions. The total radioactive airborne emissions for ORNL are presented in Table 2.1.3. Trends in historically analyzed emission parameters are presented in Figs. 2.1.6 through 2.1.9. The noble gas source term was assumed to be 83% ^{133}Xe and 17% ^{85m}Kr based on data collected at HFIR. Many of the isotopes reported this year were not analyzed for prior to 1988. This increase in the emission source term reflects changes in the sampling systems and changes in the regulatory environment. An assessment of the potential impacts of this source term to the public is presented in Sect. 3.

The 1989 noble gas emissions were substantially higher than in 1988. Several factors confound the interpretation of this result. The noble gas measurement system currently in use does not allow quantitation of individual isotopes. The efficency of the noble gas detector increases with an increase in the energy of the beta-gamma signature of the isotope mixture being measured. Because the system is calibrated with ^{85}Kr, isotopes in the mixture with energies higher than ^{85}Kr will be overestimated. This is the first complete year of data for the upgraded measurement system at the 3039 stack, and it is possible that increases in the source term are the result of improved measurement capabilities. The dose from noble gases from ORNL represents 5% of the total population dose for the ORR (see Sect. 3). A study is being conducted to develop a method for sampling and isotopic analysis of noble gases from the major emission points at ORNL. Once this methodology is in place, identifying the sources of changes in the noble gas source term will be possible.

The tritium source term is also higher than in 1988 (Fig. 2.1.6). The increase of 7000 Ci is within the error associated with estimating losses through inventory calculations at Building 3039. This method of accounting has been revised to improve the estimates.

Table 2.1.3. 1989 ORNL annual airborne radionuclide emissions[a]

Isotope	Stack number							Total (μCi)
	2026	3020	3039	7025	7830	7911	7512	
^{241}Am	33	0.25	61		0.003	5.6		0.19
^{194}Au			100					380
^{140}Ba						100		0.83
^{7}Be	0.23	0.094	95		0.13	4.0		82
^{82}Br			100					110
^{244}Cm	88	0.91	2.3		<0.0001	7.8		1.6
^{60}Co	0.026	0.005	99		0.011	0.13		400
^{137}Cs	6.2	0.32	92		0.000	0.95	0.038	650
^{152}Eu						100		1.1
^{154}Eu			21		0.68	78		1.4
^{155}Eu	20					79		1.1
Gross alpha	67	7.0	23		0.060	1.1	1.1	59
Gross beta	3.0	3.1	92		0.003	1.5	0.054	3000
^{125}I	23	72					3.9	0.69
^{129}I	0.41	0.74	98		0.001	0.27	0.15	1900
^{131}I	0.006	0.017	27		<0.0001	72	<0.0001	29000
^{132}I						100		750
^{133}I	0.002	<0.0001	0.075		<0.0001	99	0.000	27000
^{134}I						100		210
^{135}I	0.020	0.002	<0.0001		<0.0001	100	0.004	20000
^{140}La						100		0.28
^{191}Os			100					1200000
^{212}Pb	23	5.2	57		0.029	13	0.011	87000
^{238}Pu	8.4	<0.0001	91		<0.0001	0.32		1.4
^{239}Pu	77	0.048	19		<0.0001	2.7		0.49
^{228}Ra	20	28	51		<0.0001	<0.0001		0.44
Total radium	48	15	31		0.13	4.3		0.25
^{106}Ru			100					34
^{125}Sb			100					8.8
^{75}Se			99			0.14		990
Total Sr	6.6	0.15	90		0.006	3.1		35
^{228}Th	60	3.3	33		0.10	2.9		0.27
^{230}Th	6.6	3.0	85		0.20	4.9		0.041
^{232}Th	2.0	4.5	88		0.18	4.4		0.037
^{234}U	16	1.1	79		0.027	3.2		1.1
^{235}U	11	2.1	81		0.072	4.9		0.10
^{238}U	7.0	4.3	80		0.16	7.4		0.076
Total uranium			95			4.6		0.66
^{65}Zn			100					0.92
Noble gas			95			5		95000[b]
Tritium			89	10		0.002		28000[b]

[a]Percent contribution to emissions, by stack.
[b]Units are curies.

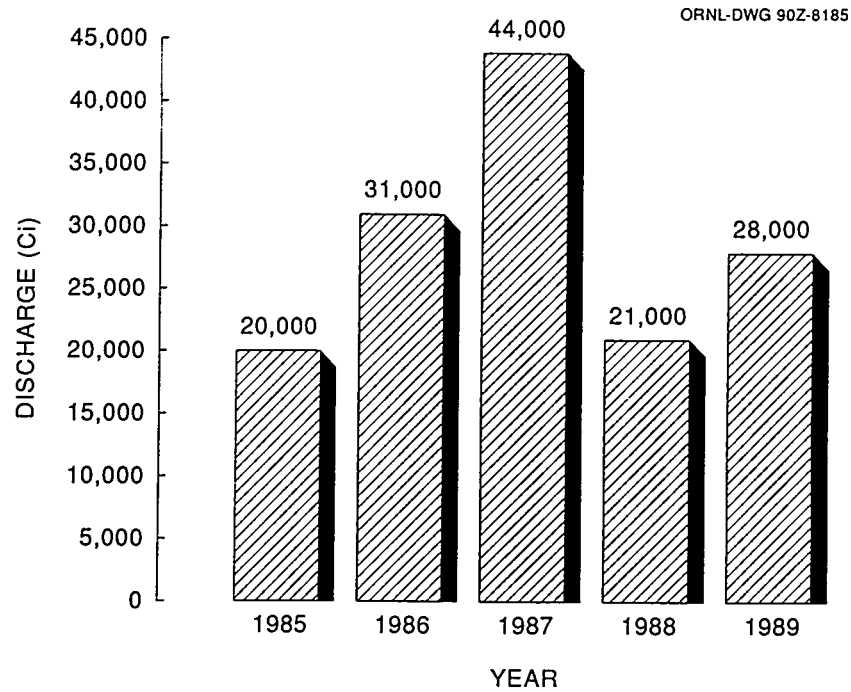

Fig. 2.1.6. Total curie discharges of tritium from ORNL to the atmosphere.

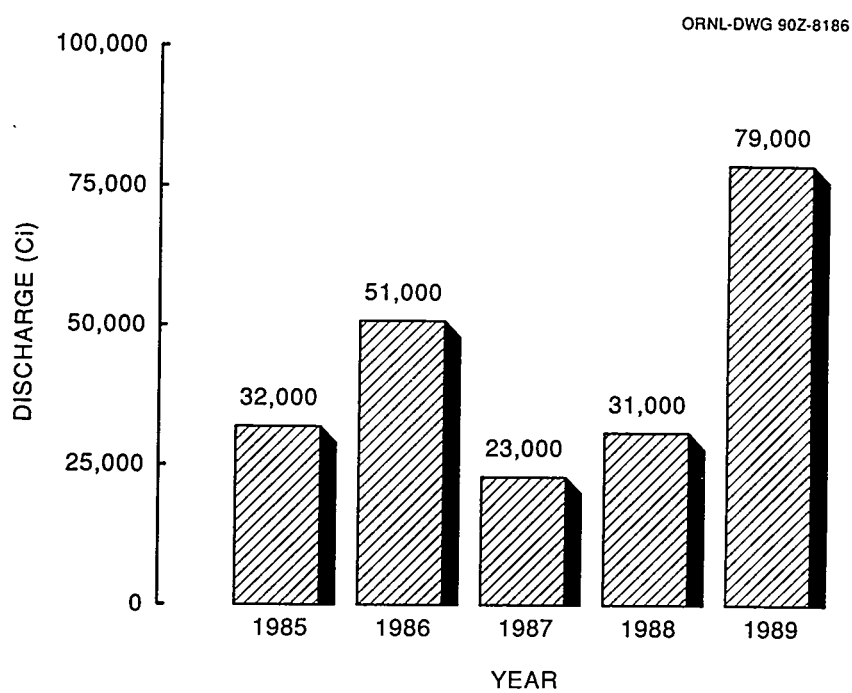

Fig. 2.1.7. Total discharges of ^{133}Xe from ORNL to the atmosphere.

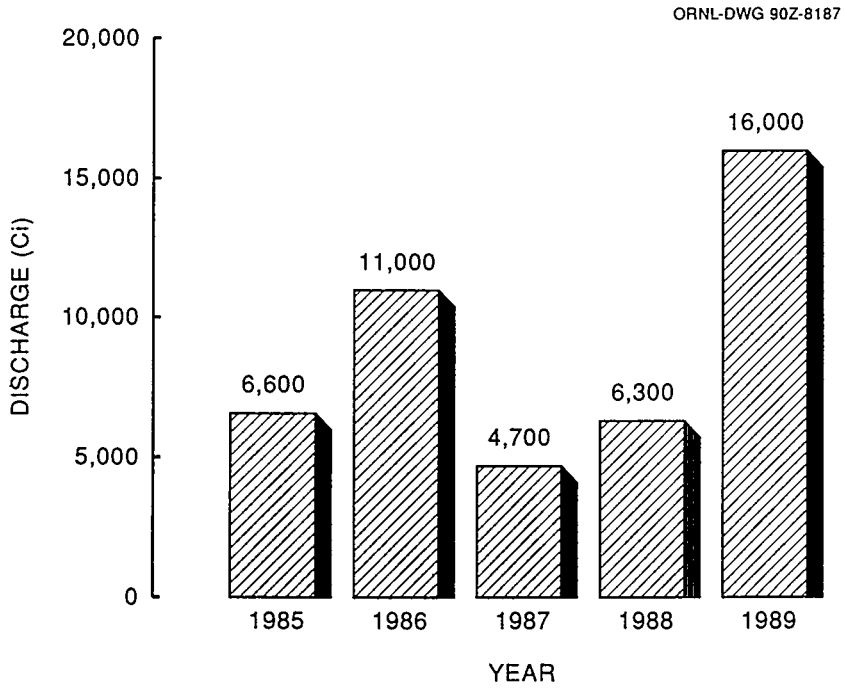

Fig. 2.1.8. Total discharges of ^{85}Kr from ORNL to the atmosphere.

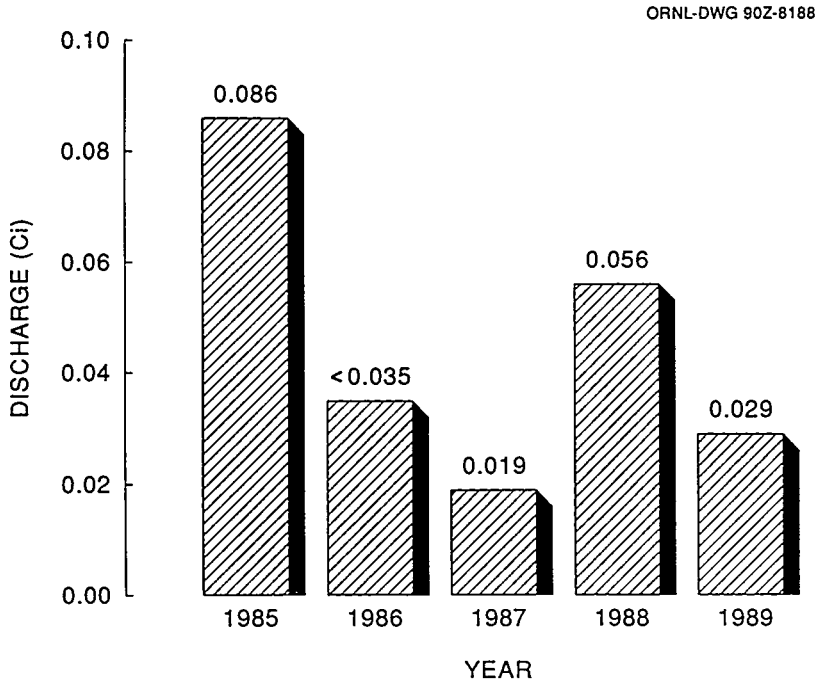

Fig. 2.1.9. Total discharges of ^{131}I from ORNL to the atmosphere.

Chemical emissions. Total particulate and chemical emissions from any one emission point at ORNL are very low, except for the Steam Plant. Therefore, the air permits issued by the TDHE, Air Pollution Control Board, do not require sampling or monitoring at any of the permitted emission points except the steam plant. Estimates of major chemical emissions are included in Appendix C.

2.1.1.3 Oak Ridge Gaseous Diffusion Plant

Description

As a result of ORGDP operations, emission sources may release permitted quantities of various contaminants into the atmosphere. To ensure that these emissions are minimized and that full compliance with CAA requirements is maintained, a comprehensive air pollution control program has been implemented.

This program involves (1) maintenance of a flexible, well-documented environmental policy with regard to air pollution control; (2) continuous review of changes/modifications of air pollution regulations; (3) implementation of projects designed to keep ORGDP in full compliance with the CAA; and (4) operational and emissions monitoring to ensure compliance.

Most of these permitted sources are inactive because of the shutdown of the gas centrifuge development program and the gaseous diffusion process. Future permitting activities depend on the introduction of new processes. Table 2.1.13 in Vol. 2 lists air permits issued by TDHE for ORGDP.

The locations of airborne radioactive effluent release points at ORGDP are shown in Fig. 2.1.10. All radionuclide emissions were included in all dose modeling. Figure 2.1.11 describes the general types of air emission sources at ORGDP, and Fig. 2.1.12 depicts the air pollution control program strategy in detail.

Currently, the major operating emission sources are the K-1501 steam plant, the K-1420 decontamination facility, and the K-1435 TSCA Incinerator. In these cases, the estimates of the amount of pollutants emitted are based on actual operating activity. The estimates for radionuclide emissions from the various stacks at K-1420 are based on both actual operating time in 1989 and stack sampling data obtained in 1988 and 1989.

The K-1501 steam plant is in continuous operation, and this system has a continuous opacity monitor. To reduce opacity excursions, a decision was made to use natural gas as fuel as much as possible. Because sufficient natural gas is not always available during cold winter conditions, some coal can be burned during peak periods of use; however, no coal was burned in 1989.

Estimates of the pollutants emitted from the K-1435 TSCA Incinerator are based on continuous sampling and actual operating time.

The K-1420 decontamination facility used several processes for various types of decontamination in 1989, and for each process used, a triplicate grab stack sample was collected.

The K-1435 TSCA Incinerator, which was built to thermally destroy PCBs and other organic hazardous wastes, has undergone another series of testing to meet the RCRA requirements. RCRA testing in 1988 proved to be inconclusive; therefore, TDHE required a retest.

An outside contractor was hired to perform the sampling and analytical activities for the RCRA retests, which were conducted in June 1989. Results from the tests were submitted to TDHE and EPA for approval in September. Both TDHE and EPA reviewed the results, and approval was granted in November. TDHE plans to modify the RCRA permit to include the conditions that were demonstrated during the trial burn. Current plans are to issue the final permit sometime in 1990.

During the RCRA trial burn, a catastrophic failure of the induced draft fan occured. The incinerator was shut down while a Type B investigation was conducted to try to determine the cause of the failure. A new fiberglass fan has been installed, and final approval to restart is being sought from DOE.

Current plans are to complete the required TDHE air compliance tests for lead, beryllium, and nitrogen oxide emissions. After these tests are completed, all permitting requirements will be

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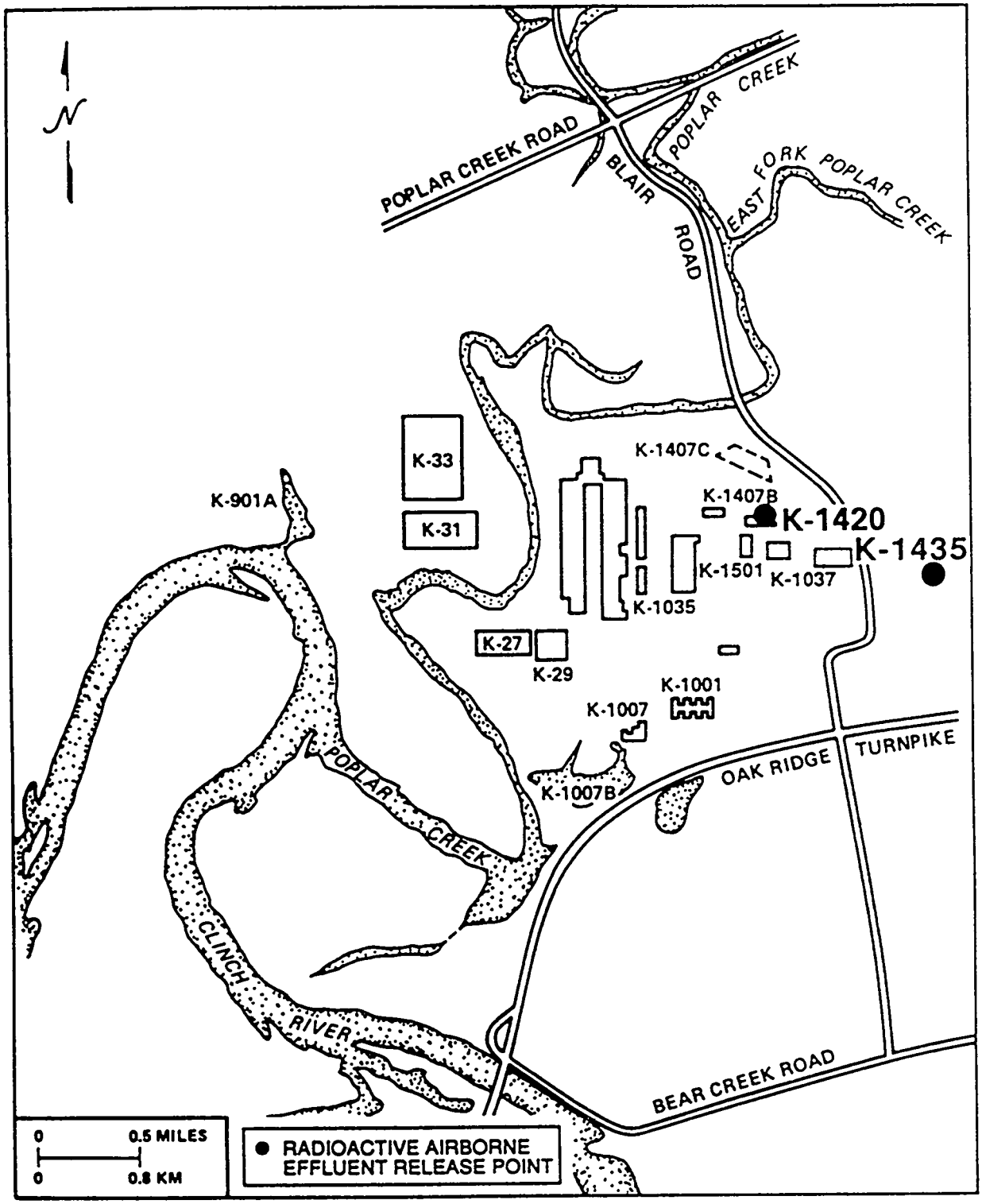

Fig. 2.1.10. Locations of airborne effluent release points at ORGDP.

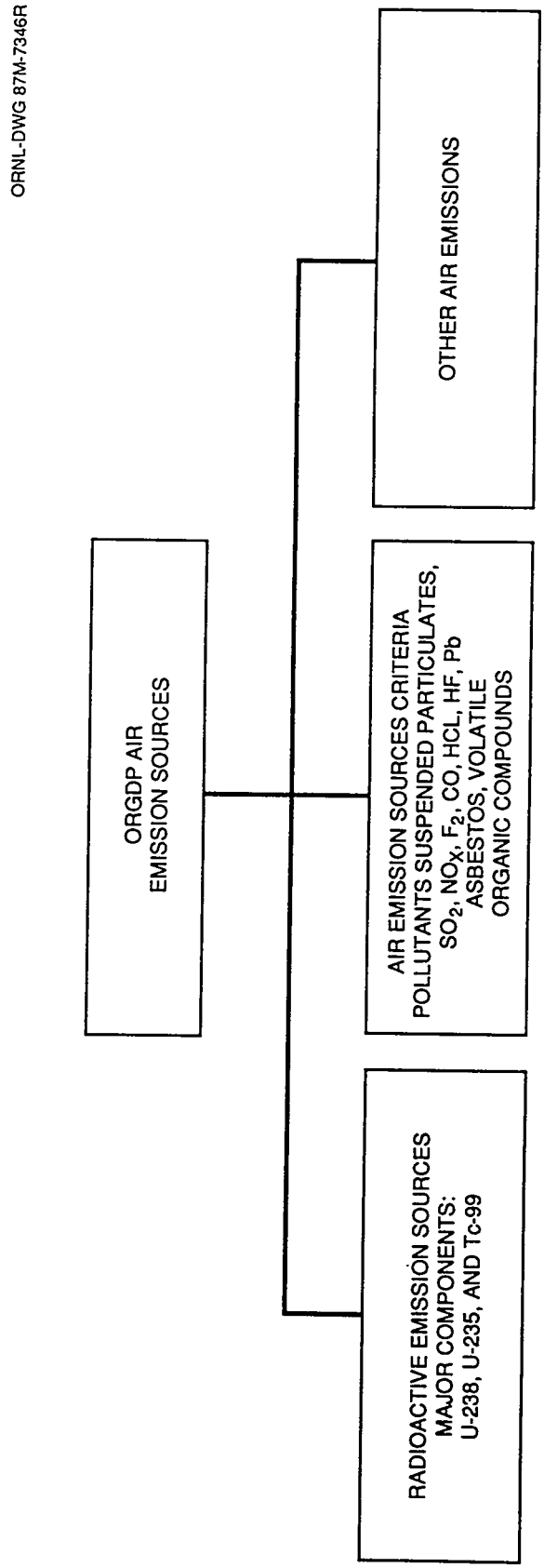

Fig. 2.1.11. Air emission sources at ORGDP.

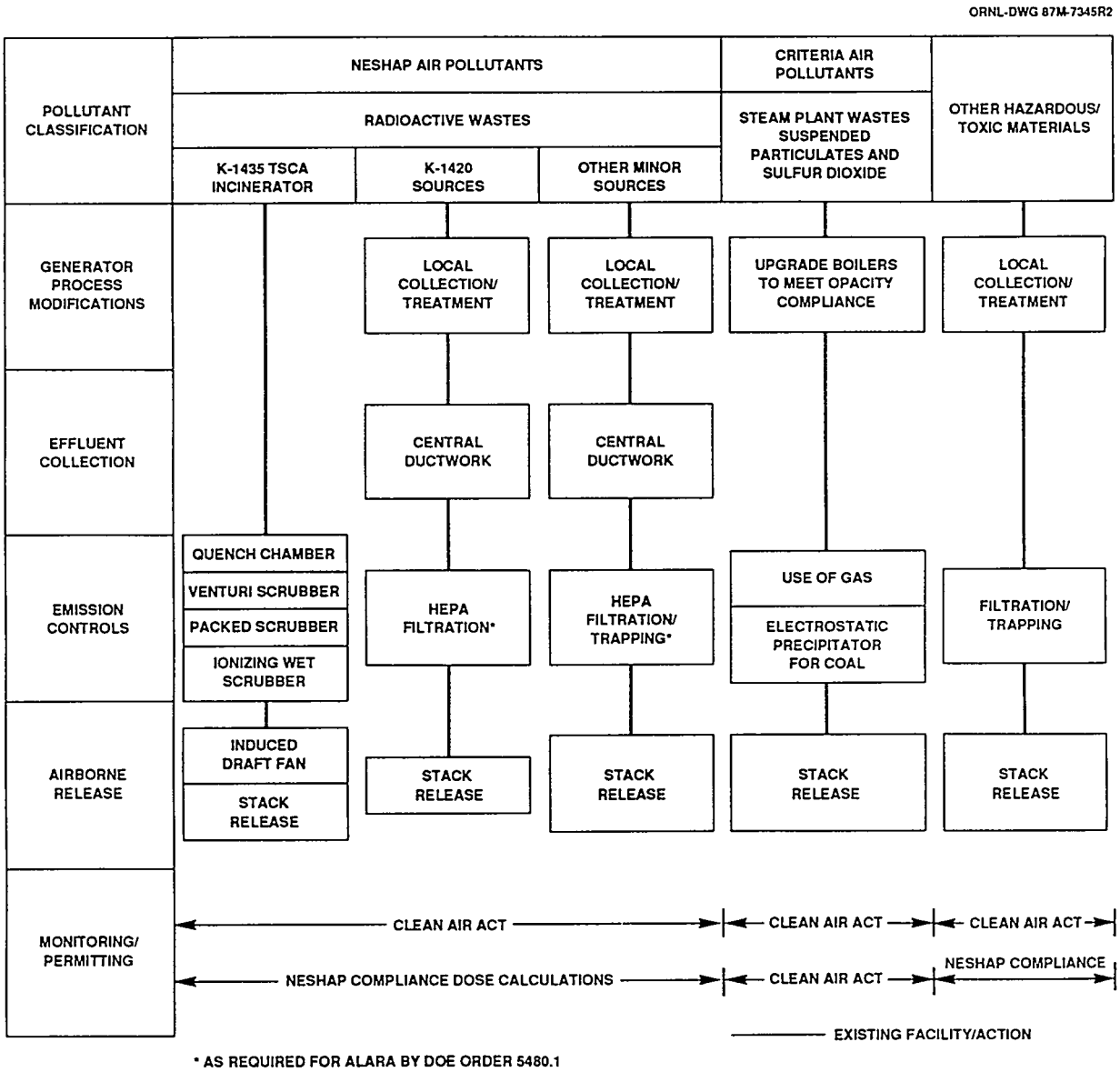

Fig. 2.1.12. Air pollution control program at ORGDP.

fulfilled and full operation can begin, probably in the fall of 1990.

The only radioactive isotopes incinerated in the K-1435 TSCA Incinerator during 1989 were uranium and technetium; therefore, no emissions of ^{125}I or ^{131}I are included. The emissions of uranium and technetium are well within the acceptable permit guidelines (15,000 μCi/year for uranium and 394,000 μCi/year for technetium). In addition, carbon monoxide, carbon dioxide, and oxygen are continuously monitored to ensure that destruction efficiency for the incinerator is sufficient to destroy 99.9999% of organics.

There are no permitting requirements to sample or monitor all chemical emissions from ORGDP; however, estimates of the major gaseous chemicals emitted to the atmosphere in 1989 (including those that require reporting under SARA Title III, Sect. 3.3) are shown in Appendix C.

Figures 2.1.13 and 2.1.14 compare ORGDP's discharges of uranium for 1989 with those of

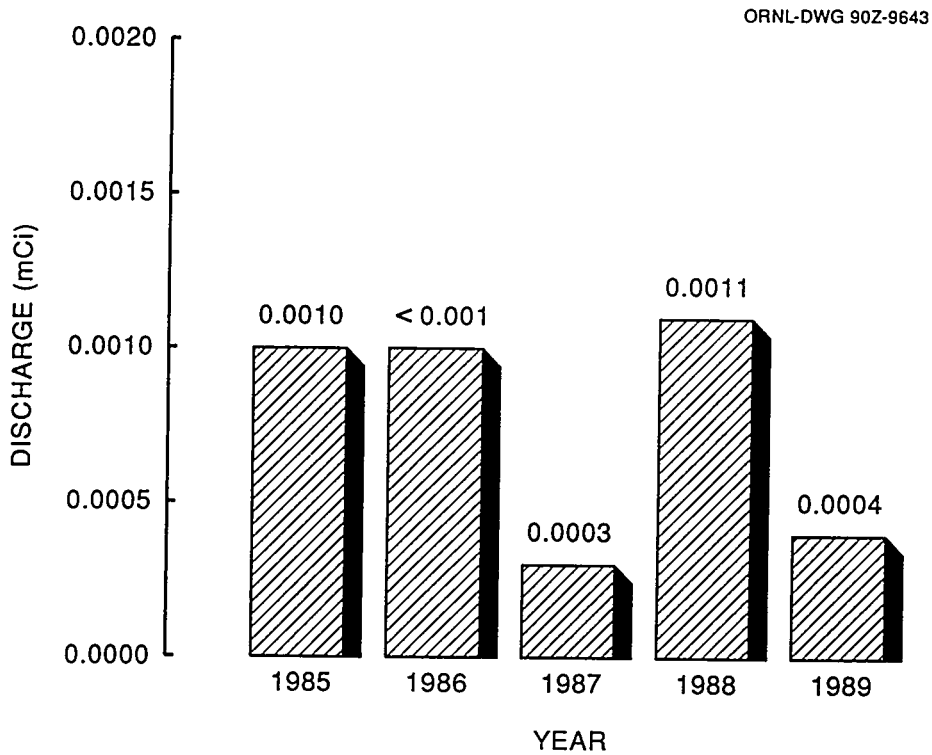

Fig. 2.1.13. Total curie discharges of uranium from ORGDP to the atmosphere.

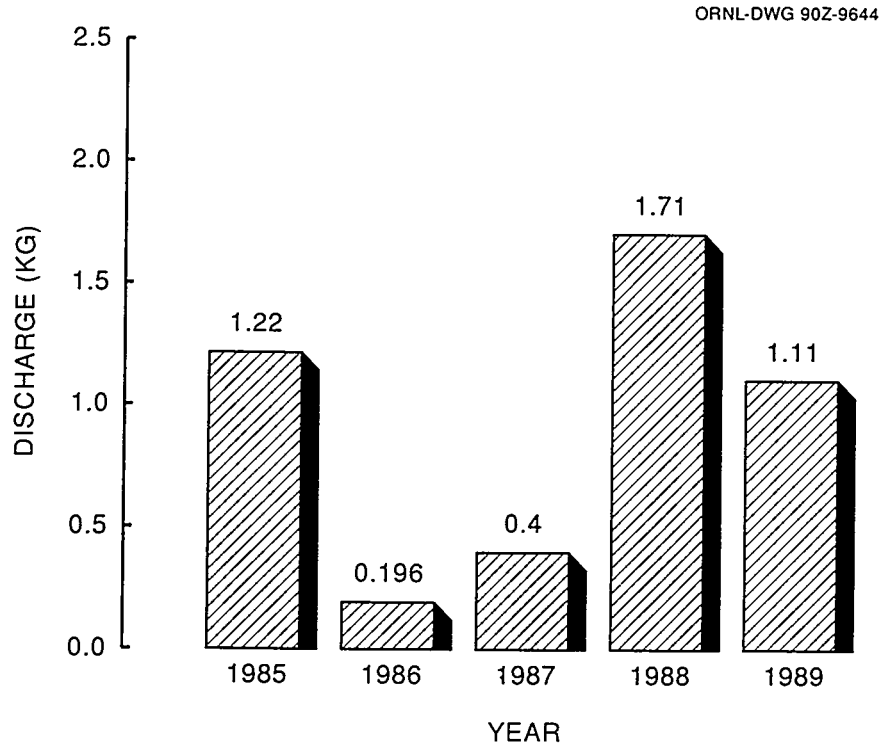

Fig. 2.1.14. Total kilograms of uranium discharged from ORGDP to the atmosphere.

previous years. Uranium emissions for 1989 resulted almost entirely from operation and testing of the K-1435 TSCA incinerator. Samples collected in 1989 detected ^{99}Tc in emissions from K-1420 and K-1435. Figures 2.1.15 and 2.1.16 compare ORGDP's discharges of ^{99}Tc for 1989 with those of previous years.

2.1.2 Ambient Air Monitoring

In addition to stack monitoring and sampling conducted at the DOE Oak Ridge installations, an ambient air monitoring program has been developed to directly measure radiological parameters in the ambient air adjacent to the facilities. Ambient air monitoring provides direct measurement of airborne radionuclide concentrations in the environment surrounding the facilities, allows facility personnel to determine the relative level of radioactivity at the monitoring locations during an emergency condition, and also serves as a check on dose-modeling calculations.

The following sections discuss the ambient air monitoring network for the Energy Systems Oak Ridge installations. This network consists of a number of ambient air monitors located around each facility within the ORR and at remote locations in the surrounding communities. With the exception of perimeter air monitors around the Y-12 Plant and ORGDP and TSCA ambient air monitors near ORGDP, all ambient air monitors were operated by ORNL during 1989. The following discussions include data summary tables in which 1989 ambient air monitoring results for each station are presented. For a more complete presentation of these data, see Vol. 2, Tables 2.1.1 through 2.1.10.

2.1.2.1 Oak Ridge Y-12 Plant

Description

With the technical assistance of ORNL, the Y-12 Plant has developed a network of ambient air

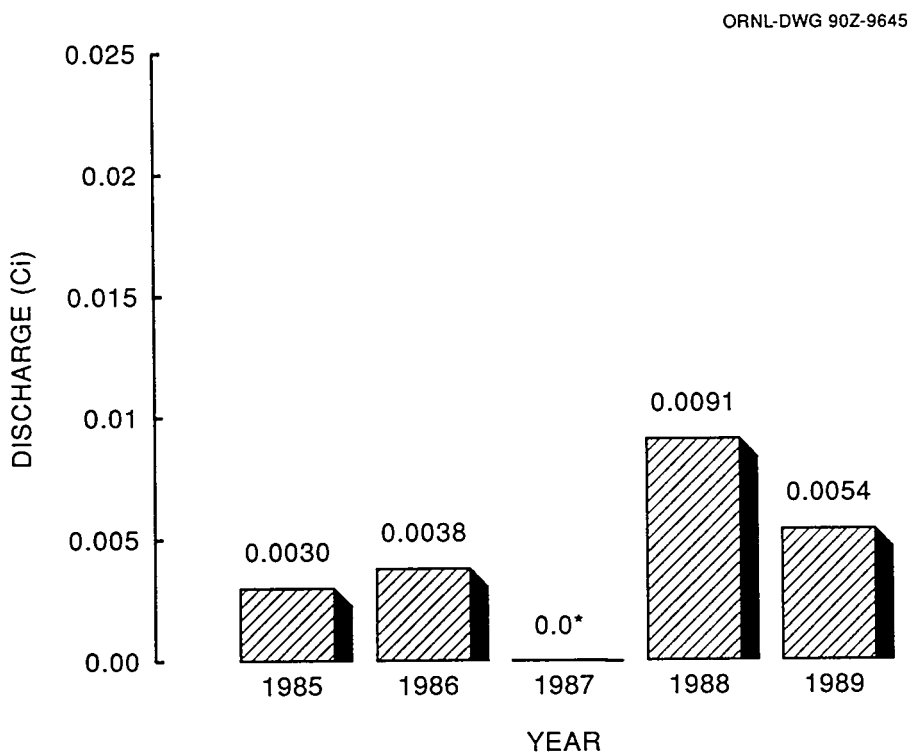

Fig. 2.1.15. Total curie discharges of ^{99}Tc from ORGDP to the atmosphere. (No ^{99}Tc was detected in 1987.)

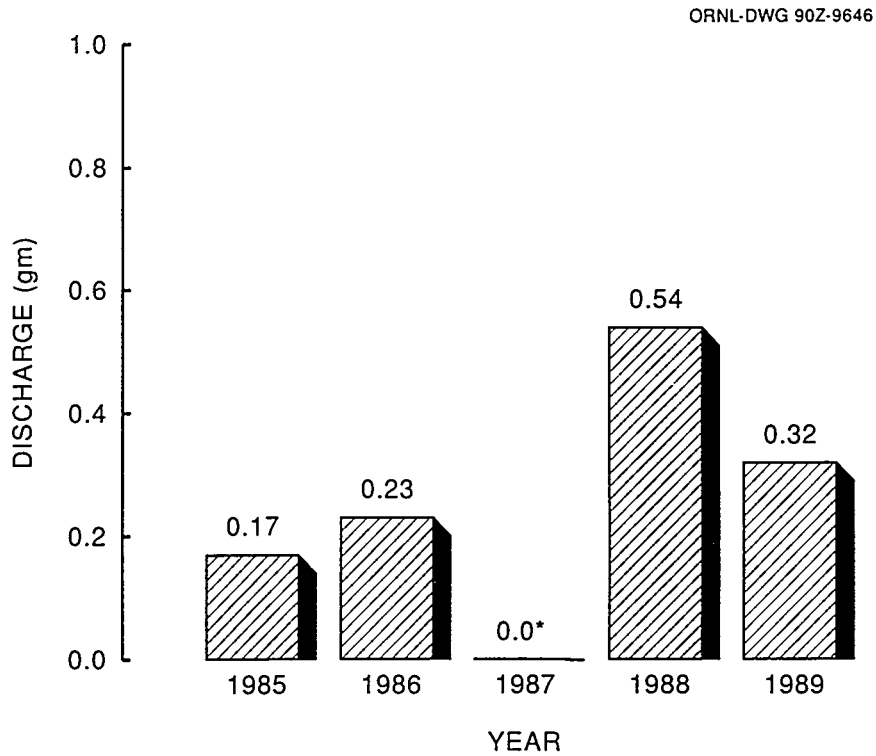

Fig. 2.1.16. Total grams of technetium discharged from ORGDP to the atmosphere. (No technetium was detected in 1987.)

monitors located around the plant perimeter. These stations are to monitor ambient air quality at the plant boundaries to determine the off-site transport of air contaminants and to verify that plant ambient air quality meets air quality standards.

The Y-12 Plant operates 12 ambient air monitoring stations around the perimeter of the plant to routinely measure suspended uranium particulates. Ambient air fluoride sampling is also conducted continuously at 11 of the 12 Y-12 Plant perimeter air monitors. Two additional ambient air monitoring stations are operated to monitor for total suspended particulates (TSP), and two stations are operated to continuously monitor ambient sulfur dioxide concentrations. The locations of the ambient air monitoring stations operated by the Y-12 Plant are shown on Fig. 2.1.17.

Atmospheric fluoride is collected at 11 sites by absorption on 37-mm-diam (1.5-in.) filters pretreated with potassium carbonate. Ambient uranium sampling is conducted at these same 11 sites and also at an additional site constructed in 1987. Uranium particulates are collected on square 14-cm (5.5-in.) filters and analyzed in the Y-12 Plant laboratory by alpha spectroscopy. Data obtained from ambient uranium and fluoride air sampling are used by Y-12 Plant personnel to monitor ambient air quality within the plant and around the plant perimeter. Monitoring of area ambient air quality ensures that plant workers and the general public are adequately protected from potential hazards of stack and other emissions.

The Y-12 Plant monitors TSP in ambient air at the east and west ends of the site. Sampling for TSP consists of drawing air at a known rate through a preweighed filter paper for 24 h every 6 d. From a weight differential resulting from particle accumulation, a particle concentration (expressed in $\mu g/m^3$) can be calculated. These values are compared with the Tennessee primary and secondary ambient air quality standards. Sample results are not submitted to the TDHE or EPA but are used as an internal measure of area

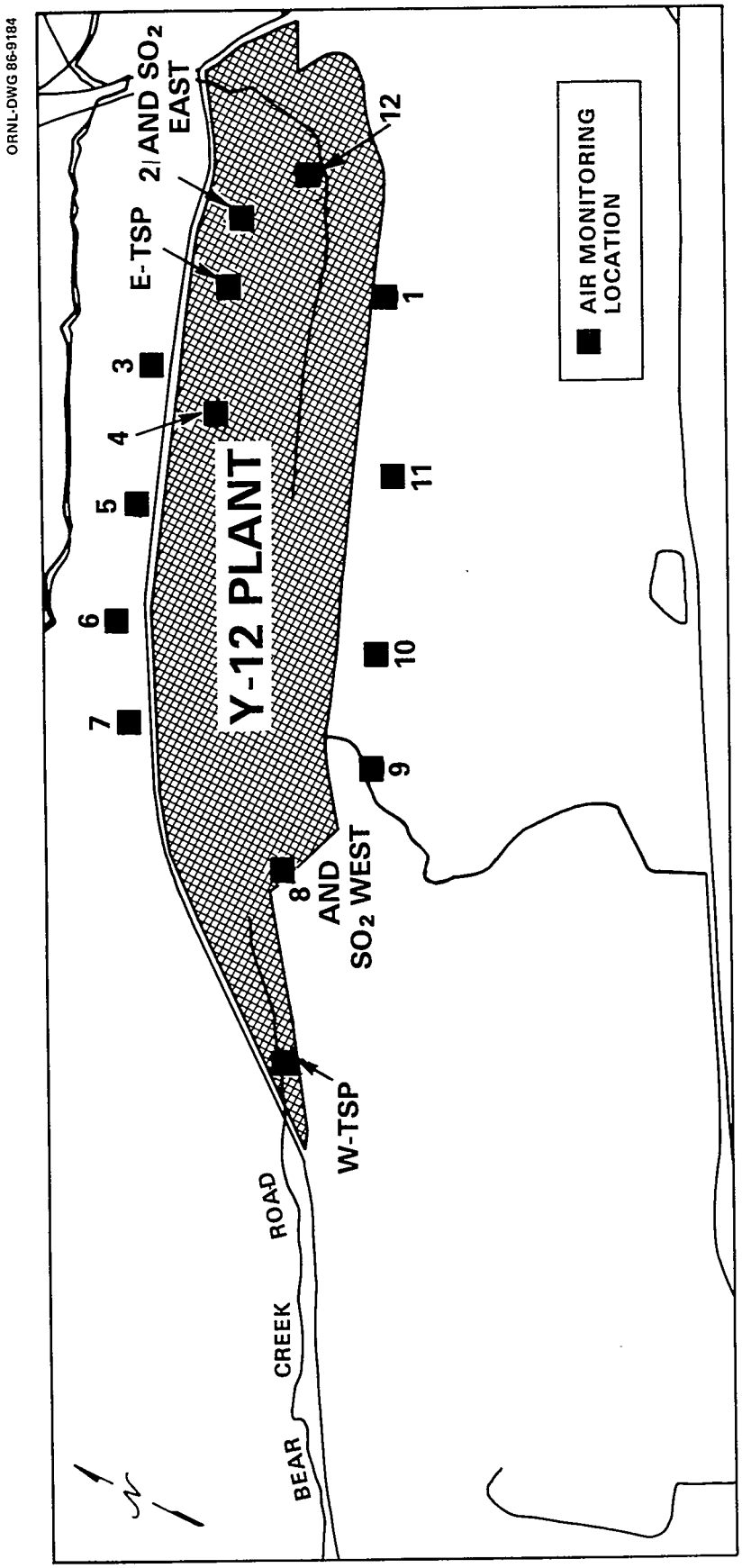

Fig. 2.1.17. Ambient air monitoring stations operated by the Y-12 Plant.

ambient air quality. If a sample was found to exceed the state standard, Y-12 Plant personnel had the filter scrutinized under a microscope to determine the cause. In all such cases, the particulate matter did not result from process emissions. Rather, the majority of the filter was covered with road dust, pollen, insects, and other particles arising from the natural environment.

Sulfur dioxide (SO_2) monitoring is conducted continuously at two stations at the Y-12 Plant by pumping ambient air into pulsed ultraviolet fluorescence analyzers that are connected to recording units housed in temperature-controlled shelters. Data from the two SO_2 monitoring stations are reported monthly to the TDHE. A quarterly audit of each system is conducted by the TDHE for quality assurance purposes. Concentrations of SO_2 are recorded in hourly intervals each month. Hourly averages are combined and compared with 3-h and 24-h air quality standards.

Summary

Ambient air monitoring results for the 12 Y-12 Plant perimeter air monitors are summarized in Tables 2.1.4 through 2.1.8. Table 2.1.4 shows the maximum, minimum, and average gross alpha and gross beta concentrations measured at each of the 12 stations during 1989. Similarly, the ^{234}U, ^{235}U, ^{236}U, and ^{238}U average uranium concentrations are shown in Table 2.1.5. Table 2.1.6 shows similar data for ambient fluoride concentration during 1989 as well as a comparison with the state standard for fluorides.

Table 2.1.7 summarizes the measured SO_2 concentrations at each of the two Y-12 Plant SO_2 monitoring stations during 1989. Table 2.1.8 shows TSP data for the two Y-12 Plant TSP ambient air monitoring stations during 1989. More detailed data are available in Sect. 2.1 in Vol. 2, Tables 2.1.1 through 2.1.5.

Discussion

Ambient air concentrations of fluorides measured during 1989 at each of the Y-12 Plant perimeter air monitoring fluoride stations were well below TDHE standards, averaging less than 5% of the standards.

Ambient uranium isotope concentrations measured at each of the 12 perimeter air monitoring stations around the Y-12 Plant were also very low. Although there is no federal or state standard that applies to ambient uranium or uranium isotope concentrations, measured values are within guidelines set forth under DOE Order 5400.5.

Measured SO_2 concentrations at the two Y-12 Plant air monitoring stations were well below state standards throughout 1989 (see Table 2.1.3 in Vol. 2).

Table 2.1.5 in Vol. 2 gives gross alpha and gross beta concentrations in air at the Y-12 Plant for 1989.

The TSP sampling program suffered greatly in 1989 with extended periods of equipment downtime. Three samples in excess of the primary standard were collected from the west TSP samples; these were collected when sampler flow was less than 35 cfm. Also, the area near the West sampler has become a lay-down area for construction items. With the increase in traffic along the gravel road, a noticeable increase in the particulate count has occurred. The area will be reviewed again against sampler siting criteria.

2.1.2.2 Oak Ridge National Laboratory

Description

Three changes were made to the ambient air surveillance program for ORNL in 1989:

- The number of stations was reduced from 27 to 18.
- The sampling period at each station was increased from weekly to biweekly.
- The compositing period for particulate filters was changed from quarterly to annually.

The reduction in the number of sampling locations was based on an analysis of data collected in previous years. The objectives for the program change were to (1) sample at stations that were most likely to show impacts of the operation of ORNL (2) maintain surveillance of the ORR perimeter, and (3) collect reference data from

Table 2.1.4. 1989 Gross alpha and gross beta in air—Y-12 Plant perimeter ambient air monitoring stations

Station ID	No. of analyses[b]	Concentration (10^{-15} μCi/cm^3)[a]		
		Max	Min	Av
		Gross alpha		
1	4	4.49	1.49	2.46
2	4	3.43	2.38	2.70
3	4	5.94	3.33	4.65
4	4	3.96	2.84	3.67
5	4	5.75	3.43	4.55
6	4	6.00	2.90	4.31
7	4	6.20	2.74	3.75
8	4	5.17	3.22	4.14
9	4	3.63	1.60	2.64
10	4	4.22	1.99	3.00
11	4	3.17	2.24	2.83
12	4	3.83	2.41	3.10
		Gross beta		
1	4	19.7	15.8	16.9
2	4	21.2	16.6	19.0
3	4	24.6	19.8	21.5
4	4	24.5	21.8	20.8
5	4	22.8	18.2	20.4
6	4	21.8	17.8	20.1
7	4	23.5	18.0	20.3
8	4	25.0	18.0	21.6
9	4	23.3	18.2	20.7
10	4	20.9	16.3	18.5
11	4	24.0	15.3	19.3
12	4	23.0	19.5	20.8

[a]To convert from 10^{-15} μCi/cm^3 to 10^{-11} Bq/cm^3, multiply by 3.7.

[b]Gross alpha and gross beta radiation analyses are performed quarterly using a composite of sample filter papers changed out weekly throughout the quarter. For average uranium air concentration data, refer to Table 2.1.5 and Vol. 2, Sect. 2.

remote locations. Figures 2.1.18 and 2.1.19 show the stations that were continued in the ORNL ambient air program and those that were dropped from the program. The specific stations associated with each of these objectives are as follows:

1. The ORNL perimeter monitoring network includes stations 3, 7, 8 (tritium only), 9, 20, 21, and 22 (Fig. 2.1.18).
2. The DOE ORR perimeter monitoring network includes stations 23, 33, 34, 40, 41, 42, 43, 44, 45, and 46 (Fig. 2.1.18).
3. The remote monitoring network consists of stations 52 and 58 (Fig. 2.1.19).

The sampling period was doubled to increase the sensitivity of the ambient air surveillance program. Data from previous years include many values that are at the analytical method detection limits. By doubling the sampling period for each

Table 2.1.5. 1989 Uranium concentrations in air at the Y-12 Plant[a]

Station ID	No. of analyses[b]	Concentration (10^{-15} μCi/cm^3)			DCG[c] (%)
		Max	Min	Av	
		^{234}U			
1	4	3.75	0.367	1.57	4.17
2	4	1.79	0.551	1.28	1.99
3	4	2.69	0.959	1.77	2.99
4	4	3.25	1.49	2.40	3.61
5	4	4.95	0.985	3.24	5.50
6	4	4.04	0.817	2.37	4.49
7	4	2.27	0.831	1.65	2.54
8	4	2.46	0.864	1.68	2.73
9	4	1.33	0.487	0.850	1.48
10	4	1.23	0.340	0.815	1.37
11	4	1.83	0.361	1.22	2.03
12	4	2.54	0.360	1.32	2.82
		^{235}U			
1	3	0.137	0.0145	0.055	0.14
2	4	0.106	0.0881	0.070	0.11
3	4	0.179	0.0183	0.102	0.18
4	4	0.146	0.0777	0.069	0.15
5	4	0.444	0.0097	0.207	0.44
6	4	0.221	0.0214	0.115	0.22
7	4	0.095	0.046	0.069	0.10
8	4	0.268	0.0772	0.137	0.27
9	4	0.151	0.0398	0.073	0.15
10	4	0.0516	0.0141	0.038	0.05
11	4	0.0974	0.0324	0.061	0.10
12	4	0.244	0.035	0.088	0.24
		^{236}U			
1	2	0.0685	0.0189	0.044	0.07
2	3	0.0405	0.0168	0.026	0.04
3	4	0.0515	0.0155	0.035	0.05
4	3	0.0644	0.0245	0.040	0.06
5	4	0.114	0.00174	0.050	0.11
6	3	0.274	0.0181	0.113	0.27
7	4	0.0334	0.0075	0.021	0.03
8	4	0.201	0.019	0.067	0.20
9	4	0.0397	0.0182	0.028	0.04
10	4	0.0344	0.0059	0.022	0.03
11	4	0.0313	0.0144	0.024	0.03
12	3	0.154	0.018	0.069	0.15
		^{238}U			
1	4	0.156	0.0876	0.124	0.16
2	4	0.144	0.012	0.101	0.14
3	4	0.171	0.057	0.137	0.17
4	4	0.313	0.205	0.269	0.31
5	4	3.94	0.165	2.183	3.94
6	4	0.344	0.142	0.200	0.34
7	4	0.218	0.109	0.156	0.22

Table 2.1.5 (continued)

Station ID	No. of analyses[b]	Concentration (10^{-15} μCi/cm^3)			DCG[c] (%)
		Max	Min	Av	
		^{238}U			
8	4	0.453	0.225	0.323	0.45
9	4	0.182	0.155	0.166	0.18
10	4	0.174	0.110	0.143	0.17
11	4	0.398	0.0944	0.213	0.40
12	4	0.166	0.053	0.115	0.17

[a]See Fig. 2.1.16.

[b]Isotopic uranium determinations are performed quarterly using a composite of samples collected weekly throughout the quarter.

[c]Percent DCG = Maximum × 100/derived concentration guide (DCG). The DCG is specified by isotope in DOE Order 5400.5.

Table 2.1.6. 1989 Fluorides in air at the Y-12 Plant

Station ID	No. of 7-d samples	Concentration (μg/m^3)				Percentage of standard[b]
		Max	Min	Av	Tenn. std.[a]	
1	52	0.0544	<0.007	<0.0123	1.6	0.77
2	52	0.1754	<0.007	<0.0219	1.6	1.37
3	52	0.2281	<0.007	<0.0363	1.6	2.27
4	52	0.2807	<0.007	<0.0477	1.6	2.98
5	52	0.1754	<0.007	<0.0276	1.6	1.73
6	47	0.1474	<0.007	<0.0136	1.6	0.85
7	52	0.1544	<0.007	<0.0208	1.6	1.3
8	52	0.1053	<0.007	<0.0163	1.6	1.02
9	52	0.1018	<0.007	<0.0144	1.6	0.9
10	52	0.0561	<0.007	<0.0113	1.6	0.71
11	52	0.0772	<0.007	<0.0128	1.6	0.8

[a]Tennessee standard 7-d average = 1.6 μg/m^3.

[b]Percentage of standard calculated using average fluoride concentration.

Table 2.1.7. 1989 Sulfur dioxide in air—Y-12 Plant sulfur dioxide monitoring stations

Station ID	Concentration (ppm SO_2)				
	Annual av	Max 3-h av	Tenn. std. 3-h av	Max 24-h av	Tenn. std. 24-h av
East (004)	0.0134	0.123076	0.50	0.06329	0.140
West (005)	0.00710	0.09761	0.50	0.04223	0.140

Table 2.1.8. 1989 Total suspended particulates in air—Y-12 Plant TSP Monitoring Station

Station ID	No. of samples	Concentration ($\mu g/m^3$)					No. exceedances
		Max	Min	Av	Tenn. Std.	% Std.	
East	46	129.2	3.7	45	260	17.3	0
West	34	385.6	3.2	76	260	29.2	3

sample, more material is trapped by the sampling media and more data above background concentrations are obtained. The result is increased sensitivity of the program to changes in ambient radionuclide concentrations.

Compositing the particulate air filters annually for analysis of long-lived isotopes was adopted, because the data from previous years show very low concentrations of these radionuclides. The annual composite provides summary information regarding these radionuclides at one-fourth the previous program cost for analysis. Since the change was made during the year, a combination of quarterly and longer-interval results is presented. In subsequent years, the program period will be annual.

Sampling is conducted at each station to quantify levels of adsorbable gas (e.g., iodine), gross alpha, and gross beta. Stations 3 and 8 are equipped with samplers for measuring tritium. Sampling and analysis frequencies for each station are given in Table 2.1.9. The real-time monitoring system is the only measure of radioactive noble gases in the area.

Airborne radioactive particulates are sampled biweekly by pumping a continuous flow of air through a 47-mm (1.88-in.) diam paper filter and then through a 47-mm-diam by 25-mm-thick (1.88-in.-diam by 1-in.-thick) charcoal cartridge. To minimize artifacts from short-lived radionuclides, the filter paper is analyzed 3 to 4 d after collection. The airborne adsorbable gases are collected biweekly using a cartridge that is packed with activated charcoal. The charcoal cartridges are analyzed within 24 h after collection. The initial and final dates, time on and off, and flow rates are recorded when a sample medium is mounted or removed. The total volume of air that flowed through the sampler is obtained from a flow totalizer. The concentration of radionuclides in air is calculated by dividing the total activity per sample by the total volume of air sampled.

During 1989, monthly samples for atmospheric tritium were collected from ORNL perimeter station 3 and Reservation perimeter station 8. Atmospheric tritium in the form of water vapor is removed from the air by silica gel. The silica gel is heated in a distillation flask in the laboratory to remove the moisture, and the distillate is counted in a liquid scintillation counter. The concentrations for September, November, and December were used to compute an average concentration for 1989.

Air filter composites from ORNL perimeter stations (3, 4, 7, 9, 20, 21, and 22), Reservation perimeter stations (8, 23, 31, 33, 36, 42, 43, and 44), remote stations (51, 52, 53, 55, 56, 57, and 58), and individual stations (34, 40, 41, 45, and 46) are analyzed for specific radionuclides. Sample analyses for isotopic uranium resulted in a high bias for ^{235}U. When a stainless steel disk containing a mixture of ^{234}U, ^{235}U, and ^{238}U isotopes is counted on a silicon surface barrier detector, the ^{235}U is frequently biased because of interferences from ^{234}U and ^{238}U. The ^{235}U alpha energy lies between the other two uranium isotopes, and at these low concentrations the detectors do not have sufficient resolution to separate all three peaks effectively. Therefore, depending on the amounts of ^{234}U and ^{238}U present in the sample, the ^{235}U will be biased high.

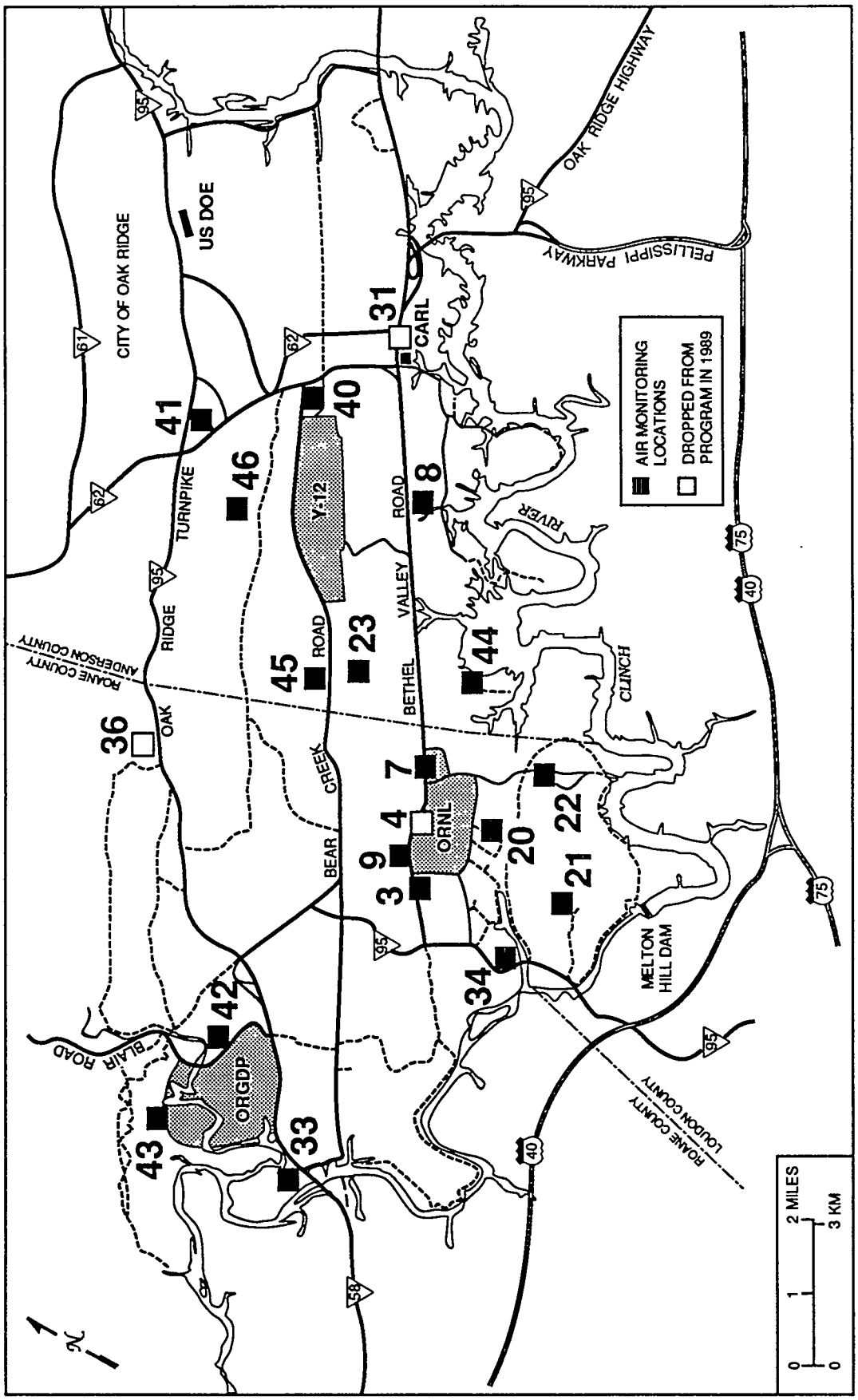

Fig. 2.1.18. ORR and ORNL perimeter monitoring locations.

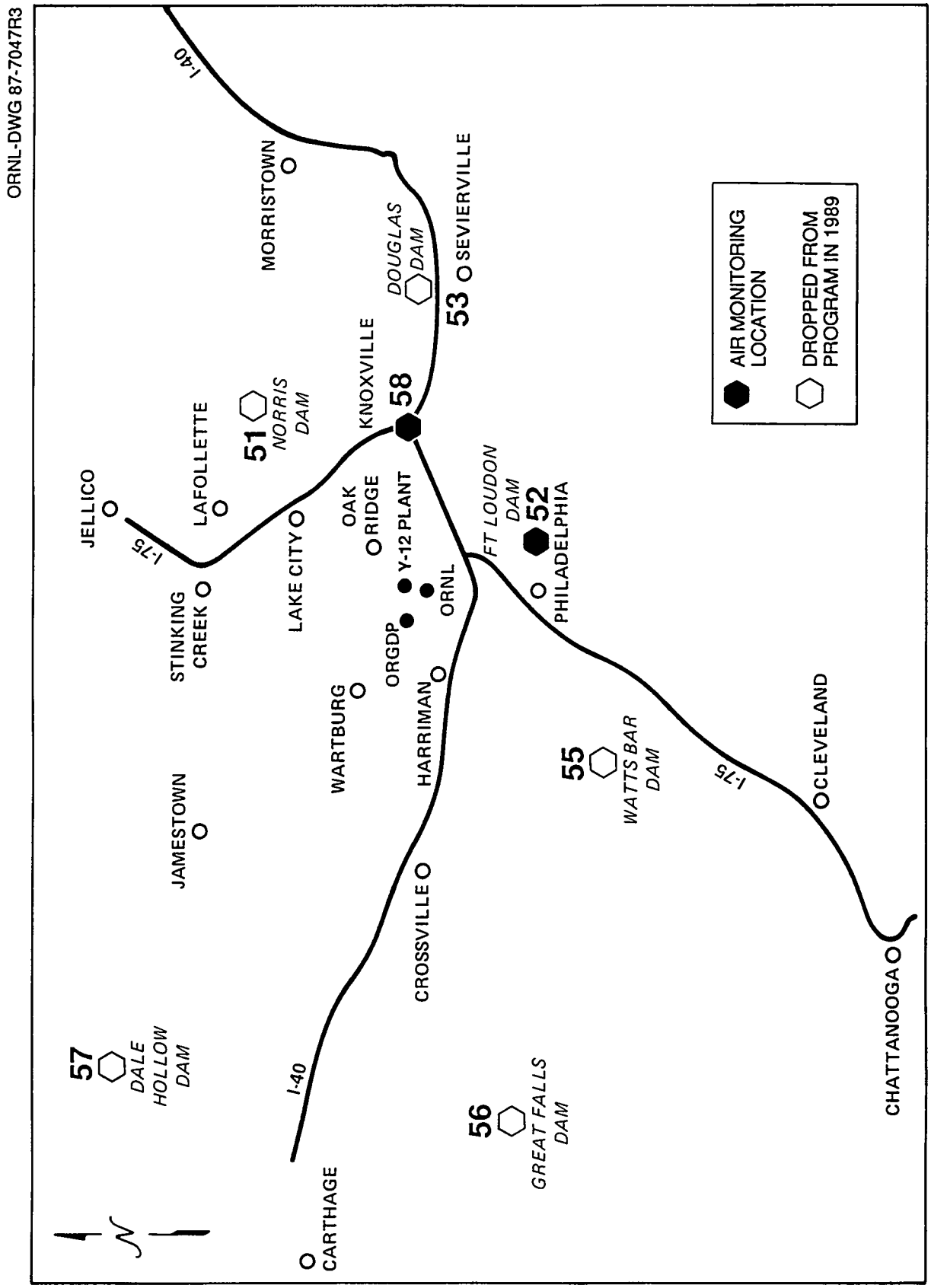

Fig. 2.1.19. Remote air monitoring locations.

Table 2.1.9. 1989 summary of collection and analysis frequencies of ORNL air monitoring stations

Station[a]	Parameter	Collection frequency	Type	Analysis frequency
3, 4,[b] 7, 8,[b] 9, 20, 21, 22, 23, 31,[b] 34, 36,[b] 40, 41, 44–46	^{131}I, gross alpha, gross beta	Biweekly	Continuous	Biweekly
33, 42, 43	Gross alpha, gross beta	Biweekly	Continuous	Biweekly
51,[b] 52, 53,[b] 55,[b] 56,[b] 57,[b] 58	Gross alpha, gross beta	Biweekly	Continuous	Biweekly
3, 8	Tritium	Monthly	Continuous	Monthly
Local, perimeter, remote, 34, 36, 40, 41, 45, 46	^{60}Co, ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{228}Th, ^{230}Th, ^{232}Th, total Sr, ^{234}U, ^{235}U, ^{238}U	Biweekly	Continuous	Yearly

[a]See Figs. 2.1.18 and 2.1.19.
[b]Dropped during 1989.

Summary

Annual data summaries are presented in Table 2.1.10 for three gross parameters and 12 radionuclides. As discussed previously, the data are divided into three groups. The ORNL perimeter air monitors (ORNL PAMs) are designed to evaluate the specific impact of ORNL upon the local air quality. The reservation perimeter air monitors (reservation PAMs) assess the impact of the entire ORR on air quality. Comparing these two sets of data provides insight into the relative contribution of ORNL as compared with other facilities on the Reservation. The remote air monitors (RAMs) provide information on reference concentrations of isotopes and gross parameters for the region. Many of the radionuclides in the data summary are naturally occurring isotopes commonly found in soil, water, and fossil fuels. It is highly unlikely that analyte concentrations at the remote stations are impacted by the operations at the ORR or ORNL. By comparing the ORNL and ORR data with the remote air monitor data, the net impact of the ORR and ORNL upon the regional air quality can be assessed.

The data summary consists of the analytical parameters, total samples for the year for each parameter, the range of values, the average, and the standard error. Only one number is reported for tritium and for the isotopes at ORNL PAMs and RAMs; this number represents the estimated average concentration for the year. For each isotope, the annual average concentration is divided by the derived concentration guide (DCG) for inhalation of that isotope, multiplied by 100, and presented in the table as the percent of the DCG, unless the percent is less than 0.01. In that case, the percent is reported as <0.01. A discussion of data conventions and the use of negative numbers as well as the definition of DCG is given in the introduction to this chapter. Data summaries for individual monitoring stations are provided in Tables 2.1.6–2.1.10 of Vol. 2.

There appears to have been little or no airborne gross alpha activity at any of the sampling stations during 1989. The average values for the ORNL perimeter and the ORR are not statistically different from the reference values obtained from the remote stations. The averages are slightly higher than the averages for 1988, which can probably be attributed to the changes in sampling periods.

The gross beta averages for 1989 are slightly lower than the averages for 1988. No gross beta activity in excess of the remote station average was associated with the ORR or ORNL.

Iodine-131 for ORNL and ORR was less than 0.01% of the DCG. There were no statistically different concentrations of ^{131}I among the ORNL

Table 2.1.10. 1989 Radionuclide concentrations in air

Area[a]	Determination	No. of samples	Concentration (10^{-15} μCi/mL)				
			Max	Min	Av	Std. error	DCG (%)
ORNL PAM	Gross alpha	153	2.1	−1.6	0.60	0.070	
	Gross beta	153	45	13	24	0.52	
	^{3}H	3			35,000		0.035
	^{131}I	153	13	−19	0.36	0.26	<0.01
	^{60}Co	1			0.0041		<0.01
	^{137}Cs	1			0.038		<0.01
	^{238}Pu	1			0.0013		<0.01
	^{239}Pu	1			0.00042		<0.01
	^{228}Th	1			0.0096		0.024
	^{230}Th	1			0.0056		
	^{232}Th	1	0.0059		0.084		
	Total Sr	1			0.059		<0.01
	^{234}U	1			0.062		0.069
	^{235}U	1			0.0039		<0.01
	^{238}U	1			0.015		0.015
Reservation PAM	Gross alpha	272	2.6	−2.0	0.53	0.057	
	Gross beta	272	42	5.0	22	0.42	
	^{3}H	3			25,000		0.025
	^{131}I	228	22	−7.8	0.44	0.14	<0.01
	^{60}Co	7	0.26	−0.21	0.014	0.060	<0.01
	^{137}Cs	7	0.13	−0.075	0.00088	0.027	<0.01
	^{238}Pu	7	0.00036	−0.0024	−0.00083	0.00039	<0.01
	^{239}Pu	7	−0.00015	−0.0031	−0.0015	0.00041	<0.01
	^{228}Th	7	0.038	0.011	0.030	0.0034	0.075
	^{230}Th	7	0.010	0.0025	0.0070	0.0010	0.018
	^{232}Th	7	0.0091	0.0035	0.0062	0.00065	0.089
	Total Sr	7	0.10	−0.012	0.031	0.015	<0.01
	^{234}U	7	0.49	0.032	0.20	0.069	0.22
	^{235}U	7	0.027	0.0019	0.012	0.0036	0.012
	^{238}U	7	0.077	0.0039	0.036	0.010	0.036
RAM	Gross alpha	108	4.6	−3.5	0.68	0.13	
	Gross beta	108	56	1.5	26	1.0	
	^{60}Co	1			−0.019		<0.01
	^{137}Cs	1			−0.0090		<0.01
	^{238}Pu	1			0.00051		<0.01
	^{239}Pu	1			−0.0015		<0.01
	^{228}Th	1			0.019		0.048
	^{230}Th	1			0.0090		0.022
	^{232}Th	1			0.0078		0.11
	Total Sr	1			0.015		<0.01
	^{234}U	1			0.015		0.017
	^{235}U	1			0.0016		<0.01
	^{238}U	1			0.016		0.016

[a]See Fig. 2.1.18 and 2.1.19.

and ORR stations. The tritium concentration for station 3 was 0.035% of the DCG, and for station 8 it was 0.025% of the DCG. Neither isotope is sampled at the remote stations because concentrations have historically been below the analytical detection limits.

Five isotopes exhibited elevated concentrations at the ORR PAMs, as compared with the remote station data. They are ^{228}Th, ^{234}U, ^{235}U, ^{238}U, and total-Sr. Uranium-234 concentrations were the most elevated, but were only 0.22% of the DCG. All the elevated values are associated with ORR perimeter stations 40, 45, and 46.

The most likely sources of these increased concentrations are fugitive dusts associated with remedial action activities at the ORR. These stations are located around the Y-12 Plant where construction activities associated with remedial actions are in progress. Additional contributions may be associated with the combustion of coal at the facility steam plants and at Bull Run.

A comparison of ORNL perimeter air sampling data with the remote air sampling data, using the percent DCG value (Table 2.1.10), shows that ORNL does not have a significant impact on the local air quality. A similar comparison for the ORR perimeter air sampling data shows that operations on the Reservation are making a very small net contribution to the local airborne radioactivity. Airborne concentrations of radionuclides ranged from <0.01 to 0.22% of the DCGs. No significant changes in the concentrations of these radionuclides were detected between 1988 data and the 1989 data for the remote stations. Therefore, based on these data, ORR operations are making a slight impact on the local air quality but have no significant impact on the regional air quality. The local impact is well below the DCG.

2.1.2.3 Oak Ridge Gaseous Diffusion Plant

Description

In 1986, ORGDP's ambient air monitoring program was reevaluated and a new system was designed to ensure improved efficiency and proper placement of monitors and to build monitors consistent with 40 CFR 58, Ambient Air Quality Surveillance. This system became operational January 1, 1987. ORGDP now has five ambient air monitoring stations, which are positioned in the predominant wind directions, as shown in Fig. 2.1.20. These monitors sample ambient air for 24 h every sixth day to be consistent with the TDHE TSP sampling schedule. The parameters analyzed for ambient air samples are uranium, nickel, lead, chromium, and TSPs. The results from these samples are evaluated monthly by station for all of these parameters.

In addition to the TSP ambient air monitoring system, a PM10 particulate monitor was added to ambient air monitoring station K4 to comply with the CAA requirement that the state of Tennessee have operational PM10 particulate systems. This monitor will provide 1 year of comparison between the PM10 data and the previous TSP monitoring data prior to obtaining actual operational data.

In 1988, two additional ambient air monitoring stations were designed, sited, and installed at ORGDP. These stations were designed to detect PCBs, furans, dioxins, hexachlorobenzene, and uranium that may be released because of possible operational upsets of the K-1435 TSCA incinerator. The two stations are shown on Fig. 2.1.20 as TSCA1 and TSCA2.

The TSCA Incinerator ambient air monitors, TSCA1 and TSCA2, are to be operational 24 h/day 7 days/week as long as the TSCA Incinerator is operational (except when not burning waste). The samples will be collected every 48 h and will be analyzed if certain predetermined abnormal operations occurred during that period.

During 1989, several area background tests were conducted with the TSCA ambient air monitor while the TSCA Incinerator was not operational. These tests were to determine background ambient levels of PCBs, furans, dioxins, and hexachlorobenzene. The results of these tests are shown in Table 2.1.12.

Fluoride sampling was not conducted at ORGDP in 1988 and 1989 because of the absence of emission sources. Fluoride sampling may be conducted in the future as needed if new processes emitting fluorine or fluoride become active.

ORNL-DWG 88-6772R2

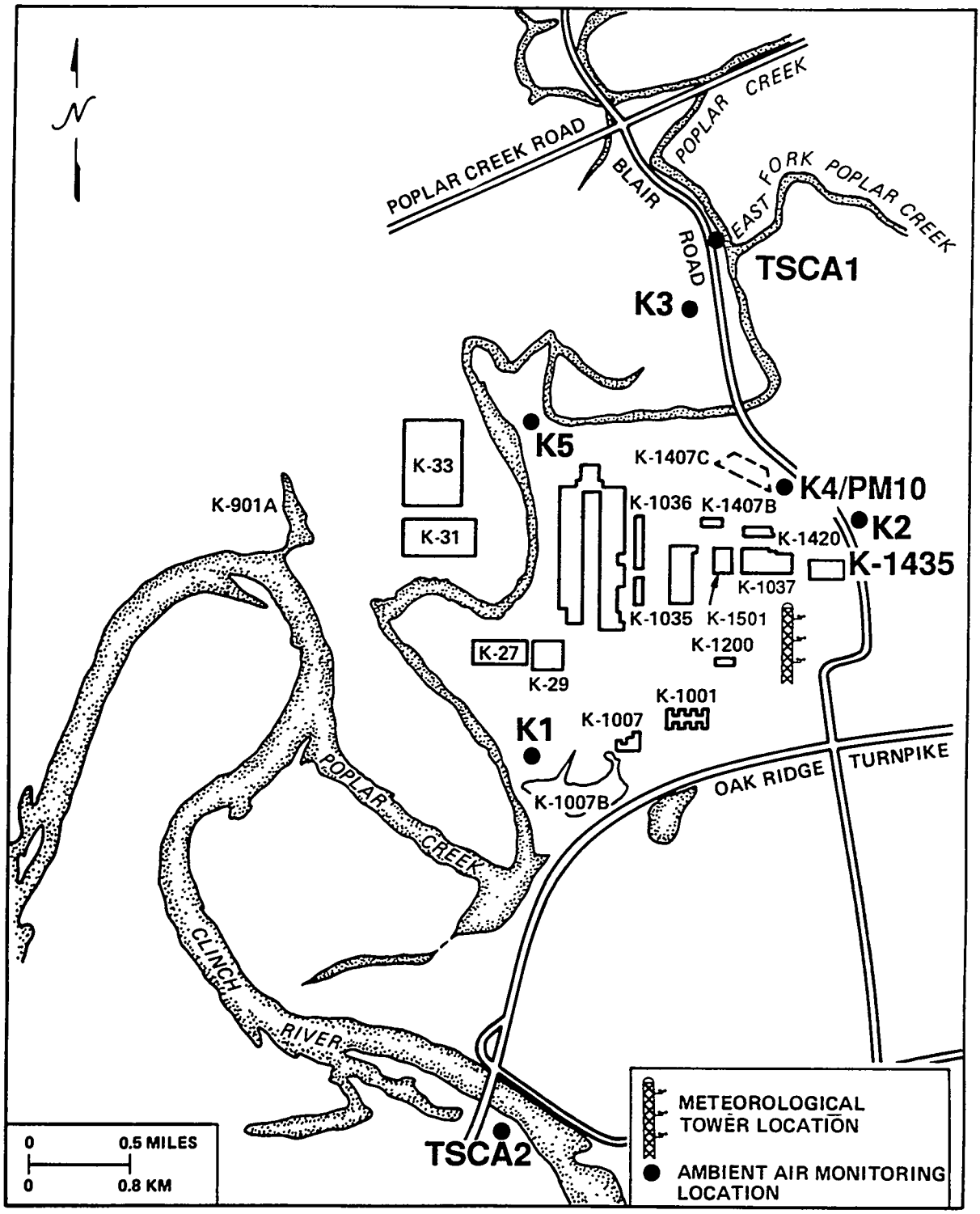

Fig. 2.1.20. Location of ORGDP ambient air monitors and meteorological tower.

Summary

Table 2.1.11 summarizes data for each parameter monitored by the ORGDP ambient air monitoring system. Each monitor, K1–K5 and PM10, was sampled for each parameter 24 h every sixth day throughout the year. The number of samples per location for K1–K5 ranged from 59 to 61. The number of samples taken by the PM10 monitor varied primarily because of startup equipment and added analysis.

As can be seen from the data summary tables, no standards were exceeded. In fact, for TSP, no maximum reading exceeded 31% of the secondary standard. For lead, the percentage of standard never exceeded 4%.

The PM10 maximum for TSP was equal to the TSP maximum for the collocated station, K4. In addition, the average 1989 TSP data for the PM10 monitor was somewhat less than that for station K4.

Table 2.1.12 summarizes data for each parameter monitored by TSCA1 and TSCA2. The number of samples taken from each location ranged from 5 to 6.

There are no standards for ambient levels of PCBs, dioxins, furans, and hexachlorobenzene. Work is being conducted at ORNL to compare the ORGDP background data with national ambient levels and to develop internal guidelines for standards that should exist for these pollutants. An initial review indicates that the ambient levels of these pollutants detected near ORGDP are similar to those found in other rural and industrial areas of the United States.

2.1.3 Meteorological Monitoring

A network of meteorological observation towers provides data on the meteorological conditions and the transport and diffusion qualities of the atmosphere on the Reservation. Data collected at the towers are used in routine dispersion modeling to predict impacts from facility operations and as input to emergency response atmospheric models used in the event of accidental releases from a facility. Data from the towers are also used as input to various research projects, engineering decisions, and site-monitoring devices.

2.1.3.1 Description

The meteorological monitoring network, depicted in Fig. 2.1.21, consists of one 60-m (196.8-ft) tower at ORGDP (MT1); one 100-m (328-ft) tower (MT2) and two 30-m (98.4-ft) towers (MT3 and MT4) at ORNL; and one 100-m (328-ft) tower (MT5) and one 60-m (196.8-ft) tower (MT6) at the Y-12 Plant.

Data are collected at different levels to determine the vertical structure of the atmosphere and the possible effects of vertical variations on releases from facilities. At all towers, data are collected at 10 m (32.8 ft) and at the top of the tower. At the 100-m (328-ft) towers, data are collected at intermediate [30- or 60-m (98.4- or 196.8-ft)] levels also. At each measuring level, wind speed and wind direction are measured, while atmospheric stability (a measure of the dispersive capability of the atmosphere) is measured at each tower. Precipitation, humidity, and solar radiation are measured at MT2 at ORNL.

Data from the towers are collected by a dedicated control computer at each site. The towers are polled and data are checked for validity against a predetermined set of parameters, summarized, and filed on disk. Fifteen-minute and hourly values are stored at each site for a running 24-h period. Only hourly data are routinely stored beyond 24 h. Data archiving on magnetic tape occurs every month. The meteorological monitoring data from all towers are checked quarterly, with summaries of data and wind roses, such as the data from MT2 presented in Fig. 2.1.22. Quarterly calibration of the instruments is conducted by each facility, either by in-house personnel or by outside contractors.

Fifteen-minute and hourly data are used directly from the facility computer or the central archival computer for emergency response purposes. The data are received at the emergency response computer dedicated telephone lines and are input to dispersion models. Annual dose

Table 2.1.11. 1989 ORGDP environmental air sampling

Sample point[a]	No. of samples	Concentration ($\mu g/m^3$)			Percentage of standard (based on maximum concentration)	
		Max	Min	Av	Primary standard	Secondary standard
				TSP[b]		
K1	59	46.98	0.00	3.17	18.1	31.3
K2	59	42.54	0.00	3.99	5	6
K3	60	46.97	0.00	4.93	6	8
K4	60	46.43	0.00	8.99	11	14
K5	59	42.42	0.00	7.37	9	12
PM10	60	46.48	0.00	7.34	31	31
				Lead[c]		
K1	61	0.0256	<0.0048	<0.0093	2	*d*
K2	60	0.0175	0.0047	0.0087	1	*d*
K3	61	0.0179	0.0047	0.0090	1	*d*
K4	61	0.0188	0.0040	0.0093	1	*d*
K5	60	0.0565	<0.0043	<0.0089	4	*d*
				Chromium[e]		
K1	61	<0.0029	<0.0023	<0.0025	*d*	*d*
K2	60	<0.0027	<0.0023	<0.0025	*d*	*d*
K3	61	0.0044	<0.0023	<0.0025	*d*	*d*
K4	61	<0.0030	<0.0018	<0.0024	*d*	*d*
K5	60	<0.0027	<0.0021	<0.0023	*d*	*d*
				Nickel[f]		
K1	61	0.0127	<0.0023	<0.0034	*d*	*d*
K2	60	0.0138	<0.0023	<0.0032	*d*	*d*
K3	61	0.0100	<0.0023	<0.0031	*d*	*d*
K4	61	0.0128	<0.0120	<0.0033	*d*	*d*
K5	60	0.0087	<0.0021	<0.0029	*d*	*d*
				Uranium[g]		
K1	61	0.0008	<0.0001	<0.0001	1	*d*
K2	60	0.0011	<0.0001	<0.0001	1	*d*
K3	61	0.0009	<0.0001	<0.0001	1	*d*
K4	61	0.0009	<0.0001	<0.0001	1	*d*
K5	60	0.0019	<0.0001	<0.0001	1	*d*

[a]See Fig. 2.1.20.

[b]Primary standard for TSP for the state of Tennessee is 260 $\mu g/m^3$/24 h. Secondary standard for TSP for the state of Tennessee is 150 $\mu g/m^3$/24 h. PM10 is 150 $\mu g/m^3$/24 h for primary and secondary standards.

[c]The primary standard for lead is 1.5 $\mu g/m^3$.

[d]Not applicable.

[e]There are no ambient air standards for chromium.

[f]There are no ambient air standards for nickel.

[g]Standard for the public for natural uranium is 1×10^{-1} pCi/m^3, which converts to 0.15 $\mu g/m^3$. There are no TDHE ambient standards for uranium.

Table 2.1.12. 1989 Background levels of PCBs, dioxins, furans, and hexachlorobenzene near ORGDP

Sample point[a]	No. of samples	Concentration		
		Max	Min	Av
		PCB (ng/m³)[b]		
TSCA1	5	0.47	0.10	0.23
TSCA2	5	1.02	0.18	0.48
		Dioxins (pg/m³)[b]		
TSCA1	6	1.534	0.121	0.789
TSCA2	6	1.004	0.096	0.573
		Furans (pg/m³)[b]		
TSCA1	6	0.707	0.281	0.429
TSCA2	6	1.424	0.266	0.656
		Hexachlorobenzene (ng/m³)[b]		
TSCA1	6	0.035	0.006	0.020
TSCA2	5	0.031	0.007	0.016

[a]See Figure 2.1.20.
[b]No ambient standards have been set for these pollutants.

estimates are calculated using archived data (i.e., either hourly values or summary tables of atmospheric conditions). In all cases, data quality is checked using predetermined values, and out-of-range parameters are marked as either questionable (requiring interpretation by a competent meteorologist) or invalid (not input to the dispersion models).

2.1.3.2 Summary

The data presented in Fig. 2.1.22 are from the 100-m tower located west of ORNL. Wind roses from other tower locations are presented in Figs. 2.1.1–2.1.14 of Vol. 2. The information contained in Fig. 2.1.22 is useful in describing the meteorological conditions of the Reservation. Prevailing winds are generally up-valley from the southwest and west-southwest, or down-valley from the northeast and east-northeast. This pattern is the result of the channeling effect of the ridges flanking the site. Winds in the valleys tend to follow the ridges, with limited cross-ridge flow. Any material released in these valley winds would tend to stay within the valley. These conditions are dominant over the entire Reservation, with the exception of the ORGDP site, which is located in a relatively open area that has more varied flows. However, somewhat weaker valley flows are noted in the ORGDP area, particularly in locations near the Clinch River.

The winds measured on the Reservation are dominated by low-wind-speed conditions. This characteristic is noted at all tower locations, as is the increase in wind speed with height at which the measurements are made. This activity is typical of tower locations and is important when selecting appropriate data for input to dispersion studies.

The atmosphere over the Reservation is dominated by stable conditions on most nights and in early morning hours. These conditions, coupled with the low wind speeds and channeling effects of

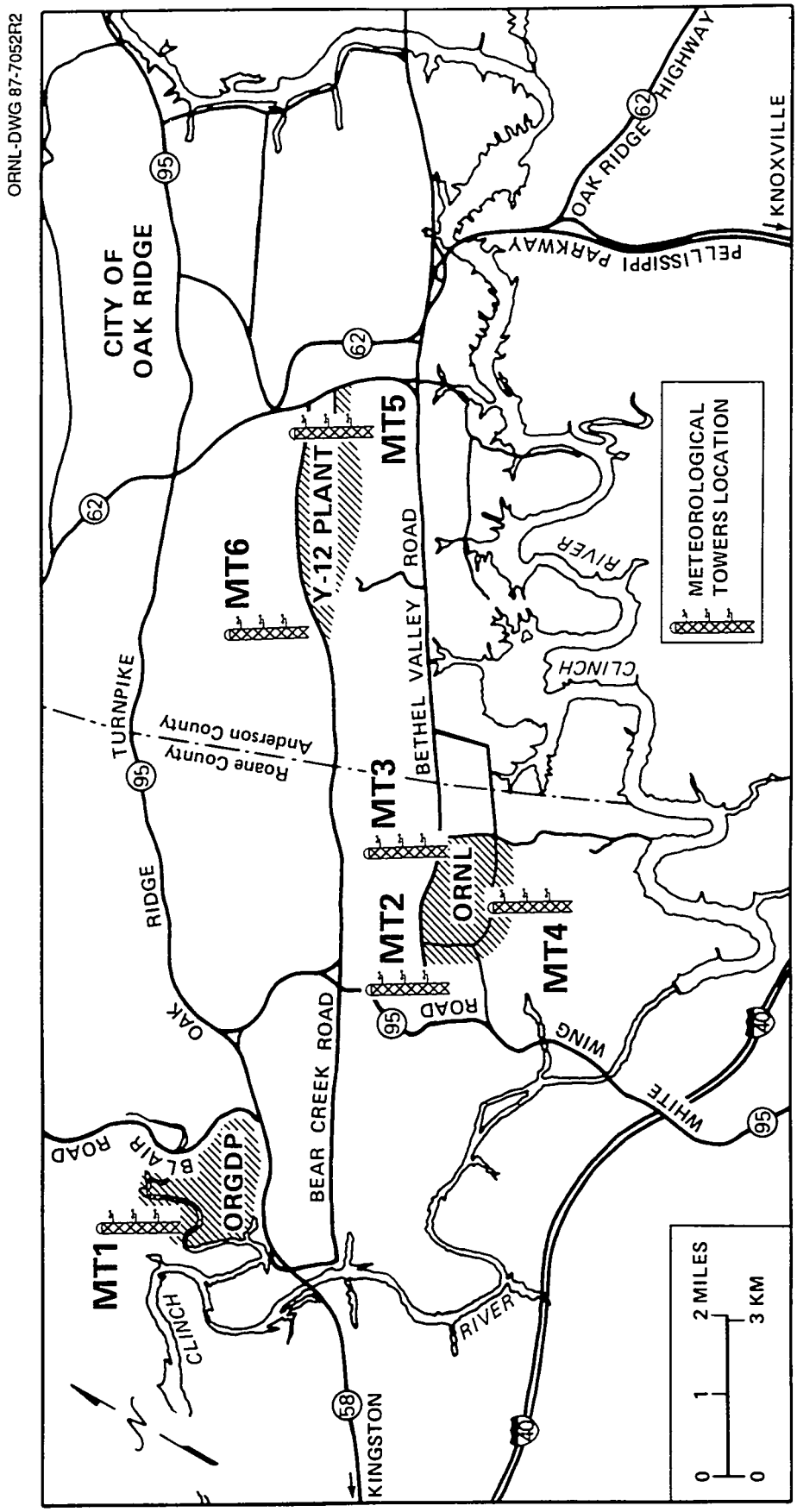

Fig. 2.1.21. ORR Meteorological monitoring network.

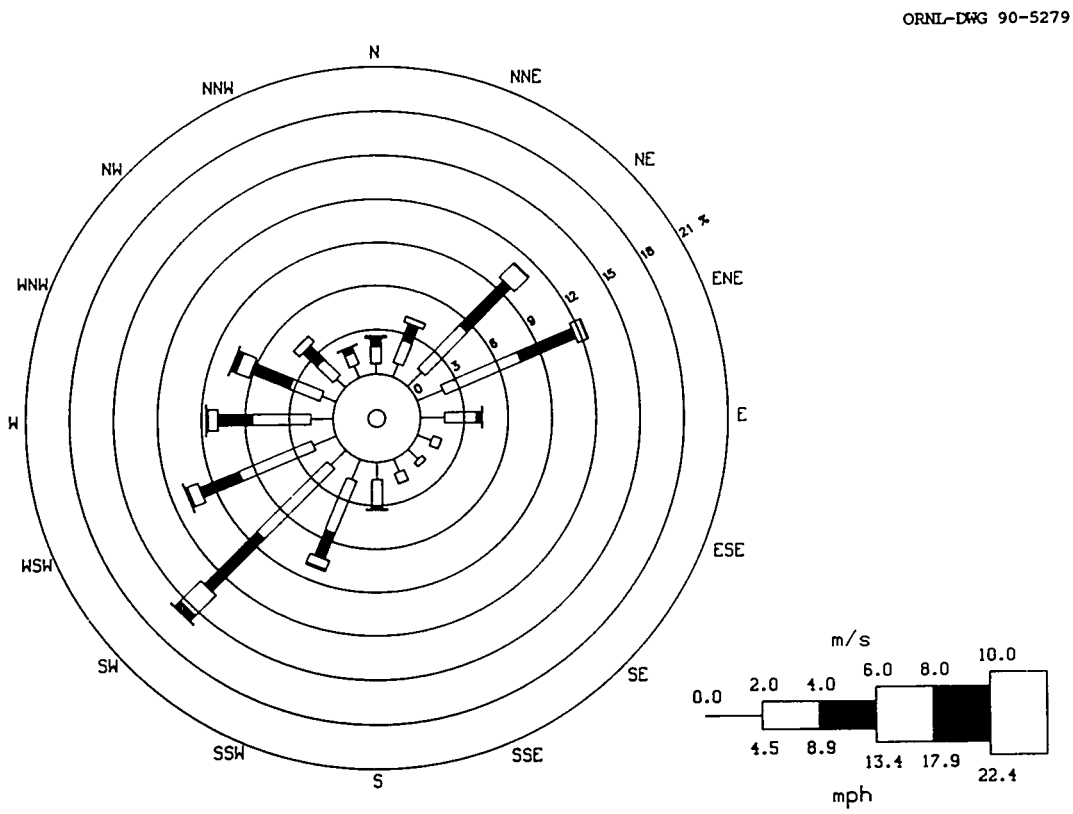

Fig. 2.1.22. 1989 Wind rose for ORNL tower MT2 [100-m (328-ft) level].

the valleys, result in poor dilution of material emitted from the facilities. These features are captured in the data input to the dispersion models and are reflected in the modeling studies conducted for each facility.

Precipitation data from tower MT2 are used in stream flow modeling and in certain research efforts by various divisions. The data indicate the variability of regional precipitation, with high winter rainfall amounts resulting from frontal storms and uneven, but occasionally intense, summer rainfall associated with thunderstorms. The region is in the midst of recovery from drought conditions, as reflected in the long-term rainfall record from the National Weather Service records for the City of Oak Ridge (see Fig. 1.7.1). The data from the ORNL tower location reflect a similar trend.

The average data capture across all 14 tower levels and locations was 86%. The maximum capture efficiency was 97.9%, and the minimum capture efficiency was 71.2%.

2.2 SURFACE WATER

The surface waters on the ORR reflect the abundance of limestone and dolomite bedrock as indicated by the presence of dissolved calcium bicarbonate. Hardness is generally moderate; total dissolved solids concentrations usually range between 100 and 250 mg/L.

Water quality in ORR streams is affected primarily by wastewater discharges and by groundwater transport of contaminants from land disposal of waste. Though bedrock characteristics differ somewhat among the watersheds of these streams, the observed differences in water chemistry are most likely attributed to manmade sources rather than to geologic variation. For example, East Fork Poplar Creek (EFPC) shows higher levels of several substances than does any other ORR stream, probably reflecting the influence of effluents from the Y-12 Plant and from the City of Oak Ridge municipal wastewater treatment facility.

Field measurements and sample collections are carried out at various effluent sources and receiving streams on the ORR. Additional sampling is done at the nearest off-site municipal water intake location. Water samples are collected and analyzed at various intervals (weekly, monthly, etc.) for radiological and nonradiological parameters. Surface water data are summarized in this report for water sampling locations both on the ORR and in receiving streams near the ORR. Information not specifically required by a NPDES Permit is presented in the Surface Water section (Sect. 2.2.1), and all NPDES Permit-related information is summarized in the NPDES Program section (Sect. 2.2.2).

Concentrations of contaminants in streams and creeks on or around the ORR are compared with Tennessee's instream water criteria, which are based on stream classifications and recommendations made by TDHE to DOE–ORO. In many cases, allowable effluent concentrations are dictated by discharge permits, which are issued by the TDHE. Water quality at the intake for the ORGDP water treatment plant is compared with Tennessee water quality criteria for domestic water supplies.

In some cases, the maximum concentrations recommended by TDHE and EPA are below the detection limit of the most sensitive EPA-approved method.

2.2.1 Surface Water Monitoring

2.2.1.1 Radiological summary

Y-12 Plant

Routine surface water monitoring not required by the NPDES permit is performed at Y-12 sites for a variety of reasons. Various radiological parameters are monitored at these sites. These sites are shown in Fig. 2.2.1.

Kilometer 12.4 on upper Bear Creek is monitored in response to Section IV, Part 4, of the Memorandum of Understanding agreed to by DOE, EPA, and TDHE. This site was agreed upon as a point in the stream that is characteristic of the

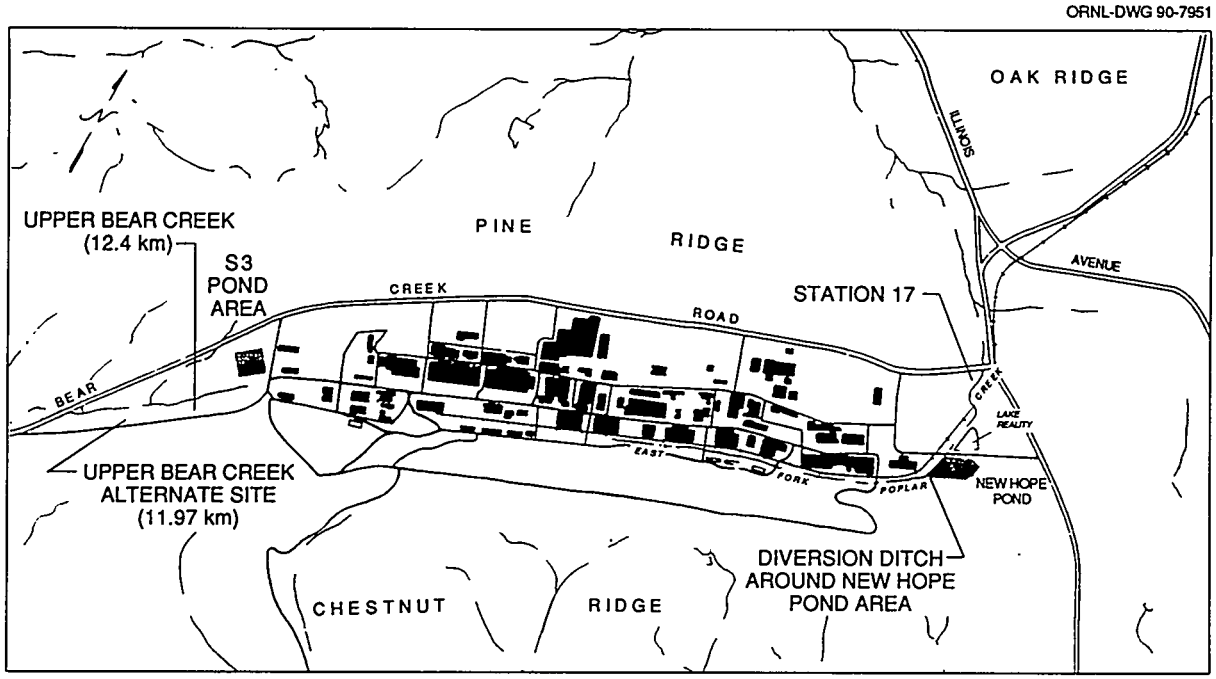

Fig. 2.2.1. Y-12 Plant non-NPDES routine surface water monitoring sites.

effects of the seepage of the S-3 Ponds. Because of decreased flow at this site since the closure of the S-3 Ponds, a new site at kilometer 11.97 is also being monitored and is being proposed as a replacement site in 1990 (Table 2.2.1). Analytical data are reported to the TDHE as an attachment to the Discharge Monitoring Report (DMR) required by NPDES. These sites were monitored once per week for the radiological parameters shown in Table 2.2.2. Figure 2.2.2 shows data from 1987 through 1989.

After New Hope Pond was closed, the sampling point for this area was moved to the diversion ditch around New Hope Pond. Samples were taken here on a weekly basis for the radiological parameters shown in Table 2.2.3. In addition, a new sampling point was constructed to monitor East Fork Poplar Creek following the final influent, but prior to its leaving the Y-12 Plant boundary. Station 17, located near the junction of Bear Creek and Scarboro roads, was chosen as the ideal site for this monitoring. Weekly samples were obtained here for the radiological parameters listed in Table 2.2.3.

The Y-12 Plant holds Industrial User's Permit Number 001 with the City of Oak Ridge. This

Table 2.2.1. 1989 Annual summary for Upper Bear Creek radiological data (km 11.97)[a]

Parameter	No. samples	Concentration[b]			Std. error	% DCG
		Max	Min	Av		
^{241}Am	42	8.9	−0.74	0.35	0.22	4.76
^{237}Np	45	3.4	−0.02	1	0.15	3.31
^{238}Pu	45	2.2	−0.22	0.15	0.06	0.98
$^{239/240}$Pu	45	0.21	−0.22	0.01	0.01	0.27
^{99}Tc	45	1.7	0.05	0.58	0.06	0.0004
Uranium, total (mg/L)	45	0.809	0.046	0.241	0.021	*c*
^{235}U (%)	45	0.524	0.228	0.362	0.008	*c*

[a]See Fig. 2.2.1.
[b]All units are in pCi/L unless otherwise noted. Negative number is indicative of less than laboratory background value.
[c]Not applicable.

Table 2.2.2. 1989 Annual Summary for Upper Bear Creek radiological data (km 12.4)[a]

Parameter	No. Samples	Concentration[b,c]			Std. Error	% DCG[c]
		Max	Min	Av		
^{241}Am	41	0.86	−31.00	−0.72	0.76	−2.39
^{237}Np	44	3.10	−1.80	0.78	0.11	2.60
^{238}Pu	44	1.20	−0.49	0.03	0.04	0.09
$^{239/240}$Pu	44	1.70	−0.08	0.06	0.04	0.19
^{99}Tc	44	2.90	0.02	0.23	0.06	0.0002
Uranium, total (mg/L)	44	1.310	0.081	0.677	0.038	*d*
^{235}U (%)	44	0.735	0.184	0.324	0.012	*d*

[a]See Fig. 2.2.1.
[b]Units are in pCi/L unless otherwise noted.
[c]Negative number is indicative of less than laboratory background value.
[d]Not applicable.

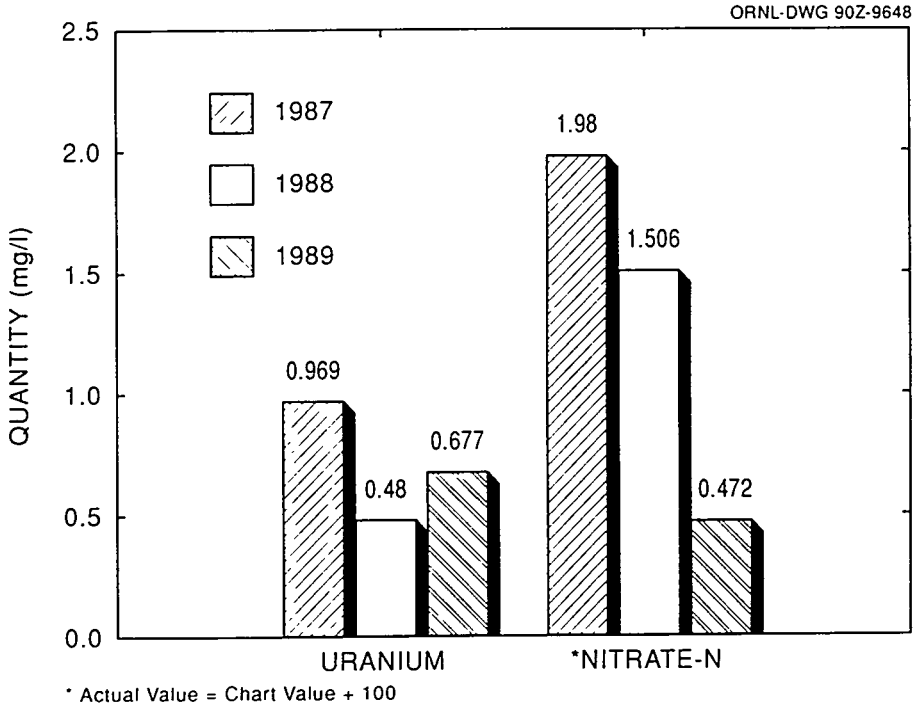

Fig. 2.2.2. Upper Bear Creek trend chart, 1987–1989.

Table 2.2.3 1989 Annual radiological summary Y-12 Plant diversion ditch and Station 17[a]

Parameter	No. samples	Concentration[b]			Std. error	% DCG
		Max	Min	Av		
		Diversion ditch				
Uranium, total	41	0.073	0.013	0.035	0.002	*c*
^{235}U (%)	41	1.81	0.311	0.549	0.036	*c*
Thorium, total	41	0.024	<0.003	<0.004	0.001	*c*
		Station 17				
Uranium, total	52	0.074	0.011	0.033	0.002	*c*
Thorium, total	52	0.01	0.0005	0.003	0.0002	*c*

[a]See Fig. 2.2.1.
[b]Units are in mg/L unless otherwise noted.
[c]Not applicable.

permit allows the Y-12 Plant to discharge wastewater from two main sewerage lines into the Oak Ridge sanitary sewer system in accordance with effluent limitations, monitoring requirements, and other conditions set forth in this permit. The radiological parameters monitored and results obtained in these sewer lines are listed in Tables 2.2.4 and 2.2.5. Table 2.2.6 shows the total uranium and associated curies released from the Y-12 Plant as a liquid effluent during both 1988 and 1989.

Oak Ridge National Laboratory

ORNL collects samples for radiological analyses at off-site locations, at background or reference locations, in streams at the ORNL site,

Table 2.2.4. 1989 Annual radiological summary for West End Sanitary Sewer

Parameter	No. samples	Concentration[a]			Std. error	% DCG
		Max	Min	Av		
Alpha, pCi/L	12	200.0	0.0	41.3	15.2	*b*
Beta, pCi/L	12	70.0	0.0	32.6	5.4	*b*
^{238}Pu, pCi/L	3	1.0	0.0	0.33	0.33	0.83
^{235}U (%)	12	6.96	0.89	2.33	0.58	*b*
Uranium	12	0.035	0.004	0.013	0.003	*b*

[a]Units are in mg/L unless otherwise noted.
[b]Not applicable.

Table 2.2.5. 1989 Annual radiological summary for East End Sanitary Sewer

Parameter	No. samples	Concentration[a]			Std. error	% DCG
		Max	Min	Av		
Alpha, pCi/L	12	110.0	−1.9	29.0	11.8	*b*
Beta, pCi/L	12	110.0	4.6	34.7	10.1	*b*
^{238}Pu, pCi/L	3	0.19	0.0	0.06	0.06	0.15
^{235}U (%)	12	3.06	0.11	0.97	0.23	*b*
Uranium	12	0.003	0.001	0.002	0.0002	*b*

[a]Units are in mg/L unless otherwise noted.
[b]Not applicable.

Table 2.2.6. Y-12 Plant release of uranium to the off-site environment as a liquid effluent

Year	Uranium (Ci)	Uranium (Kg)
	Station 17	
1988	0.164	220
1989	0.20	316
	Outfall 304	
1988	0.052	94
1989	0.138	244
	Total off-site release	
1988	0.22	314
1989	0.34	540

from process discharge point sources, and from various other outfalls. Table 2.2.7 contains a summary of the current locations, parameters analyzed, and frequencies of sample collection and analysis for all radiological samples (except category I and II outfall samples). Results from the first three types of locations are summarized in this section. Results from the process points analyses and the categories I and II analyses are deferred to Sect. 2.2.2, NPDES Monitoring Program, which also contains results for three stream locations covered by the permit. Differences between the current sampling and analysis schedule presented in Table 2.2.7 and the schedule followed earlier in the year are described as the results are presented.

Treated water samples are collected weekly at the Kingston and ORGDP (Gallaher) potable water treatment plants (Fig. 2.2.3) and are analyzed quarterly. In addition, flow-proportional samples are collected weekly at Melton Hill Dam (MHD) (Fig. 2.2.3) and analyzed monthly. This sampling location, which is on the Clinch River, is above ORNL's discharge point to the Clinch River (with the exception of the cooling tower, roof and parking lot runoff at the 7600 area) and serves as a local background or reference station.

Table 2.2.7. ORNL summary of collection and analysis frequencies of surface, pond, and effluent water samples, 1989

Station	Parameter	Collection frequency	Analysis type	Frequency
3518	Gross alpha, gross beta	Weekly	Flow proportional	Monthly
STP	Gamma scan, gross beta, total Sr[a]	Weekly	Flow proportional	Monthly
3544	Gross alpha, gross beta, gamma scan, total Sr[a]	Weekly	Flow proportional	Monthly
7500 Bridge, MB1 WOC, MB2	Gamma scan, total Sr,[a] ^{3}H	Weekly	Flow proportional	Monthly
First Creek Fifth Creek Raccoon Creek	Gamma scan, total Sr[a]	Weekly	Grab	Monthly
Gallaher	^{3}H, gamma scan, gross alpha, gross beta, total U, total Sr[a], ^{238}Pu, ^{239}Pu	Weekly	Time proportional	Quarterly
Kingston	^{3}H, gamma scan, gross alpha, gross beta, total U, total Sr,[a] ^{238}Pu, ^{239}Pu	Weekly	Grab	Quarterly
REDC and HFIR Ponds	Gamma scan, gross alpha, gross beta	During discharge	Flow proportional	Monthly
Melton Hill Dam	Gamma scan, gross alpha,[b] gross beta[c]	Weekly	Flow proportional	Monthly
NWT	Gamma scan, total Sr[a]	Weekly	Flow proportional	Monthly
WOC Headwaters	Gamma scan, gross alpha,[b] gross beta[c]	Weekly	Flow proportional	Monthly
WOD	^{3}H, gamma scan, gross alpha, gross beta, total Sr[a]	Weekly	Flow proportional	Weekly

[a]Total radioactive Sr (^{89}Sr + ^{90}Sr).

[b]If gross alpha >27 pCi/L, then analyze for ^{241}Am, ^{244}Cm, ^{238}Pu, ^{239}Pu, ^{228}Th, ^{230}Th, ^{232}Th, ^{234}U, ^{235}U, and ^{238}U.

[c]If gross beta >810 pCi/L, then analyze for total radioactive strontium.

Schedule changes occurring during 1989 included analyzing for total uranium instead of for specific uranium isotopes and analyzing for ^{238}Pu and ^{239}Pu isotopes rather than for total plutonium at the Kingston and Gallaher stations. This was prompted by technical limitations and past experience of low background levels. The complement of analyses performed on Melton Hill Dam (and White Oak Creek headwaters) samples was reduced to a gamma scan and gross alpha and beta determinations because of the historically low levels observed there. If certain gross alpha and beta thresholds are exceeded, specific isotopic analyses are performed (Table 2.2.7).

DOE Order 5400.5, Chapter II, 3.a. requires comparison of annual average discharge concentrations to DCG values. These concentrations, which result in a dose of

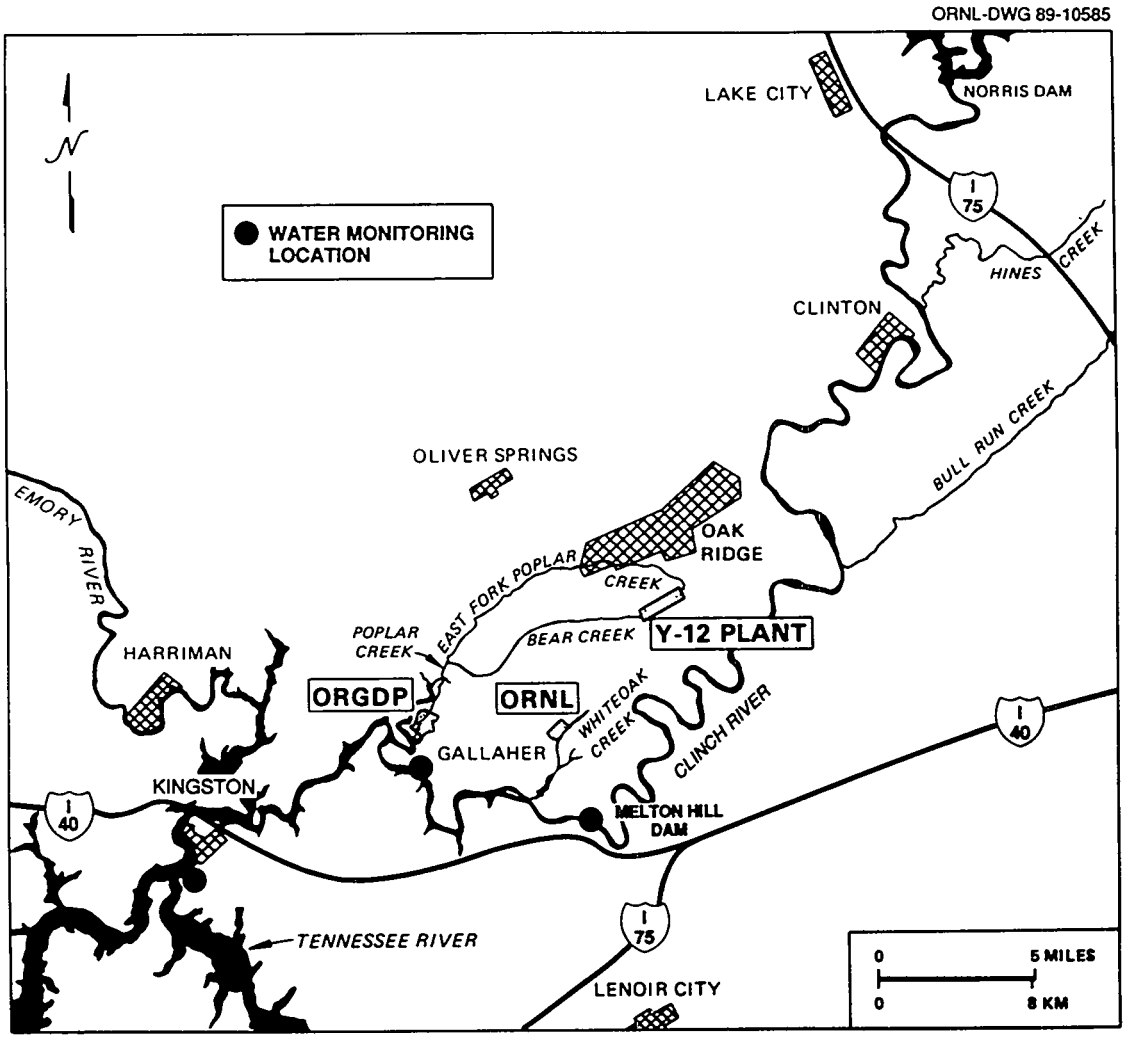

Fig. 2.2.3. TVA drainage basin near ORR.

100 mrem/yr based upon 2 L/d water consumption, apply at the point of discharge to a receiving stream prior to dilution in the stream. The EPA drinking water limits (DWL) apply at the outlet of a public water distribution system and result in a dose of 4 mrem/yr based upon 2 L/d water consumption. The EPA standards are more applicable for the Clinch River sampling locations than the DOE DCGs.

The annual radionuclide summaries for the off-site stream-monitoring locations are given in Table 2.2.8. Average concentration is given as a percentage of the DCG and as a percentage of the EPA drinking water standard. None of the percentages for analytes for which there are DCGs exceeded 0.3%. Average concentrations for analytes with DWLs were all less than 28% of the respective EPA drinking water standard. This is for Sr, assuming that all of the Sr is ^{90}Sr. The comparison of the concentrations with DWLs shows little change from a similar comparison made in 1988.

Surface water samples are collected from six streams near ORNL: White Oak Creek (WOC), Melton Branch (MB), First Creek, Fifth Creek, Northwest Tributary, and Raccoon Creek (Fig. 2.2.4). Summary statistics for each radionuclide at each surface water sampling location are given in Table 2.2.1 in Vol. 2. The last column in that table shows the average value

Table 2.2.8. 1989 ORNL radionuclide concentrations in off-site surface water

Radionuclide	No. of samples	Concentration (pCi/L)				% DCG[b]	% DWL[c]
		Max	Min	Av	Std. error[a]		
			Gallaher				
^{60}Co	4	1.2	−0.27	0.31	0.36	0.0062	*d*
^{137}Cs	4	1.2	−0.081	0.49	0.27	0.016	*d*
Gross alpha	4	0.92	−0.46	0.16	0.29	*d*	1.1
Gross beta	4	6.5	−0.81	2.2	1.5	*d*	5.5
^{238}Pu	3	0.0030	−0.014	−0.0046	0.0050	<0.001	*d*
^{239}Pu	3	0.0038	−0.0081	−0.0015	0.0035	<0.001	*d*
Total Pu[e]	1	<0.0030	<0.0030	<0.0030	*d*	0.010	*d*
Total Sr[f]	4	3.2	0.27	2.2	0.67	0.22	27
Total U	3	3.3	<0.028	<1.2	1.0	0.24	*d*
^{3}H	4	7200	1300	4300	1400	0.21	21
^{234}U	1	0.058	0.058	0.058	*d*	0.012	*d*
^{235}U	1	0.0019	0.0019	0.0019	*d*	<0.001	*d*
^{236}U	1	<0.000075	<0.000075	<0.000075	*d*	<0.001	*d*
^{238}U	1	0.039	0.039	0.039	*d*	0.0064	*d*
			Kingston				
^{60}Co	4	0.32	−0.054	0.19	0.084	0.0038	*d*
^{137}Cs	4	0.32	−0.027	0.18	0.078	0.0060	*d*
Gross alpha	4	1.3	0.027	0.72	0.28	*d*	0.18
Gross beta	4	4.1	1.3	2.4	0.59	*d*	0.22
^{238}Pu	3	0.0097	−0.012	−0.0029	0.0065	<0.001	*d*
^{239}Pu	3	0.0043	−0.0057	−0.00054	0.0029	<0.001	*d*
Total Pu[e]	1	<0.0030	<0.0030	<0.0030	*d*	0.010	*d*
Total Sr[f]	4	4.3	−0.27	2.1	0.96	0.21	0.97
Total U	3	2.5	<0.016	<0.91	0.80	0.18	*d*
^{3}H	4	1900	120	1300	440	0.063	0.23
^{234}U	1	0.061	0.061	0.061	*d*	0.012	*d*
^{235}U	1	0.0018	0.0018	0.0018	*d*	<0.001	*d*
^{236}U	1	0.00021	0.00021	0.00021	*d*	<0.001	*d*
^{238}U	1	0.035	0.035	0.035	*d*	0.0059	*d*
			Melton Hill Dam				
^{60}Co	12	22	−16	3.1	3.5	0.062	*d*
^{137}Cs	12	14	−24	−5.3	2.8	<0.001	*d*
Gross alpha	12	19	−3.8	5.8	1.9	*d*	0.053
Gross beta	12	43	−49	9.9	8.2	*d*	0.034
^{238}Pu	4	0.027	−0.065	0.0027	0.023	0.0068	*d*
^{239}Pu	4	0.054	−0.13	−0.016	0.040	<0.001	*d*
Total Sr[f]	5	4.1	−0.95	1.7	0.94	0.17	0.029
^{3}H	4	1200	−81	470	280	0.024	0.0032

[a]Standard error of the mean.
[b]Average concentration as a percentage of the derived concentration guide (DCG).
[c]Average concentration as a percentge of the National Primary Drinking Water Level (DWL).
[d]Not applicable.
[e]Total Pu (^{239}Pu + ^{238}Pu).
[f]Total radioactive Sr (^{89}Sr + ^{90}Sr).

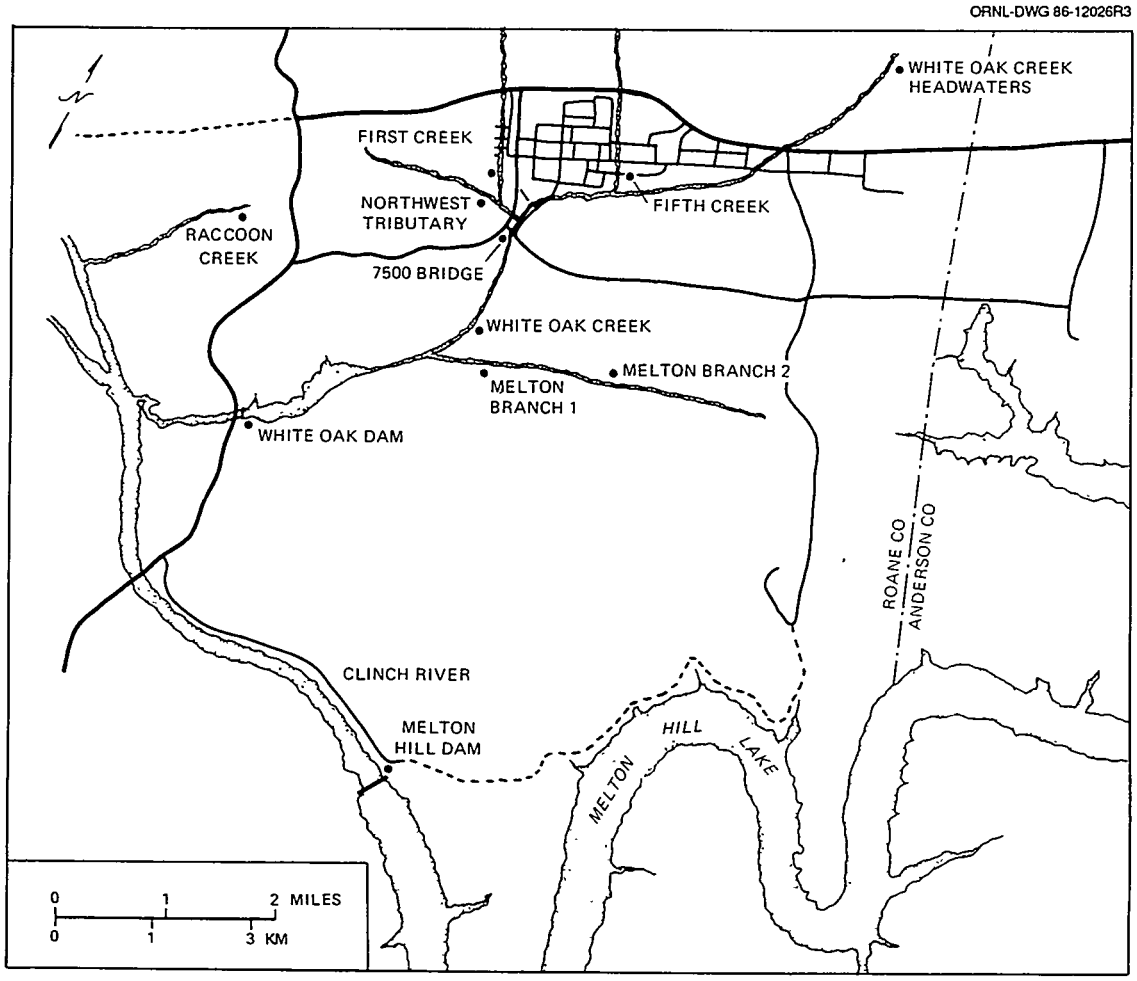

Fig. 2.2.4. ORNL surface water and reference sampling locations

for each radionuclide as a percentage of the DCG for water. Data-reporting conventions are discussed in the introduction to this chapter, as are the DCGs. Average annual concentrations of most radionuclides in surface streams were less than 1% of the DCG. Total radioactive strontium was the predominant exception. Concentrations of this analyte ranged from less than 1% at the reference locations (Melton Hill Dam and White Oak Creek headwaters) to 31% in First Creek (down from 52% at First Creek in 1988). Other average concentrations exceeding 1% of their DCGs were ^{137}Cs at 7500 bridge (2.3%) and ^{3}H at MB2 (2.0%). Further discussion of these results can be found in Sect. 2.2.2, NPDES Monitoring Program.

The variation in the number of samples contributing to the summary statistics for Melton Hill Dam and White Oak Creek headwaters is indicative of the change in the sampling and analysis schedules implemented in 1989. The change was to perform a gamma scan and gross alpha and beta measurements and do specific follow-up analyses when gross measurement limits were exceeded (Table 2.2.7).

Concentrations and discharges of radioactive contaminants in the on-site creeks and the Clinch River are affected by rainfall, surface runoff, subsurface inflow to streams, and stream flows. Flows in the Clinch River (as measured at Melton Hill Dam) and in WOC (as measured at White

Oak Dam) are summarized in Table 2.2.9. Water released at Melton Hill Dam is controlled by TVA. The flow in the Clinch River ranged from 120 × 10^9 L (31.7 × 10^9 gal) (April) to 710 × 10^9 L (188 × 10^9 gal) (June). Flow in WOC ranged from 0.78 × 10^9 L (0.21 × 10^9 gal) (August) to 2.3 × 10^9 L (0.61 × 10^9 gal) (June). The ratio of Clinch River flow to WOC flow is also given in Table 2.2.9 and was calculated daily and averaged for the month. This ratio is an indication of the dilution factor that is expected for potential contaminants entering the Clinch River from WOC. The monthly average ratios ranged from 150 (April) to 760 (October). Increased rainfall in 1989 over 1988 resulted in increased dilution factors.

Discharges of radioactivity in WOC and Melton Branch (MB) and at ORNL's final release point to the Clinch River, WOD, are summarized in Table 2.2.10. These discharges are calculated by multiplying the concentration for the period (month or week) by the flow volume. At both WOC and MB1, a single flow-proportional sample is analyzed monthly to estimate radionuclide concentrations. At WOD, weekly flow-proportional samples are analyzed. A flow-weighted concentration is calculated for each radionuclide. The discharge is calculated by multiplying this flow-weighted concentration by the total annual flow. Because of some analysis schedule changes implemented in 1989, the gross alpha, gross beta, ^{238}Pu, ^{239}Pu, ^{241}Am, and ^{244}Cm concentrations given in Table 2.2.10 are averages of values obtained during a fraction of the year. Discharges are calculated as if these concentrations were representative of all of 1989. The ratio of the flow-weighted concentration to the DCG is also given in Table 2.2.10. None of the ratios exceeded 62% of the DCG. The highest average concentration was for ^{3}H, which was about two-thirds of the 1988 highest average.

Oak Ridge Gaseous Diffusion Plant

Surface water samples are collected as part of the Clean Water Act (CWA) requirements and DOE orders. Both NPDES and perimeter ambient water sampling locations under ORGDP responsibility are shown in Fig. 2.2.5. Table 2.2.11 lists sampling locations, sample type, the agency requiring the sample, and the NPDES identification number where applicable.

Perimeter monitoring includes both water quality parameters and radionuclides. The purpose is to document ORGDP's impact on the surrounding streams and to differentiate the impact from that of other sites.

Table 2.2.9. 1989 flows for Clinch River and White Oak Creek

Month	Monthly flow (L × 10^9)		Average ratio[a]
	Clinch River	White Oak Creek	
January	510	1.8	370
February	500	2.0	280
March	250	1.8	160
April	120	0.88	150
May	430	0.94	500
June	710	2.3	390
July	500	1.1	500
August	460	0.78	610
September	490	1.1	570
October	620	1.0	760
November	660	1.4	610
December	570	0.83	730

[a]Flow ratios of Clinch River:White Oak Creek are calculated daily and averaged for the month.

Table 2.2.10. 1989 ORNL liquid releases and radionuclide concentrations

Radionuclide	Emission (Ci)	Concentration guide (DCG)[a] (pCi/L)	Concentration (pCi/L)	Percentage of DCG[b]
		Melton Branch 1		
^{60}Co	0.11	5,000	28	0.56
^{137}Cs	0.011	3,000	2.7	0.090
Total Sr[c]	1.3	1,000	340	34
^{3}H	4,800	2,000,000	1,200,000	61
		White Oak Creek		
^{60}Co	0.083	5,000	6.4	0.13
^{137}Cs	0.96	3,000	74	2.5
Total Sr[c]	2.0	1,000	150	15
^{3}H	970	2,000,000	75,000	3.8
		White Oak Dam		
^{241}Am	0.0062	30	0.38	1.3
^{244}Cm	0.0065	60	0.40	0.67
^{60}Co	0.13	5,000	8.2	0.16
^{137}Cs	1.2	3,000	74	2.5
Gross alpha	0.16	*d*	9.8	*d*
Gross beta	7.3	*d*	450	*d*
^{238}Pu	0.0019	40	0.12	0.29
^{239}Pu	0.0021	30	0.13	0.45
Total Sr[c]	2.9	1,000	180	18
^{3}H	4,100	2,000,000	260,000	13

[a]Derived concentration guide.
[b]Percent of DCG = average flow-weighted concentration × 100/DCG.
[c]Total radioactive Sr (^{89}Sr + ^{90}Sr).
[d]Not applicable.

During 1989, grab samples were collected once a quarter at the following locations: the Clinch River, West Fork Poplar Creek, and Mitchell Branch source. At K-1513, K-716, K-1710, and K-1770, 24-h composite samples were collected once each month. After the first quarter grab sample at K-901 at 892, sampling was discontinued. Sampling at K-1770 replaces this sample location. All samples were analyzed for radiological and nonradiological parameters.

Table 2.2.2 in Vol. 2 gives radiological data from the ambient surface water surrounding ORGDP. Figure 2.2.5 gives the sampling locations.

Although two radionuclides exhibited values above 0.01% of the DOE-DCG, most were below this level. Plutonium had 1.5% and 2.9% DCG within Clinch River and West Fork Poplar Creek at monitoring stations upstream for ORGDP. Values decrease downstream of ORGDP. Uranium is slightly above detection within Poplar Creek and decreases going downstream. Gross alpha, beta, and gamma are not significant within Mitchell Branch.

2.2.1.2 Nonradiological summary

Y-12 Plant

Nonradiological parameters were also monitored at the non-NPDES Y-12 sites listed in

ORNL-DWG 88-7724R2

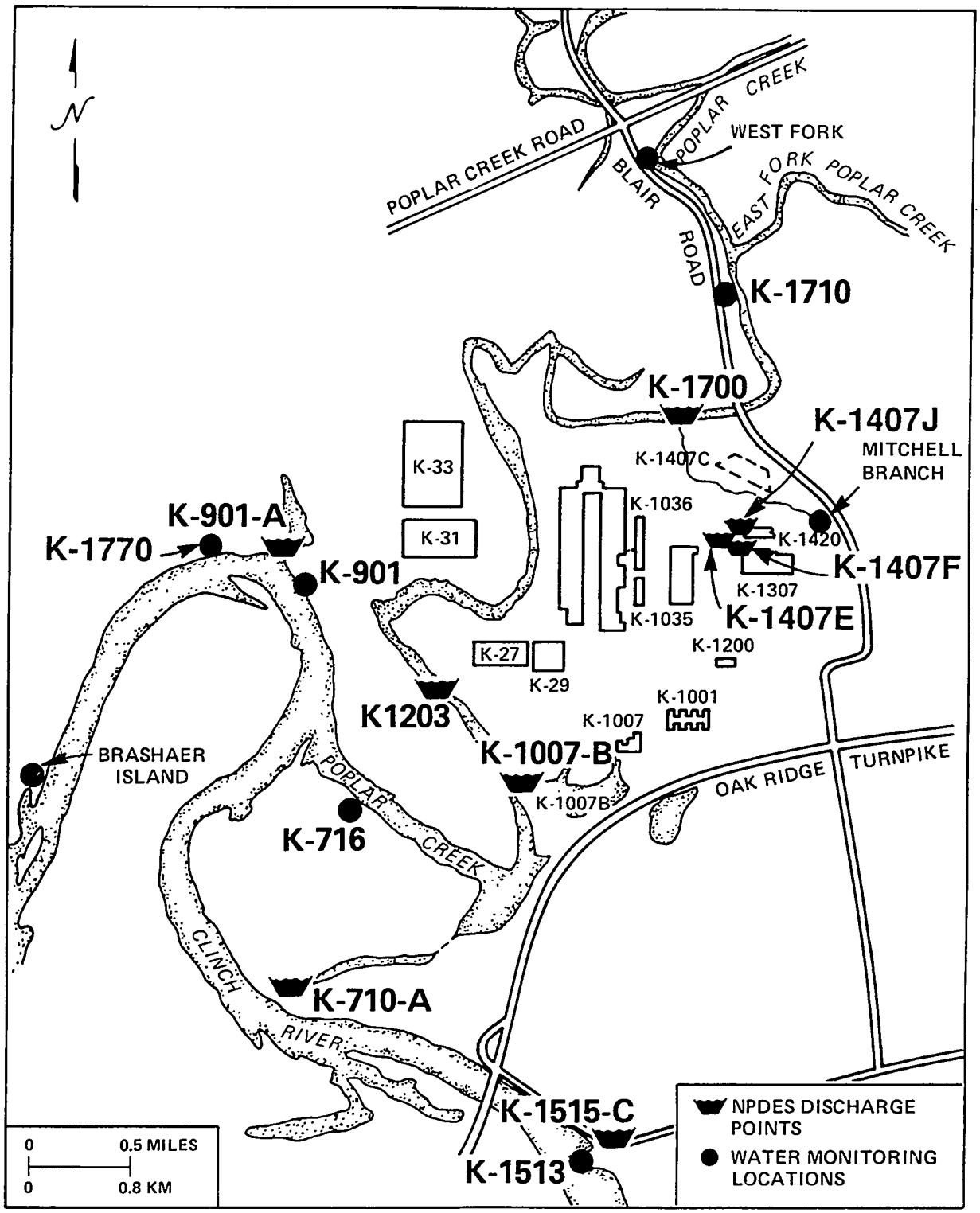

Fig. 2.2.5. ORGDP NPDES and perimeter monitoring locations.

Table 2.2.11. ORGDP water monitoring locations

Location	Agency	Type	NPDES ID if applicable
Clinch River (Brashaer Island)	DOE	Perimeter	
West Fork Poplar Creek	DOE	Perimeter	
K-710A (inactive)	TDHE	NPDES	008
K-716	DOE	Perimeter	
K-901 @ 892[a]	DOE	Perimeter	
K-901-A	TDHE	NPDES	007
K-1007-B	TDHE	NPDES	006
K-1203	TDHE	NPDES	005
K-1407-E and K-1407-F	TDHE	NPDES	010
K-1407-J	TDHE	NPDES	011
K-1513	DOE	Perimeter	
K-1515-C	TDHE	NPDES	009
K-1700	TDHE	NPDES	001
K-1710	DOE	Perimeter	
K-1770	DOE	Perimeter	

[a]The water sample is removed from the transfer pipe at K-892 pumphouse; however, the sample represents water in the Clinch River downstream of ORGDP at K-901.

Sect. 2.2.1.1 and illustrated in Fig. 2.2.1. These sites are also described more fully in that section.

A nonradiological parameter summary for kilometer 12.4 on upper Bear Creek can be found in Table 2.2.12.

The New Hope Pond influent was monitored for nonradiological parameters daily (Table 2.2.13). There were also real-time monitors for pH and mercury located at this site. The intake for these monitors was moved to the new diversion ditch after closure of the New Hope Pond inlet.

After closure activities began at New Hope Pond, station 17 became the plant's end monitoring point for nonradiological parameters also. Grab samples were obtained here twice per day for mercury, and composite samples were obtained one day per week on a rotating day of the week basis. These results are summarized in Table 2.2.14.

Nonradiological samples are obtained from the two sanitary sewer lines as required by the Industrial User's permit. These results are summarized in Tables 2.2.15 and 2.2.16.

Nonradiological analyses

At the Y-12 Plant, surface water is monitored routinely at locations that are not required by the plant NPDES permit (TN0002968) (Fig. 2.2.1). At each of these locations, samples are collected for both radiological and nonradiological parameters.

The first location is at kilometer 12.4 (mile 7.7) on upper Bear Creek where the creek first approaches Bear Creek Road. As required by the 1983 complaint and order issued by TDHE to the Y-12 Plant, grab samples are collected weekly at this location. Due to decreased flow conditions, a more representative monitoring point is also sampled (kilometer 11.97). Analytical data are reported quarterly to the TDHE as an attachment to the Discharge Monitoring Report (DMR). (A summary of 1989 data is presented in Table 2.2.12.)

Monitoring is also conducted at station 17 near the junction of Scarboro Road and Bear Creek Road. The samples at this point indicate the quality of the water in EFPC just before it leaves the Y-12 Plant boundary. Most of the samples collected at this location are flow-proportional, 24-h composites. Both radiological and nonradiological parameters are analyzed at this location, and data collected are used for a variety of purposes. See Table 2.2.4 for a summary of 1989 data.

Table 2.2.12. 1989 Annual summary for Upper Bear Creek Nonradiological data (km 12.4)

Parameter	No. samples	Concentration[a]			Std. error
		Max	Min	Av	
Arsenic	44	<0.050	<0.001	<0.006	0.001
Cadmium	44	0.02500	<0.00005	<0.00146	0.00058
Chromium	44	0.0250	<0.005	<0.0069	0.0013
Cyanide	36	0.046	<0.002	<0.007	0.001
Lead	44	0.0120	<0.0005	<0.0015	0.0003
Nitrate, as N	39	120.0	2.2	47.2	3.2
Dissolved oxygen	37	11.3	4.5	8.6	0.3
Phenols	44	0.150	<0.001	<0.005	0.003
Total dissolved solids	44	1400	230	963	41
Total suspended solids	44	40	<5	<6	1
Selenium	44	0.0020	<0.0004	<0.0019	0.0001
Thallium	43	0.0500	<0.0005	<0.0067	0.0024
pH, standard units	37	8.4	7.3	*b*	0.05
Aluminum	44	6.13	0.03	0.38	0.16
Barium	44	0.536	0.046	0.093	0.011
Beryllium	44	0.0002	<0.0001	<0.0001	0.000002
Boron	44	0.225	<0.007	<0.074	0.005
Calcium	44	274.0	40.1	200.7	7.8
Cerium	44	<0.02	<0.02	<0.02	0.00
Cobalt	44	0.008	<0.002	<0.003	0.0002
Copper	44	0.053	<0.002	<0.004	0.001
Gallium	39	0.02	<0.01	<0.01	0.0002
Iron	44	4.19	<0.02	<0.27	0.12
Lanthanum	44	<0.003	<0.003	<0.003	0.000
Lithium	44	0.120	0.004	0.020	0.003
Magnesium	44	36.1	5.7	27.9	1.1
Manganese	44	1.760	0.027	0.120	0.039
Molybdenum	44	0.182	<0.006	<0.011	0.004
Nickel	44	0.043	<0.007	<0.009	0.001
Niobium	44	<0.01	<0.01	<0.01	0.00
Phosphorus	44	0.60	<0.06	<0.12	0.02
Potassium	44	10.1	3.3	5.8	0.2
Scandium	44	0.0011	<0.0004	<0.0004	0.00002
Silver	44	0.015	<0.004	<0.004	0.0002
Sodium	44	177.0	6.5	60.5	3.9
Strontium	44	0.851	0.143	0.511	0.019
Thorium	44	0.01	<0.01	<0.01	0.00
Titanium	44	0.111	<0.002	<0.007	0.003
Vanadium	44	0.009	<0.004	<0.004	0.0001
Zinc	44	0.066	0.004	0.016	0.002
Zirconium	44	0.004	<0.002	<0.002	0.00004
PCB, total	44	<0.0005	<0.0005	<0.0005	0.0000
Volatile organics, total	44	0.011	<0.010	<0.010	0,00002

[a]Units are in mg/L unless otherwise noted.
[b]Not applicable.

Table 2.2.13. 1989 Annual summary for Upper Bear Creek Nonradiological data (km 11.97)

Parameter	No. samples	Concentration[a]			Std. error
		Max	Min	Av	
Arsenic	45	0.015	<0.001	<0.005	0.0003
Cadmium	45	0.025	<0.0002	<0.0068	0.001
Chromium	45	0.026	<0.0005	<0.0078	0.0013
Cyanide	37	0.077	<0.002	<0.008	0.002
Lead	45	0.025	<0.0005	<0.0021	0.0006
Nitrate, as N	40	290	9.6	130.99	11.35
Dissolved oxygen	38	14	4.6	9.49	0.36
Phenols	45	0.008	<0.001	<0.001	0.0002
Total dissolved solids	45	2900	300	1354	92
Total suspended solids	45	100	<5.0	<13.1	2.7
Selenium	45	0.004	<0.0004	<0.0020	0.0001
Thallium	44	<0.0500	<0.0005	<0.0078	0.0026
pH, standard units	38	8.4	7.5	*b*	0.03
Aluminum	45	17.1	<0.01	<1.03	0.41
Barium	45	1.17	<0.0004	<0.5395	0.0457
Beryllium	45	0.0005	<0.0001	<0.0001	0.000001
Boron	45	0.171	<0.007	<0.046	0.004
Calcium	45	513	<0.02	<249.58	17.66
Cerium	45	0.02	<0.02	<0.02	0
Cobalt	45	0.02	<0.002	<0.006	0.001
Copper	45	0.132	<0.002	<0.005	0.003
Gallium	39	<0.01	<0.01	<0.01	0
Iron	45	12	<0.02	<0.72	0.31
Lanthanum	45	0.003	<0.003	<0.003	0
Lithium	45	0.104	<0.01	<0.010	0.002
Magnesium	45	59.2	<0.02	<33.03	2.28
Manganese	45	4.51	0.003	1.882	0.165
Molybdenum	45	0.015	<0.006	<0.006	0.0002
Nickel	45	0.099	<0.007	<0.046	0.004
Niobium	45	<0.01	<0.01	<0.01	0
Phosphorus	45	0.49	<0.06	<0.10	0.01
Potassium	45	11.5	<0.5	<4.8	0.3
Scandium	45	0.003	<0.0004	<0.0005	0.0001
Silver	45	<0.004	<0.004	<0.004	0
Sodium	45	64	<0.02	<33.00	2.24
Strontium	45	1.49	<0.0002	<0.7777	0.055
Thorium	45	<0.01	<0.01	<0.01	0
Titanium	45	0.125	<0.002	<0.011	0.004
Vanadium	45	0.021	<0.004	<0.005	0.0004
Zinc	45	0.188	<0.002	<0.022	0.004
Zirconium	45	0.007	<0.002	<0.002	0.0001
PCB, total	45	0.0006	<0.0005	<0.0005	0.000002
Volatile organics, total	45	<0.010	<0.010	<0.010	0

[a]Units are in mg/L unless otherwise noted.
[b]Not applicable.

Table 2.2.14. 1989 Annual summary for Station 17 nonradiological data[a,b]

Parameter	No. samples	Concentration (mg/L)			Std. error
		Max	Min	Av	
Mercury	441	0.013	0.0006	0.0017	0.00004
Nitrate-N	59	6.2	2.4	3.9	0.10
Total phosphorus	45	0.84	0.024	0.263	0.02
Copper	60	0.013	<0.002	<0.008	0.0003
Zinc	60	0.109	0.029	0.063	0.002
Chromium	60	0.008	<0.006	<0.006	0.00
Molybdenum	60	0.481	0.047	0.195	0.012
Lithium	60	0.567	0.007	0.037	0.009
Selenium	42	<0.002	<0.0	<0.002	0.0001
Cadmium	60	<0.006	<0.003	<0.0035	0.0001
Lead	60	<0.02	0.002	<0.02	0.0004
Nickel	60	0.109	<0.007	<0.008	0.002
Calcium	60	77.4	41.7	59.3	1.1
Magnesium	60	13.1	6.93	11.02	0.21
Sodium	60	56.7	7.25	20.1	1.64
Potassium	60	16.6	1.2	2.6	0.2
Sulfate	44	1400	<10	<96	30.6
Chloride	44	86	11	23	1.78
Fluoride	59	1.8	0.001	0.92	0.04
Total suspended solids	60	170	<5	<19	3.5
Total dissolved solids	59	470	2.9	294.3	8.8
Alkalinity	43	170	90	113	2.1
Total organic carbons	44	29	<2	<11	1.25
Residual chlorine, total	55	0.48	<0.1	<0.11	0.007
Temperature, °F	329	72	52	69.2	0.26
pH, units	329	8.3	6.4	*b*	0.01
Dissolved oxygen	302	11	0.2	6.7	0.12

[a]Flow during operations and/or discharging.
[b]See Fig. 2.2.1
[c]Not applicable.

In November 1988, EFPC was directed through the newly constructed Lake Reality, and RCRA closure activities began for New Hope Pond (NHP). Water monitoring at NHP continued during the first quarter of 1989 on the small amount of drainage that flowed from NHP during the initial closure activities. Closure for NHP, under the approved RCRA closure plan, is now complete.

The Y-12 Plant sanitary sewage system discharges to the City of Oak Ridge sanitary sewer through two sewer lines. The wastes are treated at the City of Oak Ridge West End Treatment Facility. These discharges are monitored as required in the industrial users' permit No. 001 issued to the Y-12 Plant. These data are summarized in Tables 2.2.5 and 2.2.6.

Oak Ridge National Laboratory

Monthly surface water samples were collected at two sampling locations for the purpose of determining background concentration levels before the influence of ORNL. The two locations are Melton Hill Dam (MHD) above ORNL's discharge point into the Clinch River (with the exception of the cooling tower, roof, and parking lot runoff at the 7600 area) and White Oak Creek headwaters (WOCH) above the point where ORNL discharges to WOC (see Fig. 2.2.4). The

Table 2.2.15. 1989 Annual nonradiological summary for West End Sanitary Sewer—Y-12 Plant

Parameter	No. samples	Concentration[a]			Std. error	% DCG
		Max	Min	Av		
Mercury	12	0.005	0.0003	0.002	0.0004	NA[b]
Oil and grease	11	56	<2	<11.0	5	NA
Total suspended solids	12	170	15	72	16	NA
Cyanide	12	0.078	<0.002	<0.020	0.006	NA
Kjeldahl nitrogen	11	25.0	8.2	15.3	1.4	NA
Nitrate-N	4	11.0	5.5	7.9	1.4	NA
Total nitrogen	2	25.0	24.1	24.6	0.5	NA
Biological oxygen demand	12	96.0	<5	<31.25	6.5	NA
PCB	3	0.005	<0.0005	<0.002	0.002	NA
pH, units	11	9.0	7.5	7.8	0.1	NA
Aluminum	12	0.48	0.10	0.23	0.04	NA
Arsenic	12	<0.04	<0.04	<0.04	0.00	NA
Boron	12	0.044	<0.007	<0.026	0.003	NA
Barium	12	0.09	0.036	0.066	0.005	NA
Beryllium	12	<0.0001	<0.0001	<0.0001	0.0	NA
Calcium	12	70.8	38.7	51.5	2.8	NA
Cadmium	12	<0.006	<0.003	<0.003	0.000	NA
Cerium	12	<0.02	<0.02	<0.02	0.00	NA
Cobalt	12	0.003	<0.002	<0.002	0.000	NA
Chromium	12	<0.006	<0.006	<0.006	0.0	NA
Copper	12	0.044	0.007	0.015	0.003	NA
Iron	12	0.74	0.15	0.36	0.05	NA
Gallium	11	<0.01	<0.01	<0.01	0.00	NA
Potassium	12	11.40	4.00	6.68	0.59	NA
Lanthanum	12	<0.003	<0.003	<0.003	0.0	NA
Lithium	12	0.047	0.006	0.017	0.004	NA
Magnesium	12	13.9	9.6	11.4	0.4	NA
Manganese	12	0.36	0.06	0.18	0.03	NA
Molybdenum	12	0.020	<0.006	<0.011	0.002	NA
Sodium	12	32.1	6.7	16.2	1.9	NA
Niobium	12	<0.01	<0.01	<0.01	0.00	NA
Nickel	12	0.080	<0.007	<0.014	0.006	NA
Phosphorus	12	4.23	1.38	2.21	0.22	NA
Lead	12	<0.02	<0.02	<0.02	0.00	NA
Scandium	12	<0.0004	<0.0004	<0.0004	0.0	NA
Silver	12	<0.004	<0.004	<0.004	0.000	NA
Strontium	12	0.242	0.111	0.142	0.011	NA
Thorium	12	<0.01	<0.01	<0.01	0.00	NA
Titanium	12	0.004	<0.002	<0.003	0.0003	NA
Vanadium	12	<0.004	<0.004	<0.004	0.000	NA
Zinc	12	0.266	0.08	0.127	0.015	NA
Zirconium	12	<0.002	<0.002	<0.002	0.000	NA

[a]All units are in mg/L unless noted otherwise.
[b]NA = not applicable.

Table 2.2.16. 1989 Annual nonradiological summary for East End sanitary sewer—Y-12 Plant

Parameter	No. samples	Concentration[a]			Std. error	% DCG
		Max	Min	Av		
Mercury	12	0.006	0.0004	<0.002	0.0005	NA[b]
Oil and grease	11	7	<2	<4	1	NA
Total suspended solids	12	90	0	36	8	NA
Cyanide	12	0.081	<0.002	<.010	0.006	NA
Kjeldahl nitrogen	11	17.0	9.2	11.6	0.7	NA
Nitrate-N	4	0.5	0.1	0.3	0.1	NA
Total nitrogen	2	17.0	11.0	14.0	3.0	NA
Biological oxygen demand	12	77.0	14.0	31.8	6.1	NA
PCB	3	<0.0005	<0.0005	<0.0005	0.0	NA
pH, units	11	8.2	7.0	7.7	0.1	NA
Aluminum	12	0.62	0.08	0.20	0.05	NA
Arsenic	12	<0.04	<0.04	<0.04	0.00	NA
Boron	12	0.042	0.007	0.032	0.003	NA
Barium	12	0.0693	0.0353	0.0441	0.0026	NA
Beryllium	12	<0.0001	<0.0001	<0.0001	0.00	NA
Calcium	12	61.7	41.2	45.6	1.6	NA
Cadium	12	<0.006	<0.003	<0.004	0.000	NA
Cerium	12	<0.02	<0.02	<0.02	0.00	NA
Cobalt	12	0.003	<0.002	<0.002	0.000	NA
Chromium	12	<0.006	<0.006	<0.006	0.00	NA
Copper	12	0.021	0.007	0.012	0.06	NA
Iron	12	0.77	0.13	0.32	0.000	NA
Gallium	10	0.010	<0.010	<0.010	0.3	NA
Potassium	12	7.1	3.2	5.5	0.002	NA
Lanthanum	12	<0.030	<0.003	<0.005	0.001	NA
Lithium	12	0.011	0.003	0.007	0.2	NA
Magnesium	12	11.3	8.4	10.4	0.006	NA
Mangenese	12	0.098	0.033	0.059	0.003	NA
Molybdenum	12	0.044	<0.006	<0.019	1.0	NA
Sodium	12	17.2	6.4	13.2	0.00	NA
Niobium	12	<0.01	<0.01	<0.01	0.000	NA
Nickel	12	<0.010	<0.007	<0.008	0.13	NA
Phosphorus	12	3.08	1.45	2.20	0.00	NA
Lead	12	<0.02	<0.02	<0.02	0.0000	NA
Scandium	12	<0.0005	<0.0004	<0.0004	0.001	NA
Silver	12	0.016	<0.004	<0.007	0.004	NA
Strontium	11	0.151	0.106	0.123	0.00	NA
Thorium	11	<0.01	<0.01	<0.01	0.001	NA
Titanium	11	0.007	<0.002	<0.003	0.00	NA
Vanadium	11	<0.004	<0.004	<0.004	0.00	Na
Zinc	11	0.220	0.111	0.143	0.010	NA
Zirconium	11	<0.020	<0.002	<0.004	0.002	NA

[a]All units are in mg/L unless noted otherwise.
[b]NA = not applicable.

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The following corrections should be made to the 1988 report.

Volume 1

Page 46, Table 2.1.11. The Max, Min, and Av values for ^{3}H at ORNL PAMs should be 70,000, −320,000, and −9,800, respectively. The Max, Min, and Av values for ^{3}H at Reservation PAMs should be 540,000, −350,000, and −17,000, respectively.

Page 162, Table 2.5.2. The units of measure should be pCi/g dry wt, rather than pCi/kg dry wt.

Page 169, Table 3.1.2. The value for ^{239}Pu in endosteal bone should be 7.59×10^{1}, rather than 7.59×10^{-1}.

Page 176, Table 3.1.10. The value for effective dose at CRK 8.0 should be 0.05. The values for effective dose and endosteal bone at CRK 40.0 should both be 0.01. The effective dose given in line 5, column 2 of the text should be 0.05 mrem.

Volume 2

Page 139, Table 2.3.14. The number of values exceeding reference for ^{60}Co, ^{137}Cs, gross alpha, total radioactive strontium, and total radium should all be 0.

*U.S. GOVERNMENT PRINTING OFFICE: 1990--548-134/20071

Table 2.2.17. 1989 ORNL Surface water inorganic analysis at reference locations

Parameter	Samples (No.)	Concentration (mg/L)				Percentage DWL[b]
		Max	Min	Av	Std. error[a]	
		Melton Hill Dam[c]				
Aluminum (total)	12	3.4	0.14	1.1	0.31	
Ammonia	3	0.050	0.010	0.033	0.01	
Ammonia (as N)	1	0.041	0.041	0.041		
Antimony (total)	12	0.085	<0.030	<0.041	0.00	
Arsenic (total)	12	<0.060	<0.050	<0.053	0.00	<110
Barium (total)	12	0.069	<0.0020	<0.034	0.00	<3.4
Beryllium (total)	12	<0.0005	<0.0003	<0.0003	0.00	
Biochemical oxygen demand	4	<5.0	<5.0	<5.0	0	
Boron (total)	12	<0.080	0.0096	<0.074	0.00	
Cadmium (total)	12	0.018	<0.0020	<0.0046	0.00	<46
Calcium (total)	12	45	31	37	1.2	
Chromium (total)	12	0.021	<0.0030	<0.0095	0.00	<19
Cobalt (total)	12	<0.0050	<0.0030	<0.0035	0.00	
Copper (total)	12	0.018	<0.0040	<0.010	0.00	<1.0
Dissolved solids (total)	12	190	120	160	6.8	
Fluoride (total)	12	<1.0	<1.0	<1.0	0	
Gallium (total)	2	<0.30	<0.30	<0.30	0	
Iron (total)	12	2.9	0.10	0.91	0.27	300
Lead (total)	12	<0.050	<0.030	<0.037	0.00	<73
Lithium (total)	12	<15	<0.0040	<8.9	2.1	
Magnesium (total)	12	11	7.7	9.7	0.32	
Manganese (total)	12	0.70	<0.0020	<0.20	0.06	<410
Molybdenum (total)	12	<0.040	<0.010	<0.038	0.00	
Nickel (total)	12	0.043	<0.0050	<0.013	0.00	
Nitrate	12	<5.0	0.60	<4.6	0.36	<46
Oil and grease	12	4.0	<2.0	<2.3	0.17	
Organic carbon (total)	13	2.9	1.3	2.0	0.13	
Oxygen (dissolved)	12	12	4.4	8.0	0.50	
Phosphorus (total)	16	<0.30	0.10	<0.24	0.02	
Recoverable phenolics (total)	4	<0.0010	<0.0010	<0.0010	0	
Selenium (total)	12	<0.080	<0.040	<0.066	0.00	<660
Silicon (total)	12	7.6	0.74	3.0	0.55	
Silver (total)	12	0.014	<0.0040	<0.0058	0.00	<12
Sodium (total)	12	6.9	<2.0	<3.7	0.51	
Strontium (total)	10	0.12	0.068	0.093	0.00	
Sulfate (as SO_4)	12	30	20	25	0.89	10
Suspended solids (total)	12	90	<5.0	<25	8.2	
Tin (total)	11	<0.050	<0.050	<0.050	0	
Titanium (total)	12	0.098	0.0078	0.031	0.00	
Vanadium (total)	12	0.017	<0.0004	<0.0067	0.00	
Zinc (total)	12	0.042	0.0079	0.018	0.00	0.3
Zirconium (total)	12	<0.020	<0.0050	<0.019	0.00	
Conductivity (mS/cm)	12	1.6	0.20	0.68	0.12	
Temperature (°C)	12	21	8.7	15	1.2	
Turbidity (NTU)	12	93	0.33	17	7.9	
pH (standard units)	12	8.8	6.7	7.8	0.16	

Table 2.2.17 (continued)

Parameter	Samples (No.)	Concentration (mg/L)				Percentage DWL[b]
		Max	Min	Av	Std. error[a]	
		White Oak Creek[c]				
Aluminum (total)	12	4.5	<0.050	<1.2	0.47	
Ammonia	4	0.090	<0.010	<0.043	0.01	
Antimony (total)	12	<0.050	<0.030	<0.038	0.00	
Arsenic (total)	12	<0.060	<0.050	<0.053	0.00	<110
Barium (total)	12	0.12	0.013	0.066	0.00	6.6
Beryllium (total)	12	<0.0005	<0.0003	<0.0003	0.00	
Biochemical oxygen demand	4	<5.0	<5.0	<5.0	0	
Boron (total)	12	<0.080	<0.0040	<0.074	0.00	
Cadmium (total)	12	0.017	<0.0020	<0.0045	0.00	<45
Calcium (total)	12	32	9.3	21	1.9	
Chromium (total)	12	0.022	<0.0030	<0.010	0.00	<21
Cobalt (total)	12	0.0074	<0.0030	<0.0041	0.00	
Copper (total)	12	0.023	<0.0040	<0.0096	0.00	<0.9
Dissolved solids (total)	12	140	52	95	8.7	
Fluoride (total)	12	<1.0	<1.0	<1.0	0	
Gallium (total)	2	<0.30	<0.30	<0.30	0	
Iron (total)	12	5.5	0.067	1.4	0.57	470
Lead (total)	12	<0.050	<0.030	<0.037	0.00	<73
Liithium (total)	12	<15	<0.0040	<8.9	2.1	
Magnesium (total)	12	14	4.5	9.4	0.83	
Manganese (total)	12	0.97	<0.0020	<0.23	0.10	<450
Molybdenum (total)	12	<0.040	<0.010	<0.038	0.00	
Nickel (total)	12	0.0022	<0.0050	<0.0098	0.00	
Nitrate	12	<5.0	<0.50	<4.6	0.37	<46
Oil and grease	12	3.0	<2.0	<2.3	0.13	
Organic carbon (total)	13	1.5	0.50	1.0	0.08	
Oxygen (dissolved)	12	12	7.4	8.6	0.32	
Phosphorus (total)	16	<0.30	0.10	<0.24	0.02	
Recoverable phenolics (total)	4	<0.0010	<0.0010	<0.0010	0	
Selenium (total)	12	<0.080	<0.040	<0.066	0.0	<660
Silicon (total)	12	8.6	2.8	4.3	0.49	
Silver (total)	12	0.0067	<0.0040	<0.0052	0.00	<10
Sodium (total)	12	2.0	0.51	1.7	0.16	
Strontium (total)	10	0.035	0.083	0.020	0.00	
Sulfate (as SO_4)	12	<5.0	<5.0	<5.0	0	<2.0
Suspended solids (total)	12	150	<5.0	<26	12	
Tin (total)	11	<0.050	<0.050	<0.050	0	
Titanium (total)	12	0.18	<0.0030	<0.041	0.01	
Vanadium (total)	12	0.48	<0.0004	<0.044	0.03	
Zinc (total)	12	0.030	0.0030	0.013	0.00	0.2
Zirconium (total)	12	<0.020	<0.0050	<0.019	0.00	
Conductivity (mS/cm)	12	1.1	0.10	0.44	0.08	
Temperature (°C)	12	16	8.8	13	0.73	
Turbidity (NTU)	12	100	1.0	17	8.6	
pH (standard units)	12	8.2	6.3	7.5	0.15	

[a]Standard error of the mean.

[b]Average concentration as a percentage of National Primary or Secondary Drinking Water Regulation level.

[c]See Fig. 2.2.4.

Table 2.2.18. 1989 ORNL Surface water organic analysis at reference locations

Parameter	No. of samples	Concentration (μg/L)				Percentage DWL[b]
		Max	Min	Av	Std.[a] error	
Melton Hill Dam[c]						
1,1,1-Trichloroethane	4	<5.0	<5.0	<5.0	0	<2.5
1,1,2,2-Tetrachloroethane	4	<5.0	<5.0	<5.0	0	
1,1,2-Trichloroethane	4	<5.0	<5.0	<5.0	0	
1,1-Dichloroethane	4	<4.0	<5.0	<5.0	0	
1,1-Dichloroethene	4	<5.0	<5.0	<5.0	0	
1,2-Dichloroethane	4	<5.0	<5.0	<5.0	0	<1.0
1,2-Dichloroethene	4	<5.0	<5.0	<5.0	0	
1,2-Dichloropropane	4	<5.0	<5.0	<5.0	0	
2-Butanone	4	<10	<10	<10	0	
2-Hexanone	4	<10	<10	<10	0	
4-Methyl-2-pentanone	4	<10	<10	<10	0	
Acetone	4	<10	<10	<10	0	
Benzene	4	<5.0	<5.0	<5.0	0	<100
Bromodichloromethane	4	<5.0	<5.0	<5.0	0	
Bromoform	4	<5.0	<5.0	<5.0	0	
Bromomethane	4	<10	<10	<10	0	
Carbon disulfide	4	<5.0	<5.0	0		
Carbon tetrachloride	4	<5.0	<5.0	<5.0	0	<100
Chlorobenzene	4	<5.0	<5.0	<5.0	0	
Chloroethane	4	<10	<10	<10	0	
Chloroform	4	<5.0	<5.0	<5.0	0	
Chloromethane	4	<10	10	10	0	
Dibromochloromethane	4	<5.0	<5.0	<5.0	0	
Ethylbenzene	4	<5.0	<5.0	<5.0	0	
Methylene chloride	4	~2.0	~0.7	~1.1	0.29	
PCB-1016	4	<0.6	<0.6	<0.6	0	
PCB-1221	4	<0.6	<0.6	<0.6	0	
PCB-1232	4	<0.6	<0.6	<0.6	0	
PCB-1242	4	<0.6	<0.6	<0.6	0	
PCB-1248	4	<0.6	<0.6	<0.6	0	
PCB-1254	4	<1.1	<1.1	<1.1	0	
PCB-1260	4	<1.1	<1.1	<1.1	0	
Styrene	4	<5.0	<5.0	<5.0	0	
Tetrachloroethene	4	<5.0	<5.0	<5.0	0	
Toluene	4	<5.0	<5.0	<5.0	0	
Trichloroethene	4	<5.0	<5.0	<5.0	0	
Vinyl acetate	4	<10	<10	<10	0	
Vinyl chloride	4	<10	<10	<10	0	
Xylene, total	4	<5.0	<5.0	<5.0	0	
cis-1,3-Dichloropropene	4	<5.0	<5.0	<5.0	0	
trans-1,3-Dichloropropene	4	<5.0	<5.0	<5.0	0	
White Oak Creek[c]						
1,1,1-Trichloroethane	4	<5.0	<5.0	<5.0	0	<2.5
1,1,2,2-Tetrachloroethane	4	<5.0	<5.0	<5.0	0	
1,1,2-Trichloroethane	4	<5.0	<5.0	<5.0	0	
1,1-Dichloroethane	4	<4.0	<5.0	<5.0	0	
1,1-Dichloroethene	4	<5.0	<5.0	<5.0	0	

Table 2.2.18 (continued)

Parameter	No. of samples	Concentration (μg/L)				Percentage DWL[b]
		Max	Min	Av	Std.[a] error	
1,2-Dichloroethane	4	<5.0	<5.0	<5.0	0	<1.0
1,2-Dichloroethene	4	<5.0	<5.0	<5.0	0	
1,2-Dichloropropane	4	<5.0	<5.0	<5.0	0	
2-Butanone	4	<10	<10	<10	0	
2-Hexanone	4	<10	<10	<10	0	
4-Methyl-2-pentanone	4	<10	<10	<10	0	
Acetone	4	<10	~2.0	~6.5	2.0	
Benzene	4	<5.0	<5.0	<5.0	0	<100
Bromodichloromethane	4	<5.0	<5.0	<5.0	0	
Bromoform	4	<5.0	<5.0	<5.0	0	
Bromomethane	4	<10	<10	<10	0	
Carbon disulfide	4	<5.0	<5.0	0		
Carbon tetrachloride	4	<5.0	<5.0	<5.0	0	<100
Chlorobenzene	4	<5.0	<5.0	<5.0	0	
Chloroethane	4	<10	<10	<10	0	
Chloroform	4	<5.0	<5.0	<5.0	0	
Chloromethane	4	<10	10	10	0	
Dibromochloromethane	4	<5.0	<5.0	<5.0	0	
Ethylbenzene	4	<5.0	<5.0	<5.0	0	
Methylene chloride	4	~1.0	~0.5	~0.8	0.11	
PCB-1016	4	<0.6	<0.6	<0.6	0	
PCB-1221	4	<0.6	<0.6	<0.6	0	
PCB-1232	4	<0.6	<0.6	<0.6	0	
PCB-1242	4	<0.6	<0.6	<0.6	0	
PCB-1248	4	<0.6	<0.6	<0.6	0	
PCB-1254	4	<1.1	<1.1	<1.1	0	
PCB-1260	4	<1.1	<1.1	<1.1	0	
Styrene	4	<5.0	<5.0	<5.0	0	
Tetrachloroethene	4	<5.0	<5.0	<5.0	0	
Toluene	4	<5.0	<5.0	<5.0	0	
Trichloroethene	4	<5.0	<5.0	<5.0	0	
Vinyl acetate	4	<10	<10	<10	0	
Vinyl chloride	4	<10	<10	<10	0	
Xylene, total	4	<5.0	<5.0	<5.0	0	
cis-1,3-Dichloropropene	4	<5.0	<5.0	<5.0	0	
trans-1,3-Dichloropropene	4	<5.0	<5.0	<5.0	0	

[a]Standard error of the mean.

[b]Average concentration as a percentage of National Primary or Secondary Drinking Water Regulation Level.

[c]See Fig. 2.2.4.

Table 2.2.19. 1989 NPDES compliance at the Y-12 Plant

Discharge point	Effluent parameter	Effluent limits				Percent of compliance	Number of samples
		Daily av (kg/d)	Daily max (kg/d)	Daily av (mg/L)	Daily max (mg/L)		
301 (Kerr Hollow Quarry)	Lithium				5.0	100	14
	pH (units)			>6.5	<8.5	100	15
	Total suspended solids			30.0	50.0	100	14
	Temperature (°C)				30.5	100	14
	Zirconium				3.0	100	14
302 (Rogers Quarry)	Oil and grease			10.0	15.0	100	52
	pH (units)			>6.5	<8.5	71	52
	Settleable solids (mL/L)				0.5	100	52
	Total suspended solids			30.0	50.0[a]	100	52
	Temperature (°C)				30.5	100	52
303 (New Hope Pond)	Ammonia (as N)				1.6	43	49
	Cadmium, total			0.0025	0.0035	98	50
	Chromium, total			0.05	0.08	98	50
	Copper, total			0.015	0.022	86	50
	Dissolved oxygen			5.0[b]		83	54
	Dissolved solids				2000	100	49
	Fluoride			1.5	2.0	100	49
	Lead, total			0.012	0.17	100	50
	Lithium, total				5.0	100	50
	Mercury, total			0.0035	0.0080	98	49
	Nitrogen, total (as N)				20.0	100	49
	Oil and grease			10.0	15.0	100	53
	pH (units)			>6.5	<10.0	100	58
	Settleable solids (mL/L)				0.50	100	53
	Surfactants (as MBAS)			5.0	8.0	98	49
	Total suspended solids				20.0[c]	61	49
	Temperature (°C)				30.5	100	57
	Zinc, total			0.20	0.30	98	50
304 (Bear Creek)	Oil and grease			10.0	15.0	100	52
	pH (units)			>6.5	<8.5	100	82
305 (leaking burial grounds and wet weather springs—Oil Pond 1)	Oil and grease			10.0	15.0	100	257
	pH (units)			>6.5	<8.5	97	252
	Total suspended solids			30.0	50.0	96	257
306 (seepage from burial pit and surface water runoff—Oil Pond 2)	Oil and grease			10.0	15.0	98	90
	pH (units)			>6.5	<8.5	76	90
	Total suspended solids			30.0	50.0	98	90
307 (West Borrow Area)	Temperature (°C)					100	4
	pH (units)					100	4
	Oil and grease					100	4
	Total suspended solids					100	4
308 (East Borrow Area)	Temperature (°C)					100	4
	pH (units)					100	4
	Oil and grease					100	4
	Total suspended solids					100	4

Table 2.2.19 (continued)

Discharge point	Effluent parameter	Effluent limits				Percent of compliance	Number of samples
		Daily av (kg/d)	Daily max (kg/d)	Daily av (mg/L)	Daily max (mg/L)		
501 [Central Pollution Control Facility (CPCF-I)]	Cadmium, total	0.07	0.19	0.26	0.69	100	45
	Chromium, total	0.5	0.75	1.71	2.77	100	45
	Copper, total	0.6	0.9	2.07	3.38	100	45
	Cyanide, total	0.2	0.33	0.65	1.20	100	45
	Lead, total	0.12	0.19	0.43	0.69	100	45
	Nickel, total	0.65	1.1	2.38	3.98	100	45
	Oil and grease	7.1	14.2	26.0	52.0	100	45
	pH (units)			>6.0	<9.0	100	46
	Silver, total	0.07	0.12	0.24	0.43	100	45
	Temperature (°C)				30.5	100	45
	Total suspended solids	8.5	16.4	31.0	60.0	100	45
	Total toxic organics		0.6		2.13	100	44
	Zinc, total	0.4	0.7	1.48	2.61	96	45
502 West End Treatment Facility (WETF)	Cadmium, total	0.07	0.019	0.26	0.69	100	64
	Chromium, total	0.50	0.75	1.71	2.77	100	64
	Copper, total	0.60	0.92	2.07	3.38	100	64
	Cyanide, total	0.2	0.33	0.65	1.20	97	66
	Lead, total	0.12	0.19	0.43	0.69	100	64
	Nickel, total	0.65	1.10	2.38	3.98	95	64
	Oil and grease	7.1	14.2	26.0	52.0	100	65
	pH (units)			>0.6	<9.0	100	64
	Silver, total	0.07	0.12	0.24	0.43	100	64
	Temperature (°C)				30.5	100	64
	Total suspended solids	8.5	16.4	31.0	60.0	100	64
	Total toxic organics		0.6		2.13	100	15
	Zinc, total	0.4	0.7	1.48	2.61	100	64
503 (Steam Plant Wastewater Treatment Facility)	Chromium, total	0.38	0.38	0.20	0.20	100	152
	Copper, total	1.89	1.89	1.0	1.0	100	152
	Iron, total	1.89	1.89	1.0	1.0	99	152
	Zinc, total	1.89	1.89	1.0	1.0	100	152
	Oil and grease	28.4	37.9	15.0	20.0	100	150
	Total suspended solids	57.0	189.0	30.0	100.0	100	152
	Temperature (°C)				30.5	100	164
	pH (units)			>6.0	<9.0	99	166
Category I outfalls (precipitation runoff and small amounts of groundwater)	pH (units)			>6.5	<8.5	95	21
Category II outfalls (cooling waters, condensate, precipitation runoff, and building, roof, and foundation drains)	pH (units)			>6.5	<8.5	99	97
	Temperature[d] (°C)					100	97
Category III outfalls (process wastewaters)	pH (units)			>6.5	<8.5	93	43
Category IV outfalls (untreated process wastewaters)	pH (units)			>6.5	<8.5	96	536

Table 2.2.19 (continued)

Discharge point	Effluent parameter	Effluent limits				Percent of compliance	Number of samples
		Daily av (kg/d)	Daily max (kg/d)	Daily av (mg/L)	Daily max (mg/L)		
504 Plating Rinse Water Treatment Facility	Cadmium, total	0.07	0.019	0.26	0.69	100	22
	Chromium, total	0.50	0.75	1.71	2.77	100	22
	Copper, total	0.60	0.92	2.07	3.38	100	22
	Cyanide, total	0.2	0.33	0.65	1.20	100	22
	Lead, total	0.12	0.19	0.43	0.69	100	22
	Nickel, total	0.65	1.10	2.38	3.98	100	22
	Oil and grease	7.1	14.2	26.0	52.0	100	22
	pH (units)			>0.6	<9.0	96	24
	Silver, total	0.07	0.12	0.24	0.43	100	22
	Temperature (°C)				30.5	100	23
	Total suspended solids	8.5	16.4	31.0	60.0	100	22
	Total toxic organics		0.6		2.13	100	22
	Zinc, total	0.4	0.7	1.48	2.61	100	22
501/504 (Combined discharge Central Pollution Control Facility and Plating Rinse Water Treatment Facility)	Cadmium, total	0.07	0.019	0.26	0.69	100	31
	Chromium, total	0.50	0.75	1.71	2.77	100	31
	Copper, total	0.60	0.92	2.07	3.38	100	31
	Cyanide, total	0.2	0.33	0.65	1.20	100	32
	Lead, total	0.12	0.19	0.43	0.69	100	31
	Nickel, total	0.65	1.10	2.38	3.98	100	31
	Oil and grease	7.1	14.2	26.0	52.0	100	31
	pH (units)			>0.6	<9.0	100	34
	Silver, total	0.07	0.12	0.24	0.43	100	31
	Temperature (°C)				30.5	100	22
	Total suspended solids	8.5	16.4	31.0	60.0	100	31
	Total toxic organics		0.6		2.13	100	31
	Zinc, total	0.4	0.7	1.48	2.61	100	31
623 (Steam Plant fly ash sluice water)	pH (units)			>6.5	<8.5	100	45
506 (9204-3 sump pump oil)	Temperature (°C)				30.5	92	52
	Oil and grease			10.0	15.0	100	53
	pH (units)			>6.5	<8.5	98	52
507 (S-3 Ponds liquid treatment facility)	Cadmium, total	0.14	0.38	0.26	0.69	*e*	*f*
	Chromium, total	0.93	1.5	1.7	2.77	*e*	
	Copper, total	1.13	1.84	2.07	3.38	*e*	
	Cyanide, total	0.35	0.65	0.65	1.20	*e*	
	Lead, total	0.23	0.38	0.43	0.69	*e*	
	Nickel, total	1.30	2.17	2.38	3.98	*e*	
	Oil and grease	14.2	28.4	26.0	52.0	*e*	
	pH (units)			>6.0	<9.0	*e*	
	Silver, total	0.13	0.23	0.24	0.43	*e*	
	Temperature (°C)				30.5	*e*	
	Total suspended solids	16.9	32.7	31.0	60.0	*e*	
	Total toxic organics		1.16		2.13	*e*	
	Zinc, total	0.81	1.42	1.48	2.61	*e*	
508 (Experimental mobile wastewater treatment facility)	Mercury, total			0.002	0.004	*e*	*f*
	pH (units)			>6.5	<9.0	*e*	
	Total suspended solids			30.0	45.0	*e*	

Table 2.2.19 (continued)

Discharge point	Effluent parameter	Effluent limits				Percent of compliance	Number of samples
		Daily av (kg/d)	Daily max (kg/d)	Daily av (mg/L)	Daily max (mg/L)		
510 (Waste Coolant Processing Facility)	Biochemical oxygen demand	1.33	2.65			*e*	
	Oil and grease			15.0	20.0	*e*	
	pH (units)			>6.5	<9.0	*e*	
	Temperature (°C)				30.5	*e*	
	Total suspended solids			30.0	50.0	*e*	
Miscellaneous discharges (cooling tower blowdown)	Chromium, total				1.0	100	56
	Copper, total			0.5	1.0	100	56
	Free available chlorine			0.2	0.5	63	56
	pH (units)			6.5	8.5	50	56
	Temperature (°C)			35	38	100	56
	Zinc, total			0.5	1.0	100	55
Miscellaneous discharges (demineralizers)	pH units			6.5	8.5	100	1
	Total suspended solids			30	50	100	1

[a]Limit not applicable during periods of increased surface runoff resulting from precipitation.
[b]Daily minimum.
[c]If discharge volume exceeds 8.0×10^6 gal/d as a result of precipitation, daily maximum is 100 mg/L.
[d]Temperature shall be controlled such that the stream temperature standards delineated in the General Water Quality Criteria for the Definition and Control of Pollution in the Waters of Tennessee, as amended, are not violated as a result of this discharge.
[e]No discharge.
[f]Not applicable.

consist of four major tasks: (1) ambient toxicity testing, (2) bioaccumulation studies, (3) biological indicator studies that include measurement of selected biochemical parameters and histopathological analyses, and (4) benthic invertebrate and fish community surveys. These tasks use techniques ranging from laboratory bioassays and manipulative field experiments to routine biotic surveys to assess ecological effects at different levels of biological organization.

These programs were developed to meet two major objectives. First, biological monitoring will be used to demonstrate that the interim effluent limits established for each facility protect the classified uses of the receiving stream (e.g., growth and propagation of fish and aquatic life), as determined by TDHE. A second objective is to evaluate the effects on stream biota resulting from construction and operation of major new pollution abatement facilities and other remedial actions.

Biomonitoring can be used to assess the effectiveness of these remedial actions through documentation of the process of ecological recovery.

Results of the biological monitoring programs at the three Oak Ridge facilities are discussed in Sect. 6.4.

2.2.2.1 Radiological summary

Y-12 Plant

Development of a radiological monitoring plan for the Y-12 Plant is dictated by the NPDES permit. This plan was developed and submitted to TDHE for approval in 1987. Monitoring activities under this plan began during the third quarter of 1987.

The proposed plan addresses compliance with the NPDES permit and the "as low as reasonably

Table 2.2.20. 1989 NPDES compliance at ORNL

Discharge point	Effluent parameters	Discharge limitations				Number of noncompliances	Percent of compliance
		Monthly av (kg/d)	Daily max (kg/d)	Monthly av (mg/L)	Daily max (mg/L)		
X01 (sewage treatment plant)	Biochemical oxygen demand (summer)	8.7	13.1	10	15	0	100
	Biochemical oxygen demand (winter)	17.4	26.2	20	30	0	100
	Total suspended solids	26.2	39.2	30	45	4	97.4
	Ammonia (N) (summer)	3.5	5.2	4	6	0	100
	Ammonia (N) (winter)	7.8	11.8	9	13.5	0	100
	Oil and grease	8.7	13.1	10	15	4	97.4
	Dissolved oxygen				6.0[a]	0	100
	pH (units)					0	100
	Residual chlorine				0.5	0	100
	Fecal coliform, geometric mean			200[b]	400[b]	0	100
X02 (Coal Yard Runoff Treatment Facility)	Temperature, °C				30.5	0	100
	Total suspended solids				50	0	100
	Oil and grease			15.0	20.0	3	94.2
	Chromium, total			0.2	0.2	0	100
	Copper, total			1.0	1.0	0	100
	Iron, total			1.0	1.0	2	96.2
	pH (units)					2	99.2
	Zinc			1.0	1.0	0	100
X03 (1500 area)	pH (units)					1	94.1
X04 (2000 area)	pH (units)					0	100
X06 (3539 and 3540 Ponds)	pH (units)					0	100
X06A (1500 and 2000 areas, and 3539 and 3540 Ponds)	pH (units)					0	100

Table 2.2.20 (continued)

Discharge point	Effluent parameters	Discharge limitations				Number of noncompliances	Percent of compliance
		Monthly av (kg/d)	Daily max (kg/d)	Monthly av (mg/L)	Daily max (mg/L)		
X07 (Process Waste Treatment Plant–3544)	pH (units)					0	100
X08 (TRU)	pH (units)					0	100
X09 (HFIR)	pH (units)					0	100
X09A (TRU/HFIR)	pH (units)					1	97.1
X11 (Acid Neutralization Facility)	pH (units)					0	100
Category I	Oil and grease			10	15	5	80
	pH (units)					1	96
	Temperature, °C				30.5	1	96
	Total suspended solids			30	50	11	56
Category II	Oil and grease			10	15	19	87.1
	pH (units)[a]					1	99.3
	Total suspended solids			30	50	15	89.8
Category III	pH (units)					0	100
Steam plant (SP2519)	pH (units)					3	25
	Temperature, °C			35	38	1	75
Vehicle cleaning (VC7002)	Biochemical oxygen demand			30	45	5	54.5
	Fecal coliform			200		6	45.5
	Oil and grease			10	15	6	45.5
	pH (units)					3	72.7
	Phenols			1.0	2.0	2	81.8
	Total suspended solids			25	40	6	45.5

Table 2.2.20 (continued)

Discharge point	Effluent parameters	Discharge limitations				Number of noncompliances	Percent of compliance
		Monthly av (kg/d)	Daily max (kg/d)	Monthly av (mg/L)	Daily max (mg/L)		
Equipment Maintenance Facility (EF7007)	Oil and grease				15	2	50
	pH, units					0	100
Cooling Systems	Chlorine				0.2	6	88.9
	Chromium				1.0	0	100
	Copper			0.5	1.0	4	92.6
	Temperature, °C			35	38	0	100
	Zinc			0.5	1.0	9	83.3
	pH, units					0	100

[a]Minimum.

[b]Colonies per 100 mL.

Note: The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units. It shall be monitored by (1) a weekly grab sample taken at the effluent for discharge points X01, X02, X03, X04, X06, X06A, X07, and X11; (2) a per discharge grab sample taken at the effluent for discharge points X08, X09, and X09A; (3) a monthly grab sample taken at the effluent for discharge points X13, X14, and X15; (4) once per year by a grab sample taken at each of the category I outfalls; (5) once per quarter by a grab sample taken at the effluent for pH at each of the category II outfalls; (6) once per quarter by a grab sample taken at the effluent for pH at each of the category III outfalls; (7) once per quarter at EF7002; (8) once per month at VC7002; (9) once per quarter at SP2519. At the same time, a sample will be taken in the stream immediately downstream of every discharge point except X13, X14, X15, category III outfalls, EF7002, VC7002, and SP2519. There are no NPDES numeric limits for downstream pH; however, the state has maintained that the downstream pH shall not be less than 6.5 standard units nor greater than 8.5 standard units.

Table 2.2.21. 1989 NPDES compliance at ORGDP

Discharge point	Effluent parameters	Effluent limits				Noncompliances No.	Percent compliance
		Monthly av (mg/L)	Daily max (mg/L)	Monthly av (kg/d)	Daily max (kg/d)		
001 K-1700 discharge	Aluminum		1.0		16	21	80
	Chromium	0.050	0.080	0.80	1.2		100
	Nitrate—N		20		310		100
	Suspended solids[a]	30	50	470	780		100
	Oil and grease	10[b]	15	160	230		100
	pH, units		6.0–9.0				100
	Lead	0.0080	0.93	0.12	14		100
	Zinc	0.12	1.5	1.86	246		100
	Color		*e*				*f*
005 (K-1203 sanitary treatment facility)[d]	Ammonia nitrogen	5.0	7.0	12	17.3		100
	BOD	15	20	37	49.5	1	99
	Chlorine residual		0.24			2	99

Table 2.2.21 (continued)

Discharge point	Effluent parameters	Effluent limits				Noncompliances (No.)	Percent of compliance
		Monthly av (mg/L)	Daily max (mg/L)	Monthly av (kg/d)	Daily max (kg/d)		
	Dissolved oxygen	5.0[b]					100
	Fecal coliform, No./100 mL	200	400			1	99
	pH, units		6.0–9.0				100
	Suspended solids	30	45	74	110		100
	Settleable solids, mL/L		0.50			1	99
(K-1007-B holding pond)	COD	20	25	120	150	15	86
	Chromium, total		0.050		0.30	2	98
	Dissolved oxygen	5.0[b]					100
	Fluoride	1.0	1.5	6.1	9.1		100
	Oil and grease	10	15	61	91		100
	pH, units		6.0–9.0				100
	Suspended solids[a]	30	50	182	304		100
007 (K-901-A holding pond)	Chromium, total		0.05		0.68		100
	Fluoride	1.0	1.5	4.2	6.3		100
	Oil and grease	10	15	42	63		100
	pH, units		6.0–10				100
	Suspended solids[a]	30	50	125	210		100
	Dissolved oxygen	5[b]					100
	Visible solids		*e*				*f*
009 (K-1515-C sanitary water plant)	Suspended solids[a]	30	50	34	51		100
	Aluminum	5.0	10	5.7	11	1	98
	Sulfate		1400		1600		100
	pH, units		6.0–9.0				100
Storm drain	Unpermitted Discharge		*e*			3	*f*
011 (K1407-J)[c]	Cadmium	0.26	0.69				100
	Chromium	1.71	2.77				100
	Copper	2.07	3.38				100
	Lead	0.43	0.69				100
	Silver	0.24	0.43				100
	Zinc	1.48	2.61				100
	Cyanide	0.65	1.20				100
	TTO		2.13				100
	Oil and grease	26	52				100
	Nickel	2.38	3.98				100
	TSS	31	60			5	98
	PCB, μg/L		0.014				100
	pH		6.0–9.0				100

Table 2.2.21 (continued)

Discharge point	Effluent parameters	Effluent limits				Noncompliances (No.)	Percent of compliance
		Monthly av (mg/L)	Daily max (mg/L)	Monthly av (kg/d)	Daily max (kg/d)		
010 (K-1407-E and K-1407-F)	Temperature		30.5				100
	TSS		50			2	96
	Oil and grease	15	20				100
	Chromium	0.2	0.2				100
	Copper	1.0	1.0				100
	Iron	1.0	1.0			10	81
	Zinc	1.0	1.0				100
	PCB (μg/L)		0.014				100
	pH, units		6.0–9.0				100

[a]Limit applicable only during normal operations. Not applicable during periods of increased discharge due to surface run-off resulting from precipitation.

[b]Daily minimum.

[c]During the characterization of this effluent point more data are obtained and reported but are not subject to limits at this time.

[d]Because of the small flow rates at the K-710-A sanitary treatment facility, (discharge point W27), a rapid sand filter was installed May 1, 1978, eliminating the surface discharge and the need for monitoring.

[e]No discharge.

[f]Not applicable.

achievable" (ALARA) philosophy for radioactive discharges in liquid effluents. The monitoring program is designed to monitor effluents at treatment facilities, other point and area source discharges, and in-stream locations. Known or suspected radioactive materials and indicator parameters are monitored. The treatment facilities that are monitored include the Central Pollution Control Facility (CPCF), the West End Treatment Facility (WETF), the Steam Plant Wastewater Treatment Facility (SPWTF), and the Plating Rinsewater Treatment Facility (PRTF) (Fig. 2.2.6). Point and area discharges that include outfall 109, Y-12 Plant area drainage; outfall 135, Y-12 Plant area drainage; outfall 147, isotope separation process; outfall 305, oil retention pond number 1; and outfall 306, oil retention ponds number 1 and 2 have been closed under an approved RCRA closure plan. The in-stream location for 1989 was outfall 304, Bear Creek. These data are summarized in Table 2.2.22.

DOE Order 5400.5 requires all DOE facilities to maintain radionuclide effluents at ALARA levels. Consistent with this policy, the Y-12 Plant will continue to operate in a manner that complements the ALARA philosophy. The Y-12 Plant ALARA program includes an aggressive plan to identify sources of radioactive discharges via various monitoring programs.

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ORNL's radiological sampling plan calls for monitoring many of the same locations as required in the permit for nonradiological monitoring. The schedule of parameters analyzed and frequencies of analysis currently observed is given in Table 2.2.7. In May 1989, a change in the analysis schedule was implemented for WOD samples. Gross alpha activity measurement replaced specific alpha measurements (^{238}Pu, ^{239}Pu, ^{241}Am, and ^{244}Cm), and analysis frequency was changed to monthly for ^{3}H and total Sr. The number of NPDES stations where radiological sampling is conducted was reduced from 11 to 8 in fulfillment of a Federal Facility Compliance Agreement construction milestone. Effective May 3, 1989, a new station

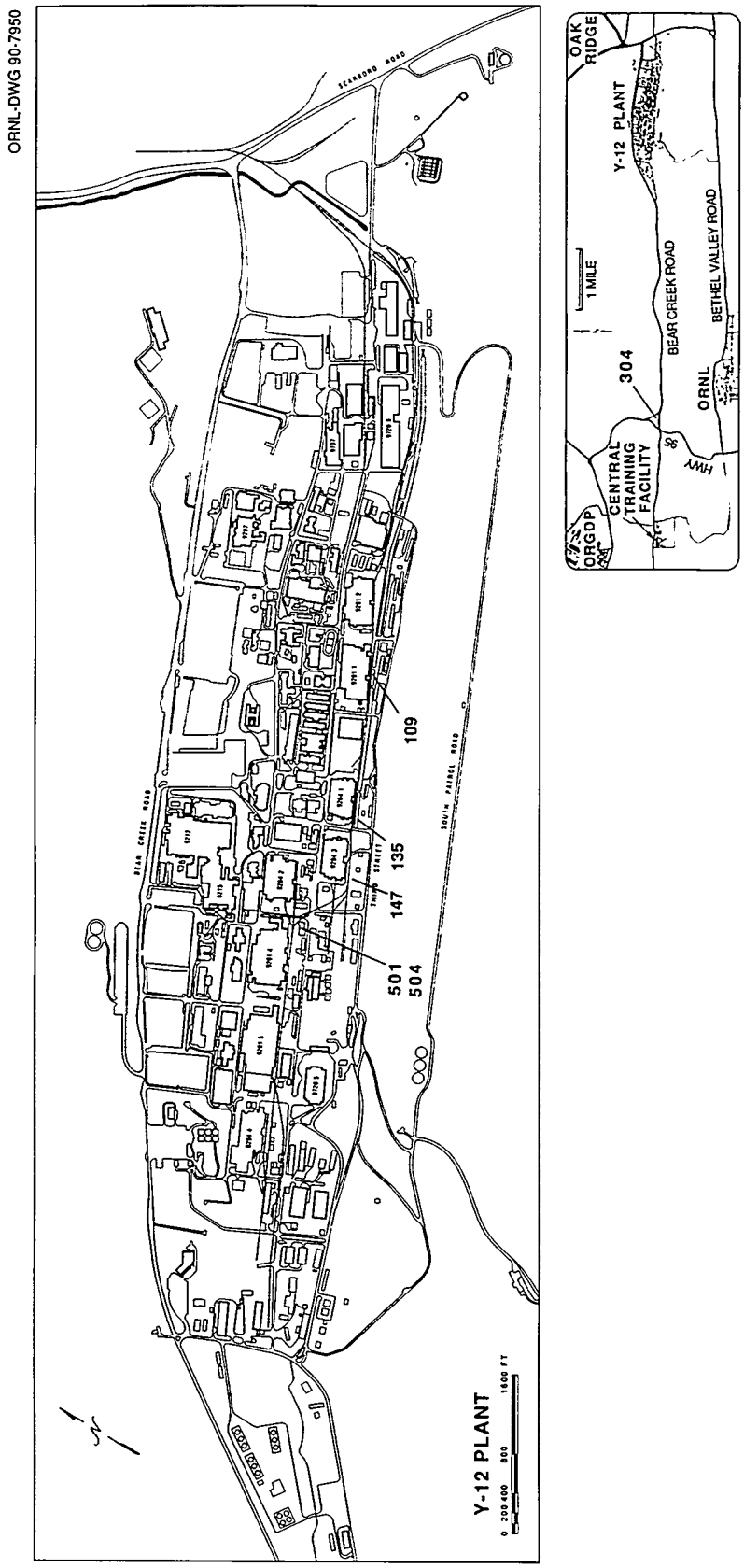

Fig. 2.2.6. Y-12 Plant NPDES radiological monitoring plan locations.

Table 2.2.22. 1989 Annual radiological summary in water around Y-12 Plant

Parameter	Count	Concentration (pCi/L)			Std. error	% DCG
		Max	Min	Av		
		Station 17				
Alpha activity	25	90	9.7	28	3.6	*a*
Beta activity	25	54	6.2	24	2	*a*
^{90}Sr	25	85	−3.2	4.9	3.39	0.49
^{237}Np	25	67	−0.78	0.2	0.05	0.67
^{226}Ra	13	0	0	0	0	0
^{228}Ra	13	0	0	0	0	0
		Bear Creek Outfall 304				
Alpha activity	50	700	0	71.9	17.1	*a*
Beta activity	50	1400	−33	72.7	28.0	*a*
^{90}Sr	37	13	−3.53	1.9	0.56	0.19
^{237}Np	10	1.1	0	0.2	0.11	0.67
^{226}Ra	9	0	0	0	0	0
^{228}Ra	8	0	0	0	0	0

[a]Not applicable.

called X06A was created by combining the 1500 area (X03), 2000 area (X04), and 190 area (X06) ponds. Effective May 31, 1989, a new station called X09A was created by combining REDC ponds (X08) and HFIR ponds (X09). Table 2.2.12 in Vol. 2 gives a summary of radiological parameter concentrations for each location. The sample sizes and station names reflect the changes occurring during the year.

Apparent discrepancies between the average concentrations are reported in Tables 2.2.10 of this volume and 2.2.12 in Vol. 2 for MB1, WOC, and WOD. This is due to calculating flow-weighted averages for Table 2.2.10 and arithmetic averages for the table in Vol. 2. The following discussion uses the arithmetic average information because these numbers provide a consistent basis of comparison across all stations. Table 2.2.10 presents flow-weighted averages because the flow information is available, and this is a more representative measure of central tendency.

For the first time during 1989, grab samples from categories I (storm drains) and II (roof drains, parking lot drains, storage area drains, spill area drains, once-through cooling water, cooling tower blowdown and condensate) outfalls were analyzed for gross beta activity. Category I outfalls are sampled annually and category II outfalls are sampled quarterly.

The three highest average ^{60}Co concentrations were observed at HFIR (54% DCG), X09A (includes HFIR) (30% DCG), and the process waste treatment plant (PWTP) (5.2% DCG). Below the HFIR area discharge point at MB1 (Fig. 2.2.8), the average ^{60}Co concentration was 0.51% of the DCG. All other ^{60}Co concentrations were less than 1% of the DCG. In 1988 the HFIR average concentration was 95% of the ^{60}Co DCG.

The stations where the average ^{137}Cs concentration exceeded 1% of the DCG were PWTP (63%), WOC (2.5%), X09A (2.4%) and WOD (2.3%). It appears that ^{137}Cs releases are primarily the result of process discharges. Average concentration of ^{137}Cs at PWTP is down from 120% of the DCG reported in 1988.

For comparison purposes, the DCG for ^{90}Sr was used to evaluate total radioactive strontium discharges. This is a conservative approach. Total radioactive strontium average concentration exceeded 1% of the DCG at MB1 (41%), WOD (18%), WOC (16%), PWTP (11%) and the sewage treatment plant (STP) (9.7%). Average

concentrations found in Table 2.2.1 in Vol. 2 (discussed in Sect. 2.2.1, Surface Water Monitoring) that exceeded 1% of the DCG were First Creek (31%), 7500 bridge (8.8%), Northwest Tributary (5.4%), Fifth Creek (3.4%) and Raccoon Creek (2.4%). Unlike ^{60}Co and ^{137}Cs discharges, which are primarily process related, the total radioactive strontium releases are more diffuse and are probably more the result of past activities and subsurface input rather than discharges from process facilities. In fact, the average total Sr concentrations are 25 to 60% higher than the 1988 average concentrations, probably because of the increased subsurface flow resulting from the increased rainfall in 1989. The calculated discharges at MB1, WOC, and WOD (Table 2.2.10) are 2.4 to 2.6 times higher than the discharges for 1988. This phenomenon is under investigation to identify the contributors to this observed increase.

The stations where the average ^{3}H concentration exceeded 1% of the DCG are MB1 (61%), WOD (13%), and WOC (3.8%). Most of the tritium is believed to come from solid waste storage area (SWSA) 5. Although the ^{3}H concentration at MB1 was higher in 1988 (91% of the DCG) than in 1989, the total ^{3}H discharge for MB1 was 1.9 times higher in 1989 because of increased flow in 1989 over 1988. The increase in flow at WOC and WOD for 1989 were 2.4 and 3.6, respectively.

A larger than expected gross beta measurement (4900 pCi/L) was obtained for the October STP sample (Table 2.2.12 in Vol. 2). This is believed to be in error. Samples from X09A and STP were analyzed for gross beta in sequence and may have been switched. This appears to be corroborated by the X09A gross beta concentration being much less than that reported for ^{60}Co obtained from a gamma scan for that time period.

A list of the category I and II gross beta concentration results is given in Table 2.2.83 of Vol. 2. Of the 101 measurements taken, three exceeded 810 pCi/L, one at 26,000 pCi/L in the 3000 area next to Fifth Street, and 4,100 and 810 pCi/L at an outfall to WOC just below the confluence with Fifth Creek. These samples were collected from intermittent flows to a storm drain and parking lot runoff and are believed to be related to historic contamination, which is being addressed by the Remedial Action Program (RAP) for ORNL.

Oak Ridge Gaseous Diffusion Plant

NPDES effluent monitoring is specified in ORGDP NPDES permit TN0002950. The radionuclide analyses for both ambient surface water and NPDES programs are restricted to the types common to past and current plant operations.

Both NPDES and perimeter ambient water sampling locations under ORGDP responsibility are shown in Fig. 2.2.5. Table 2.2.11 lists sampling locations, sample type, the agency requiring the sample, and the NPDES identification number where applicable.

Sample collection for radiological constituents is performed along with NPDES samples. Each ORGDP location is listed in Table 2.2.23 along with the sampling frequency and sampling method. A more complete description of the NPDES program is in Sect. 2.2.2.2.

ORGDP's original mission was uranium enrichment. Until the 1950s, activities were very specific and uranium was the principal radionuclide introduced into the plant area. During the 1950s, reactor return feed material was processed at the plant, and this activity introduced transuranic and fission products into the plant facilities. The radioisotopes specifically encountered were technetium, cesium, neptunium, and plutonium. The uranium enrichment process has now been shut down, and radioactive materials are no longer being introduced into the process. If additional isotopes are introduced to the plant site, monitoring of effluents will be reassessed.

The K-1700 and K-1407-J NPDES point (Fig. 2.2.5) has the greatest potential for radioactive emissions because of the facilities operating nearby. The K-1203 sewage plant has the second greatest potential for radioactive emissions. K-1007-B and K-901-A ponds have the least potential because no process effluents entering these ponds should contain radioactivity. The K-1515-C NPDES point receives backwash from the sanitary water plant. The intake for this facility is on the Clinch River, and the potential for contamination from ORGDP does not exist.

Table 2.2.23. ORGDP NPDES sampling frequency

Location	Sampling type	Sample frequency	Analysis[a] frequency	Parameter analyzed
K-1700	Grab	Daily		pH
K-1700	*b*	Daily		Flow
K-1700	24 h/comp.	2/week		Aluminum
K-1700	24 h/comp.	4/week		COD
K-1700	24 h/comp.	2/week		Chromium
K-1700	24 h/comp.	2/week		Dissolved solids
K-1700	24 h/comp.	2/week		Fluoride
K-1700	24 h/comp.	2/week		Nitrate
K-1700	Grab	2/week		Oil and grease
K-1700	24 h/comp.	4/week		Total suspended solids
K-1700	Grab	4/week		Temperature
K-1700	Grab	4/week		Turbidity
K-1700	24 h/comp.	2/week		Beryllium
K-1700	24 h/comp.	2/week		Cadmium
K-1700	24 h/comp.	2/week		Mercury
K-1700	24 h/comp.	2/week		Selenium
K-1700	24 h/comp.	2/week		Silver
K-1700	Grab	2/week		Perchloroethylene
K-1700	Grab	2/week		Trichloroethane
K-1700	Grab	2/week		Methylene chloride
K-1700	Grab	2/week		Trichloroethylene
K-1700	24 h/comp.	2/week		Lead
K-1700	24 h/comp.	2/week		Zinc
K-1700	Grab	1/quarter		Total halomethanes
K-1700	24 h/comp.	1/week		Uranium[c]
K-1700	24 h/comp.	1/week	1/month	Cesium
K-1700	24 h/comp.	1/week	1/month	Neptunium
K-1700	24 h/comp.	1/week	1/month	Plutonium
K-1700	24 h/comp.	1/week	1/month	Technetium
K-1203	Grab	Daily		pH
K-1203	Grab	Daily		Chlorine residual
K-1203	Grab	Daily		Dissolved oxygen
K-1203	Grab	Daily		Settleable solids
K-1203	*b*	Daily		Flow
K-1203	24 h/comp.	3/week		Ammonia nitrogen
K-1203	24 h/comp.	3/week		Biochemical oxygen demand
K-1203	Grab	3/week		Fecal coliform
K-1203	24 h/comp.	3/week		Total suspended solids
K-1203	24 h/comp.	1/week		Beryllium
K-1203	24 h/comp.	1/week		Cadmium
K-1203	24 h/comp.	1/week		Mercury
K-1203	24 h/comp.	1/week		Selenium
K-1203	24 h/comp.	1/week		Silver
K-1203	24 h/comp.	1/week		Lead
K-1203	24 h/comp.	1/week		Zinc
K-1203	Grab	1/week		Perchloroethylene
K-1203	Grab	1/week		Trichloroethane
K-1203	Grab	1/week		Methylene chloride
K-1203	Grab	1/week		Trichloroethylene

Table 2.2.23 (continued)

Location	Sampling type	Sample frequency	Analysis[a] frequency	Parameter analyzed
K-1203	Grab	1/quarter		Total halomethanes
K-1203	24 h/comp.	1/week		Uranium[c]
K-1203	24 h/comp.	1/week	1/month	Technetium
K-1007-B	Grab	Daily		pH
K-1007-B	Grab	1/week		Dissolved oxygen
K-1007-B	*b*	Daily		Flow
K-1007-B	24 h/comp.	1/week		Chemical oxygen demand
K-1007-B	24 h/comp.	1/week		Chromium
K-1007-B	24 h/comp.	1/week		Fluoride
K-1007-B	Grab	1/week		Oil and grease
K-1007-B	24 h/comp.	1/week		Total suspended solids
K-1007-B	24 h/comp.	1/week		Uranium[c]
K-1007-B	24 h/comp.	1/week	1/quarter	Cesium
K-1007-B	24 h/comp.	1/week	1/quarter	Plutonium
K-1007-B	24 h/comp.	1/week	1/quarter	Neptunium
K-1007-B	24 h/comp.	1/week	1/quarter	Technetium
K-901-A	Grab	Daily		pH
K-901-A	Grab	Daily		Dissolved oxygen
K-901-A	*b*	Daily		Flow
K-901-A	24 h/comp.	2/week		Chemical oxygen demand
K-901-A	24 h/comp.	1/week		Chromium
K-901-A	24 h/comp.	1/week		Fluoride
K-901-A	Grab	1/week		Oil and grease
K-901-A	24 h/comp.	2/week		Total suspended solids
K-901-A	Grab	2/week		Turbidity
K-901-A	24 h/comp.	1/week		Uranium[c]
K-901-A	24 h/comp.	1/week	1/quarter	Cesium
K-901-A	24 h/comp.	1/week	1/quarter	Neptunium
K-901-A	24 h/comp.	1/week	1/quarter	Plutonium
K-901-A	24 h/comp.	1/week	1/quarter	Technetium
K-1515-C	Grab	1/week		pH
K-1515-C	*b*	Daily		Flow
K-1515-C	Grab	1/week		Total suspended solids
K-1515-C	Grab	1/week		Aluminum
K-1515-C	Grab	1/week		Sulfate
K-1515-C	Grab	1/week		Chemical oxygen demand
K-1407-J	Continuous	Daily		pH
K-1407-J	Continuous	Daily		Flow
K-1407-J	Grab	Daily		Temperature
K-1407-J	24 h/comp.	2/week		Cadmium
K-1407-J	24 h/comp.	2/week		Chromium
K-1407-J	24 h/comp.	2/week		Copper
K-1407-J	24 h/comp.	2/week		Lead
K-1407-J	24 h/comp.	2/week		Nickel
K-1407-J	24 h/comp.	2/week		Silver
K-1407-J	24 h/comp.	2/week		Zinc

Table 2.2.23 (continued)

Location	Sampling type	Sample frequency	Analysis[a] frequency	Parameter analyzed
K-1407-J	Grab	1/week		Cyanide
K-1407-J	Grab	1/week		Total toxic organics
K-1407-J	Grab	2/week		Oil and grease
K-1407-J	24 h/comp.	4/week		Total suspended solids
K-1407-J	24 h/comp.	1/week		Polychlorinated biphenyls
K-1407-J	24 h/comp.	4/week		COD
K-1407-J	24 h/comp.	4/week		Total dissolved solids
K-1407-J	24 h/comp.	2/week		Total organic carbon
K-1407-J	24 h/comp.	1/week		Ammonia
K-1407-J	24 h/comp.	1/week		Bromide
K-1407-J	24 h/comp.	1/week		Chlorine, total residual
K-1407-J	24 h/comp.	1/week		Chloride
K-1407-J	24 h/comp.	4/week		Flouride
K-1407-J	24 h/comp.	2/week		Nitrate-Nitrite
K-1407-J	24 h/comp.	1/week		Nitrogen
K-1407-J	24 h/comp.	1/week		Phosphorus
K-1407-J	24 h/comp.	1/week		Sulfate
K-1407-J	24 h/comp.	1/week		Sulfide
K-1407-J	24 h/comp.	1/week		Sulfite
K-1407-J	24 h/comp.	1/week		Surfactants
K-1407-J	24 h/comp.	2/week		Aluminum
K-1407-J	24 h/comp.	1/week		Barium
K-1407-J	24 h/comp.	2/week		Boron
K-1407-J	24 h/comp.	2/week		Cobalt
K-1407-J	24 h/comp.	2/week		Iron
K-1407-J	24 h/comp.	2/week		Magnesium
K-1407-J	24 h/comp.	2/week		Molybdenum
K-1407-J	24 h/comp.	2/week		Manganese
K-1407-J	24 h/comp.	1/week		Tin
K-1407-J	24 h/comp.	2/week		Titanium
K-1407-J	24 h/comp.	2/week		Antimony
K-1407-J	24 h/comp.	1/week		Arsenic
K-1407-J	24 h/comp.	2/week		Beryllium
K-1407-J	24 h/comp.	2/week		Mercury
K-1407-J	24 h/comp.	2/week		Selenium
K-1407-J	24 h/comp.	1/week		Thallium
K-1407-J	24 h/comp.	1/week		Uranium[c]
K-1407-J	Grab	1/week		Phenols
K-1407-J	Grab	5/week		GC/MS[d] fraction volatile compounds
K-1407-J	72 h/comp.	1/month		GC/MS acid compounds
K-1407-J	72 h/comp.	1/month		GC/MS base/neutral compounds
K-1407-J	24 h/comp.	1/week	1/month	Cesium
K-1407-J	24 h/comp.	1/week	1/month	Plutonium
K-1407-J	24 h/comp.	1/week	1/month	Neptunium
K-1407-J	24 h/comp.	1/week	1/month	Technetium

Table 2.2.23 (continued)

Location	Sampling type	Sample frequency	Analysis[a] frequency	Parameter analyzed
K-1407-E&F	Grab	Continuous		Flow
K-1407-E&F	Grab	1/week		Temperature
K-1407-E&F	24 h/comp.	1/week		Total suspended solids
K-1407-E&F	Grab	1/week		Oil and grease
K-1407-E&F	24 h/comp.	1/week		Chromium
K-1407-E&F	24 h/comp.	1/week		Copper
K-1407-E&F	24 h/comp.	1/week		Iron
K-1407-E&F	24 h/comp.	1/week		Zinc
K-1407-E&F	24 h/comp.	1/week		Arsenic
K-1407-E&F	24 h/comp.	1/week		Cadmium
K-1407-E&F	24 h/comp.	1/week		Lead
K-1407-E&F	24 h/comp.	1/week		Manganese
K-1407-E&F	24 h/comp.	1/week		Nickel
K-1407-E&F	24 h/comp.	1/week		Selenium
K-1407-E&F	24 h/comp.	1/week		Silver
K-1407-E&F	24 h/comp.	1/month		Sulfate
K-1407-E&F	Grab	Continuous		pH
K-1407-E&F	24 h/comp.	1/week		Polychlorinated biphenyls

[a]Analysis frequency—identical to sample frequency unless otherwise noted.
[b]Not applicable.
[c]An isotopic analysis is conducted on uranium if any week is above 0.02 mg/L.
[d]Gas chromatograph/mass spectrometer.

With the exception of K-1515-C, all NPDES discharge points are analyzed weekly for uranium. If any weekly values are above 0.02 mg/L, an isotopic analysis is conducted on the monthly composites for K-1700 and K-1203 and on the quarterly composites for K-1007-B and K-901-A. Isotopic analyses cannot be performed readily on samples with <0.02 mg/L. In addition, K-1700 receives technetium, cesium, neptunium, and plutonium analyses on the monthly composite samples. K-1203 receives technetium analysis on the monthly composites, and K-901-A and K-1007-B receive technetium, cesium, neptunium, and plutonium on the quarterly composite samples. These data are transmitted quarterly to the state with the DMRs.

The data indicate that radiological effluents are well within limits at all effluent locations (see Tables 2.2.13 through 2.2.17 in Vol. 2), with the exception of K-1407-J. Uranium, determined by wet chemistry analysis, is reduced and presented by isotope in the Vol. 2 tables. Most values are well below 6.5% of the DCG. At K-1407-J, ^{234}U is 93% of the DCG, and ^{238}U is 38% of the DCG. These low values are supported by the fact that ambient surface water radiological samples do not indicate contamination from ORGDP, as shown in Table 2.2.2 in Vol. 2.

2.2.2.2 Nonradiological summary

Y-12 Plant

Over the past few years, significant changes in the interpretation of existing environmental legislation have impacted the environmental management program at the Y-12 Plant. Until 1977, EPA had total responsibility for enforcing

the CWA at federal facilities such as the Y-12 Plant. Under the EPA, the Y-12 Plant had one NPDES permit with four Y-12 perimeter outfalls: one at the outlet of New Hope Pond, one west of the main plant site on Bear Creek (at Highway 95), one at the outlet of Rogers Quarry, and one at the outlet of Kerr Hollow Quarry. While operating under the EPA NPDES permit, the Y-12 Plant regularly achieved compliance with the effluent discharge criteria.

In 1977, amendments to the Federal Water Pollution Control Act (FWPCA) allowed the states to establish their own water quality criteria. By law, these criteria took precedence over any EPA-issued NPDES permits. The NPDES permit issued May 25, 1985, is a reflection of the 1977 amendments to the FWPCA and the Y-12 Federal Facilities Compliance Agreement signed by EPA and DOE on April 17, 1985. This current NPDES permit combines water quality and industrial BAT effluent limitations for the metal finishing and steam electric power generation industries with emphasis on biological and toxicological monitoring. The Y-12 Plant is committed to achieving effluent characteristics that are better than those specified by BAT. The effluent limitations for each treatment facility may be adjusted if the treated effluent results in in-stream toxicity as determined by TCMP or if East Fork Poplar Creek does not display a healthy ecological system as determined by BMAP. The TCMP is described in Sect. 2.2.2.3.

The Y-12 Plant NPDES permit (No. TN0002968) was issued effective May 25, 1985. The Y-12 Plant NPDES-permitted outfalls are identified in Table 2.2.24. This permit requires sampling and analysis at 14 serially numbered outfalls, approximately 195 categorized outfalls, and approximately 30 miscellaneous discharges. Analytical results for Y-12 NPDES discharge points for 1989 are summarized in Tables 2.2.18 through 2.2.38 of Vol. 2.

Discharges from the Y-12 Plant affect water quality and flow in Rogers Quarry, East Fork Poplar Creek, and Bear Creek before entering the Clinch River. The Y-12 Plant is committed to

Table 2.2.24. Y-12 Plant NPDES-permitted outfalls, 1989

Kerr Hollow Quarry—outfall 301
Rogers Quarry—outfall 302
New Hope Pond—outfall 303
Bear Creek—outfall 304
Leaking Burial Grounds—Oil Pond 1—outfall 305
Seepage from Burial Pit—Oil Pond 2—outfall 306
Category I outfalls—Uncontaminated precipitation runoff and/or groundwater
Category II outfalls—Cooling water, condensate, building area, and foundation drains and/or precipitation runoff contaminated by area sources of pollution
Category III outfalls—Any of the Category I or II outfalls or process wastewaters requiring treatment at one of the on-site Y-12 treatment facilities
Category IV Discharges—Process wastewaters requiring minimal treatment—outfalls 401–420
Steam Plant fly ash sluice water—outfall 623
Central Pollution Control Facility—outfall 501
West End Treatment Facility—outfall 502
Steam Plant Wastewater Treatment Facility—outfall 503
Plating Rinsewater Treatment Facility—outfall 504
Experimental Mobile Wastewater Treatment Facility—outfall 508
Building 9204-3 Sump Pump Oil Separator—outfall 506
Miscellaneous discharges (cooling towers, regeneration wastes, vapor blasters)

providing treatment for a variety of wastewaters discharged to area streams. Discharges allowed under the permit include storm drainage, cooling water, cooling tower blowdown, and process wastewaters including effluents from pollution control facilities. Sumps that collect groundwater inflow in building basements are also discharged to the creek.

Because the existing Y-12 Plant NPDES Permit will expire in May 1990, an application for permit renewal was submitted to TDHE/EPA on November 22, 1989. This application contains an extensive collection of proposed monitoring points and subsequent categories. This collection consists of 74 Category-I-type outfalls (uncontaminated precipitation runoff and groundwater), 65 Category-II-type outfalls (roof drains, cooling-water discharges, condensate, and other effluents previously monitored), 5 plant site outfalls, 15 treatment facilities, 18 cooling-tower discharges, 1 fly-ash sluice-water discharge, 40 miscellaneous discharges, and 57 miscellaneous outfalls.

A network of storm drains, which discharges into East Fork Poplar Creek, covers the entire area of the Y-12 Plant. This system gathers rainfall from the adjacent hillsides, parking areas, the roof drains, and the flow from the testing of the fire protection system. In the past, interconnecting with the storm drainage system were numerous discharges and laboratory drains within the buildings, building floor drains, and drains from accumulation tanks outside the buildings. Efforts to improve the water quality of streams receiving Y-12 Plant discharges are ongoing and have resulted in eliminating numerous process discharges to East Fork Poplar Creek.

There are 18 major cooling tower systems and 6 small air-conditioning towers in operation at the Y-12 Plant. Approximately 1380 million L (359 million gal) per year of water are required as makeup for the 18 major cooling tower systems. About 550 million L (143 million gal) per year are discharged as blowdown into East Fork Poplar Creek, and 830 million L (216 million gal) are lost as evaporation.

During 1989 the NPDES compliance for the cooling tower blowdown showed a decrease from 72% to 63% for Free Available Chlorine (FAC) and showed an increase from 37% to 50% for pH.

In an effort to eliminate FAC, an ozonation study is under way. This study will determine the feasibility of using ozone in place of a microbiocide in order to reduce the amount of chlorine discharged to East Fork Poplar Creek. This study is scheduled to be concluded in 1991.

The increase in pH compliance is attributable to the use of an acidic corrosion inhibitor. An acidic corrosion inhibitor has been tested in the past at the Y-12 Plant and has shown the ability to consistently keep the pH below the maximum NPDES permit limit of 8.5.

Closure activities for the two oil retention ponds continued through most of 1989. Outfall 305 (Oil Retention Pond Number 1) and 306 (Oil Retention Pond Number 2) became the monitoring points for the Oil Retention Ponds Closure Project Water Management Plan. Water from Oil Retention Pond Number 2 was pumped into tanker trucks and discharged, through a filter system or a carbon filter system located at Oil Retention Pond Number 1, into tributary 7. The parameters required under this water management plan for these two outfalls (305 and 306) were the same as those listed in the NPDES permit with the addition of PCBs, volatile organics, and a more frequent monitoring schedule.

Following removal of PCB contamination to the 25 $\mu g/g$ level, both Oil Ponds 1 and 2 were filled in with clean clay and closed during 1989. Oil seep drainage, which previously went into Oil Pond 1 (Outfall 305), is collected and the water treated through the Interim Liquid Storage Facility (ILSF). Sample analyses are reported on this flow on the Discharge Monitoring Report (DMR) as Outfall 305 ILSF. Outfall 306 no longer exists.

Rogers Quarry (Outfall 302) and improvements related to coal ash disposal are discussed in the Special Studies Section 6.1.4.

The Y-12 Plant generates a variety of liquid wastes (uranium-contaminated as well as uranium-noncontaminated) from activities associated with metal finishing, plating, uranium recovery, and facility cleaning operations. Conventional liquid waste streams such as storm water runoff, steam plant wastewaters, and

coal-pile runoff also exist. Aqueous process waste streams may be divided into two categories: high nitrate wastewaters and low nitrate wastewaters. With the exception of the high nitrate wastewaters, the waste streams are amenable to physical/chemical types of treatment including pH control and solids removal. Wastewater treatment facilities that can accommodate specific waste streams (plating rinse waters, high nitrate streams, etc.) have been built in recent years.

Wastewaters at the Y-12 Plant are treated by one of the following methods.

- Nitrate-contaminated wastewaters generated throughout the plant are neutralized, biodenitrified, stored, polished, and discharged at the WETF.
- Wastewaters that are low in nitrates are collected and transported to the CPCF.
- Coal-pile runoff and boiler blowdown are collected and treated at the SPWTF.
- Sanitary wastes are discharged to the City of Oak Ridge wastewater treatment facility under an Industrial User's Permit.
- Wastewaters from the ORNL Biology Complex at the Y-12 Plant are discharged to the sanitary sewer system, where they continue on to the City of Oak Ridge wastewater treatment facility.
- Untreated waste streams such as cooling tower blowdown and noncontact cooling waters are monitored to ensure compliance with the NPDES permit. These waters are discharged to East Fork Poplar Creek.

During 1989, the Y-12 Plant improved to 98% compliance with NPDES standards as compared with 97% compliance in 1988. These trends can be seen in Figs. 2.2.7 and 2.2.8.

Progress was also made during 1989 on several projects to minimize the release of pollutants to surface waters at the Y-12 Plant.

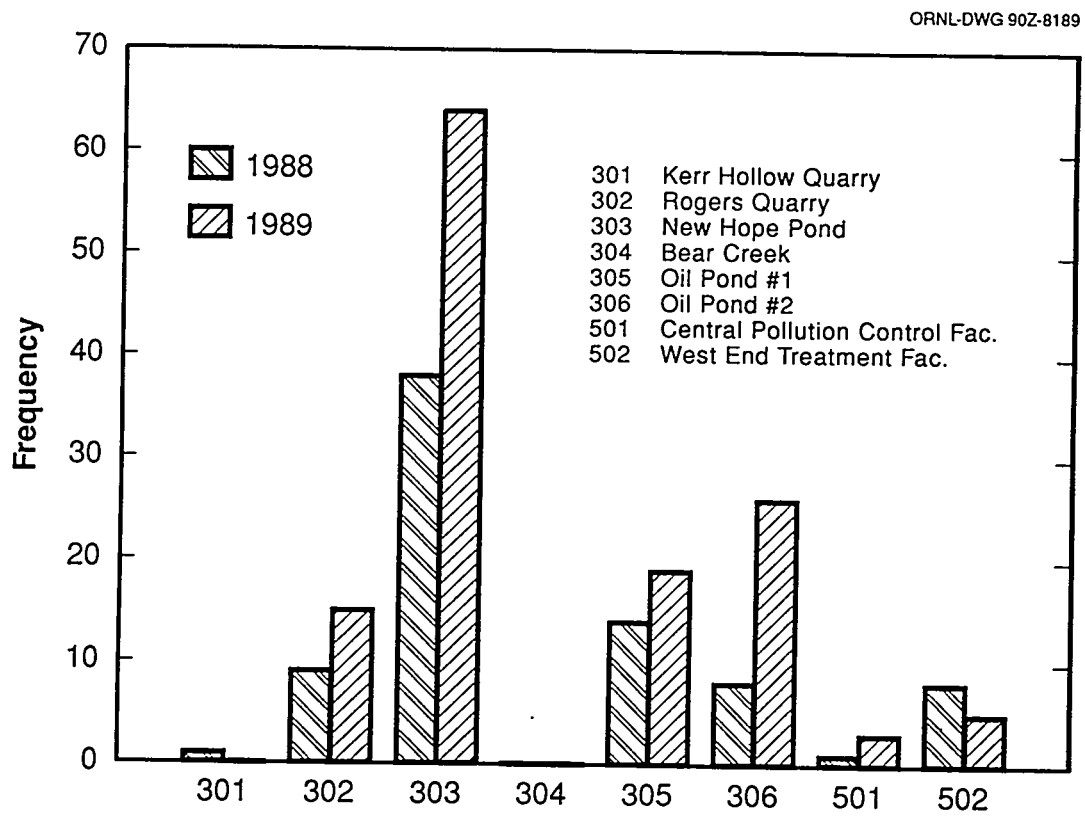

Fig. 2.2.7. Y-12 Plant NPDES excursion trend.

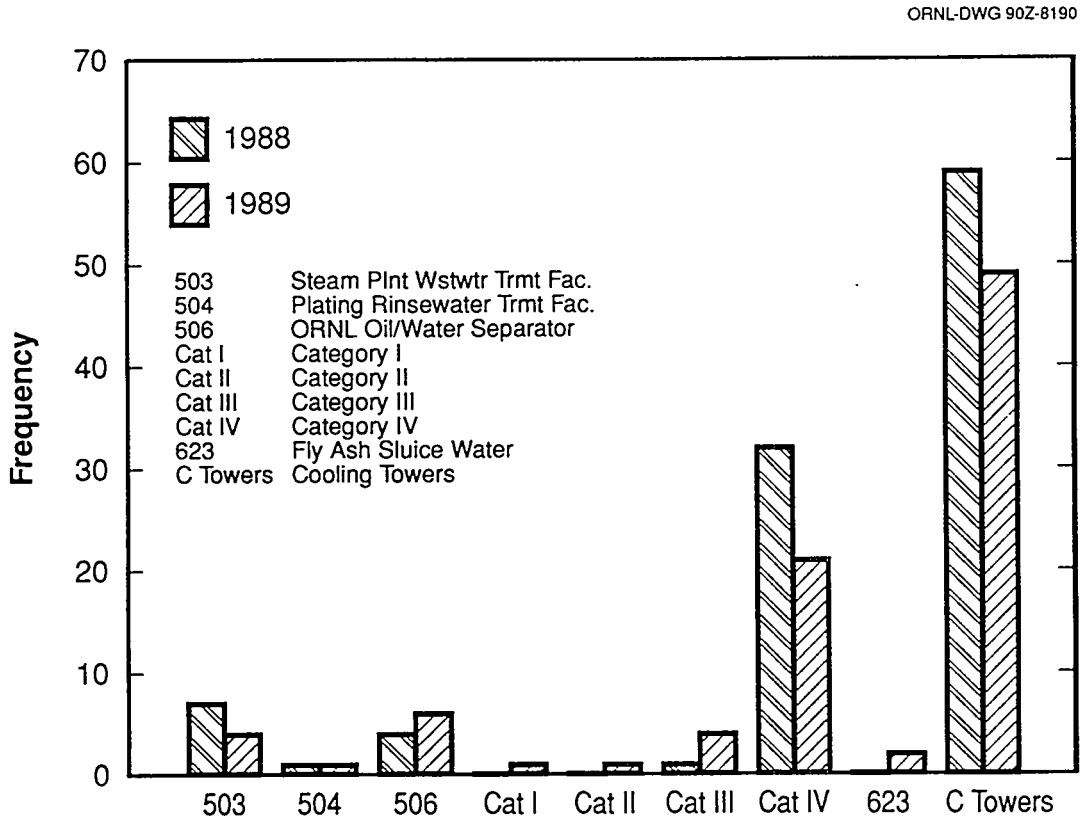

Fig. 2.2.8. Y-12 Plant NPDES excursion trend.

These include optimization improvements to CPCF, WETF, PRTF, and SPWTF.

In addition, feasibility studies for eliminating the Category IV discharges from East Fork Poplar Creek have been completed, and resulting action plans are currently being implemented. For a more detailed discussion on the treatment of Category IV discharges, refer to the Special Studies Section 6.1.5.

Another condition of the Y-12 NPDES permit is the development and implementation of a PCB monitoring plan for the Y-12 Plant. This plan specifies sampling locations and frequencies to identify PCB sources. A summary of these data can be found in Table 2.2.25.

Oak Ridge National Laboratory

The ORNL NPDES permit (TN0002941) became effective on April 1, 1986. The point source and ambient stations are shown in Fig. 2.2.9. Table 2.2.39 in Vol. 2 gives the average (and in some cases the maximum) flows for the point sources as specified in the permit. It also identifies the receiving stream.

Sampling and analysis frequencies at these locations are varied, as indicated in Tables 2.2.40 through 2.2.61 in Vol. 2. Effluent limits have been placed on the Sewage Treatment Plant and the Coal Yard Runoff Treatment Facility; categories I, II, and III outfalls; and the miscellaneous source discharges. Discharge limits are also placed on pH for most of the outfalls.

Construction of ORNL's new Nonradiological Wastewater Treatment Facility was completed in September 1989. Beginning in 1990, this facility will treat effluent from outfalls X03, X04, X06, X06A, X07, X08, X09, and X09A. These outfalls will then be eliminated.

A summary of the NPDES compliance at ORNL is given in Table 2.2.20, which provides a list of outfalls, parameters measured for which there is a permit limit, the discharge limitations, the number of noncompliances, and the percentage

Table 2.2.25. Surface water analytical results of polychlorinated biphenyls monitoring plan for the Oak Ridge Y-12 Plant, CY 1989

Site No.	Location	Date sampled	PCB concentration (mg/L)
PCB-1	Outfall 301, Kerr Hollow Quarry	04/07/89	<0.0005
		07/14/89	<0.0005
		12/13/89	<0.0005
PCB-2	Outfall 302, Rogers Quarry	04/07/89	<0.0005
		07/14/89	<0.0005
		09/19/89	<0.0005
		12/13/89	<0.0005
PCB-3	Outfall 303, New Hope Pond	*a*	<0.0005
PCB-5	New Hope Pond Inlet	*b*	
PCB-6	Upstream of Outfall 135	03/21/89	<0.0005
		04/07/89	<0.0005
		07/14/89	<0.0005
		09/19/89	<0.0005
		12/13/89	<0.0005
PCB-7	Outfall 304, Bear Creek	03/21/89	<0.0005
		04/23/89	<0.0005
		07/14/89	<0.0005
		09/19/89	<0.0005
		12/13/89	<0.0005

[a]Average of 56 data points taken from January 1 to April 14, 1989, during closure of this outfall, which was closed in April 1988.
[b]Inlet closed in November 1988.

in compliance for 1989. The percentage is based on the total number of observations for a particular parameter at a particular outfall.

At the STP (discharge point X01), the compliance rate was greater than 97% for all parameters measured. In 1988, fecal coliform and chlorine limit exceedances were occasionally experienced; elimination of these in 1989 is attributed to technical and operational refinements made by STP staff. The 1989 exceedances of total suspended solids and oil and grease parameters were based on one excursion of each parameter; the additional noncompliances were based on monthly-average and mass-load calculations that were influenced by a single excursion of each parameter.

Category I and II outfalls include storm drains and parking lot and roof drains and are not contaminated by any known activity, nor do they discharge through any oil/water separator or other treatment facility or equipment. During rain events, waters from the parking lots and surrounding areas wash into these outfalls, carrying oil, grease, and other residue. This situation frequently results in noncompliances for oil and grease (O&G), as well as total suspended solids (TSS), at a number of these outfalls. In the third quarter of 1989, a study was initiated to investigate the feasibility of various alternatives to control the exceedances at Category I & II outfalls.

The iron limit exceedance that was measured at the Coal Yard Runoff Treatment Facility was attributed to a malfunction of sampling equipment. The equipment was repaired and functioned properly thereafter. The exceedances of pH and oil and grease limits were infrequent, random events that were not associated with any upset or unusual

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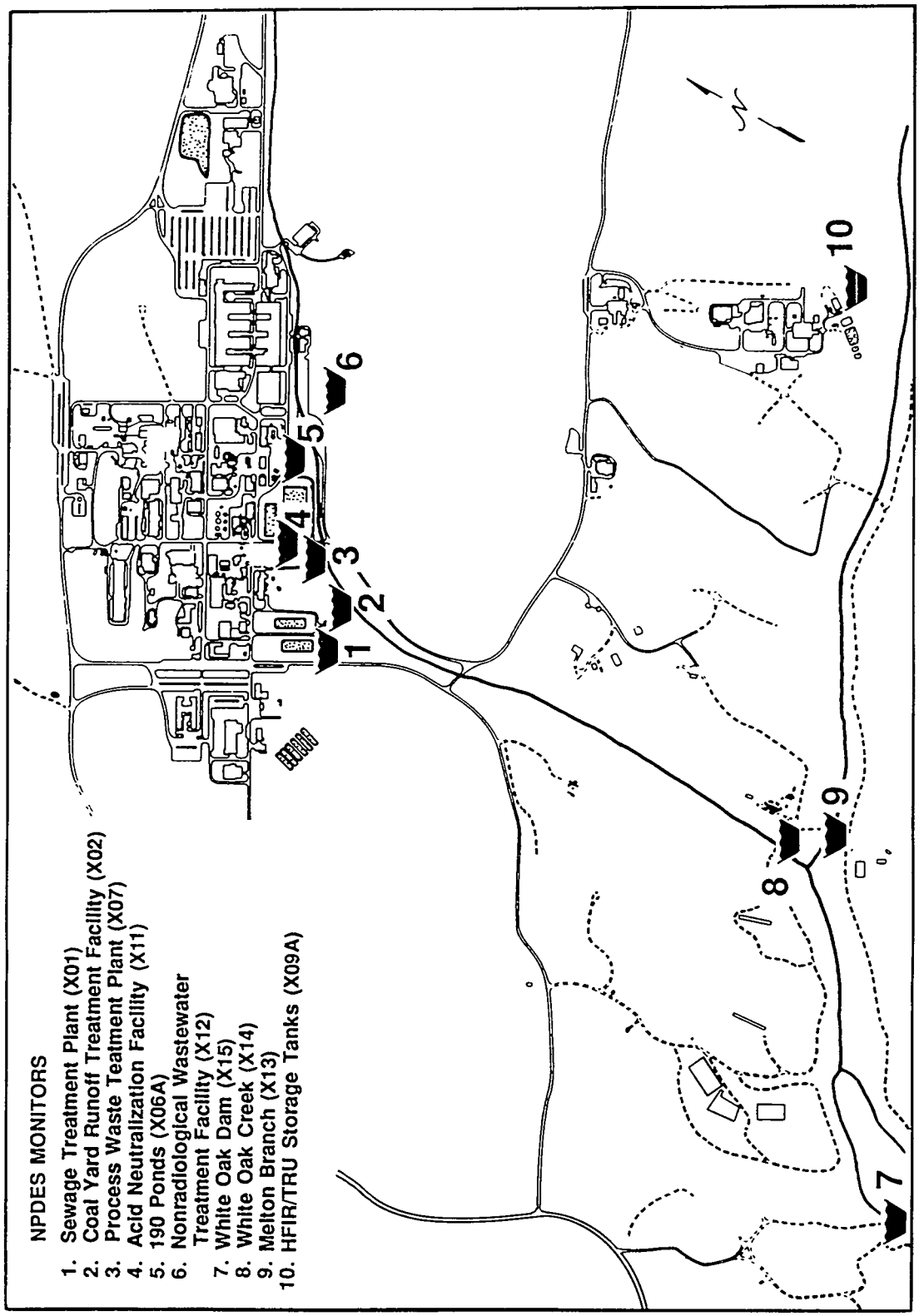

Fig. 2.2.9. ORNL NPDES and radioactivity sampling locations.

condition to which the exceedances could be attributed.

In 1989 the Vehicle Cleaning Facility (VC7002) sampling point was revised in an effort to provide more representative samples. Numerous exceedances spurred an ORNL investigation into the situation. Discharge from the VC7002 facility was halted in the first quarter of 1990 pending resolution of the situation.

The pH limit exceedance situation at the ORNL steam plant (SP 2519) continued in 1989. An ORNL investigation indicated that the pH standard was not actually being violated by the discharge at the point of entry to the receiving stream. As allowed by ORNL's NPDES Permit, an application was submitted to the TDHE requesting that permit limits be adjusted accordingly.

A 1988 cooling tower upgrade program resulted in a general decrease in the concentrations of metals discharged in cooling tower blowdown; however, occasional permit limit exceedances still occurred. Additional investigations took place in 1989 to identify measures to further eliminate exceedances. The 3518 Acid Neutralization Facility had 100% compliance in 1989, following a 1988 investigation of operations and sampling methodologies at that facility.

All data collected for the NPDES permit are also summarized monthly for reporting to DOE-ORO and to the state of Tennessee. These summaries are submitted to DOE in monthly DMRs. Monthly summaries of sampling for the NPDES permit are found in Tables 2.2.62 through 2.2.84 of Vol. 2.

Table 2.2.26 provides summary data for all parameters monitored in White Oak Creek at WOD (NPDES station number X15). The 1989 maximum concentrations for arsenic exceeded the Tennessee Draft Water Quality Criterion for protection of domestic water supply, and occasionally the biochemical oxygen demand exceeded the Tennessee Draft Criterion for Protection of Fish and Aquatic Life. Because WOC flow is diluted approximately 300 times upon entering the Clinch River, the potential for water quality impairment is considered negligible. Tables 2.2.12 and 2.2.69 in Vol. 2 give similar summary information in WOC upstream of WOD. Summary data for parameters measured at Melton Branch (NPDES station number X13) are shown in Table 2.2.27.

Oak Ridge Gaseous Diffusion Plant

The NPDES permit for ORGDP has eight authorized discharge points (Fig. 2.2.5). Samples are collected at seven of the eight outfalls and at three internal wastewater discharges. The eighth outfall has been shut down because of insufficient loading and is not monitored. All process water discharges from the plant pass through an NPDES monitoring point. However, many storm drains, some with noncontact cooling water discharges, are not monitored at an NPDES sampling point. Since ORGDP has been in standby mode, the major decreases in liquid discharge have been the result of the elimination of blowdown from both the recirculating cooling water (RCW) system and the centrifuge development cooling towers and a decrease in sewage effluent. The discharges are described according to their NPDES outfalls in Table 2.2.28. Each ORGDP location is listed in Table 2.2.23 along with sampling frequency and sample type. All analyses are performed according to EPA-approved procedures.

ORGDP operates one sanitary sewage system—an extended aeration treatment plant with a rated capacity of 2.3 million L/d (0.6 Mgd) and a current use of approximately 1.1 million L/d (0.3 Mgd). Treated effluent from the main plant is discharged into Poplar Creek.

Because of their remoteness and low volume of use, outlying facilities such as the power house area, rifle range, and water treatment plant use septic tanks with drain fields. The power house area has a packaged treatment plant with a rated capacity of 76,000 L/d (19,760 gal/d); however, because of insufficient loading, this facility has been shut down and is not monitored.

Surface runoff within the ORGDP site is drained by Mitchell Branch and Poplar Creek, which flow into the Clinch River. Improvements to the surface runoff system include drainage channeled by swales, where appropriate, rather than by piped drain systems. This technique is used

Table 2.2.26. 1989 ORNL NPDES Permit Number TN 0002941 (discharge point X15—White Oak Dam)

Parameter	No. of samples	Concentration (mg/L)			Std. error
		Max	Min	Av	
Aluminum (total)	12	2.8	<0.050	<0.86	0.22
Ammonia (as N)	12	0.16	0.011	0.046	0.012
Arsenic (total)	12	0.090	<0.050	<0.055	0.0034
Biochemical oxygen demand	12	>34	<5.0	<7.4	2.4
Cadmium (total)	12	<0.0020	<0.0020	<0.0020	0
Chlorine (total) residual	52	<0.010	<0.010	<0.010	0
Chloroform	11	<0.025	0.0010[a]	0.0041[a]	0.0021
Chromium (total)	12	0.028	<0.0030	<0.016	0.0025
Conductivity (mS/cm)	12	1.7	0.23	0.87	0.14
Copper (total)	12	0.13	0.0050	0.019	0.010
Dissolved solids (total)	12	240	140	200	9.4
Flow (Mgd)	249	150	4.2	14	1.0
Fluoride (total)	12	1.0	<1.0	<1.0	0
Iron (total)	12	2.3	0.20	0.67	0.16
Lead (total)	12	0.0040	<0.0040	<0.0040	0
Manganese (total)	12	0.10	<0.0020	<0.060	0.0081
Mercury (total)	12	0.00011	<0.000050	<0.000063	
Nickel (total)	12	<0.020	<0.0050	<0.010	0.0017
Nitrate	12	<5.0	<5.0	<5.0	0
Oil and grease	52	>200	<2.0	<10	4.3
Organic carbon (total)	12	6.4	1.7	2.9	0.37
Oxygen (dissolved)	52	14	4.0	8.5	0.29
PCBs (total)	11	<0.00050	<0.00050	<0.00050	0
pH (standard units)	12	8.9	6.7	*b*	*b*
Phosphorus (total)	12	0.50	0.10	0.23	0.031
Silver (total)	12	<0.0050	<0.0050	<0.0050	0
Sulfate (as SO_4)	12	48	12	34	2.9
TSS	12	37	<5.0	<13	3.2
Temperature (°C)	64	28	3.9	17	0.80
Trichloroethene	11	<0.025	0.00070[a]	0.0064[a]	0.0019
Turbidity (NTU)	12	240	10	74	23
Zinc (total)	12	0.040	<0.0080	<0.024	0.0036
		Concentration (pCi/L)			
^{241}Am	18	1.6	−0.23	0.40	0.097
^{244}Cm	10	1.7	−1.6	0.48	0.27
^{60}Co	52	27	−14	8.3	0.87
^{137}Cs	52	320	−11	69	9.3
Gross alpha	30	33	−38	9.5	2.3
Gross beta	40	930	210	450	23
^{238}Pu	18	0.51	−0.068	0.077	0.029
^{239}Pu	18	0.76	−0.30	0.11	0.058
Total Sr	26	380	100	180	18
Tritium	26	430,000	76,000	260,000	22,000

[a]Below detection limit, but estimated.
[b]Not applicable.

Table 2.2.27. 1989 ORNL NPDES Permit Number TN 0002941 (discharge point X13—Melton Branch)

Parameter	No. of samples	Concentration (mg/L)			Std. error
		Max	Min	Av	
Aluminum (total)	12	7.1	<0.050	<1.1	0.56
Ammonia (as N)	12	0.070	0.0090	0.030	0.0045
Arsenic (total)	12	<0.060	<0.050	<0.052	0.0011
Biochemical oxygen demand	12	<5.0	<5.0	<5.0	0
Cadmium (total)	12	<0.0020	<0.0020	<0.0020	0
Chlorine (total) residual	52	<0.010	<0.010	<0.010	0
Chloroform	11	<0.025	0.00050[a]	0.0056[a]	0.0020
Chromium (total)	12	0.027	<0.0030	<0.012	0.0022
Conductivity (mS/cm)	12	1.4	0.10	0.61	0.14
Copper (total)	12	0.23	<0.0040	<0.029	0.018
Dissolved solids (total)	12	280	120	190	14
Flow (Mgd)	249	73	0.40	3.5	0.57
Fluoride (total)	12	1.0	<1.0	<1.0	0
Iron (total)	12	10	0.12	1.1	0.81
Lead (total)	12	0.010	<0.0040	<0.0046	0.00050
Manganese (total)	12	2.1	<0.0020	<0.27	0.17
Mercury (total)	12	0.00010	<0.000050	<0.000056	
Nickel (total)	12	<0.020	<0.0060	<0.0094	0.0015
Nitrate	12	<5.0	<5.0	<5.0	0
Oil and grease	52	88	<2.0	<7.0	2.3
Organic carbon (total)	12	5.1	1.6	2.9	0.29
Oxygen dissolved	52	15	5.1	9.3	0.30
PCBs (total)	11	<0.00050	<0.00050	<0.00050	0
pH (standard units)	12	8.0	6.5	[b]	[b]
Phosphorus (total)	12	0.60	0.10	0.19	0.043
Recoverable phenolics (total)	12	0.0030	<0.0010	<0.0015	0.00026
Silver (total)	12	<0.0050	<0.0050	<0.0050	0
Sulfate (as SO_4)	12	27	12	21	1.3
TSS	12	390	<5.0	<45	32
Temperature (°C)	64	27	1.6	15	0.78
Trichloroethene	11	<0.025	0.00030[a]	0.0046[a]	0.0021
Turbidity (NTU)	12	220	10	92	17
Zinc (total)	12	0.16	<0.0080	<0.028	0.012
		Concentration (pCi/L)			
^{60}CO	12	86	−2.7	25	6.9
^{137}CS	12	27	−16	−0.36	4.1
Total Sr	12	650	190	410	45
Tritium	12	1,800,000	350,000	1,300,000	120,000

[a]Below detection limit, but estimated.
[b]Not applicable.

to moderate stream flows by enhancing percolation to groundwater systems and reducing runoff quantity and rate.

Only two cooling towers, K-1037 and K-1101, are currently operated. They require 800,000 L/d (208,000 gal/d) of makeup water; 600,000 L/d (156,000 gal/d) are evaporated to the atmosphere, and 200,000 L/d (52,000 gal/d) are discharged as blowdown.

Only the K-1407-B NPDES discharge location has changed as a direct result of the closing of the K-1407-B surface impoundment as mandated by the reauthorized RCRA. The K-1407-B pond had been used primarily for flow equalization and settling of solids from neutralization activities.

The K-1407-B pond was removed from service in November 1988, and the permitted NPDES point was split to accommodate the two effluent

Table 2.2.28. ORGDP NPDES permit discharges

Serial discharges	Effluent discharges	Average Flow (gal × 10^6/d)	Receiving stream
K-1700	K-1407-E/F effluent surface runoff once-through cooling	2.76	Poplar Creek
K-1407-J	(Discontinued)		
K-1407-J	Metals cleaning facility Uranium recovery Chemical Process Development Facility TSCA incinerator	0.16	Poplar Creek
K-1407-E/F	Steam plant and coal yard Surface runoff	0.11	Mitchell Branch
K-901-A	Lime-softening sludges from fire water makeup treatment Surface runoff	0.78	Clinch River
K-1203	Sanitary wastewaters Organic industrial wastewaters	0.30	Poplar Creek
K-1007-B	Potable water from once-through cooling systems Fire water from once-through systems Surface runoff	1.19	Poplar Creek
K-1515-C	Water from sludge and backwash systems associated with the potable water plant Surface runoff	0.38	Clinch River

streams from the central neutralization facility. One stream contains small quantities of uranium contamination; the other contains only coal pile and steam plant effluents. In November 1988, the coal pile effluent began discharging through K-1407-E and K-1407-F. The Central Neutralization Facility (CNF) discharges through K-1407-J (Fig. 2.2.5). In September 1989, the K-1407-J discharge was redirected from Mitchell Branch to Poplar Creek in order to eliminate any impact to the Mitchell Branch aquatic community.

Table 2.2.21 lists the TN0002950 NPDES permit limits, number of noncompliances, and percentage of compliance for all ORGDP locations. Overall, a 99.7% compliance rate was maintained with the NPDES permit during 1989. Individual parameters are listed by annual values for all ORGDP NPDES locations in Tables 2.2.85 through 2.2.93 in Vol. 2. The variety of parameters measured at K-1407-J is required to characterize this effluent for new treatment facilities' discharges. Most organics are below detection limits.

The excellent operating record at the K-1203 sewage treatment plant was reflected by only four noncompliances during 1989. The noncompliances occurred when the plant was overloaded because of heavy rains.

It is believed that noncompliances for aluminum at K-1700 and chemical oxygen demand (COD) at K-1007-B are caused by natural

phenomena. These issues will be addressed in the NPDES permit renewal negotiations, which are to occur during CY 1990.

The remaining noncompliances were process-related conditions and were addressed individually. When noncompliances of this type occurred, procedures and field activities were reviewed, and changes were made to help eliminate future occurrences.

Ten noncompliances for iron and two for suspended solids occurred at K-1407-E and F ponds. Quality investigations conducted because of these noncompliances resulted in the revision of the methods and the implementation of polymer addition to enhance the precipitation of iron and suspended solids. Since polymer implementation, noncompliances have decreased and a redesign of the discharge mechanism of the ponds is being investigated to further reduce these occurrences.

Nine noncompliances occurred because of failures to obtain required samples as specified in the NPDES permit. A supervisory position was created exclusively for NPDES sampling in an effort to eliminate these failures.

A policy to conduct quality investigations for each noncompliance was initiated to improve identification of causes and to establish corrective actions.

2.2.2.3 Toxicity control and monitoring program

In accordance with the NPDES permits issued to the Y-12 Plant on May 24, 1985; ORNL on April 1, 1986; and ORGDP on September 11, 1986, each plant was required to develop and implement a TCMP. Under the TCMP, toxicity tests with freshwater animals are conducted to determine a wastewater's no-observed-effect concentration (NOEC). Two EPA-approved toxicity tests are used to estimate a wastewater's NOEC: (1) the fathead minnow (*Pimephales promelas*) larval survival and growth test and (2) the *Ceriodaphnia* survival and reproduction test. These two tests, which are static renewal tests (i.e., the test solutions are replaced daily for each species), are described in detail by Horning and Weber (1985). A wastewater's NOEC is computed by comparing the responses of the animals exposed to a contaminant-free water (control water) with those of animals exposed to various concentrations of the wastewater (dilutions are made with the control water). The NOEC is the concentration of wastewater (expressed as a percentage of full-strength) that does not adversely affect either fathead minnow larvae survival and growth or *Ceriodaphnia* survival and reproduction. Therefore, the higher the NOEC, the better the quality of the wastewater. The wastewater's NOEC is then compared with its anticipated concentration in the receiving stream [the instream waste concentration (IWC)] to predict whether or not the wastewater will adversely affect the aquatic biota.

Y-12 Plant

Description. In accordance with Part III of the NPDES permit issued to the Y-12 Plant, the plant is required to develop and implement a TCMP. Under the TCMP, treated wastewaters CPCF, PRTF, and WETF discharges, untreated wastewaters classified as category IV discharges (catch basin, circuit board rinsewaters, photo rinsewaters, plasma torch, and dye penetrant discharges), and cooling tower blowdown are evaluated for toxicity.

Results. Results of the toxicity tests of watewaters from one treatment facility (WETF), one category IV nontreated wastewater, and one cooling tower are given in Table 2.2.29. For each wastewater, the table shows the month the test was conducted, the NOEC for fathead minnows and *Ceriodaphnia*, and the IWC.

The wastewater from the WETF was tested once during the year. The NOECs for fathead minnows and *Ceriodaphnia* were 15 and 5% respectively. The IWC for this wastewater is estimated to be 0.51, and it is unlikely that the wastewater would adversely affect the aquatic biota of EFPC.

Within the context of the TCMP, the only category IV discharge evaluated during the year was dye penetrant. Wastewater from this facility was tested three times during the year; the NOEC for fathead minnows was 50% for two tests, but the minnows were not used during the December test. The *Ceriodaphnia* were more sensitive to the

Table 2.2.29. 1989 Toxicity test results of Y-12 Plant wastewaters

Discharge facility	Test date	Fathead minnow NOEC[a] (%)	*Ceriodaphnia* NOEC[a] (%)	Instream waste concentration[b] (%)
West End Treatment Facility, outfall 501	Oct.	15	5	0.51
Dye penetrant, category IV	June	50	6	0.078
	Nov.	50	3	
	Dec.	*c*	0.1	
Cooling tower 9409-13	May	100	25	5.4

[a]NOEC = no-observed-effect concentation.
[b]Based on an average flow of 7.4 Mgd discharged from Lake Reality.
[c]Not tested.

wastewater than were the fathead minnows, with NOECs ranging from 0.1 to 6%. However, the NOEC for *Ceriodaphnia* was close to the IWC (0.074%) in only one of three tests. Thus, under average conditions, this wastewater would probably not harm the aquatic biota of EFPC.

Wastewaters from the photographic rinsewater facilities include rinsewater only; fixer and developer solutions are collected separately. These rinsewaters were tested three times during the year as part of a study to evaluate possible forms of pretreatment. No toxicity tests were conducted on untreated photographic rinsewaters in 1989 because the processes did not change from 1988, and elimination of this discharge to UEFPC is in progress.

Cooling tower 9409-13 wastewater was tested once during the year. The wastewater's NOECs for fathead minnows and *Ceriodaphnia* were 100 and 25% respectively. These values are much higher than the average annual IWC (5.4%) for all Y-12 Plant cooling towers.

Oak Ridge National Laboratory

Description. In accordance with Part V of the NPDES permit issued to ORNL, the plant was required to develop and implement a TCMP. Under the TCMP, wastewater from the STP, PWTP, and the coal yard runoff treatment facility (CYRTF) was evaluated for toxicity. In addition, two ambient, instream sites were evaluated; one site is located on Melton Branch (permit point X13) and the other on WOC (permit point X14; see Fig. 2.2.4).

Results. The results of the toxicity tests of wastewaters from three treatment facilities (PWTP, CYRTF, and STP) and two ambient stream sites are given in Table 2.2.30. This table provides, for each wastewater and ambient water, the month the test was conducted and the wastewater's NOEC for fathead minnows and *Ceriodaphnia.* Average water quality measurements obtained during each toxicity test are shown in Table 2.2.31.

The PWTF was tested twice during the year, while the CYRTF and STP effluents were each tested once. The PWTP wastewater's NOEC for fathead minnows and *Ceriodaphnia* ranged from 100% to <80%. The NOEC obtained for the *Ceriodaphnia* during the second test (November 1989) is consistent with the previous year, during which the NOEC for *Ceriodaphnia* was always 80%. Because the NOEC is nearly 4 times the anticipated IWC (21.9%), it is unlikely that the PWTP wastewaters would adversely impact the aquatic biota of WOC. The CYRTF wastewater had a NOEC for fathead minnows and *Ceriodaphnia* of 12% and 25%, respectively. Although this wastewater is more toxic than

Table 2.2.30. 1989 Toxicity test results of ORNL wastewaters

ORNL outfall	Test date	Fathead minnow NOEC[a] (%)	*Ceriodaphnia* NOEC[a] (%)	Instream waste concentration (%)
Coal Yard Runoff Treatment Facility (X02)	Jul.	12	25	3.6
Process Waste Treatment Plant (X07)	Jul.	<80[b]	<80[b]	
	Nov.	100	80	
Sewage Treatment Plant (X01)	Aug.	100	100	
Melton Branch (X13)	Apr.	100	100	
	Apr.	100	100	
	May	100	100	
	Aug.	100	100	
	Nov.	100	100	
	Dec.	100	100	
White Oak Creek (X14)	Apr.	100	100	
	Apr.	100	100	
	May	100	100	
	Aug.	100	100	
	Nov.	100	100	
	Dec.	100	100	

[a]NOEC = no-observed-effect concentration.
[b]Lowest concentration tested.

wastewater from the PWTP, the average IWC is very low (3.6%). Thus, it is unlikely that the CYRTF wastewater tested would affect aquatic biota in WOC. Wastewater from the STP was not toxic to either species at full strength.

The two ambient waters were not toxic to fathead minnows or *Ceriodaphnia.* These two sites were tested six times in 1989 to evaluate area-source contributions to ambient toxicity. A complete summary of survival and reproduction of *Ceriodaphnia* and of survival and growth of fathead minnows in the ambient waters of WOC and its tributaries will be published in the *Fourth Annual Report on the ORNL Biological Monitoring and Abatement Program* (Loar 1990).

Oak Ridge Gaseous Diffusion Plant

Description. In accordance with Part IV of the 1986 NPDES permit modification issued to ORGDP, the plant was required to develop and implement a TCMP. Under the TCMP, wastewater from the K-1407-E and K-1407-F ponds and K-1407-J basins were evaluated for toxicity. The K-1407-E and K-1407-F ponds are discussed as one discharge (K-1407-E/F) because they are filled and discharged alternately.

Results. The results of the toxicity tests of wastewaters from K-1407-E/F and K-1407-J are given in Table 2.2.32. This table provides, for each wastewater, the month the test was conducted and the wastewater's NOEC for fathead minnows and *Ceriodaphnia.* Average water quality measurements obtained during each toxicity test are shown in Table 2.2.33.

Wastewater from the K-1407-E/F pond was tested six times during the year. The NOEC for the fathead minnows was always 100%. The NOEC for the *Ceriodaphnia* ranged from >6% to

Table 2.2.31. 1989 Average water quality parameters measured during toxicity tests of ORNL wastewaters and ambient waters

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

ORNL outfall	Test date	pH (units)	Conductivity (μS/cm)	Alkalinity (mg/L $CaCO_3$)	Hardness (mg/L $CaCO_3$)
Coal Yard Runoff Treatment Facility (X02)	Jul.	7.7	1858	17	1337
Process Waste Treatment Plant (X07)	Jul.	7.9	1113	67	21
	Nov.	7.9	612	70	32
Sewage Treatment Plant (X01)	Aug.	7.9	401	80	147
Melton Branch (X13)	Apr.	7.9	237	110	138
	Apr.	8.1	341	143	184
	May	8.1	309	133	156
	Aug.	8.0	334	132	165
	Nov.	7.9	304	126	156
	Dec.	8.0	285	128	160
White Oak Creek (X14)	Apr.	8.0	287	106	152
	Apr.	8.1	316	120	162
	May	8.1	311	108	146
	Aug.	8.1	355	114	148
	Nov.	7.9	339	114	164
	Dec.	8.1	359	123	163

Table 2.2.32. 1989 toxicity test results of the ORGDP wastewaters

ORGDP outfall	Test date	Fathead minnow NOEC[a] (%)	*Ceriodaphnia* NOEC[a] (%)
K-1407-E/F	Feb.	100	50
	April	100	<25[b]
	June	100	100
	Aug.	100	25
	Oct.	100	12
	Nov.	100	<6[b]
K-1407-J	Feb.	100	12
	March	≥60[c]	≥60[c]
	April	100	50
	June	100	12
	Aug.	50	12
	Oct.	100	6
	Nov.	100	<6[b]

[a]NOEC = no-observed-effect concentration.
[b]This was the lowest concentration tested.
[c]This was the highest concentration tested.

Table 2.2.33. 1989 average water quality parameters measured during toxicity tests of ORGDP wastewater

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

ORDGP outfall	Test date	pH (units)	Conductivity (μS/cm)	Alkalinity (mg/L)	Hardness (mg/L $CaCO_3$)
K-1407-B	Feb.	8.1	3060	98	450
	April	8.1	1800	97	502
	June	8.2	2200	83	409
	Aug.	8.2	3400	200	340
	Oct.	8.2	2200	94	570
K-1407-E/F	Jan.	5.4	1800	12	380
	April	8.2	2200	68	540
	June	8.0	1700	72	340
	Aug.	9.4	2200	69	650
	Oct.	8.0	2800	75	720
	Dec.	7.8	2800	78	760

100%. The NOEC of 100% for *Ceriodaphnia* corresponds to the test period during which the wastewater had low conductivity and hardness (compared to the other tests periods). Because the IWC of this wastewater may be 100% during dry periods, the results of the toxicity tests show that the wastewater may adversely affect the aquatic biota in Mitchell Branch.

Wastewater from the K-1407-J basin was tested seven times during the year. The NOEC for the fathead minnows was less than 100% twice during the year. The NOEC for the *Ceriodaphnia* ranged from <6% to >60%, with an average for those tests that were definitive of 18.4%. Beginning in September 1989, this wastewater was discharged to Poplar Creek where it has an IWC of approximately 1%. Therefore, it is unlikely that this wastewater will adversely affect the aquatic biota in Poplar Creek.

2.2.2.4 Mercury assessment of ORNL streams

The mercury monitoring plan was designed to identify, locate, and minimize all sources of mercury contamination into ORNL waters. The 1989 monitoring data combined with the 1988 and the 1987 scoping survey data have accomplished the first two objectives. The latter objective is more elusive because most sources are the results of periodic spills. The data base is now sufficient to recommend the elimination of nonstrategic sampling locations.

Water and sediments were sampled semiannually during the first and fourth quarter of 1989. Three replications were collected at each sample site. During the first quarter, 91 stations or locations were sampled for water for a total of 273 samples (Figs. 2.2.10 and 2.2.11). This is in comparison with 88 stations and 264 samples during the fourth quarter. Of the 91 stations sampled during the first quarter, 15 (16%) had detectable mercury. The highest among these was near Outfall 367 with a concentration of 3.03 ± 0.34 ppb. The analytical detection limit was 0.05 ppb and, at the background location (headwaters of White Oak Creek), mercury was not detectable. Outfall 367 discharges into Fifth Creek east of Building 3036, the Isotope Area Storage and Service Building. During the spring and fall quarters of 1988 this station reported concentrations of 1.17 ± 0.03 and 1.87 ± 0.17 ppb respectively. During the fourth quarter of 1989 mercury was not detectable at this location. This highest concentration (0.37 ± 0.01 ppb) observed during 1989 was near Outfall 341, which discharges into First Creek.

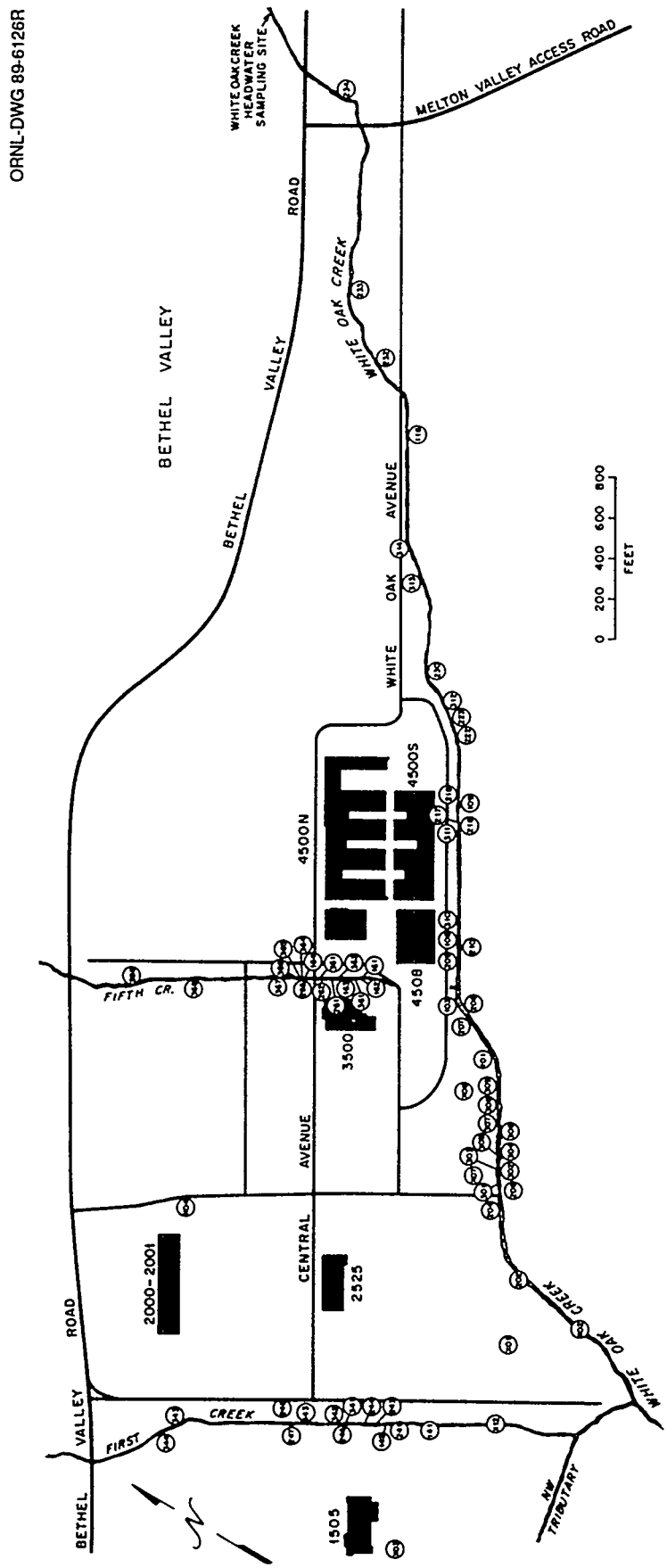

Fig. 2.2.10. Map of water sampling locations for mercury in the ORNL area. The circled numbers show the sample locations.

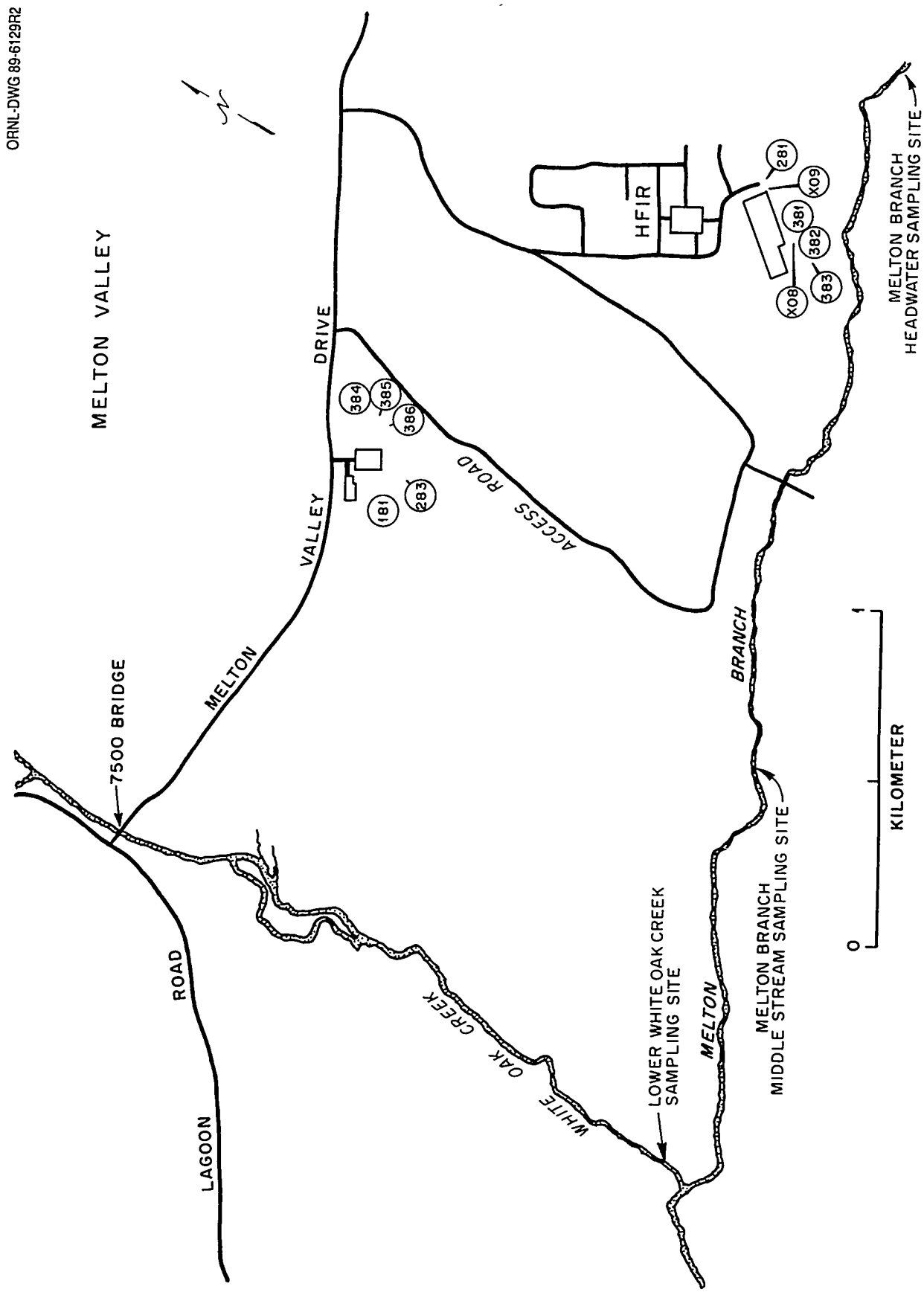

Fig. 2.2.11. Map of water sampling stations for mercury in the ORNL Melton Valley complex. The circled numbers show the sample locations.

Twelve stations were sampled for sediments during the spring quarter in contrast to 14 stations during the fall quarter. The two additional stations sampled in the fourth quarter represented a background location from the headwaters of Melton Branch and a site below the confluence of White Oak Creek and Melton Branch. Figures 2.2.12 and 2.2.13 show the locations of elevated mercury concentrations. The maximum concentration (spring quarter) detected was below Outfall 261 with a mean of 555.67 ± 310.38 ppm; this is a factor of 8 less than the concentration reported in 1988. White Oak Creek headwaters (background) sediments contained 0.02 ± 0.003 ppm. Outfall 261 enters Fifth Creek from east of Building 3500. In the fourth quarter, this location had a concentration of 7427 ppm. The second highest contaminated areas were below Outfall 362 and in the catchment box below Outfall 362, with first quarter concentrations of 23.03 ± 2.83 and 155.81 ± 131.57 ppm, respectively, and fourth quarter concentrations of 112.43 ± 47.17 and 5.67 ± 0.54 ppm, respectively.

Sediments below Outfall 261 were collected from 0–5-, 5–10-, 10–15-, and 15–20-cm depths along a distance gradient from 0 to 0.5 m from the outfall. Three replications were collected at each depth/distance combination. The data are illustrated in Fig. 2.2.14, with a maximum concentration of 21,500 ppm noted at 0.25 m from the outfall within the top 5 cm. The data suggest that the mercury present at this location represents a past spill with no recent deposition.

Data from each 5-cm-thick layer, along the 0.5-m-long by 0.02-m-wide plume, were used to calculate the total mercury present from a sediment/soil bulk density of 1.4 g/cm^3. It is estimated that 52 g is in the 0–5-cm layer, 3 g in the 5–10-cm layer, 5 g in the 10–15-cm layer, and

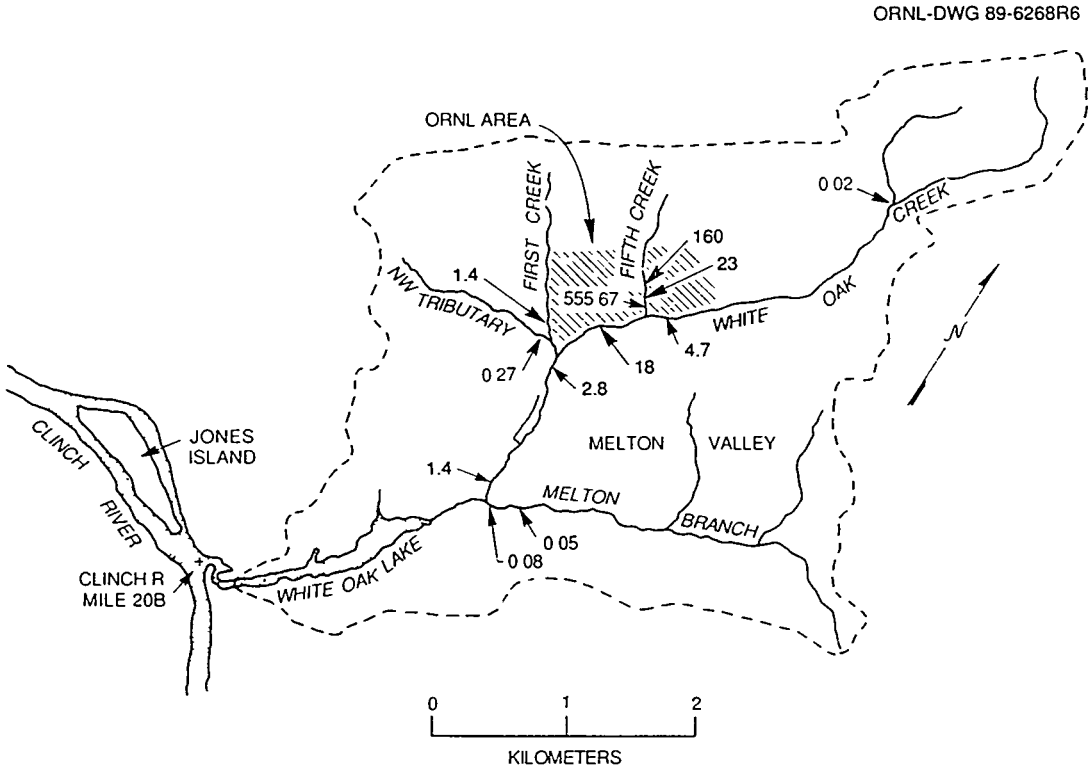

Fig. 2.2.12. Map of locations in ORNL streams with excess mercury in sediments. Units are μg/g (ppm). Data represent first quarter 1989.

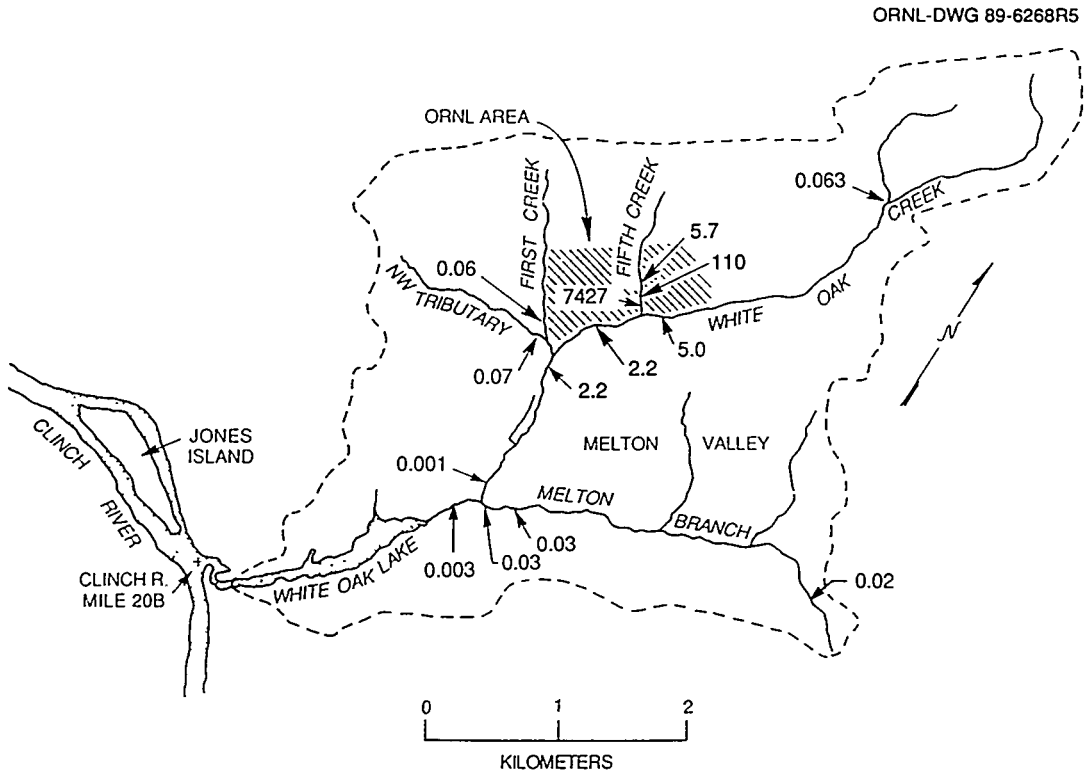

Fig. 2.2.13. Map of locations in ORNL streams with excess mercury in sediments. Units are μg/g (ppm). Data represent fourth quarter 1989.

2 g in the 15–20-cm layer for a total of 62 g. This area represents the maximum potential for mercury to enter receiving waters from a known stationary source.

2.2.2.5 Polychlorinated biphenyls in the aquatic environment

A PCB monitoring plan was developed and implemented in compliance with the Clean Water Act and the ORNL NPDES permit to assess their potential movement in drainage systems and the potential for reaching area receiving waters. To establish a base-line for environmental concentration data, duplicate water samples were collected quarterly and sediments semiannually from locations depicted in Fig. 2.2.15 and Fig. 2.2.16. Summary data by sampling station are presented in Table 2.2.94 in Vol. 2. The concentrations of PCBs (by Aroclors) in 1989 were below the analytical detection limit at all sampling locations. The quantitative detection limit is 0.6 μg/L for PCB Aroclors 1016, 1221, 1232, 1242, and 1248. The detection limit is 1.2 μg/L for PCB Aroclors 1254 and 1260. Some concentrations are reported because the presence of several compounds was detected qualitatively. From 568 water samples representing four sampling quarters, PCBs were detected in only 1.6% of the samples. Aroclor-1254, usually associated with electric transformers, was the only mixture detected. Estimated concentrations from Stations 01 and 02 (0.2 and 0.3 μg/L) represent discharges from the Building 2026 area into White Oak Creek during the second quarter. During the same period, approximately 0.9 μg/L was estimated from one replicate sample from Station 05. Station 05 is located on White Oak Creek south of the 6000 area and represents discharges from Buildings 6000 and 6010. During the fourth quarter, Aroclor-1254 was detected at Stations 01, 02, and 03. Station 02 is located at the mouth of the drainage from the sewage treatment plant (Building 2521) into White Oak Creek. The

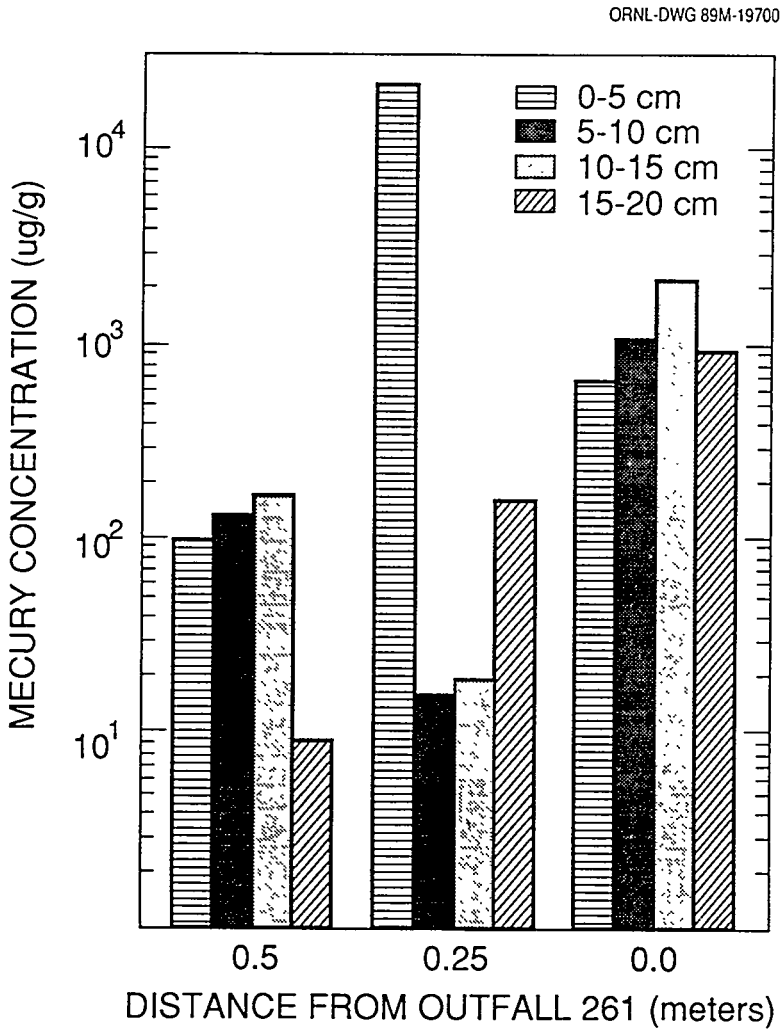

Fig. 2.2.14. 1989 Mercury concentrations in sediments along a distance gradient to a depth of 20 cm of Outfall 261.

estimated concentration for both replicates was 0.3 μg/L. Station 03 is located on White Oak Creek with probable inputs from the Building 4500-S research complex. The estimated concentration was 0.5 μg/L from one replicate.

Of the 189 sediment samples, PCBs were detected in 14 samples (7.4%). Aroclors 1254 and 1260 were the only mixtures detected. These data are shown in Fig. 2.2.17 and summarized in Table 2.2.34. During the first quarter, 0.35 μg/g (Aroclor-1254) was estimated at Station 06, and 0.5 μg/g was estimated at Station 10. Station 06 is located at the 7500 weir and represents major sediment depositions from the entire ORNL area. Station 10 represents depositions from Melton and Bethel valley sources. During the fourth quarter, Aroclor-1254 was detected at Stations 06, 07, 09, 10, 12, 13, and 14. The increase of PCB presence during the fourth quarter may be related to increased exchange sites associated with early foliage senescence and increased organic matter accumulation. Aroclor 1260 was detected at 1.9 μg/g at Station 06 and 0.34 μg/g at Station 10 during the fourth quarter sampling.

Because total organic carbon (TOC) is a direct measure of the organic carbon present, the relationship of TOC and PCB was evaluated. During both sampling periods, TOC contents were

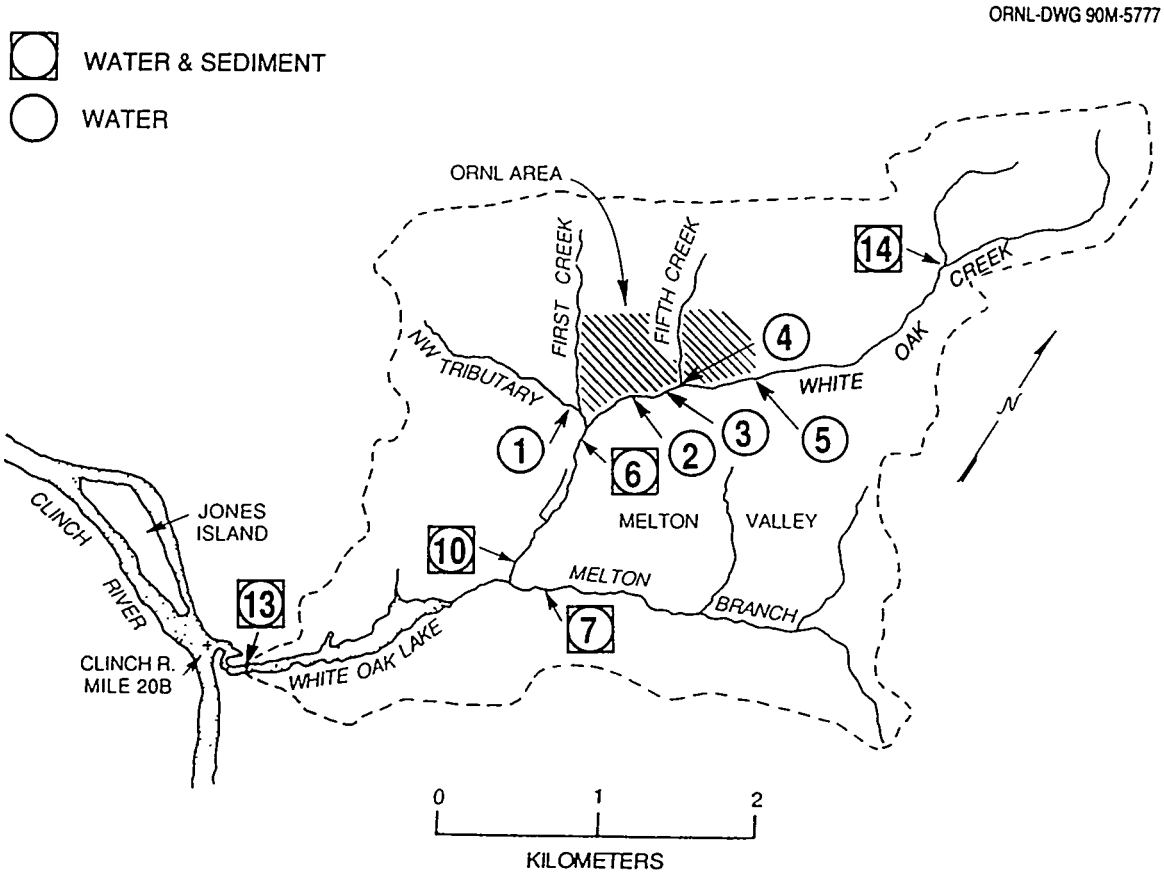

Fig. 2.2.15. Sample locations for PCB and TOC (sediment only) analyses in the ORNL area.

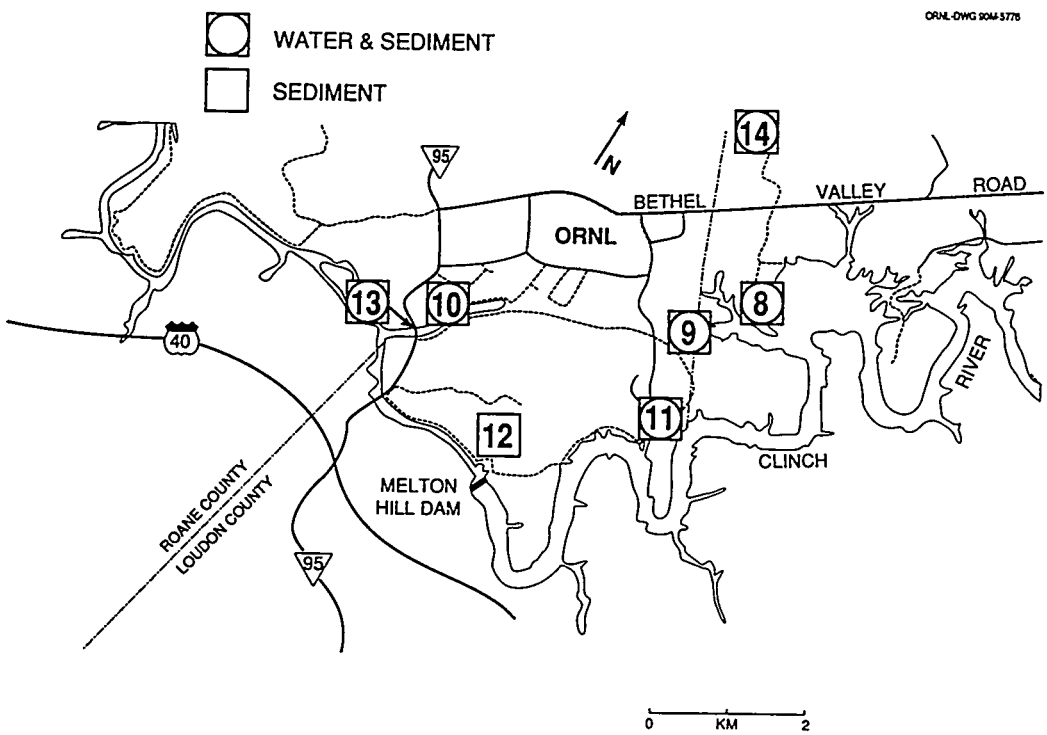

Fig. 2.2.16. Sample locations for PCB and TOC (sediment only) analyses in the greater ORNL area.

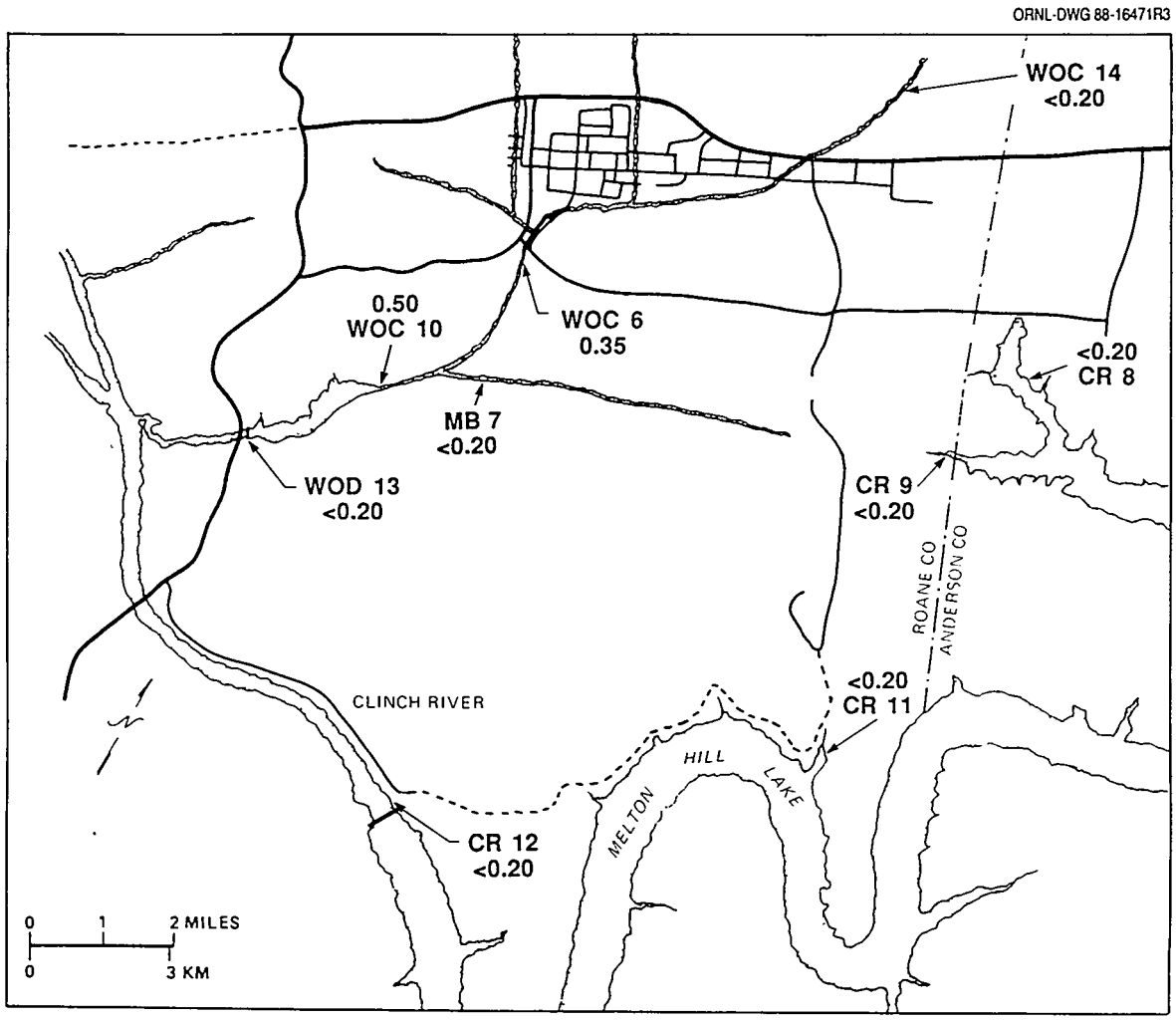

Fig. 2.2.17. PCB Sampling locations and sediment sample results (mg/g).

Table 2.2.34. Summary of ORNL PCB concentrations in sediment in the ORNL area, May through October 1989

Analysis	No. of samples	Concentration (μg/kg)			
		Max	Min	Av	Std. error
PCB-1016	27	<2600	<81	<470	120
PCB-1221	27	<2600	<81	<470	120
PCB-1232	27	<2600	<81	<470	120
PCB-1242	27	<2600	<81	<470	120
PCB-1248	27	<2600	<81	<470	120
PCB-1254	27	3400	~13	~490	150
PCB-1260	27	<5300	~94	~910	240

similar among sites. The first quarter minimum was 0.33%, as compared with a maximum of 4.3% and a mean of 2.3%. TOC during the fourth quarter ranged from 0.38 to 5.5%, with an average of 2.3%. A correlation between TOC and sediment PCB concentration was not possible, because PCBs were not detected in 93% of the samples.

2.3 GROUNDWATER

The quality of our nation's water resources is seen as a serious and pressing issue, and public awareness of the need to protect these resources has increased dramatically in this decade. Public sentiment is reflected in legislation enacted by Congress mandating that actions be taken to preserve water resources from contamination. These statutes have been codified into regulations by the EPA and equivalent programs on the state level. Two such programs promulgated by Congress and administered by the state of Tennessee and the EPA are the RCRA and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), which specifically target the protection of groundwater from contamination by hazardous wastes. These regulations guide groundwater monitoring at the DOE plants in Oak Ridge.

Groundwater suitable for most uses is potentially available in nearly all communities in Tennessee. About 51% of Tennessee's population depends on groundwater for household use. Most groundwater use occurs in the western quarter of the state; however, interest in additional development of groundwater resources is increasing in middle and eastern Tennessee (*National Water Summary 1986*). To date, no systematic study of the number of groundwater users in the immediate vicinity of the ORR has been conducted. However, it is known that in rural areas the number of individuals dependent on groundwater resources is substantial.

2.3.1 Regulatory Requirements

RCRA interim status and permit monitoring programs.

RCRA, as amended, recognizes three distinct programs that require groundwater studies: RCRA interim status, RCRA permit programs, and the RCRA 3004(u) program. Interim status requirements apply to facilities that treat, store, or dispose of hazardous waste if the facilities existed on November 19, 1980, or if the facilities became subject to permitting requirements because of new regulatory requirements. The facilities remain in interim status until a Part B operating or postclosure permit is issued. Two types of groundwater monitoring may be required while a facility is under interim status:

- Detection monitoring [defined in 40 CFR 265.91 and 265.92, and TN 1200-1-11-.05(6)] may be required to determine if hazardous waste or hazardous waste constituents have entered the groundwater underlying the facility. If so, then
- Assessment monitoring [defined in 40 CFR 265.93(a) and TN 1200-1-11-.05(6)(d)] will be required to define the rate, extent, and concentration of hazardous waste or hazardous waste constituents that have entered the groundwater from a facility suspected of or known to be leaking.

Interim status facilities must file a Part B operating permit application or postclosure permit application to the regulatory authority. At the time of issuance of the permit, a facility shifts from an interim status monitoring program to the appropriate permit monitoring program required in the facility permit, as illustrated in Fig. 2.3.1. Where no groundwater contamination has been found, detection monitoring will continue with minor modifications [40 CFR 264.98 and TN 1200-1-11.06(b)(i)]. Sites with groundwater contamination will begin either compliance monitoring or corrective action monitoring depending on whether or not an approved corrective action plan is ready to be implemented.

RCRA 3004(u) monitoring program. Section 3004(u) was added to RCRA as an amendment in 1984 to require corrective action for all releases of hazardous constituents from any solid waste management unit at any facility seeking a permit. The 3004(u) program requires that sites be characterized to determine whether there is a threat to human health and/or the environment. Should a review of available data indicate a

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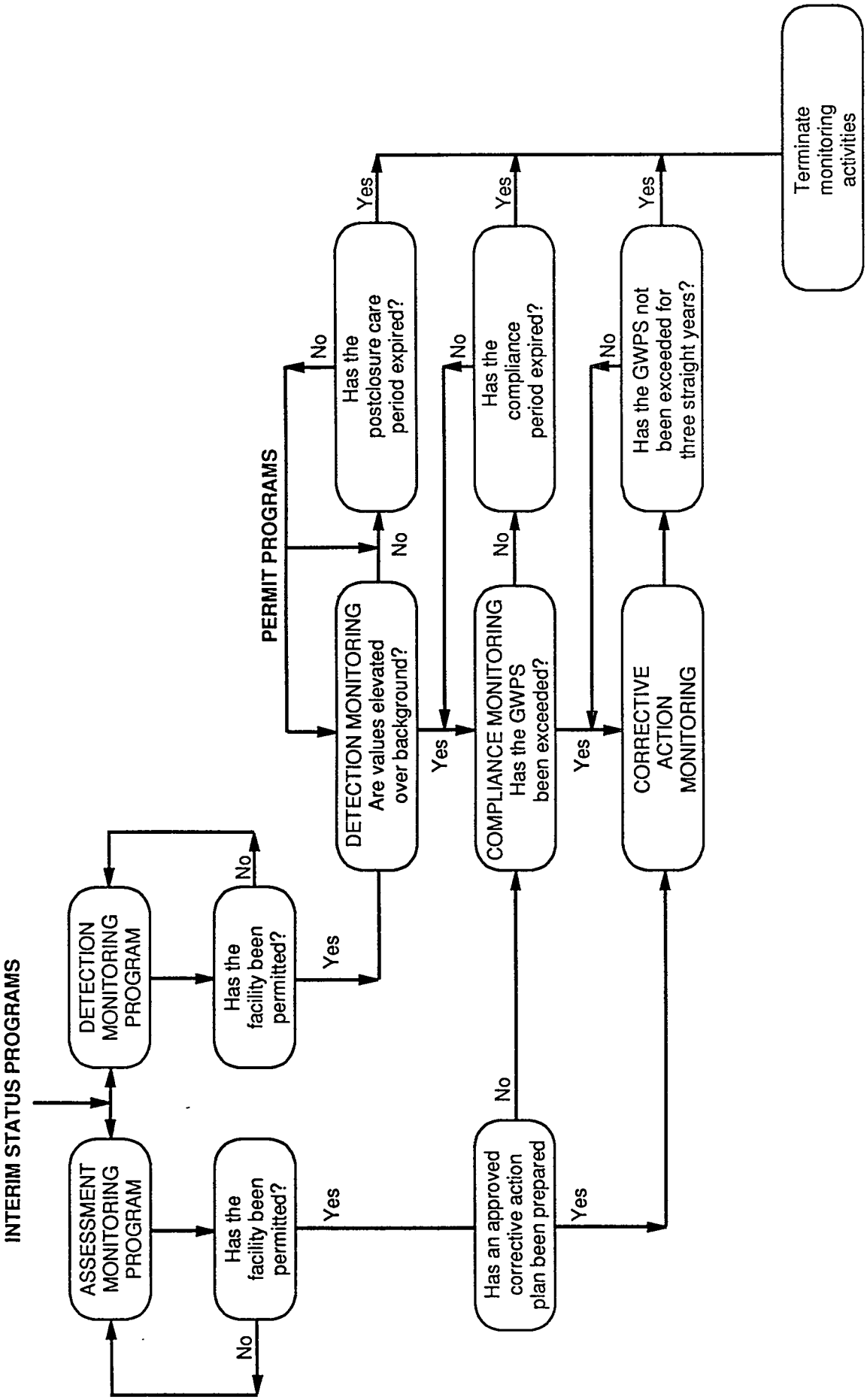

Fig. 2.3.1. Relationship between interim status monitoring and permit monitoring programs.

potential for contamination, groundwater monitoring would be necessary to evaluate that medium as an exposure pathway and for design of corrective measures.

The regulatory status and pertinent data regarding the current groundwater monitoring program being conducted at each hazardous waste unit are summarized for each site, the Y-12 Plant, ORNL, and ORGDP, in later sections of this report.

Groundwater surveillance monitoring program on the ORR. The technical objectives of groundwater monitoring under either the detection or assessment monitoring programs are similar in nature:

- collect piezometric head (water level) measurements to estimate the direction of groundwater flow,
- obtain representative water samples from the geologic strata,
- determine the reference water chemistry of each hydrogeologic unit from analysis of samples collected upgradient of waste disposal areas,
- evaluate the current impact of waste disposal activities on the groundwater through a comparison of analyses from samples collected upgradient and downgradient of the disposal area,
- identify the hazardous waste or hazardous waste constituent(s) present should contamination be detected, and
- delineate the extent of contamination and the rate of migration.

The groundwater surveillance monitoring program being implemented at the DOE facilities has been designed to obtain full compliance with regulatory requirements and the aforementioned technical objectives. Site-specific regulatory monitoring programs are supported technically by extensive site characterization and regional studies of the geohydrologic and chemical aspects of the flow system. Stringent quality control procedures for every aspect of data collection and analysis have been established, and computer data bases optimize organization and distribution of the analytical results.

Thus, the groundwater surveillance monitoring program for the ORR, while disposal site- and facility-specific, contains a number of common components (Fig. 2.3.2) that are interrelated and must be coordinated to allow both time- and cost-effective project management.

2.3.2 Groundwater Occurrence

Most of the information summarized in this section is from *Concepts of Groundwater Occurrence and Flow Near Oak Ridge National Laboratory, Tennessee,* published as ORNL/TM-10969 (Moore 1988). Groundwater comes from precipitation on the ORR. Under established vegetation, the land surface is very permeable, and nearly all precipitation infiltrates. Exceptions occur in a few areas with urban features and in a few small areas of wetlands, water bodies, and barren lands. The majority of infiltration [about 76 cm/year (30 in./year) of water] replenishes soil moisture within the root zone of vegetation and is later consumed by evapotranspiration. The remaining 56 to 62 cm (22 to 24 in.) of water in an average year moves through the ground to discharge locations at seeps, springs, and streams. Most springs are wet-weather types. Thus, most groundwater discharge ceases after a few days to weeks of dry weather, and changes in streamflow are accompanied by changes in the total length of flowing channels. Except for water imported by pipelines from Melton Hill reservoir, which after use is discharged to streams from wastewater treatment plants, nearly all streamflow is groundwater discharge.

Groundwater occurs in a stormflow zone from land surface to a depth of 1 to 2 m (3.3 to 6.6 ft) and in a zone from the water table to the base of fresh water (Fig. 2.3.3). Prolonged or intense precipitation forms a perched water table in the stormflow zone. Groundwater then moves laterally through the stormflow zone or percolates down through the vadose zone to the water table. The perched water table and the resulting groundwater flow are transient beneath the hills but may be nearly perennial at valley edges. The stormflow

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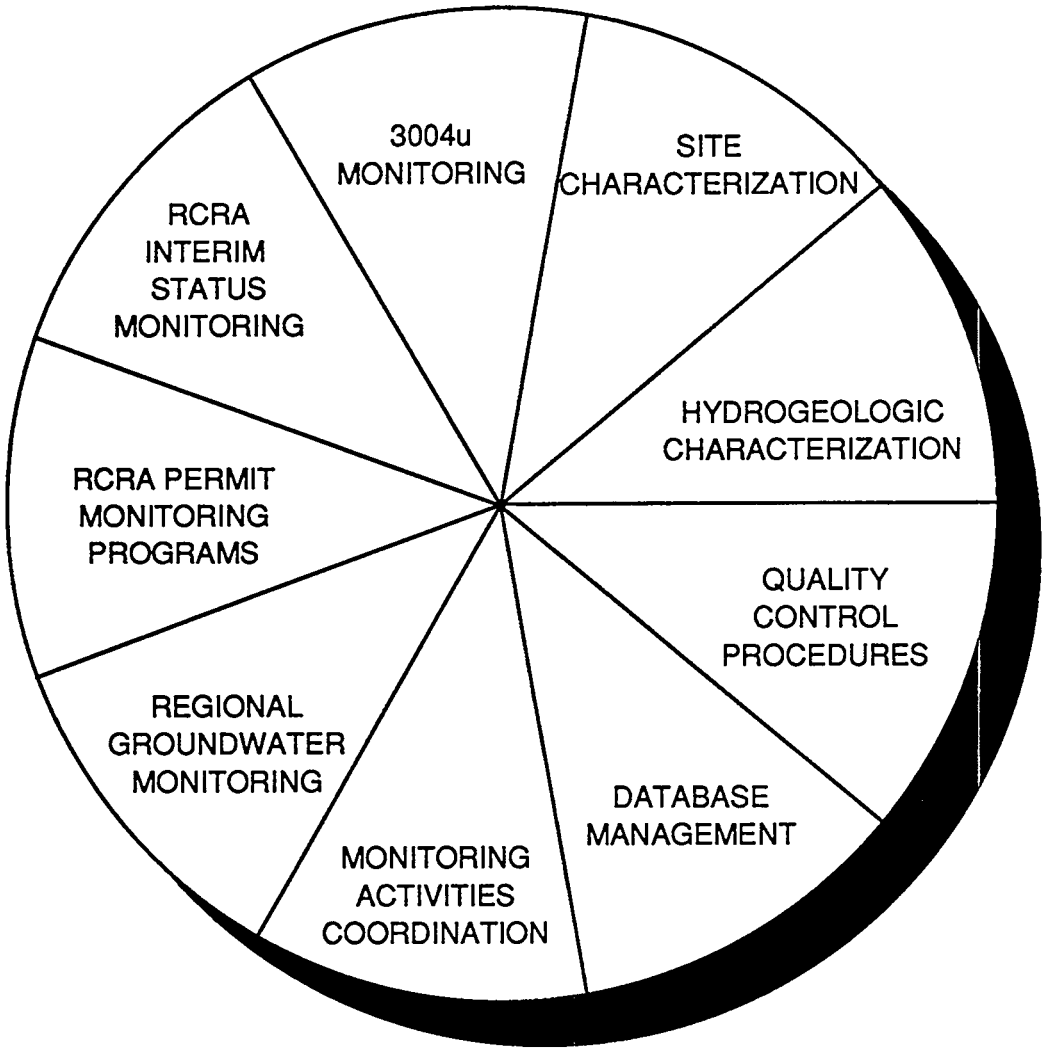

Fig. 2.3.2. Components of Oak Ridge Reservation groundwater surveillance program.

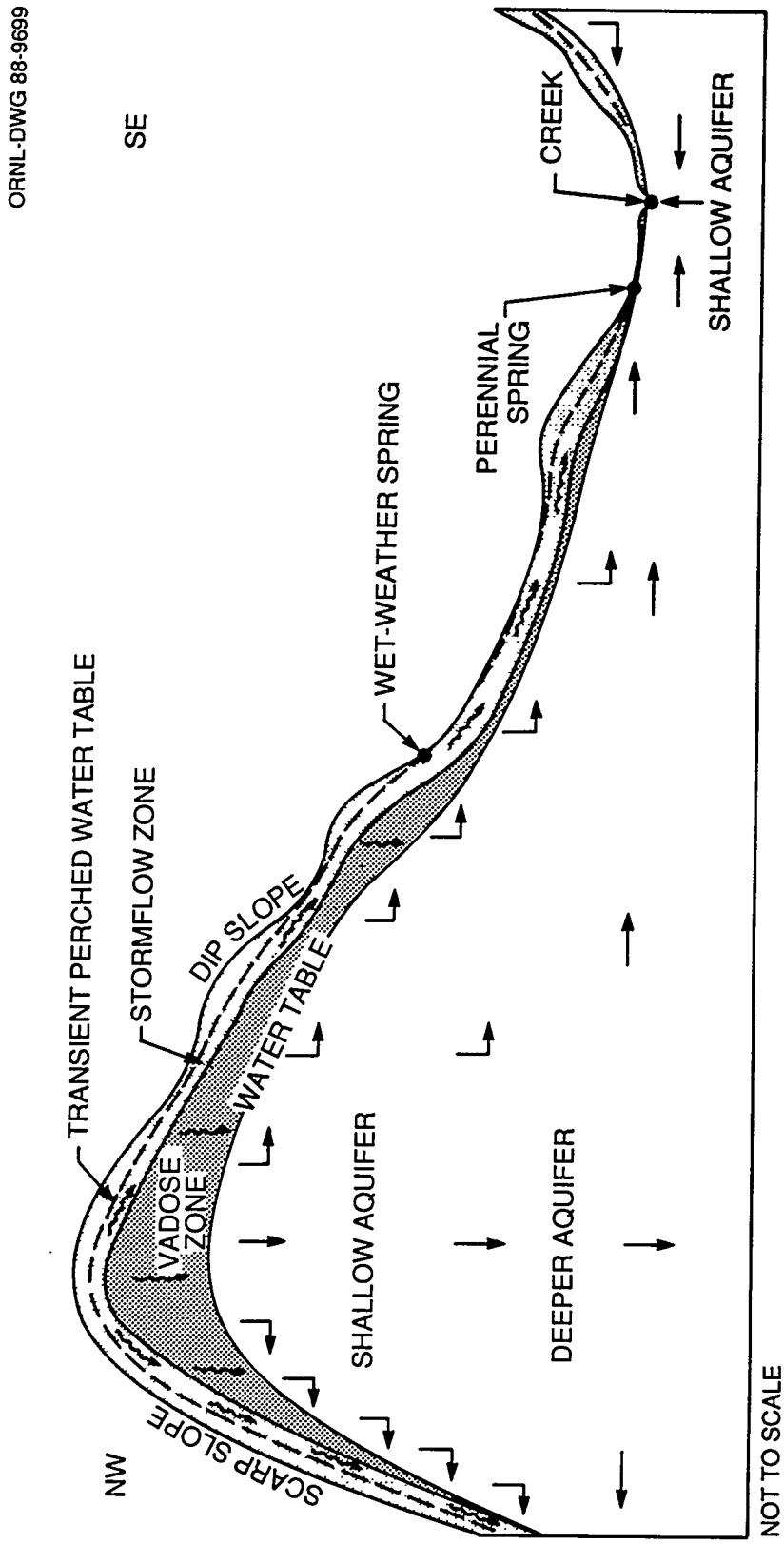

Fig. 2.3.3. Occurrence and flow of groundwater on the Oak Ridge Reservation.

zone is an average of about 1000 times more permeable than underlying material, and a large majority of all groundwater flow is in this zone.

Groundwater storage is intergranular in the stormflow zone, and effective porosity (decimal fraction volume of water that will drain by gravity) is about 0.1. The dominant openings for lateral groundwater flow and vertical drainage are macropores and mesopores. The configuration and pattern of these larger openings are unknown, but lateral flow paths generally follow the slope of the land surface. Average linear velocity is about 3 m/d (10 ft/d) for lateral flow toward downslope springs and streams.

A thin vadose zone generally separates the stormflow zone and the shallow aquifer, but the water table is within the stormflow zone near discharge locations. The geometric mean depth to the water table in October is 4.1 m (13.4 ft) in areas underlain by the Conasauga and Chickamauga Groups. The water table generally is deeper in areas underlain by the Knox Group; it is 30 to 50 m (98 to 164 ft) below land surface at a few locations on Chestnut Ridge.

The openings for groundwater flow in the vadose zone are fractures and a few cavities; effective porosity is probably about 0.003. Most flow paths are nearly vertical, and average linear velocity is in the range of 0.1 to 1 m/d (0.3 to 3.3 ft/d). However, cavities occur above or at the water table in a few areas, and lateral flow rates of 20 to 200 m/d (66 to 660 ft/d) have been documented. Cavities of this type are rare and occur only where the water table is below the top of a limestone or dolostone bedrock.

The openings for groundwater flow below the water table are fractures and cavities. The effective porosity of these openings is about 0.003 at shallow depths and may be in the range of 1E-5 to 5E-4 at deeper levels. Water-bearing fractures are ubiquitous below the water table, but enlarged fractures and cavities are common only at shallow depths. These enlarged openings are the targets for wells and constitute the water-producing intervals in wells. The geometric mean of hydraulic conductivity (a measure of aquifer permeability) is 0.041 m/d (0.13 ft/d) for the water-producing intervals but is only 0.00044 m/d (0.0014 ft/d) for other intervals and deeper levels. The shallow aquifer (Fig. 2.3.3) is characterized by the occurrence of water-producing intervals but generally consists of several water-producing intervals in otherwise relatively impermeable material. In areas underlain by the Conasauga and Chickamauga groups, the shallow aquifer extends to a depth of 20 to 30 m (65 to 100 ft). In the Knox Group, enlarged openings are common at depths of 30 to 60 m (100 to 200 ft), and one cavity was reported at a depth of 96 m (315 ft). The average linear velocity of groundwater flow is about 1 cm/d to 1 m/d (0.03 ft/d to 3.3 ft/d) in the shallow aquifer.

Groundwater is unconfined near the water table, but there is a gradual change to confined conditions at deeper levels. Flowing wells occur in a few areas, and water levels in some of the deeper wells respond to earth tides and other loading forces. The geometric mean depth of the first water-producing interval in the Conasauga and Chickamauga groups is 8.2 m (27 ft), the average thickness of an interval is 3.9 m (12.8 ft), and the geometric mean of the vertical spacing between intervals is 10.4 m (34 ft). Similar information is not available for the Knox Group. Cavities may occur in all units that have limy layers but are more common in the Knox Group. Both the lateral and vertical spatial frequency of cavity occurrence are about four times larger in the Knox Group than in the Rome Formation, the Conasauga Group, and the Chickamauga Group. Based on relatively few data, cavities below the water table have a geometric mean hydraulic conductivity that is not significantly larger than that of other water-producing intervals.

Flow paths in the shallow aquifer are complex. Along a single fracture, groundwater may flow downdip and laterally in either or both of two directions. Changes in flow direction are common at fracture intersections, as are splits and joins of the flow paths. The flow paths that connect any two points in the aquifer are more likely to be tortuous than linear, and other flow paths intersect only one of the points. Thus, hydraulic gradients cannot be determined easily, and a contaminant introduced at one point in the aquifer may eventually occur in all fractures within a

semicylindrical volume of the aquifer. Nevertheless, flow paths generally trend toward lower elevations and discharge to springs and streams. Groundwater in the shallow aquifer flows into the stormflow zone near these locations.

Fractures in the deeper aquifer have a geometric mean hydraulic conductivity about 0.01 times as large as in the shallow aquifer. Thus, only about 10% of the groundwater that reaches the shallow aquifer follows flow paths through the deeper aquifer. This water eventually flows upward, back into the shallow aquifer, near discharge locations. Brine, which probably is connate, occurs at depths below about 150 m (492 ft) in Melton Valley, and this is the approximate base of the deeper aquifer. Elsewhere, however, brine does not occur in wells at depths of 120 m (394 ft) in Bear Creek Valley, and only two wells at this depth produce an alkaline, sodium carbonate water that may be a transitional type. Neither brine nor a sodium carbonate water has been identified in wells up to 75 m (246 ft) deep in Bethel Valley. Thus, the base of fresh water has not been determined in most of the ORR area.

2.3.3 Groundwater Monitoring Well Systems

The ORR has more than 1000 groundwater monitoring wells. Because of the enormous volume of data taken annually from these wells, only the results that do not meet applicable standards are shown in this report. Tables 2.3.1–2.3.11 in Vol. 2 outline the applicable standards and depict levels of parameters found in groundwater that do not meet the standards.

2.3.3.1 Oak Ridge Y-12 Plant

The Y-12 Plant comprehensive groundwater program consists of several parts: monitoring to meet permit requirements, characterization at or surrounding particular sites and areas, and the use of all data to determine the overall water quality and flow patterns in the area.

Each land based waste disposal facility operated by the Y-12 Plant has a network of groundwater monitoring wells that consists of at least one well hydraulically upgradient and three wells downgradient from the facility. Water samples are collected from these wells and analyzed each quarter or at a frequency consistent with EPA and TDHE requirements. Chemical parameters are chosen to meet regulatory requirements of both agencies and to acquire water chemistry data for interpretation of groundwater types and flow patterns.

The 1989 groundwater surveillance program is summarized in Tables 2.3.1, 2.3.2, and 2.3.3. Detailed groundwater constituent data are presented in Table 2.3.12 in Vol. 2 of this report. During 1989, 221 wells were routinely sampled. Figures 2.3.4 and 2.3.5 show the locations of the various waste disposal sites in the vicinity of the Y-12 Plant.

Groundwater monitoring at RCRA interim status facilities

Seven sites were under RCRA interim status monitoring in 1989: S-3 Site (S-3), Chestnut Ridge Security Pits (CRSP), New Hope Pond (NHP), Chestnut Ridge Sediment Disposal Basin (CRSDB), Kerr Hollow Quarry (KHQ), Bear Creek Burial Grounds (BCBG) area (includes the Oil Retention Ponds), and the Oil Landfarm Area (OLF). Five of these sites (S-3 Site, Oil Landfarm, BCBG, NHP, and CRSP) were in assessment monitoring during all of 1989. RCRA groundwater quality assessment plans (GWQAP) were prepared for these sites in accordance with TDHE regulations. Assessment monitoring is conducted according to each site's GWQAP. Monitoring results are compiled and presented in annual groundwater quality assessment reports (GWQAR). The format for presenting the 1989 GWQARs was modified at four sites to accommodate both the voluminous data reduction and data evaluation process and the integration of additional monitoring data. Because plumes from various waste management units have intermingled, the scope of the S-3 Site, OLF, BCBG, and NHP GWQARs has been increased. The three Bear Creek hydrogeologic regime (BCHR) site, (S-3 Site, OLF, and BCBG) were incorporated into a single report that addressed contaminant releases noted during the course of other site-specific monitoring activities also in the Bear Creek

Table 2.3.1. Summary of groundwater surveillance program at the Y-12 Plant site, 1989

Unit name	Regulatory status	Current groundwater monitoring program						Parameters monitored[a]	Monitor wells	Sampling frequency
		Interim status		Permit						
		Detection	Assessment	Detection	Compliance/ corrective action	Operating	3004(u)			
Bear Creek										
Burial Grounds	RCRA	1985	1986	*b*			*b*	3–7, 10, 11	36	Quarterly
LLWDDD lysimeter demonstration site								1–11	6	Quarterly
LLWDDD packaging site								2–7, 10, 11	5	Quarterly
Beta-4 security pits[c]	3004(u)	*b*		*b*			1985	3, 11	6	Semiannual
Chestnut Ridge Security pits	RCRA	1985	1988	*b*			*b*	3–7 10, 11	11	Quarterly
Chestnut Ridge Sediment disposal basin	RCRA	1985		*b*			*b*	2–7, 10, 11	8	Quarterly
East Chestnut Ridge Waste pile	RCRA	*b*				1988	*b*	3, 11	5	Semiannual
Fly ash pond	3004(u)	*b*		*b*				1–11	4	Quarterly
Industrial landfill III	3004(u)	*b*		*b*			1988	2–7, 10, 11	7	Quarterly
Industrial landfill IV	3004(u)	*b*		*b*			1988	2–7, 10, 11	5	Quarterly
Kerr Hollow Quarry	RCRA	1985		*b*			*b*	3, 11	7	Quarterly
New Hope Pond	RCRA[d]	1985	1988	*b*			*b*	3–7, 10, 11	17	Quarterly
Oil landfarm area	RCRA	1985	1986	*b*			*b*	3–7, 10, 11	24	Quarterly
Rogers Quarry[c]	3004(u)	*b*		*b*			1985	2–6, 10, 11	4	Annual

Table 2.3.1 (continued)

Unit name	Regulatory status	Current groundwater monitoring program: Interim status: Detection	Interim status: Assessment	Permit: Detection	Permit: Compliance/corrective action	Permit: Operating	Permit: 3004(u)	Parameters monitored[a]	Monitor wells	Sampling frequency
Rust spoil area	3004(u)	*b*		*b*			1987	2–8, 10, 11	7	Quarterly
Sanitary Landfill II						1986		1–7, 9	3	Semiannual
S-3 Ponds										
S-3 Ponds	RCRA	1985	1986	*b*			*b*	3–7, 10, 11	39	Quarterly
Salvage yard/OSDS[c]	3004(u)	*b*		*b*			1985	2–7, 10, 11	7	Quarterly
Spoil Area I	3004(u)	*b*		*b*			1987	2–7, 10, 11	5	Quarterly
United Nuclear landfill	3004(u)	*b*		*b*			1985	2–4, 6, 10, 11	5	Quarterly
Waste Coolant Facility								1–11	8	Quarterly
9754-2 Fuel Facility								1–11	5	Quarterly

[a]See the following tables for parameters monitored.

1. Primary drinking water parameters (Table 2.3.1 in Vol. 2).
2. Parameters establishing groundwater quality (Table 2.3.2 in Vol. 2).
3. Indicator parameters (Table 2.3.3 in Vol. 2).
4. Metals analyzed by inductively coupled argon plasma (Table 2.3.4 in Vol. 2).
5. Metals analyzed by atomic absorption spectroscopy (Table 2.3.5 in Vol. 2).
6. Anions (Table 2.3.6 in Vol. 2).
7. Volatile organics (Table 2.3.7 in Vol. 2).
8. Pesticides and PCBs (Table 2.3.8 in Vol. 2).
9. Acid-base/neutral extractable organics (Table 2.3.9 in Vol. 2).
10. Radionuclides and radioactive metals (Table 2.3.10 in Vol. 2).
11. Other parameters (Table 2.3.11 in Vol. 2).

[b]Not applicable.
[c]Wells installed for plant site characterization program; authority transferred to 3004(u) in 1986.
[d]Site is treated like a RCRA site.

Table 2.3.2. Summary of Y-12 Plant groundwater analyses during 1989

Analytical procedure	No. of samples run	No. of items reported
Elemental analyses		
ICAP	1,488	18,541
AAS	1,386	6,129
Hg	962	962
U	1,497	1,497
Inorganic analyses	768	6,710
Phenols	287	287
Organics		
Volatile	674	22,881
Acid/base-neutral	71	4,485
Herbicides, pesticides, and PCBs	79	2,204
Field measurements	781	3,896
Laboratory replicates		
Conductivity and pH	784	6,234
TOC and TOX	321	2,742
Radiochemical analyses		
Gross alpha and beta	714	1,428
Radium	445	451
Alpha emitters	28	128
Beta emitters	94	755
Total	10,379	79,330

Table 2.3.3. Y-12 Plant sites submitted for RFI plans for 1989

Solid waste management units	Site designation	Groundwater monitoring
Nitric Acid Pipeline	*a*	*b*
SY-200 Yard	S-125	*b*
Mercury Use Areas	S-127	*b*
Line Yard	S-120	*b*
Upper East Fork Poplar Creek	*a*	No

[a]Not applicable.

[b]Soil samples and/or piezometers will be used to make preliminary determinations regarding the need for groundwater monitoring. If deemed necessary, it will be conducted in accordance with the Y-12 Plant's Comprehensive Groundwater Monitoring Program.

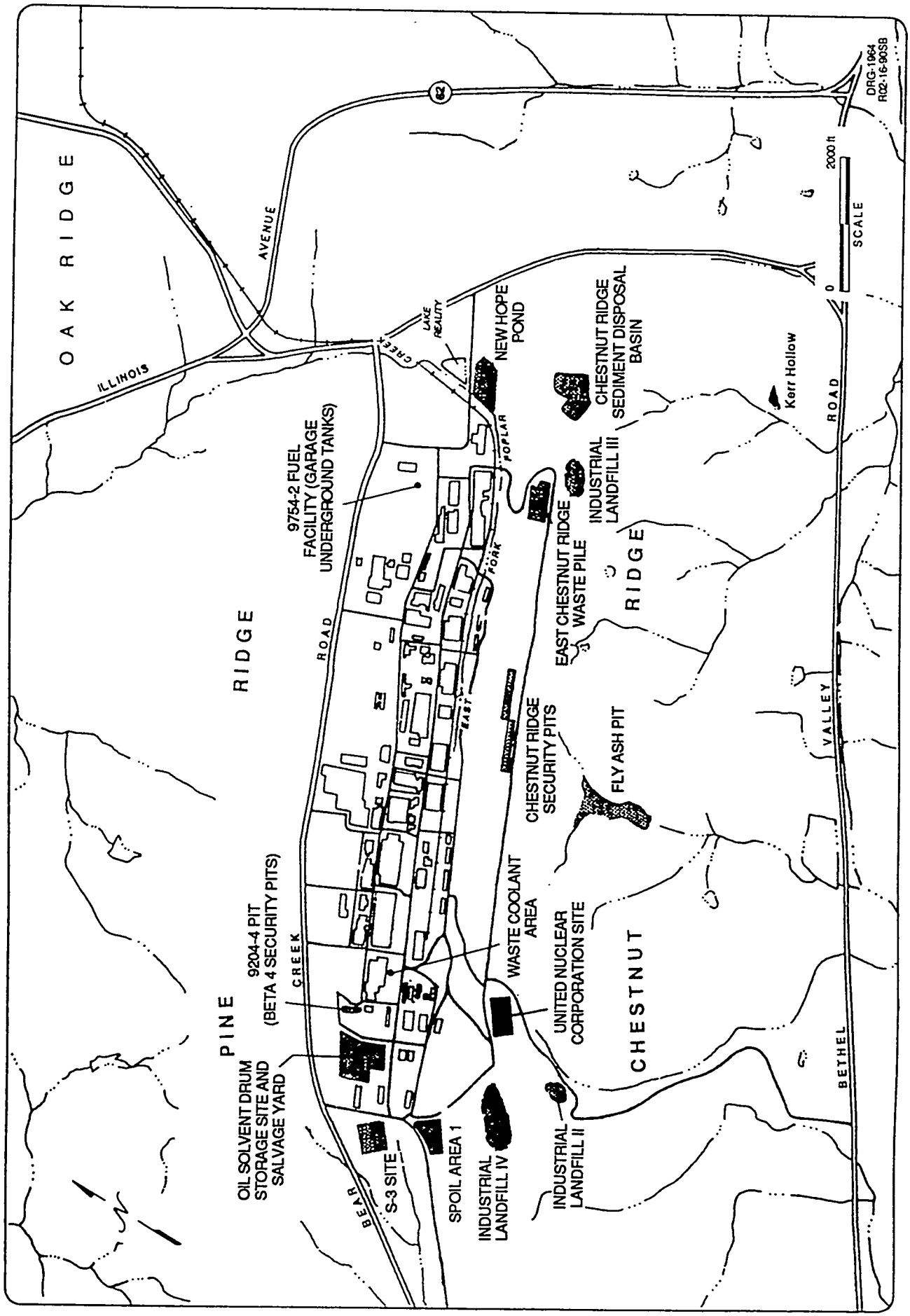

Fig. 2.3.4. Index map of Y-12 Plant comprehensive groundwater characterization program by sites (part 1).

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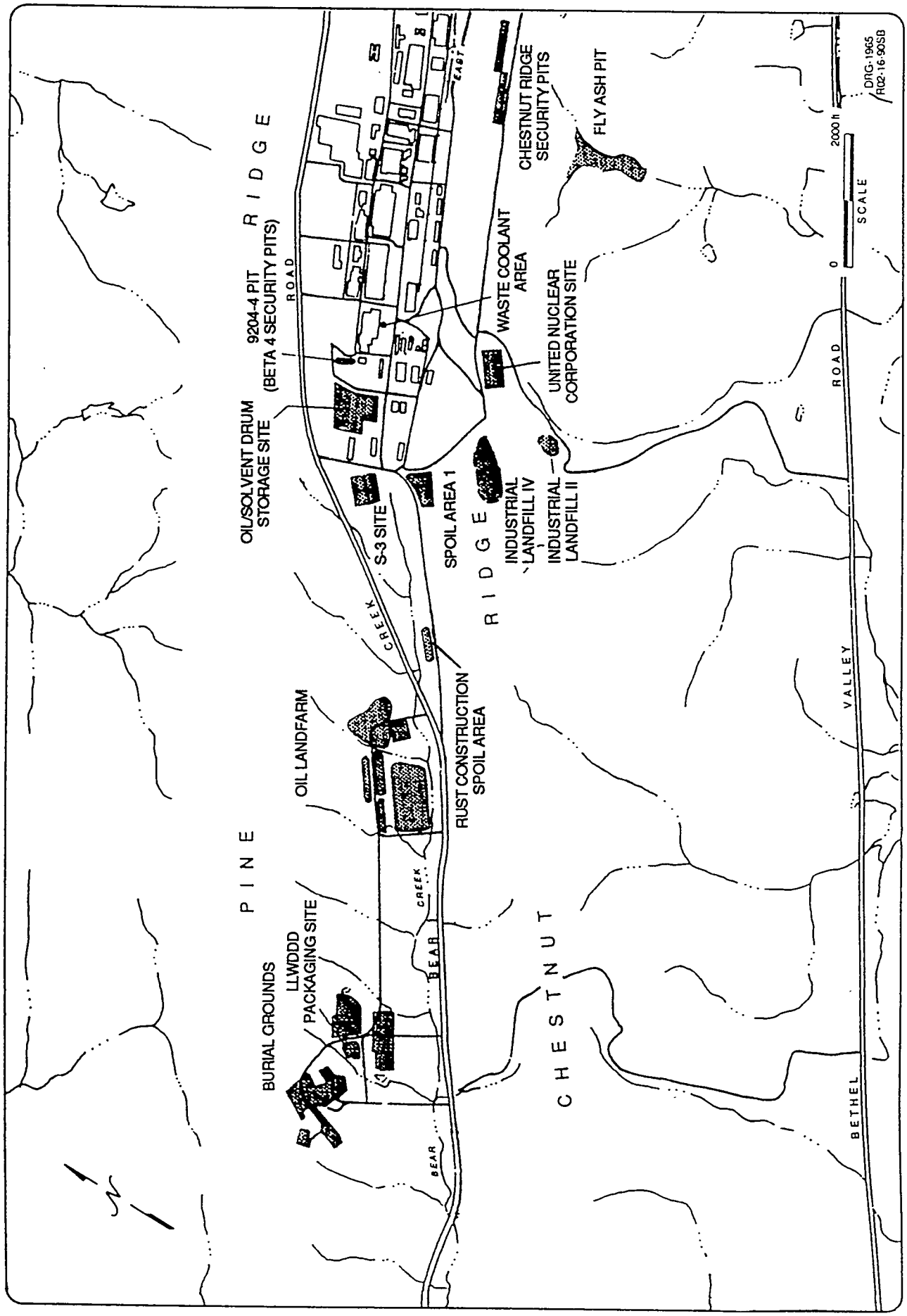

Fig. 2.3.5. Index map of Y-12 Plant comprehensive groundwater characterization program by sites (part 2).

Watershed. The NHP GWQAR was expanded to cover releases from all monitored sites within the Y-12 Plant compound in the Upper East Fork Poplar Creek Hydrogeologic Regime (UEFPCHR). The format of the CRSP GWQAR was unchanged from 1988. The assessment monitoring will continue on a quarterly basis until a postclosure permit is obtained for the respective facility. Late in 1989 a postclosure permit was issued for CRSDB, but a legal appeal has been filed. Monitoring is continuing under interim status.

Bear Creek Hydrogeologic Regime—Site descriptions

S-3 Ponds. The S-3 Ponds, constructed in 1951 adjacent to the west end of the Y-12 Plant, consisted of four unlined impoundments covering an area of roughly 122 by 122 m (400 by 400 ft). The original pond excavations penetrated residual soil and fill materials but did not extend down to bedrock. The ponds were approximately 5 m (17 ft) deep and contained sludge ranging from 0.6 to 1.5 m (2 to 5 ft) in thickness. The sludge was produced by the in situ denitrification and neutralization of wastewater in the ponds. While in operation, each pond had a storage capacity of about 9.5 million L (2.5 million gal). Hazardous waste disposal at the S-3 Ponds was terminated in 1984. During 1988, sediments from upper Bear Creek were excavated and placed in the S-3 Ponds as part of the RCRA closure. The site was then filled, and the construction of an impervious cap was begun. The GWQAP for the S-3 Ponds includes both quarterly and annual assessment-well networks.

Oil Landfarm. The Oil Landfarm hazardous waste disposal unit (HWDU) includes the Oil Landfarm Disposal Plots, the Boneyard, the Burnyard, the Sanitary Landfill I, and the Chemical Storage Area (also referred to as the Hazardous Chemical Disposal Area). Sanitary refuse from plant operations (including pesticide containers, metal shavings, solvents, oils, and laboratory chemicals) was placed in unlined earthen trenches at the Burnyard and burned. Remains of these materials were pushed by heavy equipment to the adjacent areas and to the ends of the trenches. Ultimately, the trenches were covered by dirt. Hazardous and explosive chemicals were disposed of by various treatment methods at the Chemical Storage Area. At the Oil Landfarm Disposal Plots, waste oils and coolants were applied to nutrient-enriched soils and allowed to biodegrade under aerobic conditions. The Sanitary Landfill I was designed to serve as the burial site for uncontaminated solid waste after the open-trench burning method was discontinued in 1968.

The Boneyard/Burnyard was deactivated in about 1970, and the Chemical Storage Area has not received waste since 1981. Waste disposal was terminated at the Oil Landfarm Treatment Plots and the Sanitary Landfill I in 1982. The landfill was graded and capped in 1983 in accordance with a TDHE-approved closure plan. Since that time, no waste has been disposed of at the Oil Landfarm HWDU.

Bear Creek Burial Grounds. The BCBG consist of several principal sites designated as burial grounds A, B, C, D, E, and J. Each site consists of a series of trenches used for disposal of liquid and solid wastes, including uranium turnings and fines. The trenches are between 4.3 and 7.6 m (14 and 25 ft) deep. Perforated standpipes were installed vertically into some trenches for liquid waste disposal; rock and gravel were backfilled around the standpipes for support and to maximize the rate of drainage. Oil Retention Ponds 1 and 2 were constructed adjacent to Burial Ground A to collect seepage from the trenches. The Burial Grounds HWDU is drained by three tributaries of Bear Creek. Hazardous waste disposal at the Burial Grounds was terminated in 1981.

Water-quality analyses of samples collected from the Burial Grounds assessment wells during the four sampling quarters of 1989 show that contamination by VOCs is generally restricted to areas near the disposal trenches, with the highest concentrations in the vicinity of Burial Ground A.

S-2 Site. The S-2 Pond is located within the confines of the Y-12 Plant. It served as the disposal site for corrosive and toxic liquid wastes generated by the Y-12 Plant from approximately 1943 to 1951. The S-2 Site consisted of an unlined earthen reservoir. Liquid waste streams were transferred by tank truck to the reservoir for

percolation, evaporation, or neutralization. The waste was untreated, and no barriers or leachate collection systems were used. In 1951, the S-2 Site was closed by neutralization of the remaining liquids and backfilling of the reservoir with soil. At the completion of backfilling, the site was leveled and seeded with grass.

The facility was used for the disposal of deteriorated chemical reagents and spent extraction raffinates, but specific records were not kept. These wastes consisted of nitric-acid-rich solutions containing traces of copper, nickel, chromium, diethyl ether, and pentaether; nitric, hydrochloric, and sulfuric acids; minor quantities of sulfates, dibutyl carbitol, and tributyl phosphate; and complexes of aluminum nitrate, hydrogen fluoride, and cadmium. Some of these wastes contained natural and enriched uranium, and some are considered highly toxic and persistent.

Groundwater near this site contains organics, heavy metals, and nitrate. Although the S-2 Site is very suspect as the source of some of these materials, other sites in the area are also probable contributors. During 1989, groundwater studies for this area were included in the S-3 Site Waste Management area.

Salvage Yard Area. The Salvage Yard Area at the Y-12 Plant is used for storage of scrap metal and liquid hazardous wastes. The use and configuration of this site have changed numerous times since it began operating as a scrap metal storage area in 1950. In 1985, plans for altering the current design and location of the salvage yard began.

Construction of a new scrap metal storage site was completed west of the Y-12 Plant and north of Bear Creek Road. The Salvage Yard Area consists of five SWMUs: Salvage Yard oil storage tanks (unit S-108), Salvage Yard Oil/Solvent Drum Storage Area (unit S-020), Salvage Yard drum deheader (unit T-109), Salvage Yard Scrap Metal Storage Area (unit S-111), and tank 2063-U (unit S-204). A 3-in.-diam acid waste line, which transported nitric acid wastes from the uranium recovery area of the Y-12 Plant to the S-3 Ponds, runs underneath the salvage yard. The line was flushed out, plugged, and abandoned in 1983. Releases from the acid line will be assessed as a separate RFI activity under RCRA 3004(u).

The area has been under study in conjunction with the S-3 Ponds since 1983. Groundwater sampling and extensive chemical analyses have been conducted in the salvage yard area as part of the recent RCRA closure activities at the Salvage Yard Oil/Solvent Drum Storage Area (unit S-020) and the comprehensive groundwater monitoring program at the Y-12 Plant.

Spoil Area I. Spoil Area I is located in Bear Creek Valley at the base of the northern slope of Chestnut Ridge. The area has been in operation since about 1980 as a nonhazardous, nonradioactively contaminated construction spoil disposal area. The site is approximately 2 ha (5 acres) in size. Since 1985, Spoil Area I has had a permit from TDHE as a landfill for rubble and noncombustible, nonputrescible solid waste. It is estimated that roughly 74,000 m^3 (100,000 yd^3) of nonuranium-contaminated construction debris has been disposed at the site.

The bulk of the waste disposed of at Spoil Area I consists of asphalt, masonry materials (e.g., brick and concrete), roofing materials, brush, metal (e.g., steel and rebar in concrete), rock, and tile. The waste was determined to be nonradioactively contaminated according to health physics requirements established for the Y-12 Plant.

Construction material disposed of in this area may have contained asbestos, mercury, beryllium, uranium, thorium, and other contaminants; however, existing administrative and other established in-plant controls prevent the disposal of significant amounts of chemical or radioactively contaminated waste at Spoil Area I.

The S-3 Ponds contaminant plumes have been depicted as extending beneath the Spoil Area I. Data collected during 1989 from the six monitoring wells around Spoil Area I support this theory.

Rust Construction Spoil Area. The Rust Spoil Area lies in Bear Creek Valley at the base of the northern slope of Chestnut Ridge. Bear Creek borders the northern portion of the Rust Spoil Area. Along the eastern edge of the spoil area is an unnamed spring-fed tributary of Bear Creek.

From 1975 to 1983, the Rust Spoil Area was operated as a waste disposal area with periodic grading (typically once per month) to promote positive drainage. It is estimated that less than 74,000 m^3 (100,000 yd^3) of spoil was disposed of at the site. The spoil material apparently was not covered with soil.

Because routine compaction of the soil was not intended but occurred only as grading took place, it is likely that the compaction operations at the site were somewhat deficient. No formal design plans were developed for the disposal area.

Although no detailed disposal records are available, the bulk of the waste disposed at the Rust Spoil Area consisted of (1) soil, (2) masonry materials (e.g., brick and concrete), and (3) metal (e.g., steel and rebar in concrete). A portion of the demolition debris was packaged and disposed of in open-top metal containers and determined to be radioactively noncontaminated according to health physics requirements established for the Y-12 Plant.

Minor amounts of solvents-contaminated material and material containing asbestos, mercury, and uranium may have been disposed of in this area. The existing administrative and other established in-plant controls prevented the disposal of significant amounts of chemicals, wastes, or contaminated material at the Rust Spoil Area.

During 1989, data were collected from seven monitoring wells around this site. During the year, values exceeded water quality standards for acetone, chloroform, coliform, dissolved solids, gross alpha and beta, cadmium, iron, lead, manganese, nitrate-nitrogen, pH, trichloroethene, turbidity, and 1,2-dichloroethene.

Bear Creek Hydrogeologic Regime—Principle groundwater contaminants

The principal groundwater contaminants in the BCHR are nitrate (as N), metals VOCs and radionuclides. The primary source of nitrate, metals, and radionuclides is the S-3 Site WMA. Although the S-3 Site is also a source of VOCs, these contaminants are more prevalent at OLF and BCBG.

Nitrate contamination in excess of the 10 mg/L MCL is found in the unconsolidated and bedrock zones in the BCHR, with the highest concentrations found in wells close to the S-3 WMA. Nitrate is present in wells located at the Rust Spoil Area and OLF, but with the exception of well GW-087 at OLF, the S-3 Site is the likely source of nitrate in these wells. The extent of the nitrate plume is believed to mark the maximum extent of potential migration of all contaminants, because it is transported in groundwater with little or no retardation, and it has low propensity for chemical alteration. There are indications that concentrations in shallow groundwater at depths of 10 to 20 ft may vary seasonally.

The determination of extent of metals contamination in the BCHR was based on total metals concentrations in excess of background levels or MCLs (where applicable). Principal metal contaminants in the BCHR are barium, cadmium, chromium, lead, and mercury; the respective MCLs for each of these metals was exceeded in at least one well in the BCHR during 1989. Metals contamination is most widespread at the S-3 Site. The occurrence of metals above MCLs elsewhere in the BCHR is erratic and somewhat inconsistent with respect to location, depth, and concentration.

Volatile organic compounds (VOCs) were detected in groundwater beneath each of the waste sites in the BCHR. A dissolved VOC plume extends from the S-3 Site westward to beyond the OLF, and a separate dissolved plume is present in the groundwater underlying BCBG. The VOC plume originating from the S-3 Site has entered the Maynardville Limestone and intermingled with plumes originating from OLF and possibly the Rust Spoil Area. However, the plume in the Maynardville does not extend as far west as BCBG; data indicate that the dissolved VOC plume underlying BCBG is confined to the low permeability shales of the Conasauga Group.

The VOC plume in the vicinity of the S-3 Site is comprised predominantly of tetrachloroethene (PCE), 1,1,1-trichloroethane (1,1,1-TCA), acetone, chloroform, and methylene chloride. In the Maynardville downgradient of the Rust Spoil Area and OLF, trichloroethene (TCE) and

1,2-dichloroethene (1,2-DCE) are the primary VOCs. Groundwater in the shales underlying OLF also include 1,1-dichloroethane (1,1-DCA), 1,1,1-TCA, and PCE. The highest concentrations of dissolved VOCs in the BCHR are found in samples from wells at BCBG. Dissolved VOCs at BCBG are primarily PCE, TCE, 1,2-DCE, and 1,1-DCA.

In addition to the dissolved-phase VOCs in groundwater at BCBG, in December 1989, accumulations of dense nonaqueous phase liquids (DNAPLs) were discovered at depths of approximately 274 ft below ground surface during drilling of well GW-625 located along the southern border of Burial Ground A South. A preliminary investigation was immediately initiated, and the results will be reported in early 1990.

Wells in the S-3 Site, BCBG, and OLF had mean gross alpha activity that exceeded the 15 pCi/L drinking standard. Several wells had mean gross alpha activity that exceeded the mean activity for the background. The maximum mean gross alpha activity was calculated for well GW-243 at the S-3 Site at 10,733 ± 445 pCi/L. This well also had the maximum calculated mean gross beta radioactivity at 36,360 ± 721 pCi/L. Well GW-243 also had the highest mean uranium concentration (38.5 mg/L) in the valley as well as maximum mean activity of ^{237}Np. Mean gross beta radioactivity exceeding the 50 pCi/L guideline is reported for wells at the S-3 Site, BCBG, and OLF, although the latter two areas reported gross beta activity in several wells that was anomalously high only for the third quarter sampling event. Sample standard deviations were several orders of magnitude greater than the mean counting error, which suggests systematic errors. Two wells at the Rust Spoil Area had mean gross beta and photon radioactivity that exceeded the 50 pCi/L guideline. Mean gross beta radioactivity in the vicinity of the S-3 Site was primarily because of ^{99}Tc. Dose calculations indicate that the 4 mrems/year MCL was exceeded in only two wells (GW-243 and GW-109), which are both located at the S-3 Site.

Upper East Fork Hydrogeologic Regime—Site descriptions

New Hope Pond Site. NHP was located in Bear Creek Valley at the base of Chestnut Ridge at the east end of the Y-12 Plant. NHP was constructed in 1963 and operated until November 8, 1988, at which time water was diverted around the pond to Lake Reality. The pond was designed to regulate flow and quality of water in EFPC as it exits the Y-12 Plant and flows toward the city of Oak Ridge. The pond was closed and capped in 1989.

In 1973, sediments from NHP were removed and placed in the Chestnut Ridge Sediment Disposal Basin (CRSDB). Between 1973 and May 6, 1988, sediment from the inlet diversion ditch was removed periodically and disposed of in the CRSDB. Extraction procedure (EP) toxicity analyses of NHP sediment, including in-place sediments and those disposed at the CRSDB, indicate that the sediments did not exhibit the characteristics of an RCRA waste (Saunders 1983; Kimbrough and McMahon 1989a and 1989b).

Waste Coolant Processing. The Waste Machine Coolant Biodegradation Facility (WMCBF) was located in the western portion of the UEFPCHR near the intersection of Second Street and J Road within the Y-12 Plant. The WMCBF was a converted cooling tower basin that was used to treat waste machine coolants from various shops within the Y-12 Plant. The facility included a 30,000-gal elevated treatment basin, two effluent drain fields, and an unloading/storage area. The drain fields are believed to be located to the southwest and east of the facility. The facility underwent an RCRA closure in 1988.

Fuel Facility. The 9754-2 Fuel Facility is located in the eastern portion of the UEFPCHR near the east portal of the Y-12 Plant. The facility consisted of a refueling area and two underground storage tanks (USTs). A 20,000-gal tank was used to store unleaded gasoline, and a 10,000-gal tank was used to store diesel fuel. The tank pit was approximately 12 ft deep and was filled with gravel. Adjacent to the 9754-2 Fuel Facility is the Garage Underground Tanks (GUT). The GUT consisted of two RCRA tanks and one petroleum tank and will be closed under the RCRA regulations with an approved closure plan. Currently, all tanks at the two facilities have been removed.

Rust Garage Area. The Rust Garage Area is located in the northwestern portion of the

UEFPCHR. Building 9720-15, which houses the Rust Garage, is located about 650 ft east of the S-3 Site. The area is currently used to perform maintenance on vehicles and equipment and to store motor fuel, lubricants, and coolants. At least four underground fuel storage tanks with associated piping are located in the Rust Garage Area. These tanks are currently being investigated under the Y-12 Underground Storage Tank Program. A bulk-oil storage platform and an elevated gasoline tank are located south of the garage, and a wash pad is reported to be present on the east side of the building. Previously, the site was used as a sand-blasting area.

Industrial products containing hazardous constituents that are stored on-site include lubricating oil, gasoline, diesel fuel, hydraulic fluid, antifreeze, battery acid, and mineral spirits (which are used for degreasing). Gasoline leaks have been documented, originating either from the USTs or associated piping. Temporary piezometers were installed during early 1988 to investigate the leaks, and free product was observed in at least one of these piezometers.

Beta-4 Security Pit. The Beta-4 Security Pit site is located on the western edge of the exclusion area within the Y-12 Plant complex. The site was used for disposal of classified material from February 1968 through 1971. Six groundwater investigation wells were installed at the Beta-4 Security Pit in late 1985.

Hydrologic data for the Beta-4 Security Pit area indicate that the shallow groundwater system is relatively uncomplicated. Shallow groundwater flow directions are consistently to the east-southeast. The data also indicate that there is an upward flow component to the shallow groundwater system throughout the site. Analysis of the water quality data is not suggestive of contamination.

Upper East Fork Poplar Creek Hydrogeologic Regime—Extent of groundwater contamination

This section describes the extent of groundwater contamination in the UEFPCHR observed in 1989.

The principal groundwater contaminants in the UEFPCHR are nitrate (as N), metals, VOCs, and radionuclides. The primary source of nitrate, metals, and radionuclides is the S-3 Site. Although the S-3 Site is also a source of VOCs, these contaminants are more prevalent at the Waste-Coolant Processing Area and New Hope Pond. Descriptions of the overall extent of groundwater contamination are discussed in the following summary.

Groundwater contamination by nitrate (as N) was evaluated with respect to the EPA primary drinking-water standards. Groundwater samples with nitrate concentrations exceeding the drinking-water maximum contaminant level (MCL) of 10.0 mg/L were considered to be contaminated. The average 1989 nitrate concentration for each well has been used for evaluating the distribution of nitrate in groundwater.

Nitrate concentrations exceeding the MCL are found in the unconsolidated and bedrock zones in the vicinity of the S-3 Site in the UEFPCHR. Nitrate concentrations found in the assessment wells elsewhere in the UEFPCHR did not exceed the MCL. The extent of the nitrate plume is believed to mark the maximum extent of potential migration of all contaminants, because it is transported in groundwater with little or no retardation and it has a low propensity for chemical alteration. There are indications that concentrations in shallow groundwater at depths of 10 to 20 ft may vary seasonally.

Groundwater contamination by metals was evaluated with respect to the EPA primary drinking-water standards and reported background concentrations and was based on a review of both total and dissolved metals content. Drinking-water MCLs have been promulgated by EPA for eight of the assessment metals (arsenic, 0.05 mg/L; barium, 1.0 mg/L; cadmium, 0.01 mg/L; chromium, 0.05 mg/L; lead, 0.05 mg/L; mercury, 0.002 mg/L; selenium, 0.01 mg/L; and silver, 0.05 mg/L). These metals are not necessarily analyzed at all of the UEFPCHR sites. Some of the sites are at different stages of the assessment program. In addition, the assessment parameters at some sites have been reduced to reflect only the groundwater constituents identified through historical sampling activities.

The metals of concern in the UEFPCHR are barium, cadmium, chromium, lead, and mercury.

The MCLs for these metals have been exceeded in groundwater samples from a given well during the 1989 sampling program. Metals contamination is greatest and most widespread at the S-3 Site with barium, cadmium, and mercury being the primary contaminants. The occurrence of metals above MCLs elsewhere in the UEFPCHR is limited to the 9754-2 Fuel Facility where unusually high levels of chromium were present; there was also a sporadic occurrence of lead at New Hope Pond.

In the UEFPCHR, VOCs were detected in the groundwater at the S-3 Site, Waste Coolant Area, and New Hope Pond. A dissolved VOC plume extends from the S-3 Site eastward to the Waste Coolant Area. A dissolved VOC plume is also present in the groundwaters underlying New Hope Pond. The lack of monitor wells in the plant area precludes defining the eastward extent of the VOC plume originating from the S-3 WMA and Waste Coolant Area as well as determining the upgradient source of VOCs contributing to the plume underlying New Hope Pond.

Although located in the BCHR, during the operational history of the S-3 Site, a groundwater mound existed beneath the ponds which allowed groundwater to flow towards the east and contributed to groundwater contamination in the UEFPCHR. The distribution of constituents and concentrations in the dissolved VOC plume in the upper reaches of the UEFPCHR indicate several source contributors to the plume in addition to the S-3 Site. Within the S-3 Site, the Salvage Yard and S-2 Site appear to have been a source of tetrachloroethene and trichloroethene. Based on 1986 and 1987 data from wells GW-278, GW-279, and GW-280, which were plugged and abandoned in 1988, the Interim Drum Yard may have contributed carbon tetrachloride to the plume. The highest concentration of dissolved VOCs (about 16,000 μg/L) are found in groundwater underlying the Waste Coolant Area. The VOC plume in this area is dominated by the presence of 1,2-dichloroethene with relatively even proportions of tetrachloroethene and trichloroethene.

Groundwater flow patterns in the vicinity of New Hope Pond and the upgradient presence of VOCs suggest that New Hope Pond may not be the primary source of groundwater contamination. Water level data collected in 1989 strongly suggest that the area northwest of the pond near the discharge point to East Fork Poplar Creek may be the only area downgradient of the site. In addition, the VOC plume is this area is dominated by the presence of carbon tetrachloride, with the highest concentrations (8000 μg/L) found in GW-381, west and upgradient of New Hope Pond.

Wells in the S-3 Site and NHP had mean gross alpha activities that exceeded the 15 pCi/L drinking standard. The mean gross alpha activity for wells at the Fuel Facility and Waste Coolant Areas did not exceed the drinking water standard. The maximum mean gross alpha activity was calculated for well GW-243 at the S-3 Site at 10,733 $\pm$ 445 pCi/L. This well also had the maximum calculated mean gross beta radioactivity at 36,360 $\pm$ 721 pCi/L. Well GW-243 also had the highest mean uranium concentration (38.5 mg/L) in the valley as well as maximum activity of ^{237}Np. Mean gross beta radioactivity exceeding the 50 pCi/L DWL guideline is reported at S-3 and two wells at NHP. One well at New Hope Pond and one well at the Fuel Facility had mean gross beta radioactivity that exceeded the 50 pCi/L guideline. Mean gross beta radioactivity in the vicinity of the S-3 Site was primarily because of ^{99}Tc. Dose calculations indicate that the 4 mrems/year MCL was exceeded in only two wells (GW-243 and GW-109), which are both located at the S-3 Site. Dose calculations were not performed on wells at NHP, Waste Coolant Area, and the Fuel Facility.

Chestnut Ridge Security Pits Assessment

Chestnut Ridge Security Pits. The CRSP are located on the crest of Chestnut Ridge, southeast of the central portion of the Y-12 Plant. Operated since 1973, the CRSP consist of a series of trenches used for the disposal of classified hazardous and nonhazardous waste materials. Disposal of hazardous waste materials was discontinued in December 1984; operation of the facility for disposal of nonhazardous wastes was discontinued November 8, 1988.

Water-quality analyses of samples collected from the CRSP assessment wells during the four

quarters of 1989 indicate that contamination by VOCs is found in wells near the disposal sites. The highest concentrations of VOCs in groundwater are found near the center of the CRSP. Two distinct populations of contaminants are present at the site: one dominated by 1,1,1-trichloroethane adjacent to the western trench area and one dominated by tetrachloroethene adjacent to the eastern trench area. This distribution suggests that each trench area is a distinctive source of VOC contaminants. Closure of this site began in 1989 under a plan approved by TDHE, and the site was closed with a multilayer cap.

Groundwater contamination by VOCs beneath and adjacent to the Chestnut Ridge Security Pits HWDU has been documented in the past. Evaluation of data collected during 1989 indicates that no significant changes in overall characteristics of VOC contamination has occurred.

The most commonly detected VOCs, as indicated by frequency of detection and area distribution, are 1,1,1-trichloroethane, tetrachloroethene, 1,1-dichloroethane, and 1,1-dichloroethene. In addition, isolated occurrences of 1,2-dichloroethene (total), trichloroethene, 1,2-dichloroethane, carbon tetrachloride, and acetone were detected. Detectable concentrations ranged from a maximum of 630 μg/L for 1,1,1,-trichloroethane in GW-322 to 0.8 μg/L for tetrachloroethene in wells GW-177 and GW-178. Acetone was detected in GW-181 in the third and fourth quarters of 1989 in concentrations of 9 and 11 μg/L, respectively. Acetone is a common laboratory contaminant and has been detected in blank data during 1989; however, blank data were not available for the fourth quarter to evaluate the result. It is possible the result may be an artifact of laboratory or field contamination, but this cannot be corroborated. It is therefore considered as possibly occuring in the groundwater. Other VOCs were detected and were determined not to be representative of actual groundwater quality, because these were reported in field and laboratory blank samples. Two compounds, fluorotrichloromethane and Freon 113, which are common laboratory contaminants, were commonly detected in various samples during 1989 but not in associated laboratory or field blanks. Despite their absence in laboratory and field blanks, it is believed these compounds are not indicative of actual groundwater contamination.

Two distinct populations of VOCs can be identified in groundwater at the site: one characterized by a high percentage of 1,1,1-trichloroethane and located generally westward of the middle portion of the easternmost trench, and a second population characterized by a high percentage of tetrachloroethene and located generally eastward and northward of the middle portion of the eastern trench. No significant change in these values has occurred since 1988; however, a moderate increase in concentration was observed during the seond quarter of 1989 in GW-175 from 10 μg/L in 1988 to 75 μg/L. Concentrations of 1,1,1-trichloroethane and 1,2-dichloroethane were reported in minor amounts (<5 μg/L) during 1988 in GW-181. Well GW-511 also contained minor amounts (<5 μg/L) of 1,1,1-trichloroethane in 1988 and in 1989. Lowest and highest summed VOC concentration ranged from 0 μg/L in GW-181 to 837 μg/L in GW-179 during 1989.

Highest concentrations of VOCs are associated with wells GW-176 and GW-322, located south of the trenches, and GW-179 located adjacent to the easternmost trench on the northern side. VOC concentration appears to decrease with distance more rapidly in the north/south direction, mimicking topography and water-table elevation isopoleths. In addition, the "concentration gradient" appears to be steeper towards the northeast than to the northwest.

RCRA Interim status facilities—Detection monitoring

Chestnut Ridge Sediment Disposal Basin. The CRSDB is an unlined, man-made, sediment disposal facility on the east end of Chestnut Ridge, south of New Hope Pond. The CRSDB was constructed in 1972–1973 for the disposal of sediments hydraulically dredged from New Hope Pond in 1973. Closure of this site began in November 1988 under a plan approved by TDHE. Closure was certified and accepted by TDHE in

1989. During 1989, CRSDB was in detection monitoring.

Kerr Hollow Quarry. KHQ is located on a low ridge running along the north side of Bethel Valley. The quarry was active in the 1940s and was abandoned sometime in the late 1940s. Since the early 1950s, the quarry was used for the disposal of reactive materials from the Y-12 Plant and ORNL. Disposal into KHQ ceased on November 8, 1989. During CY 1989, this site was in detection monitoring. No evidence of releases has been found in the groundwater.

Other site-specific groundwater monitoring

In addition to the sites previously mentioned, groundwater monitoring has been ongoing in 1989 for several additional solid waste management units (SWMUs) at the Y-12 Plant. These SWMUs are being addressed under the RCRA 3004(u) program and include the following sites (see Figs. 2.3.4 and 2.3.5): UNC Site, Rogers Quarry, Sanitary Landfill II, Industrial Landfill III, Industrial Landfill IV, and Filled Coal Ash Pond.

The following commentary summarizes the findings from the 1989 data.

UNC Site. The UNC Site is located on the northern crest of Chestnut Ridge, immediately south of the western end of the Y-12 Plant complex. The site was used to dispose of waste from a UNC plant in Rhode Island. Materials disposed of are nitrate-contaminated, low-level radioactive wastes, and contaminated equipment that is packaged in 208-L (55-gal) drums and in boxes. Available information on site hydrology has been summarized by Geraghty and Miller (1985). Groundwater flow directions have not been determined but are probably generally controlled by a groundwater divide that runs along the crest of Chestnut Ridge in the vicinity of the site. The location of the groundwater divide would influence whether water from the site would flow northward into the Bear Creek watershed or southward toward watersheds in Bethel Valley.

Three groundwater investigation wells were installed at the UNC Site in 1985. Hydrological data indicate that the shallow groundwater system is relatively uncomplicated. Shallow groundwater flow directions are consistently to the northeast. The data also indicate that there is a downward flow component to the shallow groundwater system throughout the site. Major element data suggest that all of the groundwaters at the site are chemically similar and belong to the same groundwater flow system.

The water quality data from 1989 were consistent with the conclusion that the UNC Site is not contributing contamination to the groundwater.

Rogers Quarry. Rogers Quarry is located along Bethel Valley Road, approximately 5 km west of KHQ and 8 km (5 miles) east of ORNL. The quarry is approximately 910 m (2985 ft) south of the Y-12 Plant complex and is located on a line of low hills running along the north side of Bethel Valley at the southern edge of Chestnut Ridge. The quarry was a source of stone construction materials from the 1940s through the late 1950s. It was abandoned in the early 1960s, when it filled with water. It currently receives fly ash slurry from the Y-12 Steam Plant.

Seven groundwater investigation wells (GW-184, GW-185, GW-186, GW-187, GW-188, GW-189, and GW-224) were installed surrounding the Rogers Quarry site in 1985. Construction details for the wells are presented in Haase et al. (1987a). Hydrological data for the Rogers Quarry locality suggest that the shallow groundwater system is complex and seasonally variable. During periods of high precipitation, one well consistently is upgradient. During low precipitation periods, however, any one of several wells or the quarry itself can be considered upgradient within the groundwater system surrounding the site. The data also indicate that, for several of the wells surrounding the quarry, the hydrostatic heads (gradients) and the trend patterns are influenced by quarry water level fluctuations. Other wells appear to have trend patterns that behave independently of quarry water level fluctuations. The shallow and variable nature of the water table gradient suggests that groundwater flow surrounding the quarry may be sluggish and that the direction of the gradient may vary throughout the year.

Values above drinking water standards in 1989 included coliform bacteria dissolved solids, iron, manganese, nitrate-nitrogen, and turbidity.

Sanitary Landfill II. The Y-12 Centralized Sanitary Landfill II (also known as Industrial Landfill II) is a TDHE-permitted solid waste disposal facility. Semiannual groundwater monitoring is performed per a TDHE-approved monitoring plan. During 1989, an additional sampling was conducted to evaluate elevated TOC data (avg. 32 mg/L TOC found during first semiannual sample of 1989). For this investigation, samples were submitted to three different laboratories for TOC analyses, and additional organic analyses were conducted for acid/base/neutral organics, pesticides, herbicides, and volatile organics. Results indicated TOC values ranged from less than detectable to 6 mg/L and were consistent with previous years' data. Results also indicated TOC data collected from the initial 1989 sample to be erroneous. Trace levels of 1,1,1-trichloroethane and 1,1-dichloroethane were detected. An RFI plan for the site has been prepared as part of the 3004(u) program, and monitoring for volatile organic contamination will continue.

Industrial Landfill III. Industrial Landfill III is located on the east end of Chestnut Ridge. It is designed for the placement of construction debris and soils from mercury-contaminated areas in and around the Y-12 Plant. Landfill III incorporates the existing East Chestnut Ridge mercury-contaminated soil pile, a former borrow area, which received mercury-contaminated material relocated from around the city of Oak Ridge Civic Center. Seven groundwater wells were installed in 1987.

During 1989, groundwater at this site exhibited elevated levels of coliform bacteria, fluoride, iron, lead, manganese, pH, radium, and turbidity. There is no indication that this site is contributing to groundwater contamination; the water quality is similar to the background values at Industrial Landfill IV.

Industrial Landfill IV. Industrial Landfill IV is located on the west end of Chestnut Ridge, southeast of the S-3 Ponds. Five groundwater wells were installed in 1987 in preparation for this waste disposal facility. One of these wells was later plugged and abandoned to allow additional construction work, and it was later replaced. Although several parameters (coliform bacteria, iron, lead, pH, radium, and turbidity) were above standards, these are background numbers because the site was not opened to waste disposal activities until late 1989.

East Chestnut Ridge Waste Pile. The East Chestnut Ridge Waste Pile is an interim status, RCRA-hazardous waste storage facility constructed in FY 1987. Five groundwater wells were installed around this facility to allow monitoring, although the regulations do not require monitoring because this is a lined facility.

The 1989 data show values above standards for arsenic, iron, lead, pH, silver, and turbidity. The values are similar to those at the Industrial Landfill IV.

Above-grade demonstration—Bear Creek Burial Grounds. A low-level waste disposal development and demonstration (LLWDDD) project was planned for this site in BCBG, approximately 2.5 km (1.6 miles) west of the Y-12 Plant. In preparation for this facility, four groundwater wells were installed to enable better understanding of the hydrology of the area and to acquire baseline characterization data. Background data were collected at this site. Values above standards were found for chromium, coliform bacteria, dissolved solids, fluoride, gross alpha, iron, lead, manganese, pH, tetrachloroethene, trichloroethene, and turbidity. Although these values may be indicative of groundwater contamination, the values are background for LLWDDD, and the sources are upgradient in the BCBG Waste Management Area within which the site is contained. Construction of this facility has been halted. There has been no additional construction beyond the initial site preparation phase.

LLWDDD—uranium lysimeter demonstration project. The Y-12 Plant generates solid wastes contaminated with low levels (less than 1% by weight) of ^{238}U. Permitted burial grounds for these wastes may be filled as early as 1992. Permits for new burial grounds will require verification that human health and the environment will be adequately protected.

The uranium lysimeter demonstration project will generate the data required to verify that uranium-contaminated wastes from the Y-12 Plant

can be adequately managed using shallow-land burial. During 1988 and 1989 about 30 large (8-ft-diam by 12-ft-deep) lysimeters were built for the purpose of filling with contaminated wastes. All leachate will be collected, analyzed for uranium and other important parameters, and treated prior to discharge from permitted treatment facilities. The lysimeters will have a design life of 50 years and will be monitored for at least 5 years.

Associated laboratory work will characterize Y-12 Plant wastes and provide leaching data needed to prepare environmental impact statements for this and future facilities.

In 1988, five wells were installed to monitor background conditions at the site, and the wells were sampled during 1989. Values above standards included barium, chromium, gross alpha, gross beta, iron, lead, manganese, nitrate, radium, and turbidity. These data were not, however, indicative of contamination.

Filled Coal Ash Pond. The Y-12 Plant disposes of coal ash from its steam plant operations as a slurry that is discharged into an ash retention impoundment. This impoundment, named the Filled Coal Ash Pond, and known generically as the Coal Ash Pond, the Coal Ash Basin or the Fly Ash Pit, is a 3.2- to 3.6-ha (8- to 9-acre) impoundment area on the southern slope of Chestnut Ridge, 0.8 km (0.5 mile) south of the main Y-12 Plant and geographically separated from the Y-12 Plant by Chestnut Ridge.

The Filled Coal Ash Pond was constructed in 1955 by building a 19.1-m-high (62-ft-high) earthen dam across the northern tributary of McCoy Branch. The dam was designed to provide settlement pond storage for approximately 129 acre-ft of ash sluice water during sedimentation and was expected to have sufficient capacity to hold 20 years of Y-12 Steam Plant Ash. The ash was pumped as a slurry over Chestnut Ridge, released, and allowed to flow southward by gravity to the storage behind the dam. However, by July 1967, ash had filled the impoundment storage behind the 19.1-m-high (62-ft-high) dam to within 1.2 m (4 ft) of the top. As the sediment trap efficiency decreased, the slurry began to pass over the settled ash residue and flow directly to the emergency spillway along the left abutment and into McCoy Branch. In 1967 and 1968, McCoy Branch was diverted into Rogers Quarry, located about 0.8 km (0.5 mile) downstream from the dam. By October 1968, the Coal Ash Pond was reported to be almost completely filled with ash sediment. The Coal Ash Pond currently contains 146 acre-ft of ash, and ash slurry continues to be pumped over Chestnut Ridge, where it flows across the Filled Coal Ash Pond and into McCoy Branch and Rogers Quarry. Rogers Quarry, with an estimated life expectancy for ash disposal of 65 to 115 years, currently serves as the main settling basin for the ash.

The state of Tennessee and the EPA have recently expressed concern about the ash disposal system. In 1986, in response to this concern, the Y-12 Plant (1) investigated the chemical characteristics of the ash sluice water and the McCoy Branch stream water; (2) conducted a geotechnical evaluation and hydrologic study of the Filled Ash Pond and its dam; and (3) investigated the groundwater in the vicinity of Rogers Quarry, which receives ash slurry from the ash pond.

As part of DOE's Environmental Survey field work at the Y-12 Plant, two wells were installed on the downstream face of the ash pond dam in August and September 1987. Laboratory testing of groundwater samples taken from these wells in 1988 has shown no evidence of contamination above regulatory standards or above expected background.

Three additional groundwater monitoring wells were recently installed north of the Filled Coal Ash Pond. These wells serve a dual purpose by monitoring groundwater upgradient of the filled ash pond and downgradient of the CRSP. Monitoring of these wells commenced in the fourth quarter of 1988. During 1989, the following parameters exceeded standards: bis(2-ethylhexyl)phthalate, coliform bactria, iron, PCB, pH, turbidity, and 2-butanone. The PCB number is thought to be anomolous.

Monitoring wells installed in 1989

In CY 1989, 33 new groundwater monitoring wells were installed. Four additional wells were installed as free product observation and potential recovery wells at sites of leaking underground

tanks. Table 2.3.4 lists the sites and the number of wells installed. The sites are divided into three categories. Category I sites are those monitoring sites requiring additional data to delineate the extent of groundwater contamination. Wells installed at Category II sites are for the purpose of obtaining background data at either a waste disposal demonstration facility or at the designated area for the expansion of the existing Sanitary Landfill. Category III wells were installed to aid underground tank investigations.

2.3.3.2 Oak Ridge National Laboratory

The groundwater monitoring program at ORNL consists of a network of wells of two basic types and functions: (1) water quality monitoring wells built to RCRA specifications and used for site characterization and compliance purposes, and (2) piezometer wells used to characterize groundwater flow conditions. ORNL has established a RAP to provide comprehensive management of areas where past and current research, development, and waste management activities may have resulted in residual contamination of facilities or the environment. Because of the large number of SWMU sites at ORNL located close to one another and the proven hydrologic interconnections between many of these units, individual monitoring and assessment was shown to be impractical. Therefore, the concept of waste area groupings (WAGs) has been developed to evaluate potential sources of releases to the environment. A WAG is a group of multiple sites that are geographically contiguous and/or hydrologically defined areas. It allows the establishment of a suitably comprehensive groundwater and surface water monitoring system in a far shorter time than that required to deal with every facility, site, and SWMU individually. Some WAGs share common boundaries, but each WAG represents distinct small drainage areas within which similar contaminants may have been introduced. Monitoring data from each WAG will direct further groundwater studies aimed at addressing individual sites or units within a WAG, as well as contaminant plumes that extend beyond the perimeter of the WAG.

At ORNL, 20 WAGs were identified by the RCRA Facilities Assessment. Eleven of these have been identfied as potential sources of groundwater contamination. Additionally, there are a few areas where potential SWMUs are located outside the major waste area groupings. These individual sites are being considered separately (instead of expanding the area of the WAG) where this would cause excessive distances between the SWMU and the nearest monitoring point. Water quality monitoring wells are being established around the perimeter of the WAGs determined to have a potential for the release of contaminants. Table 2.3.5 lists the 20 WAGs at ORNL and the number

Table 2.3.4. Y-12 Plant 1989 well installation program

Site	Category	Wells installed
LLWDDD lysimeter demonstration	II	2
Sanitary Landfill II	II	8
Chestnut Ridge Security Pits	I	5
Oil Landfarm	I	2
S-3 Pond Site	I	2
9754-2 Fuel Facility	III	1
Salvage Yard/Oil Solvent Storage	III	1
Tank 0134-U at 9204-2	III	1
Tank 2331-U at 9201-1	III	1
New Hope Pond	I	2
Bear Creek Burial Grounds	I	6
United Nuclear Corp. Site	I	2
Total		33

Table 2.3.5. Summary of ORNL waste area groupings, 1989

WAG number	Description	Number of sites
1	Main plant area	99
2	White Oak Creek/White Oak Lake	2
3	SWSA 3	3
4	SWSA 4	3
5	SWSA 5	25
6	SWSA 6	3
7	LLW pits and trenches area	15
8	Melton Valley area	20
9	Homogeneous reactor experiment (HRE) area	6
10	Hydrofracture injection wells and grout sheets	4[a]
11	White Wing scrapyard	1
12	Closed contractors' landfill	1
13	Environmental research areas	2
14	Tower Shielding Facility (TSF)	2
15	ORNL facilities at Y-12 Plant	5
16	Health Physics Research Reactor area	5
17	ORNL services area	10
18	Consolidated fuel reprocessing area	9
19	Hazardous waste treatment and storage facility	7
20	Oak Ridge land farm	1
	Total	223
	Additional Sites	
b	Surplus-contaminated facilities	29

[a]Principal sites located underground beneath WAG 5.
[b]Not applicable.

of potential remedial action sites within each WAG. Figure 2.3.6 shows the location of each of the 20 WAGs.

WAG 6 area. WAG 6 consists of three SWMUs: (1) SWSA 6, (2) the emergency waste basin, and (3) the explosives detonation trench. The location of WAG 6 is shown in Fig. 2.3.6. SWSA 6 is located in Melton Valley, northwest of White Oak Lake and southeast of Lagoon Road and Haw Ridge. The site is approximately 2 km (1.2 miles) south of the main ORNL complex. Geologically, WAG 6 is within the White Oak Mountain thrust block and is underlain by strata of the middle-to-late Cambrian Conasauga Group. Waste burials at the 68-acre site were initiated in 1973 when SWSA 5 was closed. A variety of radioactive and hazardous wastes were buried in trenches and auger holes. The emergency waste basin was constructed in 1961 to provide storage of wastes that could not be released from ORNL to WOC. The basin is located northwest of SWSA 6 and has a capacity of 15 million gal. To date, the basin has not been used and radiological sampling of the small drainage from the basin has not shown the presence of contamination.

WAG 1 area. WAG 1, the ORNL main plant area, contains about one-half of the SWMUs identified to date by the RAP (Table 2.3.5). WAG 1 lies within the Bethel Valley portion of the WOC drainage basin. The boundaries of the basin extend to the southeast and northeast along Chestnut Ridge and Haw Ridge. The WAG boundary extends to the water gap in Haw Ridge. The total area of the basin in Bethel Valley is approximately 2040 acres. The location of WAG 1 is shown in Fig. 2.3.6. Bedrock beneath the main plant area is limestone, siltstone, and calcareous shale facies of the Ordovician Chickamauga Group. Most of the WAG 1 SWMUs are sites used to collect and store low-level waste (LLW) but also include spill

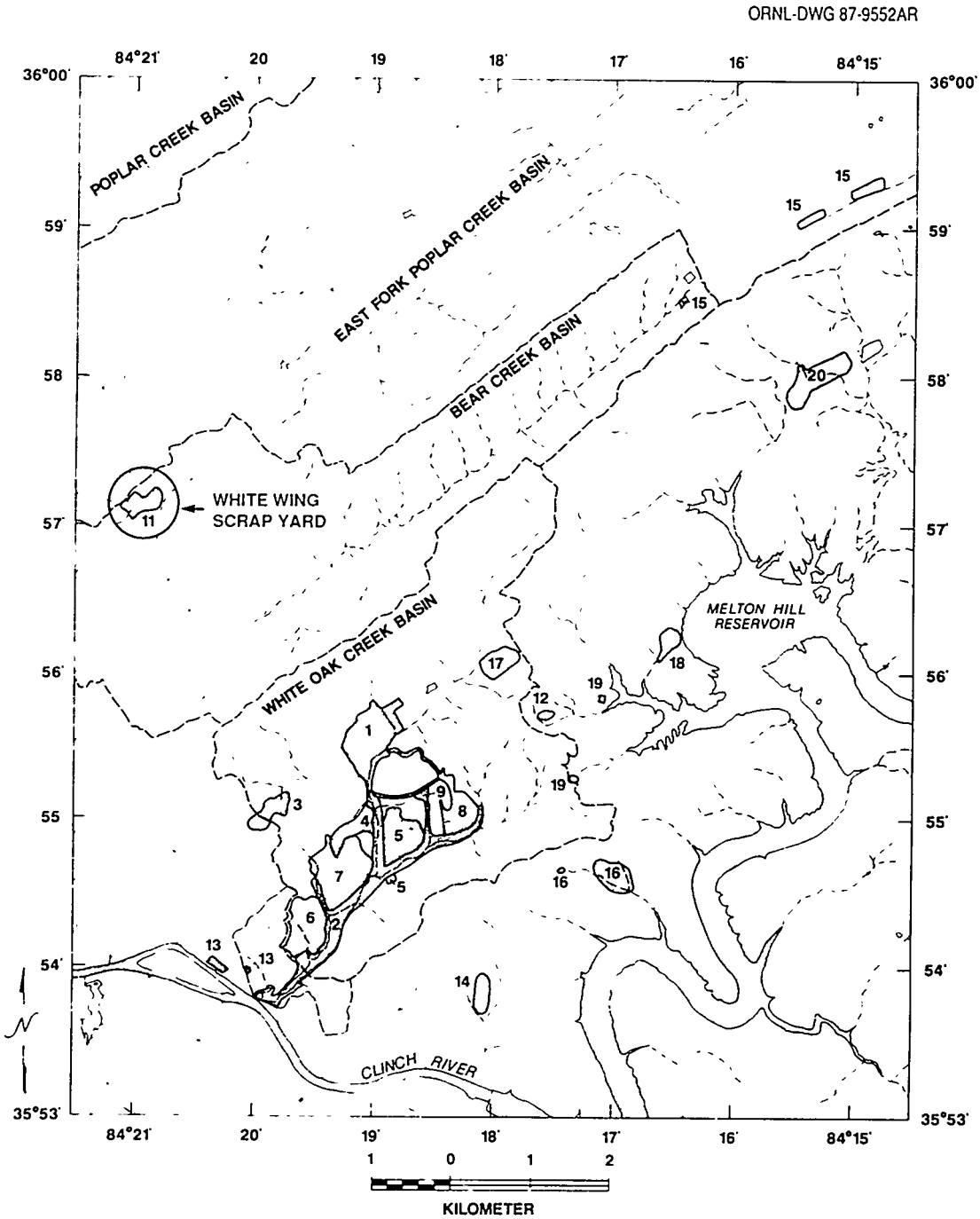

Fig. 2.3.6. ORNL WAGs.

and leak sites identified over the last 40 years. Because of the nature of cleanup and repair, it is not currently possible to determine which spill or leak sites still represent potential sources of release. Many types of SWMUs (tanks, ponds, waste treatment facilities, leak/spill sites, and landfills) listed by EPA in the definition of a SWMU are included in WAG 1. Most of the SWMUs are related to ORNL's solid and liquid radioactive waste management operations. A listing of the type and number of sites within WAG 1 is given in Table 2.3.6.

Table 2.3.6. Listing of WAG 1 sites by type, 1989

Type of site	Number of sites
Collection and storage tanks (LLW)	
Inactive	22
Active	24
Leak/spill sites and contaminated soils	
Radioactive	30
Chemical	4
Ponds and impoundments	
Radioactive	6
Chemical	3
Waste treatment facilities	
Radioactive	2
Chemical and sewage waste	2
Solid waste storage areas	
Radioactive	3
Chemical and sewage waste	1
Miscellaneous facilities	
Chemical and sewage waste	2
Total	99

ORNL 1989 Groundwater quality well installation, development, and sampling activities

Groundwater quality monitoring wells in WAG 6 and WAG 1 are designated as upgradient or downgradient (perimeter) depending on their location relative to the general direction of groundwater flow. Upgradient wells are located to provide groundwater samples that are not expected to be affected by possible leakage from the site. Downgradient wells are positioned along the perimeter of the site to detect possible groundwater contaminant migration from the site. WAG 6 also contains internal site-characterization wells that are located near burial trenches within the WAG 6 area.

Installation of RCRA-type groundwater quality monitoring (GQM) wells resumed in 1989. Drilling of the remaining 83 upgradient and perimeter wells along WAG boundaries began in late May, following completion of the new equipment decontamination facility. By December 31, 52 wells had been drilled; well development began in mid-December. All well construction and development is scheduled for completion by September 1990, at which time a total of 162 wells will form the initial network of upgradient and perimeter monitoring wells for the ORNL WAGS. All monitoring wells are scheduled to be available for sampling by the end of the third quarter of 1990. The number of wells for each WAG is as follows:

WAG 1/SWSA 1	27	WAG 7	16
WAG 2/WOD	14	WAG 8	9
WAG 3	14	WAG 9	4
WAG 4	15	WAG 11	11
WAG 5	22	WAG 17	8
SWSA 6	22		

The GQM wells at SWSA 6 and WAG 1 were the first completed, and sampling of these wells began in 1988.

SWSA 6, the only currently operating disposal area for low-level radioactive waste at ORNL, is under interim-status regulations that require four quarters of detection monitoring, and, if contamination is detected at the waste area boundary, submission and implementation of a

groundwater assessment plan. The remaining WAGs are currently remedial action sites regulated under RCRA 3004(u), which does not specify sampling schedules. ORNL has plans to sample downgradient GQM wells at the remaining WAGs on a semiannual schedule; upgradient wells would be sampled on a quarterly basis for the first year to establish natural ambient groundwater quality and its seasonal variations.

The fourth set of quarterly detection monitoring samples for GQM wells at SWSA 6 was collected in the second quarter of 1989, and analytical results became available in November. Statistical analysis of the results confirmed the presence of contamination along the northeastern boundary in wells 841–844 and 847. The contaminants are tritium (detected in four wells at levels above 3000 Bq/L) and the volatile organic compounds 1,2-dichloroethane, 1,2-dichloroethene, carbon tetrachloride, chloroform, and trichloroethene, which, at 0.51 mg/L, was the VOC detected at the highest concentration. Analytical results from SWSA 6 are presented in Table 2.3.14 in Vol. 2.

On December 15, as required by state and federal regulations, a groundwater assessment plan was submitted through DOE for transmission to TDHE and EPA. The plan describes the general field investigation approach for assessment monitoring and the detailed sampling and analysis plan to be used in defining the horizontal and vertical extent of the contaminant plume, characterization of contaminants, and rates and directions of movement.

Results of analyses of samples from groundwater quality monitoring wells at WAG 1 indicate the presence in several wells of low levels of radionuclides, including tritium, strontium, and total radium; the metals barium, chromium, and cadmium at concentrations that do not meet primary drinking water standards; and of the volatile organic carbon compounds trichloroethene and vinyl choride in two wells. Results of analyses of water from WAG 1 are shown in Table 2.3.13 in Vol. 2.

ORNL groundwater results

For the boundary wells at SWSA 6, only those along the eastern boundary (841–844 and 847) have consistently exceeded the drinking water standard for tritium of 20,000 pCi/L, and only wells 841, 842, 843, and 847 have consistently exceeded the EPA drinking water dose standard of 4 mrem (81,000 pCi/L). This is 0.04 of the 100 mrem value for tritium contained in Draft DOE Order 5400.5. Two boundary wells on the northeast side of SWSA 6, wells 841 and 842, have shown volatile organic contamination. Well 842, the shallower well, contains much higher levels of organic contamination than well 841, the deeper well. The discussion of contaminants that follows deals primarily with data generated during the four quarters of sampling (third quarter 1988 through second quarter 1989) of the 30 SWSA 6 water quality wells.

Total and dissolved metals concentrations from SWSA 6 boundary water quality wells have met the primary drinking water standards. Concentrations of metals and anions in the boundary wells are generally typical of shallow groundwaters in eastern Tennessee. The only boundary water quality well that has shown significant volatile organic contamination is well 842, a shallow well on the eastern boundary of SWSA 6. VOCs detected include trichloroethene, carbon tetrachloride, chloroform, 1,2-dichloroethane, and 1,2-dichloroethene. Trichloroethene, with a maximum concentration of 0.51 mg/L, is the VOC that has been detected at the highest concentrations. Trichloroethene and 1,2-dichloroethene have also been detected at much lower concentrations in well 841, a deeper well adjacent to well 842. No semivolatile organic compounds above the method detection limits have been found in the boundary water quality wells.

Quarterly sampling of the boundary compliance wells has confirmed the presence of tritium at the waste area boundary. Although several of the boundary water quality wells have exceeded the EPA primary drinking water standard of 20,000 pCi/L, only boundary wells,

841, 842, 843, and 847, have consistently shown tritium levels above 81,000 pCi/L, the regulatory 4-mrem level for beta emitters based on the latest DOE guidance (value is 0.04 of the 100-mrem dose level contained in DOE Order 5400.5). The highest levels have been found in well 843 (760,000 to 1.2 million pCi/L). Tritium levels in well 842 have been measured in excess of 540,000 pCi/L. For both of these wells, adjacent deeper wells have shown much lower concentrations of tritium (levels are 10 to 40% of the adjacent shallower wells).

Downgradient boundary water quality wells 842 and 857 have shown the highest gross alpha or beta activity. However, the activity is not due to ^{90}Sr, and the levels are below the primary drinking water limits. Gross alpha activities at other downgradient wells have also been below the EPA primary drinking water limit of 15 pCi/L. None of the boundary wells have exceeded the allowable 4-mrem dose level of 41 pCi/L for ^{90}Sr, when this level is calculated based on the most recent DOE guidance (value calculated based on 0.04 of the 100-mrem dose level given in DOE 5400.5).

Activities of gamma emitting radionuclides have been either low or absent in the boundary water quality wells. The only boundary wells with measurable levels of a gamma emitter are wells 842 and 843, which have consistently shown low levels of ^{60}Co activity. Well 842 has consistently shown 270 to 410 pCi/L, and well 843 has measured 11 to 51 pCi/L for ^{60}Co. ^{60}Co levels were at or near the detection limits in all of the samples. Thus, it appears that gamma emitting radionuclides do not represent a significant contamination problem at the site boundary, although ^{60}Co levels in well 842 are clearly elevated above values found in the upgradient wells.

Wells in WAG 1 have been sampled four times, two of which were in CY 1989. Cadmium levels exceeded the primary drinking water standard in downgradient wells 809, 820, and 829, as did barium in well 820 and chromium in well 812. Specific conductance, pH, and temperature were within normal ranges for groundwater in this area. Fluoride content in wells 811 and 808 exceeded the state of Tennessee limit of 1.4–2.4 mg/L, but it did not exceed the EPA primary drinking water standard of 4.0 mg/L. Low levels of radionuclides were detected in several wells, and included tritium, total radioactive strontium, total radium, ($^{226+228}Ra$), and gross alpha and beta activity. Total radioactive strontium exceeded the drinking water standard in wells 806, 812, 829, and 830. Of these, only wells 806 and 812 exceeded the value currently accepted to represent 4 mrem/year (41 pCi/L). Well 812, a shallow well in which the water table is only a few feet below ground surface, contained as much as 2300 pCi/L total radioactive strontium. Efforts to evaluate the origin and extent of radioactive contamination in this well and the low levels of radioactivity in several other wells in WAG 1 are continuing. Two volatile organic compounds, trichloroethene in well 813 and vinyl chloride in wells 825 and 830, were detected at levels exceeding primary drinking water standards. Additional data will be required to verify these results.

Future ORNL groundwater quality monitoring activities

The Groundwater Quality Assessment Plan for SWSA 6 will be implemented in 1990, requiring that assessment monitoring wells be installed in the area affected by contaminant migration. The number and location of assessment wells will be determined from results of soil gas surveys and closely spaced surface water quality sample analyses along the adjacent drainageway.

The planned sequence for sampling and analysis of groundwater from the remaining nine WAGs is based on the nature and inventory of contaminants at the WAG; near-term release potential; position relative to other potential, hydrologically upgradient sources; regulatory considerations; and costs and funding availability. The sequence as presently projected is WAGs 5, 4, 3, 7, 8, 9, 2, 11, and 17. Perimeter (downgradient) wells at these sites will be sampled on a semiannual basis, and upgradient wells will be sampled quarterly. After evaluation of the first year of baseline data, about 10% of the samples from upgradient and perimeter wells will be analyzed for RCRA Appendix IX constituents on a one-time basis to ensure that all potential hazardous contaminants have been identified.

The second and third sets of samples from wells in the off-site monitoring program will be collected and analyzed during 1990. (See Sect. 2.3.5 for more information on off-site monitoring).

2.3.3.3 Oak Ridge Gaseous Diffusion Plant

In an effort to determine the nature and extent of groundwater contamination at ORGDP, 191 RCRA quality monitoring wells have been installed throughout the plant, 111 of which were installed in 1989. Also in 1989, documentation was developed that grouped contamination sites, SWMUs, into areas that are hydrogeologically separate, WAGs. Currently 14 WAGs have been established at ORGDP. The boundaries may change as new data become available and others may be added to the current list. Table 2.3.7 lists the sites monitored in 1989, their status in the program, and the samples being obtained. Figure 2.3.7 shows the locations of the sites.

Samples from many of the wells at each site throughout the ORGDP area indicated high concentrations of iron and manganese in groundwater. In general, these constituents are not considered in assessing contamination of the area, because they occur naturally in high concentrations in the underlying geologic formations.

The data tables for groundwater monitoring sites that are presented in Vol. 2 include the parameters for which concentrations above detection limits were detected. The number of samples analyzed for that parameter is included in the first column. The number of samples that had a concentration above the detection limit and the average of those is included in the next two columns. The fourth and fifth columns provide the minimum and maximum values of concentrations for all samples collected. The column labeled "reference value" refers to the drinking water standard for that parameter, and the last column is the number of samples that had a concentration above the drinking water standard.

The SWMUs for which goundwater assessment has begun are listed below with a brief description of the facility and a short discussion of the data. A summary of the 1989 groundwater monitoring data for ORGDP is presented in Table 2.3.15 of Vol. 2.

Recirculating cooling water (RCW) lines: Sites K-27, K-29, K-31, K-33

Four RCW lines (not including those incorporated into WAGs) at ORGDP are being investigated for possible groundwater contamination caused by leakage. RCW lines are underground steel pipes that circulated treated cooling water between the cooling tower basins and the process buildings. They are buried from 3 to 10 ft below grade and range from 16 to 54 in. diam. Most were in use from the 1950s to 1985. Potential contaminants include chromium, zinc, phosphate, other heavy metals, and radioactivity.

K-27/29. The data collected from wells near these lines indicate heavy metals and solvents have been detected at this site. The solvents detected are benzene, carbon tetrachloride, trichloroethene, and vinyl chloride. The presence of solvents in this area is probably indicative of a contaminant plume that has migrated from another area of the plant. Heavy metals detected at this site are cadmium and lead; however, since only one sample had a concentration of lead above the drinking water standard, this may be due to raised detection levels for that sample.

K-31. Of the data collected thus far, the only analytes that have been detected are manganese and coliform bacteria.

K-33. Of the samples collected to date, the only potentially hazardous materials detected are coliform bacteria and trichloroethene. These constituents may also indicate that a contaminant plume has migrated from another area of the plant.

K-720 Fly Ash Pile

The K-720 Fly Ash Pile is located southwest of ORGDP near the east bank of the Clinch River. Fly ash was generated during the 1940s and 1950s by the nearby coal-powered steam plant. The pile covers an area of 10 to 15 acres. Potential contaminants include heavy metals, sulfates, and radioactivity. The data collected to date indicate that lead, sulfate, and nitrate are present.

K-770 Scrap Yard and contaminated debris

The K-770 Scrap Yard has been used since the 1960s for storage of radioactively contaminated

ORNL-DWG 88-7871R

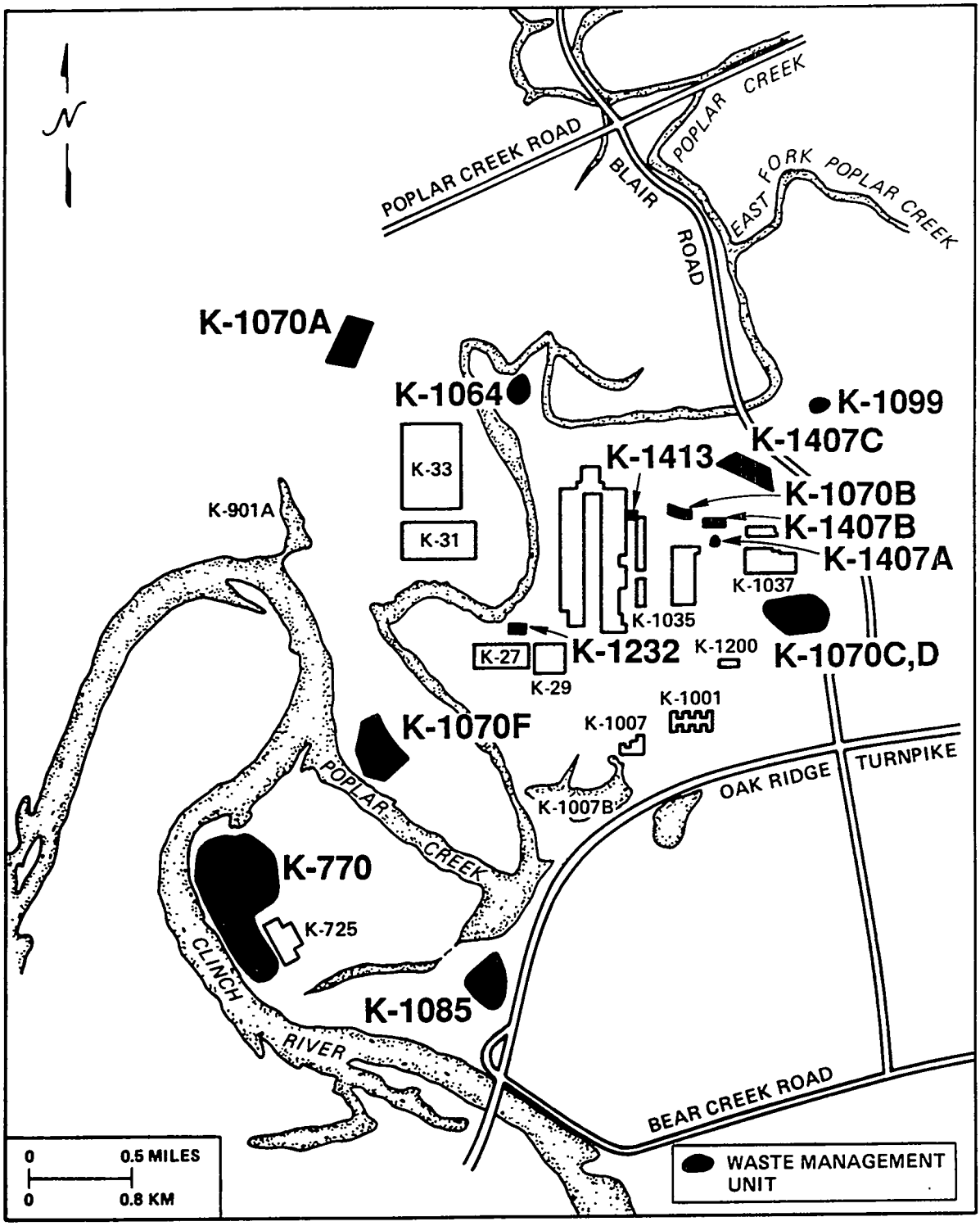

Fig. 2.3.7. Locations of monitoring wells in the ORGDP area.

Table 2.3.7. Oak Ridge Gaseous Diffusion Plant groundwater protection program site information

Unit name	Groundwater status	Current groundwater monitoring program						Date started	Monitored parameters	Annual sampling frequency
		Interim status		Permit			RCRA 3004(u)			
		Detection	Assessment	Detection	Compliance	Corr. action	RFI	CM			
K-1407-B surface impoundment	Interim	X							Nov. 1985	*a,b*	Semiannually
K-1407-C holding pond	Interim	X							Nov. 1985	*a,b*	Semiannually
K-1407 WAG K-1070-B classified burial ground	3004(u)						X		Apr. 1987	*b*	Quarterly
K-1407-A neutralization pit											
K-1700 stream											
K-1407-C upgradient area	3004(u)						X		Apr. 1987	*b*	Quarterly
K-1413 treatment facility	3004(u)						X		Apr. 1987	*b*	Quarterly
K-1070-C/D classified burial ground	3004(u)						X		Apr. 1987	*b*	Quarterly
K-770 scrap yard	3004(u)						X		Apr. 1987	*b*	Quarterly
K-1064-G burn area	3004(u)						X		Apr. 1987	*b*	Quarterly
K-1085 old firehouse burn area	3004(u)						X		Apr. 1987	*b*	Quarterly
K-1070-A contaminated burial ground	3004(u)						X		Apr. 1987	*b*	Quarterly
K-1070-F contractor's burial ground	3004(u)						X		Apr. 1987	*b*	Quarterly
K-1232 treatment facility	3004(u)						X		Apr. 1987	*b*	Quarterly
K-1099-C Blair Road quarry	3004(u)						X		Apr. 1987	*b*	Quarterly
Recirculating cooling water (RCW) lines sites (K-27, K-29, K-31, K-33)	3004(u)						X		Apr. 1989	*b*	Quarterly
K-27/29	3004(u)						X		Apr. 1989	*b*	Quarterly
K-31	3004(u)						X		Apr. 1989	*b*	Quarterly

Table 2.3.7 (continued)

Unit name	Groundwater status	Current groundwater monitoring program							Date started was begun	Monitored parameters	Annual sampling frequency
		Interim status		Permit			RCRA 3004(u)				
		Detection	Assessment	Detection	Compliance	Corr. action	RFI	CM			
K-33	3004(u)						X		Apr. 1989	*b*	Quarterly
K-720 fly ash pile	3004(u)						X		Apr. 1989	*b*	Quarterly
Cooling tower basins	3004(u)						X		Apr. 1989	*b*	Quarterly
K-802-B/H	3004(u)						X		Apr. 1989	*b*	Quarterly
K-832-H	3004(u)						X		Apr. 1989	*b*	Quarterly
K-862-E	3004(u)						X		Apr. 1989	*b*	Quarterly
K-892-G/H	3004(u)						X		Apr. 1989	*b*	Quarterly
K-892-J	3004(u)						X		Apr. 1989	*b*	Quarterly
K-901-A holding pond	3004(u)						X		Apr. 1989	*b*	Quarterly
K-1004 area laboratory drain, K-1004-L vaults, K-1004-N cooling tower basin lines	3004(u)						X		Apr. 1989	*b*	Quarterly
K-1007 underground gasoline storage tank	3004(u)						X		Apr. 1989	*b*	Quarterly
K-1070-C/D classified burial ground	3004(u)						X		Apr. 1989	*b*	Quarterly
K-1401 acid line and degreaser tanks	3004(u)						X		Apr. 1989	*b*	Quarterly
K-1410 neutralization pit	3004(u)						X		Apr. 1989	*b*	Quarterly
K-1407-C upgradient area	3004(u)						X		Apr. 1989	*b*	Quarterly

[a]Parameters establishing groundwater quality (Table 2.3.2 in Vol. 2) and indicator parameters (Table 2.3.3 in Vol. 2).

[b]Primary drinking water parameters (Table 2.3.1 in Vol. 2); parameters establishing groundwater quality (Table 2.3.2 in Vol. 2); indicator parameters (Table 2.3.3 in Vol. 2); metals analyzed by inductively coupled argon plasma (Table 2.3.4 in Vol. 2); metals analyzed by atomic absorption spectroscopy (Table 2.3.5 in Vol. 2); anions (Table 2.3.6 in Vol. 2); volatile organics (Table 2.3.7 in Vol. 2); pesticides and PCBs (Table 2.3.8 in Vol. 2); acid base/neutral extractable organics (Table 2.3.9 in Vol. 2); radionuclides and radioactive metals (Table 2.3.10 in Vol. 2); other parameters (Table 2.3.11 in Vol. 2).

scrap metal. Potential contaminants include radioactivity, PCB, mercury, and asbestos, which might be incidental to scrap-metal operations. No hazardous substances have been detected from groundwater samples collected to date.

Cooling Tower Basins K-802-B & H, K-832-H, K-862-E, K-892 G & H, K-892-J

Seven cooling tower basins (not including those incorporated into WAGs) within the plant are being evaluated for possible groundwater contamination. They are large, rectangular, concrete basins that are 300 to 400 ft long, 50 to 65 ft wide, and 13 to 16 feet deep (mostly below grade). Capacities range from 2.4 to 5.8 million gal, and ages range to 43 years. The basins underlie cooling towers and were used for recirculating chromate, zinc, and phosphate-treated cooling water. Additional potential contaminants include other heavy metals and radioactivity.

K-802-B & H. The only heavy metal in samples collected through 1989 is lead, and its being seen in only one sample in concentrations above drinking water standards may be due to raised detection levels in that sample. Additional contaminants in groundwater samples from this area are carbon tetrachloride and trichloroethene.

K-832-H. The hazardous heavy metals in groundwater samples collected from this area are cadmium and lead. Other detected metals are not considered a threat to human health and environment. An additional contaminant detected but not expected from this area is trichloroethene; however, its concentration above drinking water standards in one sample may be due to raised detection levels for that sample.

K-862-E. Several of the anticipated contaminants of concern were detected in groundwater samples collected from this area. The heavy metals detected include cadmium, chromium, lead, and sulfate. As with some of the other cooling tower basins, trichloroethene was also detected. Analysis of samples from this site also indicated the presence of coliform bacteria.

K-892-G & H. Although heavy metals were detected, only lead is considered hazardous; however, it was found in only 2 of 46 samples.

K-892-J. Unlike the other cooling tower basins, alpha activity was detected in groundwater samples. Lead and chromium are the two heavy metals that were detected; trichloroethene was also detected.

K-901-A Holding Pond

The K-901-A Holding Pond is a surface impoundment of approximately 5 acres located adjacent to the Clinch River. The pond was built in the early 1970s and was in use until 1985 for settling chromium-hydroxide (trivalent chromium) precipitates generated by electrochemical treatment of chromated RCW blowdown. The pond contains sludge composed of these chromium-hydroxide precipitates along with lead, nickel, copper, and uranium.

Although barium was detected in all groundwater samples collected from this area, it was above drinking water standards in only 1 of the 46 samples collected. Other heavy metals, chromium and lead, were seen in only two of the 46 samples that were collected and analyzed for those constituents. As at other sites, those two occurrences may be due to increased detection limits in those one or two samples. Trichloroethene was also detected at this site.

K-1004 Area laboratory drain, K-1004-L vaults, and K-1004-N cooling tower basin lines and RCW lines

The K-1004 Area Laboratory Drain carries laboratory wastes from several laboratories to the K-1007-B holding pond. The drain was used for disposal of laboratory wastes (including acids, bases, solvents, and other organics) prior to receipt of an NPDES permit in 1984. The drain is now used for disposal of rinse water only.

The K-1004-L vaults contain concrete casks that were used in the 1950s and 1960s for storage of reactor return samples. The K-1004-N cooling tower basin is a 30- to 40-year-old above-ground tank that is 21 ft long × 21 ft wide × 3 ft deep. The K-1004-L RCW lines circulated cooling water between the K-1004-L building and the K-1004-N cooling tower. Potential contaminants are

chromium, zinc, phosphate, other heavy metals, and radioactivity.

Of all the samples collected and analyzed for heavy metals through 1989, only one sample had a concentration above detection levels for chromium and lead. The lead sample may be due to raised detection limits in that one sample. Other contaminants detected but not anticipated are coliform bacteria and trichloroethene. Trichloroethene was detected in 21 of the 26 samples analyzed for that substance.

K-1007 underground gasoline storage tank

The K-1007 gasoline storage tank was a 250-gal tank located north of the K-1007 building. The top of the tank was 6 to 8 ft below ground. Gasoline was observed in the soil surrounding the tank when it was excavated and removed in 1986. Contaminants expected from this source are volatile organic aromatics (VOAs), petroleum hydrocarbons, and lead. Of these, only lead has been detected in groundwater samples collected through 1989. Three other metals were also detected, but only chromium is considered a potential threat to human health and the environment. Concentrations above drinking water standards were detected in only one of the samples that were analyzed for chromium.

K-1064-G Burn Area/Peninsula Storage

The K-1064-G Burn Area/Peninsula Storage Area was used in the 1950s and 1960s for burning solvents in an open metal container and in the 1960s and 1970s for drum storage of potential contaminants such as organic solvents, PCBs, and radioactively contaminated waste oils. The drums were removed, and the unit was closed in 1979.

Several potentially hazardous contaminants have been detected in groundwater samples collected to date. These include alpha activity, heavy metals, and solvents. In several samples, lead and arsenic were detected in concentrations above the drinking water standard. Silver and cadmium were also detected, but this may be due to increased detection levels in one of the several samples analyzed for these metals. The solvents detected in groundwater samples collected from this site are 1,1-dichloroethene and trichloroethene. Alpha activity was detected in all samples for which that analysis was performed; 40% were above the drinking water standard.

K-1070-A Contaminated Burial Ground

The K-1070-A Contaminated Burial Ground was used from the late 1940s to 1976 for disposal of unclassifed low-level radioactive solid and mixed chemical waste. The wastes were emptied into auger holes and trenches or buried in drums. Potential contaminants include chemicals, radioactivity, heavy metals, and some organics and oils.

No radioactivity and only two heavy metals were detected in groundwater samples collected from wells at this site. The two metals are cadmium and lead. Three solvents were detected from wells at this site, but only trichloroethene was detected in concentrations above the drinking water standard. This substance was detected in 8 of the 16 samples and was above the drinking water standard in 6 samples.

K-1070-C/D Classified Burial Ground

The K-1070-C/D Classified Burial Ground has been used since 1975 for burial of classified waste materials and equipment in trenches. Disposal of hazardous wastes in pits also occurred in the late 1970s. Potential contaminants include organic solvents, waste oils, heavy metals, chemicals, pesticides, and radioactivity.

Most of the contaminants expected at this site have been detected in groundwater samples collected through 1989. Heavy metals include barium, cadmium, chromium, and lead. Solvents include 1,1-dichloroethene, trichloroethene, and vinyl chloride; however, the one sample in which vinyl chloride was detected in concentrations above the drinking water standard may be due to increased detection levels for that sample. Alpha activity was also detected.

K-1070-F Old Contractors' Burial Ground

The K-1070-F Old Contractors' Burial Ground was used from 1974 to 1978 and once in

1982 for disposal of construction/demolition debris such as dirt and rock, scrap, roofing material, concrete, asphalt, and asbestos. These materials were supposed to be uncontaminated, but disposal records were not kept prior to 1977.

Heavy metals and a solvent were detected in groundwater samples collected from wells at this site through 1989. The heavy metals are cadmium and lead; however, the one occurrence of these metals in a concentration above the drinking water standard may be due to increased detection levels for those samples. Trichloroethene was detected in one of three samples analyzed for that component.

K-1085 Firehouse Burn Area

The K-1085 Firehouse Burn Area was used in the mid-1940s as a firehouse, garage, and fuel station (with UST). From the late 1940s to 1960, the area was used for fire training by burning waste oil in metal pans and excavated pits. Potential contaminants include waste oils, solvents, and heavy metals/uranium that may have contaminated the oils and petroleum products.

Samples collected to date have not indicated the presence of any of the anticipated contaminants in this area. The only hazardous substances detected thus far are chromium and lead. Lead was detected in 12 of the 41 samples collected, but only 3 samples had concentrations in excess of the drinking water standard. Two samples had concentrations of chromium in excess of the drinking water standard.

K-1099 Blair Road Quarry

The K-1099 Blair Road Quarry was used for material disposal and open burning from 1945 to 1957. According to personnel interviews, a policy existed that no contaminated materials be disposed of at the quarry; however, contaminated materials (e.g., cleaning rags) may have been mixed with the trash.

The only analyte of concern in samples collected through 1989 is alpha activity. One of the four samples collected to date had slightly more activity than the drinking water standard.

K-1232 Treatment Unit

The K-1232 Treatment Unit is a RCRA facility consisting of eight above-ground steel tanks and four in-ground concrete tanks used for pH adjustment and chemical precipitation of hazardous wastes. Because the unit treats wastes in tanks, it is not subject to RCRA groundwater monitoring. However, groundwater is being monitored at the unit for 3004(u) RCRA Facility Investigation (RFI) characterization. Potential contaminants include nitrates, heavy metals, organics, and uranium.

The contaminants detected in groundwater samples collected through 1989 include both solvents and heavy metals. The solvent most likely to pose a concern for this area is trichloroethene. This substance was detected in all of the ten samples collected from this area and was above drinking water standards in six samples.

K-1401 acid line and degreaser tanks

The K-1401 acid line is an underground vitreous clay pipeline used to transport corrosive fluids from the K-1401 degreaser tanks to K-1407-A for neutralization. The K-1401 degreaser tanks are stainless steel tanks in brick-lined pits within a large concrete structure in the K-1401 building. Equipment is lowered into the tanks for degreasing, and trichloroethane is used as the solvent. Both of these facilities are still in use.

As expected, trichloroethene has been seen in 11 of 13 samples collected from this area and was above the drinking water standard in 10 of those. Other contaminants of potential concern are cadmium, chloride, and vinyl chloride; however, the frequency of occurrence of these substances is not nearly as common as that of trichloroethene.

K-1407-B Pond

The K-1407-B Pond is a RCRA interim status unit currently in assessment monitoring. This surface impoundment was used for settling the metal hydroxide precipitates generated during the neutralization and precipitation of metal-laden solutions treated in the K-1407-A neutralization

pit. Potential contaminants are heavy metals. The unit was removed from service during 1988 and is undergoing RCRA closure. A postclosure permit application has been submitted to TDHE.

Data that had indicated an increase of conductivity and total organic halogens (TOX) were analyzed in the report, *K-1407-B and K-1407-C Surface Improvement False Positive Groundwater Assessment.* The report was approved by the TDHE on March 10, 1989. This report described the laboratory analyses from samples collected from November 1987 through December 1988. According to its recommendations, the monitoring program for both the B and C Ponds was modified to remove the possibility for future false-positive readings.

The wells monitoring groundwater quality at the B-pond were sampled twice in 1989, during March and September. In March, no statistically significant concentrations were noted. In September, statistically significant increases of both pH and manganese were noted in UNW-5, and an increase in lead was noted in UNW-4. In accordance with the modified detection program, these wells were immediatedly resampled. The second set of samples from these wells indicated that the high concentration of lead noted earlier was probably the result of sampling or laboratory error and that the high concentrations of pH and manganese are probably due to seasonal fluctuations of these constituents, as may be expected in this region.

The upgradient well for the B-Pond, UNW-1, has also shown significant increases in pH and manganese concentrations throughout 1989. The gradual increases in these parameters at wells surrounding the B-Pond may be indicative of a contaminant plume approaching this area or could possibly be the natural result of high rainfall during the last few months of 1989. Different water quality parameters would be expected after the long drought of the mid-1980s.

K-1407-C Pond

The K-1407-C Pond is a RCRA interim status unit currently in detection monitoring. This surface impoundment was used primarily for storing potassium hydroxide scrubber sludge, although sludges from B Pond also were placed here prior to 1973. Potential contaminants are heavy metals. The C-Pond is undergoing a RCRA clean closure by removal of all contaminated materials. Although postclosure groundwater monitoring will not be required, verification monitoring at the unit will be continued for at least 3 years.

As noted above, the monitoring program for this unit also was changed to a modified detection program. This monitoring program for the C-Pond was approved on July 11, 1988. Sampling for this site took place in March and September, as it was for the B-Pond. Increased levels of metals in the upgradient UNW-6 for this site during 1989 resulted in planning the beginning of an investigation for unknown sources of contamination upgradient of the C-Pond.

K-1407-C Upgradient Area

As discussed above, the upgradient well at C-Pond has shown elevated levels of lead, barium, and total chromium during its sampling history. Therefore, the area upgradient of C-Pond will be investigated to determine the source of these contaminants. The samples collected through 1989 continued to show the contaminants for which the investigation was initiated. Heavy metals and radioactivity were detected in the samples collected from wells in this area.

K-1407 WAG

The K-1407 WAG includes the K-1070-B classified burial ground, the K-1407-A neutralization pit, and the K-1700 stream. The K-1407-B pond and its associated interim status compliance monitoring system are located within the WAG boundaries.

The K-1070-B Clasified Burial Ground was used from the early 1950s through the mid-1970s for burial of classified equipment, materials, and parts. Potential contaminants include heavy metals and organic solvents. The K-1407-A Neutralization Pit was used as a reaction pit where sulfuric acid and calcium hydroxide were added to neutralize corrosive wastewater. Potential contaminants are

heavy metals. The K-1407-A WAG remains in service (a permit-by-rule application has been submitted to TDHE) to neutralize coal pile runoff and to serve as a backup to the new K-1407-H Central Neutralization Facility. The K-1700 stream receives discharge from the K-1407-B pond and surface runoff from several waste management units. Sampling has shown the stream sediments to contain elevated levels of heavy metals and uranium.

Trichloroethene and vinyl chloride are the contamination solvents that have been detected most often. Radioactivity has also been detected.

K-1410 Neutralization Pit

The K-1410 Neutralization Pit is a 15,800-gal (21 × 14 × 7 ft) concrete tank used from 1975 to 1979 for the neutralization of nickel-plating solutions prior to discharge to Poplar Creek. Some of the other chemicals known to be present include nickel sulfate, degreaser bath, acid, and corrosive solutions. So few samples were collected from this area through 1989 that no conclusions can as yet be drawn concerning potential contaminants in this area.

K-1413 WAG, process lines, and sumps

The K-1413 WAG includes four components as follows: the K-1413-C Neutralization Pit, two smaller pits (the sumps) located to the north and east of the K-1413 building, the lines from the pits to the K-1401 Acid Line, and the storm drains in the vicinity of the K-1413 building. The capacity of the sumps is about 500 to 1000 gal each. Corrosive wastewater and metal hydroxides drain from the two sumps to 1407-A for neutralization. Potential contaminants at the site include organic solvents and uranium from early uranium fluorination activities at the site.

No uranium or radioactivity has yet been detected from groundwater samples collected at wells in this area; however, the presence of organic solvents and heavy metals have been indicated by sample analyses. Trichloroethene was detected most frequently, and vinyl chloride was also detected. The heavy metals detected at this site include cadmium, chromium, and lead; however, they have been detected infrequently and in low concentrations.

K-1420 oil storage area and process lines

The K-1420 oil storage area consists of a paved area 50 by 275 ft, located 75 ft north of the K-1420 building. Uranium-contaminated oil is stored at the facility in 5-gal buckets for transfer to 55-gal drums and is then transported to the waste-oil decontamination facility inside K-1420. The K-1420 process lines are underground pipelines that connected K-1420 to the K-1407-B pond for transport of radioactive liquid. One of the abandoned pipelines was found to contain PCBs, mercury, and uranium.

Alpha activity and organic solvents were detected in groundwater samples collected through 1989. The solvent detected most frequently is trichloroethene, but vinyl chloride has also been detected. Detected heavy metals are lead and chromium, but their concentrations have exceeded the drinking water standard in only one sample.

K-1503 Neutralization Pit

The K-1503 Neutralization Pit was used for neutralization of corrosive liquids generated in water-softening operations in the past. Currently, it is used only as a sump for temporarily holding of corrosive liquids. It is approximately 10 ft^2 by 12 ft deep. Some heavy metals and trichloroethene have been detected in groundwater samples collected in this area. The concentration of trichloroethene was above the drinking water standard in three of the seven samples collected. Metals detected so far are chromium, iron, and manganese. Chromium was above the drinking water standard in only 1 of 13 samples.

K-1414 Fuel Storage Center

The K-1414 Fuel Storage Center has had three steel USTs containing automotive fuel. One 5500-gal tank contains unleaded gasoline, a second 12,000-gal UST contains methanol, and the third UST was removed after it was found to be leaking diesel fuel in February 1987. An Environmental Assessment and a RAP were completed in 1989.

The RAP was submitted to the TDHE, and it was conditionally approved. A bioremediation system for this site is currently being designed. Remedial activities are scheduled to begin in 1990. The analytical data for this site are included in the data for K-1070-C/D site.

2.3.4 Plugging and Abandonment

An open borehole or well may provide a potential route for surface contamination to enter previously uncontaminated groundwater. Transfer or spread of contamination from one zone to another occurs when an open borehole provides a pathway for contaminated water in an aquifer to enter or mix with that in an uncontaminated aquifer. Mixing in the subsurface can confuse monitoring results and spread contamination. To minimize the potential for groundwater cross-contamination, a program was initiated to identify, plug, and abandon unused, unnecessary, or damaged boreholes.

2.3.4.1 Y-12 Plant

On April 18, 1988, DOE received conditional approval from the TDHE of a plugging and abandonment procedure for selected groundwater wells at the Y-12 Plant.

No wells were plugged in 1989 although 90 to 100 candidates have been identified for future action.

2.3.4.2 Oak Ridge National Laboratory

Six groundwater monitoring wells were plugged in 1989 in SWSA 6 at the Tumulus II area. They were installed as part of the initial site characterization activities to assess the subsurface geology and shallow groundwater characteristics. Their removal was necessary as part of the construction activities for the project. The well designations were 278, 1035, T-8, T-12, T-14, and T-15. Well 617, designed to help determine the monitoring locations for a waste area, was plugged because it was in the way of new steamline construction. State-approved methodology was used for plugging and abandoning this well.

Future plans call for the areas surrounding some wells in SWSA 6 that are located in the interim corrective measure capping areas to be covered by a high-density polyethylene liner and fill material. Since future sampling of wells in these areas is necessary, the wells will not be plugged at the present time. When the site is permanently closed, all wells will be plugged except those peripheral monitoring wells necessary for closure.

2.3.4.3 Oak Ridge Gaseous Diffusion Plant

No wells were plugged and abandoned at ORGDP during 1989.

2.3.5 Off-Site Monitoring

Under the direction of the Energy Systems Environmental and Safety Activities (E&SA) Organization, ORNL implemented a long-term, off-site, residential drinking water quality monitoring program in 1989. The objective of the program is to document water quality from groundwater sources in areas adjacent to the ORR to help assure residents that DOE-ORO plant operations do not affect the quality of groundwater sources.

Twenty wells were selected on the bases of their proximity to the ORR and a representative distribution of sources from the different geologic formations of the area. The wells, to be sampled on a semiannual basis, were first sampled in September 1989. Analytical parameters to be used for the first year of monitoring include volatile organics; selected atomic absorption metals (As, Hg, Pb, Se); inductively coupled argon plasma metals; anions (fluoride, chloride, sulfate, nitrate, and nitrite); total fluorometric uranium; and the radioactive parameters gross alpha, gross beta, total radioactive strontium, ^{99}Tc, tritium, and a gamma scan. The list of parameters may be reduced after evaluation of the first year of data, but one full set of analyses will be made at least once every 3 years. These data are presented in Tables 2.3.8–2.3.10.

The first set of analyses revealed only one parameter that did not meet primary drinking

Table 2.3.8. Off-site well water inorganic analyses of 20 samples, October 1989

Parameter	Concentration (mg/L)			Std. error	Percentage DWL[a]
	Max	Min	Av		
Arsenic	<0.0050	<0.0050	<0.0050		<10
Barium	0.50	0.0021	0.10	0.023	10
Beryllium	0.0036	<0.00030	<0.00049	0.00016	
Cadmium	0.0048	<0.0030	<0.0030	0.00009	<31
Calcium	120	1.2	50	7.5	
Chloride	64	1.0	7.7	3.3	3.1
Chromium	0.046	<0.010	<0.013	0.0020	<26
Cobalt	0.037	<0.0050	<0.0078	0.0019	
Conductivity, mS/cm	1.5	0.010	0.35	0.071	
Copper	0.082	<0.0040	<0.020	0.0054	<2.0
Fluoride	6.0	<0.10	<0.46	0.29	<12
Iron	44	<0.0040	<3.7	2.5	<1200
Lead	0.056	<0.0040	<0.0093	0.0030	<19
Magnesium	31	0.50	15	2.1	
Manganese	4.3	<0.0010	<0.33	0.23	<670
Mercury	<0.00020	<0.00020	<0.00020		<10
Nickel	0.047	<0.010	<0.013	0.0022	
Nitrate	2.0	<0.20	<0.80	0.091	<8.0
Nitrite	<1.0	<0.40	<0.64	0.067	<64
Selenium	<0.0050	<0.0050	<0.0050		<50
Silver	<0.0060	<0.0060	<0.0060		<12
Sodium	360	0.45	32	18	
Sulfate	44	2.0	12	2.6	4.6
Temperature, °C	22	16	18	0.36	
Uranium fluorometric	0.0010	<0.0010	<0.0010		
Vanadium	0.034	<0.0050	<0.0079	0.0020	
Zinc	0.56	<0.0010	<0.12	0.037	<2.3
pH, standard units	8.3	6.0	7.2	0.12	

[a]Average concentration as a percentage of National Primary or Secondary Drinking Water Regulation level.

Table 2.3.9. Off-site well water radiochemical analyses of 20 samples, October 1989

Parameter	Concentration (pCi/L)			Std. error	Percentage DWL[a]
	Max	Min	Av		
^{60}Co	4.6	−5.9	0.35	0.60	NA[b]
^{137}Cs	3.2	−2.4	0.85	0.35	NA
Gross alpha	5.4	−0.24	1.8	0.40	12
Gross beta	38	−7.8	6.9	2.2	NA
^{99}Tc	3.0	−1.6	1.0	0.26	NA
Total strontium	4.6	−1.9	1.0	0.36	12
Tritium	2100	−540	49	130	0.24

[a]Average concentration as a percentage of National Primary or Secondary Drinking Water Regulation level.

[b]NA = not applicable.

Table 2.3.10. Off-site well water organic analyses of 20 samples, October 1989

Parameter	Concentration (μg/L)			Std. error	Percentage DWL[a]
	Max	Min	Av		
1,1,1-Trichloroethane	<5.0	<5.0	<5.0		<2.5
1,1,2,2-Tetrachloroethane	<5.0	<5.0	<5.0		
1,1,2-Trichloroethane	<5.0	<5.0	<5.0		
1,1-Dichloroethane	<5.0	<5.0	<5.0		
1,1-Dichloroethene	<5.0	<5.0	<5.0		<71
1,2-Dichloroethane	<5.0	<5.0	<5.0		<100
1,2-Dichloroethene (total)	<5.0	<5.0	<5.0		<7.1
1,2-Dichloropropane	<5.0	<5.0	<5.0		<100
2-Butanone	<10	<10	<10		
2-Hexanone	<10	<10	<10		
4-Methyl-2-pentanone	<10	<10	<10		
Acetone	<10	~5.0	<9.7	0.26	
Benzene	<5.0	~0.60	<4.8	0.22	<96
Bromodichloromethane	<5.0	<5.0	<5.0		
Bromoform	<5.0	<5.0	<5.0		
Bromomethane	<10	<10	<10		
Carbon disulfide	<5.0	~1.0	<4.8	0.20	
Carbon tetrachloride	<5.0	<5.0	<5.0		<100
Chlorobenzene	<5.0	<5.0	<5.0		<5.0
Chloroethane	<10	<10	<10		
Chloroform	<5.0	~1.0	<4.8	0.20	
Chloromethane	<10	<10	<10		
Dibromochloromethane	<5.0	<5.0	<5.0		
Ethyl benzene	<5.0	<5.0	<5.0		<0.71
Methylene chloride	<5.0	<5.0	<5.0		
Styrene	<5.0	<5.0	<5.0		<100
Tetrachloroethene	<5.0	<5.0	<5.0		<100
Toluene	<5.0	<5.0	<5.0		<0.25
Trichloroethene	<5.0	<5.0	<5.0		<100
Vinyl acetate	<10	<10	<10		
Vinyl chloride	<10	<10	<10		<500
Xylene (total)	<5.0	<5.0	<5.0		<0.050
cis-1,3-Dichloropropene	<5.0	<5.0	<5.0		
trans-1,3-Dichloropropene	<5.0	<5.0	<5.0		

[a]Average concentration as a percentage of National Primary or Secondary Drinking Water Regulation level.

water standards for radiological and chemical analyses; that parameter was fluoride with a concentration of 6 mg/L. A search of the ORNL and Y-12 Plant water quality data bases for elevated fluoride content showed 16 wells at ORNL and 4 at the Y-12 Plant had fluoride content of 2.5 mg/L or greater. All wells having water with elevated fluoride, including the off-site well, are deep, ranging from 180 to 510 ft, and all are in the Conasauga Group.

The water quality characteristics are distinctive from those of shallower wells. The pH is higher (≥8.5); high pH is required for the dissolution of any fluoride minerals present in the rock materials. Sodium content is markedly greater (320 to 4400 mg/L), as is sulfate content (21 to 839 mg/L), and calcium content is markedly less (≤2.7 mg/L). Water from shallower wells in the Conasauga Group typically is of the calcium bicarbonate type, whereas water associated with elevated fluoride is of the sodium sulfate type. No elevated fluoride content has been measured in shallow wells of the area, showing that air deposition as a source of fluorides is unlikely. The

elevated fluoride content, the distinctive characteristics of the water quality associated with it, and the depth of wells in which it is found, including the off-site well, indicate that the fluoride content is the product of natural processes as the water flows through deeper strata.

2.4 BIOLOGICAL SAMPLING

Air and water are the principal dispersal media for the Oak Ridge DOE facility releases. However, the environmental surveillance programs also include biotic and other abiotic media that may be affected by these releases or may provide pathways of exposure to people. Table 2.4.1 gives a summary of the media sampled, the types of analyses performed, and the sampling and analysis frequencies for the biological samples.

One of the problems encountered when analyzing samples for uranium isotopes is the high bias associated with the ^{235}U activity. When a stainless disk containing a mixture of ^{234}U, ^{235}U, and ^{238}U is counted with a silicon surface barrier detector, the ^{235}U activity is often biased because of interference from the ^{234}U and ^{238}U. The ^{235}U alpha energy lies between the other two isotopes, and the detectors do not have sufficient resolution to separate all three peaks effectively. Therefore, depending on the amount of ^{234}U and ^{238}U present in the sample, the ^{235}U will be biased high.

2.4.1 Milk

One of the pathways of radioactivity to man involves the ingestion of radionuclides. Radionuclides can be transferred from the environment to humans via food chains such as the grass-cow-milk pathway. Milk is a potentially significant pathway for the transfer of radionuclides from their point of release to humans because of the relatively large surface area that can be grazed daily by the cow, the rapid transfer of milk from producer to consumer, and the importance of milk in the diet.

2.4.1.1 Sample collection and analytical procedures

The 1988 milk sampling program consisted of biweekly samples from each of four local sources (Stations 1–4, Fig. 2.4.1) and semiannual samples from two remote sources (Stations 51 and 53, Fig. 2.4.1). In May 1989, this program was reduced to include monthly samples from the local stations only. The reduction was motivated by budgetary constraints. Analysis of previous data showed that the remote station results were the same as those from the local stations.

Milk samples are analyzed at ORNL for ^{131}I by gamma spectrometry and for total radioactive

Table 2.4.1. Summary of collection and analysis frequencies of biological samples in 1989

Station	Parameter	Collection frequency	Sample type	Analysis frequency
		Milk[a]		
1,2,3,4	^{131}I, total Sr[b]	Monthly	Grab	Monthly
51,53	^{131}I, total Sr[b]	Monthly	Grab	Monthly
		Fish[c]		
CRK 8.0, CRK 33.0, CRK 40.0	Gamma scan, total Sr, Hg, PCBs	Semiannually	Grab	Semiannually

[a]See Fig. 2.4.1.
[b]Total radioactive strontium ($^{89}Sr + {}^{90}Sr$).
[c]See Fig. 2.4.2.

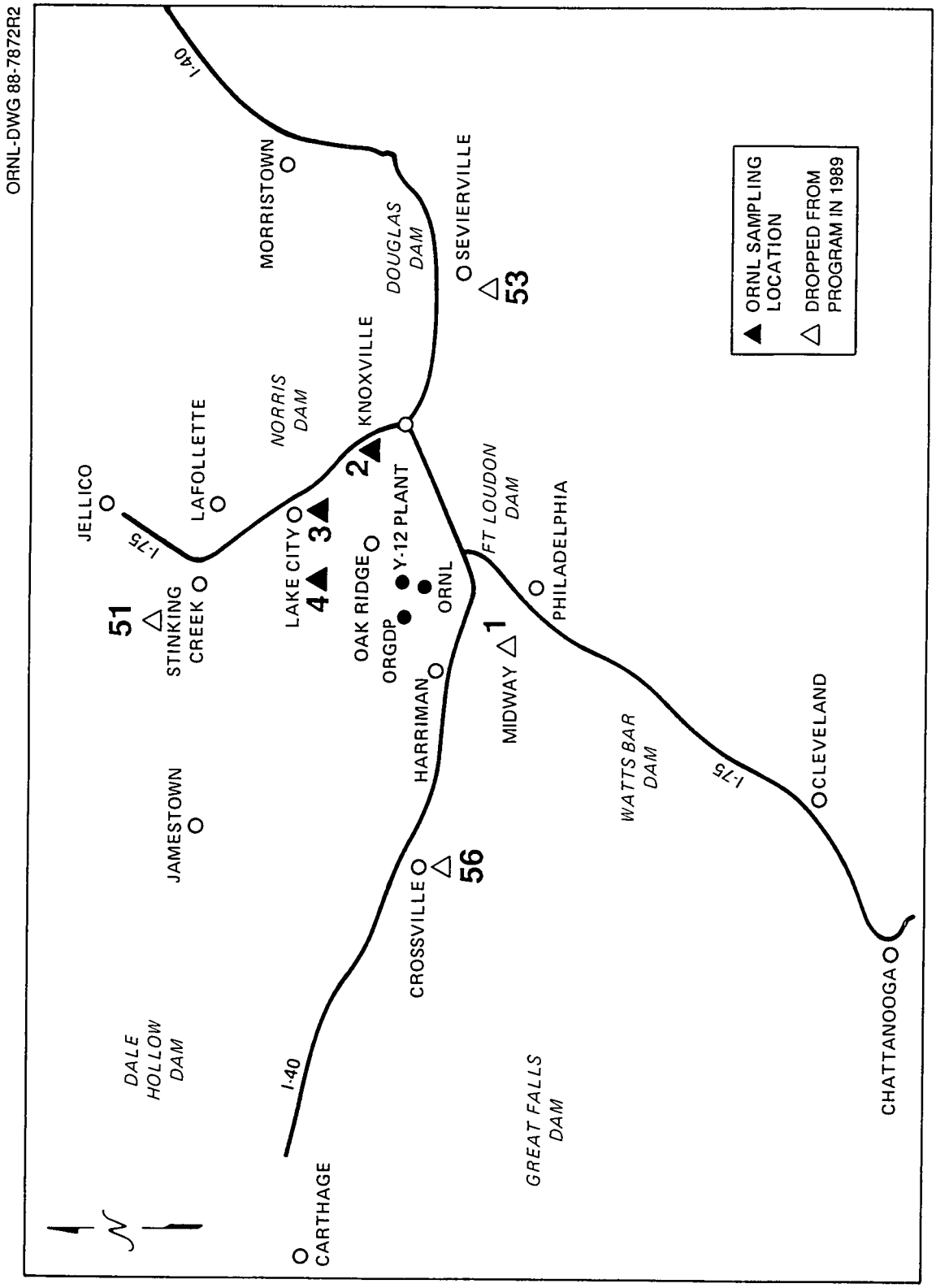

Fig. 2.4.1. Map showing milk sampling stations.

strontium (^{89}Sr and ^{90}Sr) by chemical separation and low background beta counting.

2.4.1.2 Results

Concentrations of ^{131}I and total radioactive strontium in milk are summarized for the 1989 data in Table 2.4.2. As previously noted, the remote sampling program was discontinued after the first semiannual samples were collected. The average values were converted to effective dose equivalents and are presented in the last column of the table. These results are consistent with data from previous years. The location-specific data are included in Vol. 2, Tables 2.4.1 and 2.4.2.

2.4.2 Fish

Ingestion of fish is a pathway for contaminant uptake in man. Prior to 1985, five species of fish were measured for PCBs, mercury, and radionuclide concentrations: bluegill, catfish, bass, carp, and crappie. The highest mercury and PCB concentrations were found in carp and the next highest were in bluegill. For several of the radionuclides, concentrations were highest in bluegill. Because of this and because of the large number of available fish, bluegill (*Lepomis macrochirus*) were collected during 1989 for tissue analysis to estimate concentrations for dose assessment models. In addition, bluegill are favored by sport fishermen in Tennessee and can be obtained in the large numbers required for tissue analysis.

2.4.2.1 Sample collection and analytical procedures

Bluegill from three Clinch River locations were collected twice during the year for muscle analyses of radionuclides, mercury, and PCBs (Fig. 2.4.2; Table 2.4.3) by ORNL. Sampling locations include the following CRKs: (1) 40.0 (river mile 24.8), which is above Melton Hill Dam and serves as a background location for the DOE facilities, because it is above all the Oak Ridge DOE facilities' outfalls with the exception of those from the ORNL 7600 area, the radioactive effluents from which are negligible; (2) 33.3 (river mile 20.6), which is ORNL's discharge point from White Oak Creek to the Clinch River; and (3) 8.0 (river mile 5), which is downstream from both ORNL and ORGDP.

The primary radionuclides of concern at ORNL regarding fish consumption are total radioactive strontium and ^{137}Cs. These two result in the highest dose to man from ingestion of fish. Radionuclide concentrations were determined on at least three composites of six to ten fish per sampling period. Mercury and PCB concentrations were measured in six individual fish from each sampling location during each period. Scales, head, and entrails were removed from each fish before

Table 2.4.2. 1989 radionuclide concentrations in milk[a]

Location[b]	Analysis	No. of samples	Concentration (pCi/L)			
			Max	Min	Av	Standard error
Immediate environs	^{131}I	65	2.4	−2.4	0.30	0.10
	Total Sr[c]	65	12	−1.6	2.9	0.32
Remote environs	^{131}I	2	1.3	0.27	0.81	0.54
	Total Sr[c]	2	1.8	0.29	1.0	0.77

[a]Raw milk samples.
[b]See Fig. 2.4.1.
[c]Total radioactive strontium (^{89}Sr + ^{90}Sr).

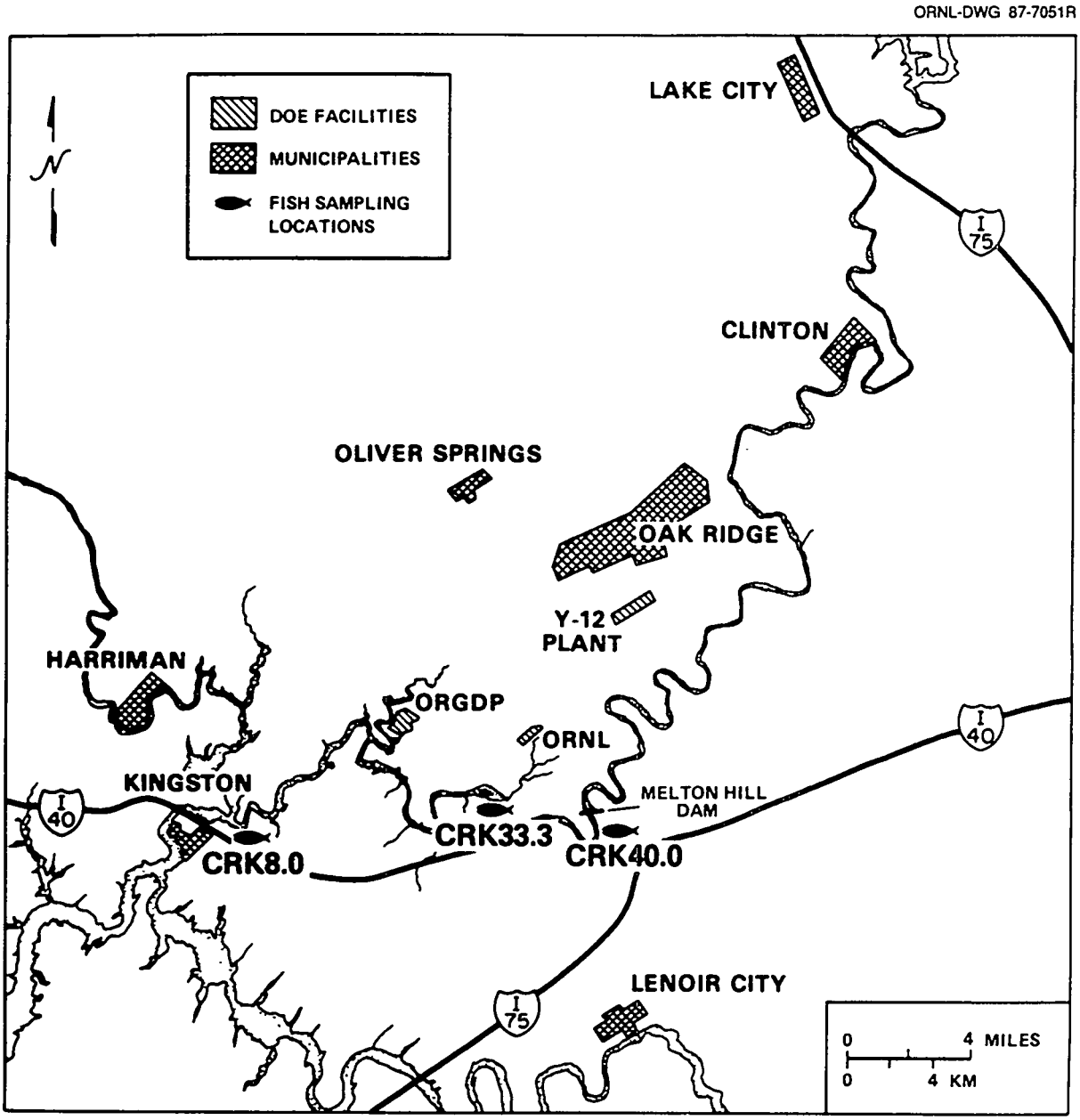

Fig. 2.4.2. Fish sampling locations along the Clinch River.

samples were obtained. Composite samples were ashed and analyzed by gamma spectrometry and radiochemical techniques for the radionuclides that contribute the majority of the potential radionuclide dose to humans.

The ash constituted only 1% of the original sample. In previous years, radionuclide concentrations in fish were reported in pCi/kg wet weight. This was a convenient unit for estimating the annual dose from fish ingestion. This year, the revised DOE Order 5400.1 requires that concentrations be reported in pCi/g ash weight. The 1989 concentration data were converted to a wet weight basis and are presented in Vol. 2, Table 2.4.5.

Table 2.4.3. 1989 Tissue concentrations of Clinch River bluegill

Location[a]	Determination	No. of samples	Concentration[b]				Percent of guidelines[d]
			Max	Min	Av	Std. error[c]	
Clinch River	Hg	36	0.35	0.016	0.078	0.011	7.8
	PCB Aroclor 1254	36	0.10	<0.010	<0.016	0.0026	<0.79
	PCB Aroclor 1260	36	0.10	<0.010	<0.019	0.0033	<0.97
	^{60}Co	18	0.51	−0.14	0.15	0.044	*e*
	^{137}Cs	18	16	0.26	6.4	1.3	*e*
	Total Sr[f]	18	1.9	−0.27	0.76	0.17	*e*

[a]See Fig. 2.4.2.
[b]Mercury and PCB units are μg/g wet weight. All radionuclides are in pCi/g ash weight.
[c]Standard error about average.
[d]Percent of Food and Drug Administration action level of mercury in fish (1.0 μg/g wet weight) and tolerance for PCBs in fish (2.0 μg/g wet weight) for the average concentration.
[e]Not applicable.
[f]Total radioactive strontium (^{89}Sr and ^{90}Sr).

2.4.2.2 Results

Concentrations of mercury, PCBs, ^{60}Co, ^{137}Cs, and total radioactive strontium in bluegill collected in the Clinch River are given in Table 2.4.3, which provides a summary of the highest, lowest, and average concentrations of these parameters observed in bluegill from any of the three Clinch River locations. The average value is compared with the appropriate Food and Drug Administration (FDA) guideline for fish tissue. For the 36 fish analyzed, the average mercury concentration was 7.8% of the FDA guideline. For PCBs, the percentage of the guideline was <0.79% for PCB Aroclor 1254 and <0.97% for PCB Aroclor 1260 (or <1.8% for total PCBs). There are no guidelines for radionuclide concentrations in fish. However, dose calculations are made based on concentrations of radionuclides in fish. Refer to Sect. 3 for more information and for the dose estimates from ingestion of fish.

Annual mercury concentrations in bluegill from the three Clinch River sampling locations are given in Table 2.4.3 of Vol. 2. An analysis of variance test was used to compare concentrations of parameters in fish from the different locations. Mercury concentrations were significantly higher in fish from CRK 8.0 (river mile 5) than CRK 33.3 (river mile 20.7) and CRK 40.0 (river mile 25). The highest concentration of mercury was measured at CRK 8.0 (0.35 μg/g wet weight). The average concentration at each station was compared with the FDA action level for mercury in fish (1.0 μg/g wet weight). The average values at all stations were 7.8% of this limit. None of the individual fish concentrations of mercury exceeded the FDA action level (Table 2.4.3 in Vol. 2).

PCB concentration summaries for bluegill for 1989 are given in Table 2.4.4 of Vol. 2. There were no statistically significant differences in the concentrations of PCB Aroclor 1254 or PCB Aroclor 1260 in fish among the locations sampled. The highest concentration of PCB Aroclor 1254 (0.10 μg/g) was measured in fish collected at CRK 33.3 (river mile 20.7), near White Oak Creek. The maximum concentration of PCB Aroclor 1260 (0.10 μg/g) was also observed in fish collected at CRK 33.3 (river mile 20.7). The average concentration of each type of PCB at each CRK was compared with the Food and Drug Administration (FDA) tolerance limit for PCBs in fish (2 μg/g wet weight). All average concentrations were less than 1% of the tolerance limit. None of the individual fish concentrations of PCBs exceeded the FDA tolerance limit (Table 2.4.4 in Vol. 2).

Annual summaries of radionuclide concentrations in Clinch River fish are given in

Table 2.4.5, Vol. 2. No statistically significant differences in ^{60}Co were detected in fish collected at the three locations. Total radioactive strontium and ^{137}Cs concentrations in fish were significantly higher in fish collected at CRK 33.0 (river mile 20.7) than in fish from the other two locations. Cesium-137 concentrations were significantly higher in fish from CRK 8.0 and CRK 33.3 than in fish collected from CRK 40.0.

These statistical relationships are the same as for the 1988 data. The magnitudes of the averages are also not different between 1988 and 1989 for all six determinations in Table 2.4.3 at a confidence level of 95%.

2.4.3 ORR deer population

The fifth annual DOE-TWRA Managed Deer Hunts were held during the final quarter of 1989. Analytical Chemistry Division (ACD) personnel assisted by student members of the Wildlife Society (University of Tennessee chapter) performed most of the necessary operations at the checking station. The radiological surveillance of the harvest continues to be the responsibility of ACD personnel.

The basic conduct of the managed hunts for 1989 was similar to those of previous years; however, they consisted of only one archery hunt (October 21–22) and two shotgun/muzzle-loader hunts (November 11–12 and December 9–10). During the archery hunt 124 deer were taken, and 316 were killed during the two gun hunts. From the total harvest of 440 animals, 261 (59%) were bucks and 179 (41%) were does. The 1989 harvest of 440 is down considerably from that of 1988, when 507 deer were taken. The heaviest buck had 11 antler points and weighed 202 lbs. The greatest number of points (17) was on a buck that weighed 91 lbs. The heaviest doe weighed 117 lbs.

Soft tissue (liver or muscle) radioactivity concentrations of ^{137}Cs continued to be low and acceptable, with only 2% of the harvest exceeding 1.0 pCi/g (confiscation limit is 20 pCi/g). The maximum concentration of ^{137}Cs was 1.9 pCi/g. Strontium-90 concentrations in bone exceeded 30 pCi/g (confiscation limit) in 22 deer out of the 440 harvest (5%). The maximum ^{90}Sr concentration was 450 pCi/g, up considerably from the 250-pCi/g maximum of the 1988 harvest when 2.6% of the animals were confiscated. Thyroid glands from selected animals were counted for radioiodine nuclides. Both ^{125}I and ^{129}I were detected in some animals. The previously observed correlation of elevated ^{90}Sr bone concentrations with increased ^{129}I in thyroid tissue was found to exist in this harvest.

2.4.4 Vegetation

Contamination of growing plants may result from absorption of materials from soil or from deposition of materials from the atmosphere. Grass was analyzed routinely for fluorides by ORGDP because of its importance as pasture for dairy herds and its year-round availability. Grass also provides an early indication of fallout because of the relatively large surface area of the grass blades exposed to air.

Radioactivity measurements of grass samples were not conducted at ORNL in 1989. This program was eliminated because of a shortage of funds to support the analyses. The grass program was assessed a lower priority than other programs because grass samples from the ORR do not represent a direct pathway to man. Contamination of grass used for agricultural grazing is monitored through the milk program.

2.4.4.1 Sample collection and analytical procedures

Grass samples were collected semiannually at ORGDP from 16 locations, and pine needles were collected in the summer from 6 locations. These locations are shown in Fig. 2.4.3. About 0.45 kg (1 lb) of vegetation is picked and submitted for uranium, technetium, and fluoride analyses. Fluorometric analysis is used to determine concentrations of uranium, while a fluoride-selective ion electrode is used to determine the presence of fluorides. Table 2.4.4 gives a summary of the grass and pine needle sampling data. Table 2.4.6 in Vol. 2 provides data on individual sampling locations.

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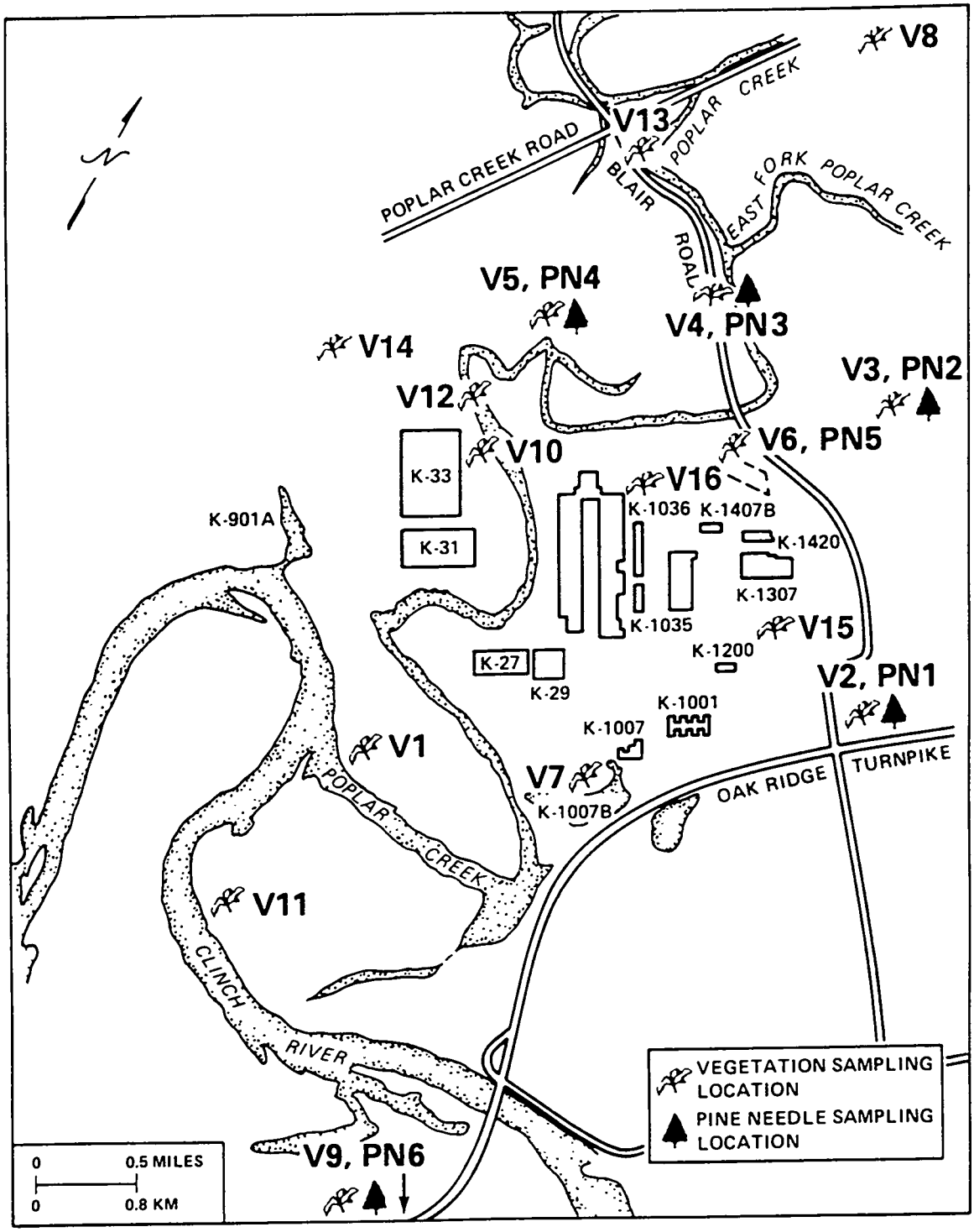

Fig. 2.4.3. Map of ORGDP pine needle and grass sampling locations.

Table 2.4.4. 1989 Grass analyses at ORGDP[a]

Radionuclide	Number of samples	Concentration (μg/g dry wt)			Standard error[b]
		Max	Min	Av	
		Grass			
F^-	29	55	<3	11.3	14.2
U	29	1.7	<0.5	0.9	1.2
^{99}Tc	29	23.7[c]	<0.1[c]	2.9[c]	6.5

[a]See Fig. 2.4.3.
[b]Standard deviation about the average.
[c]Units are pCi/g instead of μg/g.

2.4.4.2 Results

Oak Ridge Gaseous Diffusion Plant

The results for the grass and pine needle samples are given in Table 2.4.4. Three additional grass sampling sites, V14 at the K-1070A burial ground, V15 at K-1070C/D classified burial ground, and V16 at K-1070B burial ground were added in August.

Average fluoride levels in grass at all sampling points were below the 30-μg/g level, which is considered to produce adverse effects when ingested by cattle with average grazing intakes (AIHA 1969). Technetium concentrations were highest at V11, the contaminated scrap yard, and V16, the K-1070B burial ground. The uranium concentrations ranged from below detection to 5 μg/g (V9), with technetium concentration ranging from below detection to 23.7 pCi/g (V11).

2.5 SOIL AND SEDIMENT MONITORING

2.5.1 Soil

Soil samples from noncultivated areas provide a measure of the quantity of radioactivity or other pollutants that have been deposited from the atmosphere.

2.5.1.1 Oak Ridge National Laboratory and Y-12 Plant

Soil samples were collected at the ORNL perimeter stations and the Y-12 perimeter. Table 2.5.1 provides a summary of the locations sampled and the frequencies of sampling and analysis. In previous years, remote stations were used as a reference or background for conditions that are not influenced by discharges from the Oak Ridge DOE facilities. These locations were deleted in the 1989 program because of insufficient funding. Sampling stations around ORGDP and the reservation perimeter were deleted for similar reasons.

The concentrations of radionuclides in soil vary because of differences in rainfall patterns and the mechanics of transport in different types of soil. The rate of migration in soil also varies significantly from one radionuclide to another. For example, strontium tends to migrate through soil more freely than do cesium or plutonium. In addition, chemical separation of radionuclides such as strontium and plutonium from soil samples is complicated by the heterogeneity of the soil and the difficulty of stripping ions from the soil. Therefore, individual measurements may not be representative of large areas. Average concentrations of several samples provide a better measure of soil radionuclide concentrations. Thus, three samples are collected from each station annually.

Sample collection and analytical procedures

Soil samples were collected at the ORNL perimeter air monitoring stations and the Y-12 perimeter air monitoring stations once during 1989. The three samples collected at each location were randomly selected from the four cardinal directions at each of the stations. Each sample was a

Table 2.5.1. Summary of collection and analysis frequencies of soil sampling in 1989

Station[a]	Parameter	Collection frequency	Sample type	Analysis frequency
3, 7, 9, 20, 21, 40, 45, 46	Total Sr,[b] ^{239}Pu, gamma scan, ^{238}Pu, ^{234}U, ^{235}U, ^{238}U	Annually	Grab	Annually

[a]See Fig. 2.1.18.
[b]Total radioactive strontium (^{89}Sr + ^{90}Sr).

composite of ten aliquots taken from two 1-m^2 plots. Each aliquot was 8 cm (3.7 in.) in diameter by 2 cm (0.8 in.) deep. All samples were dried and pulverized prior to analysis.

Results

Summary concentrations of radioactive materials in soils for each of the facility perimeters are presented in Table 2.5.2. All results are reported on a dry weight basis. Summary concentrations of radionuclides and total radioactive strontium at each of the stations within each network are given in Tables 2.5.1 through 2.5.8 in Vol. 2. Because the number of stations was reduced from last year, it was not useful to compare the perimeter summary data between the two years to evaluate trends. Instead, the data were compared using a *t* test at 95% confidence between the data collected from stations this year and the data for those same stations last year. This

Table 2.5.2. 1989 concentrations of radioactive materials in soil

Analysis	No. of samples	Concentration (pCi/g dry wt)			
		Max	Min	Av	Std. error[a]
ORNL Perimeter Stations[b]					
^{60}Co	15	0.057	−0.035	0.0041	0.0086
^{137}Cs	15	1.5	0.051	0.53	0.13
^{238}Pu	15	0.0035	−0.00070	0.00028	0.00028
^{239}Pu	15	0.049	−0.000027	0.014	0.0042
Total Sr	15	0.78	0.014	0.25	0.060
^{234}U	15	0.97	0.20	0.38	0.057
^{235}U	15	0.041	0.0057	0.016	0.0026
^{238}U	15	0.62	0.14	0.27	0.036
Oak Ridge Reservation Stations[b]					
^{60}Co	9	0.032	−0.0027	0.017	0.0043
^{137}Cs	9	0.46	0.0081	0.21	0.049
^{238}Pu	9	0.0012	−0.0014	0.00019	0.00028
^{239}Pu	9	0.0065	−0.0025	0.0030	0.00097
Total Sr	9	0.24	−0.030	0.10	0.034
^{234}U	9	3.2	0.43	1.4	0.36
^{235}U	9	0.30	0.012	0.10	0.032
^{238}U	9	4.3	0.25	1.2	0.43

[a]Standard error, about avrage.
[b]See Fig. 2.1.18.

is important because of the variable radioactivity signature of soils. There were no significant differences between the two years of data except for ^{137}Cs, which was lower this year than last year. The uranium concentrations around the Y-12 perimeter were higher than around the ORNL perimeter. This is typical for soil data from these locations. These data are similar in magnitude to the data from the remote stations from last year, except for the uranium values around Y-12.

Two of the stations sampled in 1988 were located near process areas on the ORNL site. These stations would have been dropped from the soil sampling program this year regardless of funding because they do not represent the facility impacts at the perimeter or the potential exposure to off-site individuals. Their influence on the summary data is to inflate the estimates of the perimeter averages and confound the analysis of multiyear trends by inflating the variance associated with the averages.

2.5.1.2 Oak Ridge Gaseous Diffusion Plant

Sample collection and analytical procedures

Samples were collected from 14 locations in and around the Oak Ridge Gaseous Diffusion Plant (ORGDP) (Fig. 2.5.1) semiannually. Approximately 450 g of soil was collected using a stainless steel scoop to remove the top 1 cm

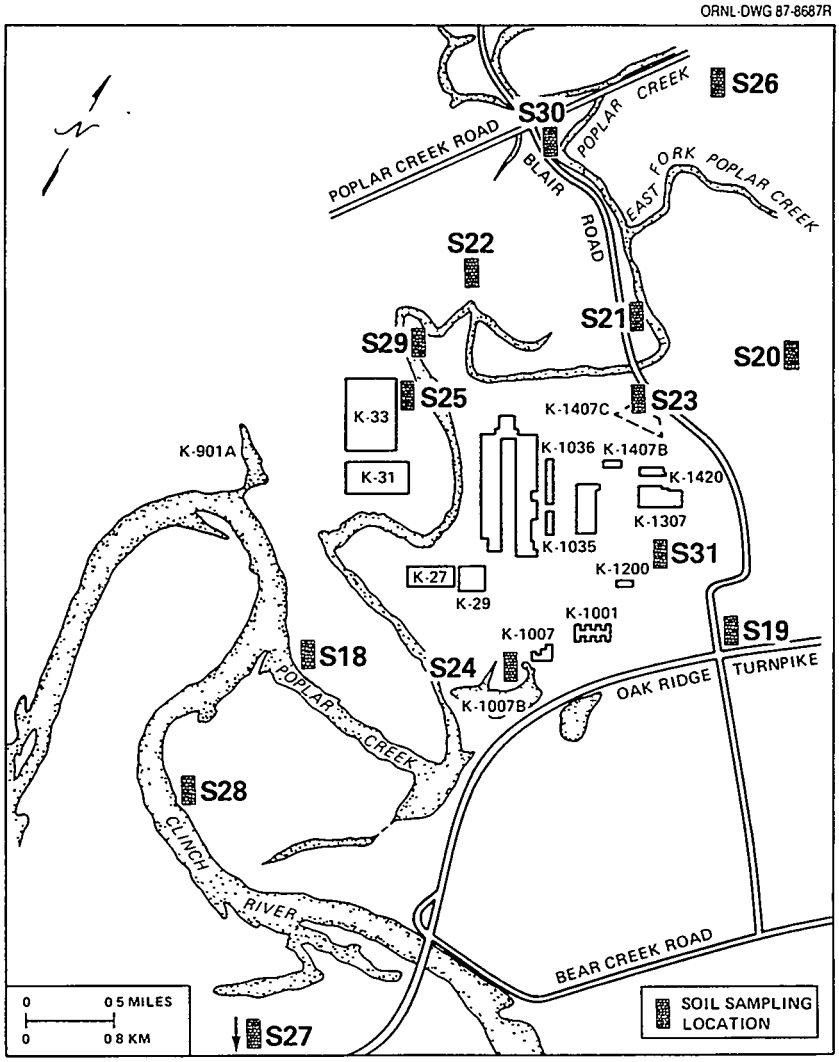

Fig. 2.5.1. Soil sampling locations around ORGDP.

(0.4 in.) of the sampling area. Fluorometric analysis was used to determine uranium levels, and a fluoride-selective-ion electrode was used to determine fluoride levels. An additional site, S31 at the K-1070C/D classified burial ground, was added in August.

Results

The results of the semiannual sampling are given in Table 2.5.9, Vol. 2. The fluoride concentrations ranged from <50 $\mu g/g$ at station S26 to 1442 $\mu g/g$ at station S29. The concentration of fluoride in the soil is almost 100 times higher than that in grass. Uranium concentrations have not changed significantly since 1985. The concentration of uranium in the soil is generally 10 times the amount in grass. Sample S28, from the contaminated scrap yard, continues to have the highest concentration of uranium.

2.5.2 Sediment

2.5.2.1 Sample collection and analytical procedures

The stream sediment sampling program consists of six sampling locations from Poplar Creek and two locations from the Clinch River (Fig. 2.5.2). These samples are collected in the fall and analyzed for concentrations of mercury, lead,

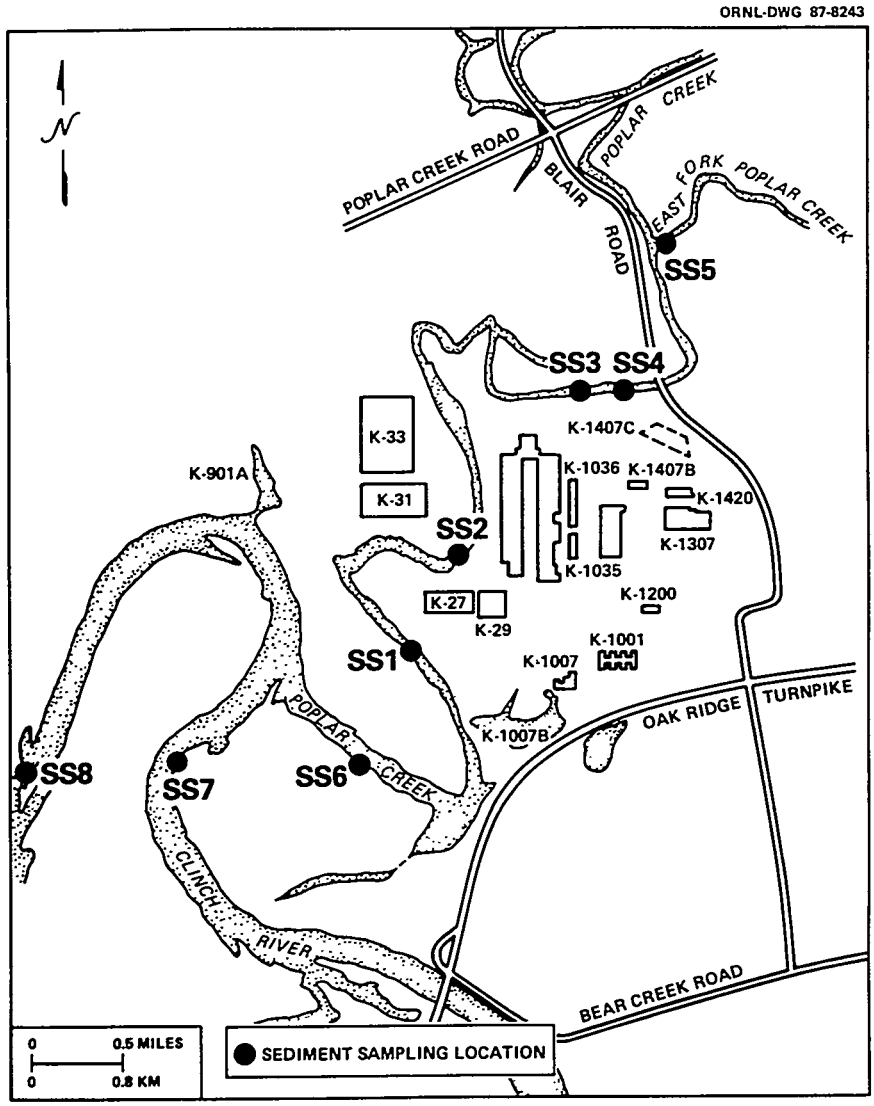

Fig. 2.5.2. Stream sediment sampling locations at ORGDP.

nickel, copper, zinc, chromium, manganese, aluminum, thorium, cadmium, and total uranium by atomic absorption, inductively coupled plasma, and fluorometric methods. The surface samples are collected using a core sampler that is lowered over the side of a boat. Approximately 50 g of sediment is needed for the analyses.

2.5.2.2 Results

Table 2.5.10 in Vol. 2 gives data for the ORGDP stream sediment samples. Since 1985, the concentrations of lead, nickel, copper, chromium, and aluminum have been decreasing.

In 1989, the concentrations of uranium, mercury, nickel, and chromium were all lower than the 1988 values. The concentrations of lead increased at stations SS1, SS3, SS5, SS6, and SS7. From 1988 to 1989, the concentrations of all the metals decreased at station SS4, located at the mouth of Mitchell Branch. Samples from SS7 and SS8 on the Clinch River continue to have the lowest concentrations of the sampling stations.

2.6 EXTERNAL GAMMA RADIATION

External gamma radiation measurements are made to determine if routine radioactive effluents from ORNL are increasing external radiation levels significantly above normal background levels.

2.6.1 Sample Collection and Analytical Procedures

Gamma radiation measurements are made continuously at ORNL perimeter stations and at ORR perimeter stations (Table 2.6.1 and Fig. 2.1.18). Continuous readings of external gamma radiation are averaged over 10-min intervals for all stations. The real-time monitoring system provides an alert or alarm message if the reading is significantly above a preset background or expected value. These continuous monitoring data are not reported here. The values reported here are summarized from weekly averages of hourly averages that are, in turn, derived from the 10-min readings. A weekly average is considered valid if less than 25% of the hourly values are either missing or invalid because of instrument malfunction.

2.6.2 Results

Table 2.6.2 presents network summaries of external gamma radiation measurements. The average value for the ORNL perimeter stations was 18 μR/h, and the average for the Reservation stations was 7.1 μR/h. The higher value for the ORNL perimeter stations results from the inclusion, for part of the year, of station 4, which is very close to the Process Waste Treatment Plant and the treatment ponds. External gamma values for station 4 are more than 10 times the values for any of the other stations, which is to be expected considering the location of that particular station. The use of this station was discontinued during the year because it does not serve the purpose of surveilling the off-site impacts of the facility. With station 4 removed from the network, the average value for the ORNL perimeter stations (weighted according to the number of valid weekly averages at each station) is 7.3 μR/h.

Data for individual ORNL perimeter stations and ORR stations are presented in Table 2.6.1, Vol. 2. Typical values for cities in the contiguous United States are usually between 5 and 20 μR/h. The median value published by EPA (1987) for cities in the United States during 1987 was 9.3 μR/h, with 75% of the values between 7.5 and 15 μR/h (the distribution is positively skewed).

Table 2.6.1. Summary of collection and analysis frequencies of external gamma radiation measurements, 1989

Area[a]	Stations	Collection frequency	Analysis frequency (min)
ORNL perimeter	3, 4, 7, 20	Continuous	10
Oak Ridge Reservation	8, 31, 33, 34, 36 40–45	Continuous	10

Table 2.6.2. 1989 external gamma radiation measurements

Location	No. of samples	Exposure rate (μR/h)			Std. error[a]
		Max	Min	Av	
ORNL Perimeter stations					
Network summary	80	110	6.6	18	3.5
Oak Ridge Reservation stations					
Network summary	254	11	5.8	7.1	0.043

[a]Standard deviation of the mean.

3. POTENTIAL RADIATION AND CHEMICAL DOSE TO THE PUBLIC

3. POTENTIAL RADIATION AND CHEMICAL DOSE TO THE PUBLIC

3.1 RADIATION DOSE

Small quantities of radionuclides were released to the environment from operations at the Oak Ridge Reservation (ORR) facilities during 1989. Those releases are quantified and characterized in Sect. 2. Section 3 presents estimates of the potential consequences of the releases and describes the methods used to make the estimates.

3.1.1 Terminology

Most consequences to humans associated with radionuclide releases to the environment are caused by interactions between radiations emitted by the radionuclides and human tissue. These interactions involve the transfer of energy from the radiations to tissue, a process that may damage the tissue. The radiations may come from radionuclides located outside the body (in or on environmental media or objects) or from radionuclides deposited inside the body (via inhalation; ingestion; and, in a few cases, absorption through the skin). Exposures to radiations from nuclides located outside the body are called external exposures; exposures to radiations from nuclides deposited inside the body are called internal exposures. These two types of exposures differ as follows: 1. External exposures occur only when a person is near or in a radionuclide-containing medium; internal exposures continue as long as the radionuclides remain inside the person. 2. External exposures may result in uniform irradiation of the entire body and all its components; internal exposures usually result in nonuniform irradiation of the body. (Most radionuclides, when taken into the body, deposit preferentially in specific organs or tissue and thus do not irradiate the body uniformly.)

A number of specialized units have been defined for characterizing exposures to ionizing radiation. Because the damage associated with such exposures is due primarily to the deposition of radiant energy in tissue, the units are defined in terms of the amount of incident radiant energy absorbed by tissue and the biological consequences of the absorbed energy. Some of these units are as follows.

Absorbed dose. A physical quantity that defines the amount of incident radiant energy absorbed per unit mass of an irradiated material; its unit of measure is the rad. The absorbed dose depends on the type and energy of the incident radiation and on the atomic number of the absorbing material.

Dose equivalent. A quantity that expresses the biological effectiveness of an absorbed dose in a specified human organ or tissue; its unit of measure is the rem. The dose equivalent is numerically equal to the absorbed dose multiplied by modifying factors that relate the absorbed dose to biological effects. In this report, as in many others, the term "dose equivalent" often is shortened to "dose."

Effective dose equivalent. A measure of the overall carcinogenic and genetic risk resulting from exposures to radiations. It is a weighted sum of dose equivalents to specified organs. The weighting factors and specific organs are described in Publications 26 and 30 of the International Commission on Radiological Protection (ICRP 1977; ICRP 1978).

Committed (effective) dose equivalent. The total (effective) dose equivalent that will be received over a specified time period (50 years in

this document) because of exposures to and intakes of radionuclides during the year of interest.

Collective (committed) effective dose equivalent. The sum of (committed) effective dose equivalents to all individuals in an exposed population.

Dose conversion factor (DCF). The dose equivalent received from exposure to a unit quantity of a radionuclide via a specific exposure pathway. Two types of DCFs exist. One type gives the committed dose equivalent (rem) resulting from intake (via inhalation and ingestion) of a unit activity (1.0 μCi) of a radionuclide. The second gives the dose equivalent rate (mrem/year) per unit activity (1.0 μCi) of a radionuclide in a unit (cm^3 or cm^2) of an environmental compartment (air or ground surface). Tables 3.1.1 and 3.1.2 are lists of DCFs for inhalation and ingestion, respectively, of selected radionuclides released from the ORR; Tables 3.1.3 and 3.1.4 are lists of DCFs for immersion in contaminated air and for exposure to a contaminated ground surface,

Table 3.1.1. Dose equivalent conversion factors (rem/μCi) for inhalation[a]

Radionuclide (solubility)[b]		Effective
^{3}H		1.25×10^{-4}
^{85}Kr		6.28×10^{-7}
^{90}Sr	(D)	2.22×10^{-1}
^{99}Tc	(W)	8.39×10^{-3}
^{131}I	(D)	3.29×10^{-2}
^{133}I	(D)	5.91×10^{-2}
^{133}Xe		6.24×10^{-7}
^{234}U	(D)	2.67
	(W)	7.94
	(Y)	1.32×10^{2}
^{235}U	(D)	2.54
	(W)	7.37
	(Y)	1.22×10^{2}
^{238}U	(D)	2.40
	(W)	7.05
	(Y)	1.18×10^{2}
^{191}Os	(Y)	4.25×10^{-6}
^{231}Th	(W)	

[a]Factors taken from the EPA Clean Air Act data tapes.

[b]D = soluble; W = moderately soluble; Y = insoluble.

Table 3.1.2. Dose equivalent conversion factors (rem/μCi) for ingestion[a]

Radionuclide (solubility)		Effective
^{3}H		8.93×10^{-5}
^{85}Kr		0
^{90}Sr	(D)[b]	1.30×10^{-1}
^{99}Tc	(D)	1.40×10^{-3}
^{131}I	(D)	5.05×10^{-2}
^{133}Xe		0
^{234}U	(D&W)[b]	2.74×10^{-1}
	(Y)[b]	2.50×10^{-2}
^{235}U	(D&W)	2.63×10^{-1}
	(Y)	2.58×10^{-2}
^{236}U	(D&W)	2.60×10^{-1}
^{236}U	(Y)	2.38×10^{-2}
^{238}U	(D&W)	2.47×10^{-1}
	(Y)	2.30×10^{-2}
^{231}Th	(W)	1.23×10^{-3}
^{234}Th	(W)	1.30×10^{-2}
^{234m}Pa	(W)	5.80×10^{-6}
^{60}Co	(W)	1.13×10^{-2}
^{137}Cs	(D)	4.30×10^{-2}
^{238}Pu	(W)	3.85
^{239}Pu	(W)	4.45
^{241}Am	(W)	4.43
^{244}Cm	(W)	2.32
^{133}I	(D)	9.95×10^{-3}
^{191}Os	(Y)	2.11×10^{-3}

[a]Factors taken from the EPA Clean Air Act data tapes.

[b]D = soluble; W = moderately soluble; Y = insoluble.

respectively (Dunning et al. 1980). The radionuclides listed account for about 98% of the radiation doses from the ORR.

3.1.2 Methods of Evaluation

3.1.2.1 Airborne radionuclides

Characterization of the radiological consequences of radionuclides released to the atmosphere from ORR operations during 1989 was accomplished by calculating, for each plant and for the entire ORR, dose equivalents to the maximally exposed off-site individual (Table 3.1.5) and to the population residing within 80 km (50 miles) (Table 3.1.6). Airborne releases from the three plants are characterized in Sect. 2.1 and are

Table 3.1.3. Dose equivalent rate conversion factors (mrem/year per μCi/cm^3) for immersion in air[a]

Radionuclide	Effective
^{3}H	0
^{85}Kr	1.09×10^{7}
^{90}Sr	0
^{99}Tc	2.50×10^{3}
^{131}I	1.86×10^{9}
^{133}Xe	1.66×10^{8}
^{234}U	7.36×10^{5}
^{235}U	7.37×10^{8}
^{236}U	5.80×10^{5}
^{238}U	5.00×10^{5}
^{231}Th	5.52×10^{7}
^{234}Th	3.65×10^{7}
^{234m}Pa	5.83×10^{7}
^{133}I	3.00×10^{9}
^{191}Os	3.28×10^{8}

[a]Factors taken from the EPA Clean Air Act data tapes.

Table 3.1.4. Dose equivalent rate conversion factors (mrem/year per μCi/cm^2) for ground surface exposure[a]

Radionuclide	Effective
^{3}H	0
^{85}Kr	2.54×10^{3}
^{90}Sr	0
^{99}Tc	5.91×10^{-1}
^{131}I	3.93×10^{5}
^{133}Xe	4.80×10^{4}
^{234}U	7.94×10^{2}
^{235}U	1.64×10^{5}
^{236}U	7.20×10^{2}
^{238}U	6.35×10^{2}
^{231}Th	1.83×10^{4}
^{234}Th	9.53×10^{3}
^{234m}Pa	1.11×10^{4}
^{133}I	6.01×10^{5}
^{191}Os	8.03×10^{4}

[a]Factors taken from the EPA Clean Air Act data tapes.

Table 3.1.5. Calculated maximally exposed offsite individual 50-year committed dose equivalents from airborne releases in 1989

Release location	Effective dose equivalents (mrem)
ORNL[a]	0.3
ORGDP[b]	0.0005
Y-12 Plant[c]	1
Entire ORR[d]	1

[a]The maximally exposed individual is located 4970 m (3.1 miles) SW of the 3039 stack and 5160 m (3.2 miles) WSW of the 7911 stack.

[b]The maximally exposed individual is located 5100 m (3 miles) SW of Building K-1420.

[c]The maximally exposed individual is located 1050 m (0.6 miles) NNE of the center of the Y-12 Plant.

[d]The maximally exposed individual for the entire ORR is the Y-12 Plant individual.

Table 3.1.6. Calculated collective 50-year committed effective dose equivalents due to airborne releases in 1989

Release location	Dose equivalents (person-rem)
ORNL[a]	14
ORGDP[b]	0.04
Y-12[c]	21
ORR[d]	35

[a]The collective 50-year committed dose equivalents to the 933,000 persons residing within 80 km (50 miles) of the ORNL.

[b]The collective 50-year committed dose equivalents to the 907,757 persons residing within 80 km of the ORGDP.

[c]The collective 50-year committed dose equivalents to the 943,000 persons residing within 80 km of the Y-12 Plant.

[d]The collective 50-year committed dose equivalents for the area within an 80-km radius of the ORR are the sums of the corresponding doses for each of the three plants.

summarized in Table 3.1.7. Emissions of radionuclides from the ORR to the atmosphere are regulated under NESHAP. For 1989, NESHAP limits annual radionuclide emissions to a level that will not cause any member of the general public to receive total radiation dose equivalents that are equal to or greater than 25 mrem to the whole body or 75 mrem to any organ. Beginning in 1990, the NESHAP limit will be expressed in the currently accepted units of radiation dose, the effective dose equivalent. The new limit will be based on a total effective dose equivalent of less than 10 mrem to any member of the public. Since use of the new limit is conservative with respect to the old limits and it uses contemporary units, all dose estimates are presented as effective dose equivalents. Calculated whole-body and maximum organ dose equivalents were 1% and 16%, respectively, of their limits and were reported to the EPA (Mitchell Apr. 18, 1990). Doses were calculated using a suite of computer codes (Moore et al. 1979; Begovich et al. 1981; Dunning et al. 1980; Sjoreen and Miller 1984) developed under sponsorship of the U.S. Environmental Protection Agency (EPA) for use in demonstrating compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAP)—Radionuclides (CFR 1986). The atmospheric transport code AIRDOS-EPA calculates concentrations of released radionuclides in air, on the ground, and in foodstuffs (meat,

Table 3.1.7. Annual report of radionuclides released to the atmosphere during 1989 per 40CFR61.94

ORNL[a]

Section I. Air emissions (Ci/year)

Radionuclide	Quantity
^{3}H	2.8×10^{4}
^{7}Be	8.2×10^{-5}
^{60}Co	4.0×10^{-4}
^{65}Zn	9.2×10^{-7}
^{75}Se	9.9×10^{-4}
^{82}Br	1.1×10^{-4}
^{85m}Kr	1.6×10^{4}
^{90}Sr	3.4×10^{-5}
^{106}Ru	3.4×10^{-5}
^{125}Sb	8.8×10^{-6}
^{125}I	6.9×10^{-7}
^{129}I	1.9×10^{-3}
^{131}I	2.9×10^{-2}
^{132}I	7.5×10^{-4}

Table 3.1.7 (continued)

^{133}I	2.7×10^{-2}
^{134}I	2.1×10^{-4}
^{135}I	2.0×10^{-2}
^{133}Xe	7.9×10^{4}
^{137}Cs	6.5×10^{-4}
^{140}Ba	8.3×10^{-7}
^{140}La	2.8×10^{-7}
^{152}Eu	1.1×10^{-6}
^{154}Eu	1.3×10^{-6}
^{155}Eu	1.1×10^{-6}
^{191}Os	1.2
^{194}Au	3.8×10^{-4}
$^{212}Pb^{b}$	8.7×10^{-2}
^{226}Ra	2.4×10^{-7}
^{228}Ra	4.4×10^{-7}
$^{228}Th^{c}$	2.6×10^{-7}
^{230}Th	4.0×10^{-8}
^{232}Th	3.4×10^{-8}
U	2.0×10^{-6}
^{238}Pu	1.3×10^{-6}
^{239}Pu	4.9×10^{-7}
^{241}Am	1.8×10^{-7}
^{244}Cm	1.6×10^{-6}

Section II. Methods for dose assessment

Dose equivalents were estimated using the DARTAB computer code, which uses the atmospheric concentrations predicted by the AIRDOS-EPA atmospheric dispersion model and the dose conversion factors contained in the RADRISK data base.

Section III. Dose equivalent estimates (mrem)

EPA standard	Facility estimate	Percent of standard
≤10 Effective	0.3	3

ORGDP[a]

Section I. Air emission (Ci/year)

Radionuclide	Quantity
^{234}U	2.3×10^{-4}
^{235}U	1.2×10^{-5}
^{238}U	1.4×10^{-4}
^{99}Tc	5.4×10^{-3}

Section II: Methods for dose assessment

Dose equivalents were estimated using the DARTAB computer code, which uses the atmospheric concentrations predicted by the AIRDOS-EPA atmospheric dispersion model and the dose conversion factors contained in the RADRISK data base.

Section III. Dose equivalent estimates (mrem)

EPA standard	Facility estimate	Percent of standard
≤10 Effective	0.0005	<0.005

Y-12 Plant[a]

Section I. Air emissions (Ci/year)

Radionuclide	Quantity
^{234}U	1.4×10^{-1}
^{235}U	3.0×10^{-3}
^{236}U	4.0×10^{-4}
^{238}U	1.4×10^{-2}

Section II. Methods for dose assessment

Dose equivalents were estimated using the DARTAB computer code, which uses the atmospheric concentrations predicted by the AIRDOS-EPA atmospheric dispersion model and the dose conversion factors contained in the RADRISK data base.

Section III. Dose equivalent estimates (mrem)

EPA standard	Facility estimate	Percent of standard
≤10 Effective	1	10

[a]Owner: U.S. Department of Energy; Operations Office: Oak Ridge, Tennessee. Site Operator: Martin Marietta Energy Systems, Inc.
[b]Includes isotopic ^{212}Pb activity and particulate beta activity.
[c]Includes isotopic ^{228}Th activity and particulate alpha activity.

milk, and vegetables). Through the DARTAB computer code, the DCFs in the RADRISK data base are applied to the calculated concentrations to give estimates of individual and collective committed dose equivalents from inhalation of and immersion in contaminated air, from exposure to contaminated ground surfaces, and from ingestion of locally grown foodstuffs (milk, meat, and vegetables).

Radionuclide release data were collected or estimated for eight stacks at Oak Ridge National Laboratory (ORNL), two stacks at Oak Ridge Gaseous Diffusion Plant (ORGDP), and the entire Y-12 Plant. Table 3.1.8 contains a list of the pertinent parameters (height, diameter, and exit velocity) for each stack. Also included in Table 3.1.8 are the distance and direction from each stack to the maximally exposed individual for the corresponding plant. Dose calculations were made separately for each stack but were added together to estimate maximum individual and collective dose equivalents. Note that some stacks are assumed to be colocated. This assumption was made if (1) the stacks actually are very close to each other or (2) the stacks are reasonably close to each other and the emissions from one of the stacks dominate the dose calculations.

Plant-specific meteorological data, population distributions, and source terms were used in all calculations. At ORNL, doses due to airborne releases from all eight stacks were characterized using 1989 meteorological data. The 3039, 2026,

Table 3.1.8. Stack parameters used in the AIRDOS calculation

Stack	Height (m)	Diameter (m)	Gas exit velocity (m/s)	To maximum individual	
				Distance (m)	Direction
			ORNL		
3039[a]	76.2	2.4	16.6	4970	SW
2026[a]	22.9	1.1	11.4	4970	SW
3020[a]	61.0	1.5	11.5	4970	SW
7911[b]	76.2	1.5	10.1	5160	WSW
7512[b]	30.5	0.9	7.3	5160	WSW
7025	4.0	0.3	14.0	6910	SW
7830	4.6	0.2	7.1	3860	WSW
			ORGDP		
K-1420[c]	16.2	0	0	5100	SW
K-1435[c]	30.5	1.3	6.8	5100	SW
			Y-12 Plant		
All	20.0	0	0	1050	NNE

[a]Collocated stacks.
[b]Collocated stacks.
[c]Collocated stacks.

and 3020 stacks were characterized using data from the 100-m (328-ft) sensor on Tower MT2; the 7911, 7512, and 7830 stacks using data from the 30-m (98-ft) sensor on Tower MT4; and the 7025 stack using data from the 30-m (98-ft) sensor on Tower MT3. Releases from ORGDP were characterized using 1989 data from the 60-m (197-ft) sensor on tower MT1. Meteorological data used to estimate doses resulting from releases at the Y-12 Plant during 1989 were collected from the 30-m (98-ft) sensor on the MT5 during 1989.

Beef, milk, and food crop production were assumed to be the maximum possible for the available ground area, an assumption that overstates these activities in the area. It was further assumed that one-third of the foodstuffs consumed by the local population was grown locally; the remaining two-thirds was assumed to be imported from outside an 80-km radius of the ORR.

Releases from ORNL were mainly from the 3039 and 7911 stacks. The noble gas releases were assumed to be 83% ^{133}Xe and 17% ^{85m}Kr, a combination chosen to represent the relative proportions of the two gases found in the High Flux Isotope Reactor core after 24 days of operation. For the purposes of the ORNL dose calculation, particulate alpha activity was assumed to be ^{228}Th and particulate beta activity was assumed to be ^{212}Pb. It is recognized that particulate alpha and beta activities are most likely due to a mixture of isotopes. A study is being conducted to evaluate these components. The calculated effective dose equivalent to the maximally exposed resident, who is located 4970 m (3.1 miles) SW from the 3039 stack and 5160 m (3.2 miles) WSW from the 7911 stack, is 0.3 mrem (Table 3.1.5). Most of the effective dose equivalent (88%) is from tritium. The 0.3-mrem effective dose equivalent is well below the new NESHAP standard (Table 3.1.7). The 50-year collective committed effective dose equivalent to the ~933,000 persons residing within 80 km of ORNL was calculated to be ~14 person-rem (Table 3.1.6).

Releases from ORGDP during 1989 came from Building K-1420 and the TSCA incinerator. The total release was 2.2×10^{-4} Ci of U in an insoluble (class Y) form and 1.6×10^{-4} Ci of U in a soluble (class D) form. In addition, 5.4×10^{-3} Ci of ^{99}Tc was released. The calculated

effective dose equivalent to the maximally exposed resident is 0.0005 mrem (Table 3.1.5). Essentially all of the dose is due to inhalation and ingestion. The calculated dose equivalent is small when compared with background, as is the 0.04-person-mrem collective dose equivalent (Table 3.1.6).

A total of 0.15 Ci of uranium was released from the Y-12 Plant during 1989 (Table 3.1.7). The isotopic composition of the uranium is given in Table 3.1.7. The released uranium was assumed to be one-third chemically soluble in the lung (D solubility), one-third moderately soluble (W solubility), and one-third insoluble (Y solubility). The release point was assumed to be 20 m high, located between the two buildings that release most of the uranium. The calculated effective dose equivalent to the maximally exposed resident, who is located 1050 m (0.6 miles) NNE of the release point, is ~1 mrem (Table 3.1.5). The dominant exposure pathway is inhalation. The 1-mrem effective dose equivalent is well below the new NESHAP standard. The collective 50-year committed effective dose equivalent to the ~940,000 persons residing within 80 km of the Y-12 Plant was calculated to be 21 person-rem (Table 3.1.6). The collective committed effective dose equivalent due to releases from ORR to the atmosphere during 1989 is estimated to be 35 person-rem. This collective dose results in a calculated fatal cancer risk of ~0.01, based on a fatal cancer risk of 0.0004/rem of effective dose equivalent. The actual risk could be zero.

3.1.2.2 Waterborne radionuclides

Waterborne discharges of radionuclides from ORNL flow into White Oak Creek, through White Oak Lake, and discharge into the Clinch River. Discharges from the Y-12 Plant and from ORGDP enter the Clinch River via Bear Creek, Poplar Creek, and East Fork Poplar Creek. These discharges are characterized in Sect. 2.2. Committed dose equivalents to persons drinking water from the Clinch River were calculated using measured, annual-average concentrations of radionuclides in water samples taken at the locations listed in Table 3.1.9 and the assumption that a person drinks 2 L (2.1 quarts) of water per day [730 L/year (193 gal/year)]. Two nuclides, ^{90}Sr and ^{137}Cs, are responsible for most of the doses. Tritium, when present, is also important. The resulting potential dose estimates are given in Table 3.1.9. The dose estimated for consumption of water at Melton Hill Dam, 0.3 mrem, represents an upstream (background) dose. Water sampled at the inlet to ORGDP (Gallaher process water) is the closest nonpublic water supply downstream. The calculated dose equivalent at this location is 0.5 mrem effective. The public water supply closest to the ORR is located about 26 km (15.6 miles) downstream, at Kingston. Based on measurements of radionuclides in river water samples taken at the Kingston filtration plant, the maximum dose from drinking water is 0.3 mrem effective. This could result in a collective committed effective dose of about 2 person-rem to the estimated 7500 persons who could drink this water. The primary contributors to the doses are ^{90}Sr, ^{137}Cs, and ^{3}H. Radionuclide concentrations are also measured in Bear Creek and East Fork Poplar Creek, which contain discharges from the Y-12 Plant and ORGDP. However, no one is known to drink water from these streams;

Table 3.1.9. Potential 50-year committed dose equivalents from drinking water in 1989[a]

Location	Effective dose equivalent (mrem)
Melton Hill Dam	<0.3
Gallaher process water	<0.5
Kingston water plant	<0.3

[a]Assumes ingestion of 730 L of water per year (2 L per day).

therefore, dose estimates were not made for drinking water from these creeks.

Potential doses to individuals eating 21 kg (about 46 lb) of fish per year are given in Table 3.1.10. These doses were calculated using measured concentrations of radionuclides in fish harvested at the given locations (see Sect. 2.4.2). The highest dose, 0.2 mrem effective, is possible by eating fish from CRK 33.3, which is at the confluence of White Oak Creek and the Clinch River, ORNL's discharge point. Doses to persons upstream at Melton Hill Dam (CRK 40.0) and downstream at Kingston (CRK 8.0) are lower. The 0.1-mrem effective dose to an individual from eating 21 kg of fish caught at Kingston could result in a population dose of about 0.8 person-rem, if all of the inhabitants of Kingston each caught and ingested 21 kg of fish. The primary contributor to the effective dose is ^{137}Cs and to the highest organ dose is ^{90}Sr. To put these doses from waterborne radionuclides further into perspective, the nearest population (Kingston) exposed to these radionuclides would receive an annual collective committed dose equivalent of about 3 person-rem from drinking water and eating fish. This represents about 0.01% of the annual dose from background radiation (2250 person-rem) to this population.

3.1.2.3 Radionuclides in other environmental media

One of the important pathways for movement of radionuclides from environmental media to man is the atmosphere→pasture→cow→milk food chain. Strontium-90 and ^{131}I are radionuclides that are especially important in this terrestrial food chain. Table 3.1.11 gives doses to an individual from drinking 310 L of milk per year. Measured, annual-average concentrations of total radioactive strontium (assuming 100% ^{90}Sr) and ^{131}I in milk taken from sampling stations near the ORR and from stations located away from the ORR (see Sect. 2.4.1) were used to calculate the doses. Effective doses are given in Table 3.1.11. Doses at immediate and remote environs stations are similar; for example, effective dose equivalents of 0.1 and 0.06, respectively. Concentrations of ^{90}Sr and ^{131}I in milk at all of these stations were extremely low (see Tables 2.4.1 and 2.4.2 in Vol. 2).

Table 3.1.10. Potential 50-year committed dose equivalents from eating fish in 1989[a]

Location	Effective dose equivalents (mrem)
CRK 8.0	0.1
CRK 33.3	0.2
CRK 40.0	0.03

[a]Assumes ingestion of 21 kg of fish per year.

3.1.2.4 Direct radiation

External radiation exposure rates have been measured at a number of locations on and off the ORR. Most of this radiation is due to natural radioactivity in the ground. Table 3.1.12 gives postulated effective doses to individuals exposed, unshielded, to direct radiation at each monitoring station for 8760 h/year (24 h/d, all year). Doses due to background direct radiation over the state of Tennessee range from about 30 to 100 mrem/year and average 56 mrem/year (Myrick et al. 1981). The dose values given in Table 3.1.12 are within this range, with the exception of measurements along the Clinch River at stations 64 through 67, located along the bank of the Clinch River between CRK 34 and 30. Those elevated radiation levels are due to air-scattered gamma radiation from an experimental ^{137}Cs field located on the Reservation. It is extremely unlikely that an individual would be exposed to this gamma radiation for an entire year (8760 h). However, a hypothetical maximally exposed individual might spend 5 h/week fishing along the shore. This individual could receive an effective dose equivalent of 6 mrem from a 250-h exposure to the average of the measured exposure rates at stations 65 and 66.

3.1.3 Current-Year Summary

A summary of the maximum effective dose equivalents to individuals via several pathways of

Table 3.1.11. Potential 50-year committed dose equivalents from drinking milk in 1989[a]

Location[b]	Effective dose equivalents (mrem)
Immediate environs (stations 1, 2, 3, 4)	0.1
Remote environs (stations 51, 53)	0.06

[a]Assumes ingestion of 310 L of milk per year using the average radionuclide concentrations at each location.
[b]See Fig. 2.4.1.

Table 3.1.12. Potential radiation dose equivalents from external exposures at locations on and off the ORR

Station	Effective dose equivalent (mrem/year)[a]
ORNL perimeter stations[b]	
3	55
7	48
9	61
21	51
22	65
ORR stations[b]	
8	43
23	46
Clinch River stations[b]	
41	73
42	96
47	73
60	52
61	88
64	160
65	180
66	210
67	105
68	88
69	46
Background stations[c]	
Average of 12 locations in Tennessee	56

[a]Assumes an exposure of 8760 h/year.
[b]*Source: Environmental Surveillance of the U.S. Department of Energy Oak Ridge Reservation and Surrounding Environs during 1987,* ES/ESH-4/V1 (1988).
[c]*Source:* Myrick, T. E., B. A. Bervin, and F. F. Haywood, *State Background Radiation Levels,* ORNL/TM-7343 (1981).

exposure is given in Table 3.1.13. It is unlikely (if not impossible) that any real person can be irradiated by all of these sources and pathways for a period of one year. However, if the nearest resident to the Y-12 Plant, who could receive an effective dose of 1 mrem from gaseous effluents, also drank milk from the sampled stations (0.1 mrem), ate fish from CRK 33 (0.2 mrem); and fished the Clinch River between CRK 33 and 30 (6 mrem), he or she could receive a committed effective dose equivalent of about 8 mrem/year, or about 3% of the annual dose from background radiation.

DOE Order 5400.5, effective date February 8, 1990, limits to no more than 100 mrem the effective dose equivalent that an individual may receive from all exposure pathways from all radionuclides released from the ORR during one year. As described above, the 1989 effective dose equivalent, 8 mrem, was 8% of the DOE Order 5400.5 limit.

3.1.4 Five-Year Trends

Dose equivalents associated with selected exposure pathways for the years 1985 through 1989 are given in Table 3.1.14. The variation in values over this 5-year period is probably not statistically significant. The slight increases in effective doses from consumption of milk and water during 1987 probably are not real because the calculations are based on "less than" values of radionuclide concentrations, and the "less than" values reported for 1987 are higher than the "less than" values reported for 1986. For the water data, a lower limit of reporting for the three Oak Ridge facilities was used; it is an order of magnitude

Table 3.1.13. Summary of estimated radiation dose equivalents to an adult during 1989 at locations of maximum exposure

Pathway	Location	Effective (mrem)
Gaseous effluents	Nearest resident:	
Inhalation plus direct radiation from air, ground, and food chains	Y-12 Plant	1
	ORNL	0.3
	ORGDP	0.004
Terrestial food chain (milk)	Average of sampling stations	0.1
Liquid effluents		
Drinking water	Kingston	0.3
Eating fish	CRK 33 (ORNL discharge point)	0.2
Direct radiation	Clinch River shoreline (33.3 to 30.0 CRK)	6 (250 h/year)

Table 3.1.14. Five-year trends in committed effective dose equivalent for selected pathways

Pathway	Effective dose equivalent (mrem)				
	1985	1986	1987	1988	1989
Inhalation	2.4	3.6[a]	2.1	0.7	1.5
Milk consumption	0.01	0.14	<0.26	0.3	0.1
Fish consumption	1.3	0.8	0.3	0.2	0.2
Drinking water (Kingston)	0.12	0.11	<0.5	0.1	0.3
Direct irradiation	5.0	8.8	5.6	5.6	5.6

[a]These are corrected values that were incorrectly reported in the 1986 report. In 1986, 0.13 Ci of enriched uranium and 0.06 Ci of depleted uranium were released from the Y-12 Plant. The depleted uranium was not included in the airborne dose calculations.

higher than the detection limit reported. These doses should be considered "less than" values.

3.1.5 Findings and Conclusions

The maximally exposed off-site individual due to airborne effluents from the ORR could receive a 50-year committed effective dose equivalent of 1 mrem. This dose is well within the limit specified in the Clean Air Act for Department of Energy (DOE) facilities. The estimated collective committed effective dose equivalent to the approximately 9.4×10^5 persons living within 80 km (50 miles) of the ORR is 35 person-rem for 1989 airborne emissions. This represents about 0.01% of the 2.8×10^5 person-rem the surrounding population would receive from all sources of background radiation.

3.2 CHEMICAL DOSE

Varying amounts of chemicals were released to the environment from operations at ORR facilities during 1989. Those releases are quantified in Tables 3.2.1 through 3.2.5 and are compared to

Table 3.2.1. Potential chemical dose comparison for ORR surface waters annual 1989 average values

Chemical	Calculated daily intake[a] (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
	Melton Hill Dam		
Antimony (total)	<0.082	0.028	<2.93
Arsenic (total)	<0.106	0.100	<1.06
Barium (total)	0.068	3.50	<0.194
Beryllium (total)	<0.0006	0.0002	<3
Cadmium (total)	<0.0092	0.0574	<0.16
Chromium (total)	<0.0019	0.100	<0.19
Copper (total)	<0.02	2.6	<0.01
Lead (total)	<0.074	0.100	<0.74
Selenium (total)	<0.132	0.21	<0.6286
Silver (total)	<0.0116	0.21	<0.055
Zinc (total)	0.036	14.7	0.002
	White Oak Creek Headwaters		
Antimony (total)	<0.076	0.028	<2.714
Arsenic (total)	<0.106	0.100	<1.06
Barium (total)	0.132	3.50	0.04
Beryllium (total)	<0.0006	0.0002	<3
Cadmium (total)	<0.009	0.0574	<0.157
Chromium (total)	<0.02	0.100	<0.2
Copper (total)	<0.0192	2.6	<0.007
Lead (total)	<0.074	0.100	<0.74
Nickel (total)	<0.0196	1.4	<0.014
Selenium (total)	<0.132	0.21	<0.63
Silver (total)	<0.0104	0.21	<0.05
Zinc (total)	<0.026	14.7	<0.002

[a]Values represent annual averages.

Table 3.2.2. Potential chemical dose comparison for ORR surface waters annual 1989 average values—Y-12 Plant

Chemical	Calculated daily intake[a] (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
	Discharge Point: 303		
Cadmium (total)	<0.005	0.0574	<0.0871
Copper (total)	0.03	2.6	0.0115
Lead (total)	0.024	0.100	0.24
Mercury (total)	0.007	0.0235	0.298
Zinc (total)	0.4	14.7	0.027

[a]Values represent annual averages.

Table 3.2.3. Potential chemical dose comparison for ORR surface waters annual 1989 average values—ORNL

Chemical	Calculated daily intake[a] (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
	Discharge Point: X15		
Arsenic (total)	<0.11	0.100	<1.1
Cadmium (total)	<0.004	0.0574	<0.0697
Chloroform (total)	<0.0082	0.1148	<0.07
Chromium (total)	<0.032	0.100	<0.32
Copper (total)	0.038	2.6	0.0146
Lead (total)	<0.008	0.100	<0.08
Mercury (total)	<0.000126	0.0235	<0.0054
Nickel (total)	<0.02	1.4	<0.0143
PCBs (total)	<0.001	0.0002	<5.00
Silver (total)	<0.01	0.21	<0.05
Trichlorethene	<0.0128	0.064	<0.2
Zinc (total)	<0.048	14.7	0.0033

[a]Values represent annual averages.

Table 3.2.4. Potential chemical dose comparison for ORR surface waters, annual 1989 average values—ORGDP

Chemical	Calculated daily intake[a] (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
	Discharge Point: K-901A		
Chromium (total)	<0.04	0.100	<0.40
	Discharge Point: K-1007B		
Chromium (total)	<0.02	0.100	<0.20
	Discharge Point: K-1700		
Arsenic (total)	<0.01	0.100	<0.1
Barium (total)	<0.02	3.5	<0.06
Benzene	<0.01	0.0241	<0.4
Beryllium (total)	<0.002	0.0002	<10
Bromoform	<0.01	0.004	<2.5
Cadmium (total)	<0.004	0.0574	<0.07
Carbon tetrachloride	<0.01	0.0054	<1.85
Chlorobenzene	<0.01	0.04	<0.25
Chloroethane	<0.02	930	<0.00002
Chloroform	<0.01	0.1148	<0.09
Chromium (total)	0.02	0.1	<0.2
Ethylbenzene	<0.01	1.6	<0.006
Lead (total)	<0.016	0.1	<0.16
Mercury (total)	<0.002	0.0235	<0.09
Methylene chloride	<0.01	0.093	<0.11
Nickel (total)	<0.1	1.4	<0.07
Selenium (total)	<0.01	0.21	<0.05
Silver (total)	<0.02	0.21	<0.1
Tetrachloroethane	<0.01	0.014	<0.7
Vinyl chloride	<0.013196	0.0003	<43.99

Table 3.2.4 (continued)

Chemical	Calculated daily intake[a] (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
Zinc (total)	<0.044	14.7	<0.003
1,1-Dichloroethane	<0.01	0.0012	<8.33
1,2-Dichloropropane	<0.01	0.42	<0.02
1,1,2-Trichloroethane	<0.01	0.0123	<0.813
1,1,2,2-Tetrachloroethane	<0.01	0.0035	<2.86
Discharge Point: K-1407-J			
Antimony (total)	<0.1	0.028	<3.6
Arsenic (total)	<0.018	0.1	<0.18
Barium (total)	<0.202	3.5	<0.06
Benzene	<0.01	0.0241	<0.415
Benzo(a)pyrene	<0.018176	0.0001	<181.76
Beryllium (total)	<0.002	0.0002	<10
Bis(2-chloroethyl)ether	<0.018176	0.0006	<30.39
Bromoform	<0.01	0.004	<2.5
Cadmium (total)	<0.004	0.0574	<0.07
Carbon tetrachloride	<0.00968	0.0054	<1.8
Chorobenzene	<0.009948	0.04	<0.25
Chloroethane	<0.02	930.0	<0.00002
Chloroform	<0.01	0.1148	<0.09
Chromium (total)	<0.044	0.1	<0.44
Copper (total)	<0.068	2.6	<0.03
Cyanide	<0.004	1.4	<0.003
Ethylbenzene	<0.009948	1.6	<0.006
Hexachlorobenzene	<0.018176	0.0004	<45.44
Hexachlorobutadiene	<0.018176	0.009	<2.02
Hexachloroethane	<0.018176	0.05	<0.36
Lead (total)	<0.022	0.1	<0.22
Mercury (total)	<0.002	0.0235	<0.09
Methylene chloride	<0.00911	0.093	<0.10
Nickel (total)	<0.48	1.4	<0.34
N-nitroso-di-N-propylamine	<0.018176	0.0001	<181.76
N-nitrosodimethylamine	<0.018136	0.00001	<1813.6
N-nitrosodiphenylamine	<0.018176	0.1429	<0.13
PCBs			
Aroclor-1016	<0.001	0.0002	<5
Aroclor-1221	<0.001	0.0002	<5
Aroclor-1232	<0.001	0.0002	<5
Aroclor-1242	<0.001	0.0002	<5
Aroclor-1248	<0.001	0.0002	<5
Aroclor-1254	<0.002	0.0002	<10
Aroclor-1260	<0.002	0.0002	<10
Selenium (total)	<0.01	0.21	<0.05
Silver (total)	<0.02	0.21	<0.1
Thallium (total)	<0.02	0.0049	<4.1
Vinyl chloride	<0.02	0.0003	<65.5
Zinc (total)	<0.11	14.7	<0.007
1,1-Dichloroethane	<0.01058	290	<0.00004
1,2-Dichloropropane	<0.01	0.42	<0.02
1,1,2-Trichloroethane	<0.01	0.0123	<0.813
1,1,2,2-Tetrachloroethane	<0.01	0.0035	<2.86
2,4-Dichlorophenol	<0.018176	0.21	<0.09
2,4-Dinitrotoluene	<0.018176	0.002	<9.088
2,4,6-Trichlorophenol	<0.018176	0.035	<0.52

[a]Values represent annual averages.

Table 3.2.5. Acceptable daily intakes for selected contaminants

Contaminant	Acceptable daily intake (mg/d)	Reference[a]
Antimony	0.028	1 (RfD)
Arsenic	0.100	2
Barium	3.50	1 (RfD)
Benzene	0.0241	1 (CPF)
Benzo-a-pyrene	0.0001	1 (CPF)
Beryllium	0.0002	3
Bis(2-chloroethyl)ether	0.0006	1 (CPF)
Bromoform	0.004	3
Cadmium	0.0574	3
Carbon tetrachloride	0.0054	1 (CPF)
Chlorobenzene	0.04	3
Chloroethane	930.0	3
Chloroform	0.1148	1 (CPF)
Chromium	0.100	3
Copper	2.6	4
Cyanide	1.4	1 (RfD)
1,1-Dichloroethane	290.0	3
1,1-Dichloroethene	0.0012	1 (CPF)
1,2-Dichloroethane	0.0077	1 (CPF)
2,4-Dichlorophenol	0.21	1 (RfD)
1,2-Dichloropropane	0.42	3
2,4-Dinitrotoluene	0.002	1 (CPF)
Ethylbenzene	1.6	3
Hexachlorobenzene	0.0004	1 (CPF)
Hexachlorobutadiene	0.009	1 (CPF)
Hexachloroethane	0.05	1 (CPF)
Lead	0.100	3
Mercury	0.0235	3
Methyl chloroform	6.3	1 (RfD)
Methylene chloride	0.093	1 (CPF)
Nickel	1.4	1 (RfD)
N-nitrosodimethylamine	0.00001	1 (CPF)
N-nitrosodi-N-propylamine	0.0001	1 (CPF)
N-nitrosodiphenylamine	0.1429	1 (CPF)
PCBs, total	0.0002	1 (CPF)
Aroclor 1016	0.0002	3
Aroclor 1221	0.0002	3
Aroclor 1232	0.0002	3
Aroclor 1242	0.0002	3
Aroclor 1248	0.0002	3
Aroclor 1254	0.0002	3
Aroclor 1260	0.0002	3

Table 3.2.5 (continued)

Contaminant	Acceptable daily intake (mg/d)	Reference[a]
Selenium	0.21	4
Silver	0.21	1 (RfD)
1,1,2,2-Tetrachloroethane	0.0035	1 (CPF)
Tetrachloroethylene	0.014	1 (CPF)
Thallium	0.0049	1 (CPF)
1,1,2-Trichloroethane	0.0123	1 (CPF)
Trichloroethylene	0.064	1 (CPF)
2,4,6-Trichlorophenol	0.035	1 (CPF)
Vinyl chloride	0.0003	1 (CPF)
Zinc	14.7	4

[a]Reference numbers refer to the following:

1. U.S. EPA (1989) Integrated Risk Information System (IRIS) data base. An acceptable daily intake was based on oral reference dose (RfD) for noncarcinogens. For carcinogens, an oral carcinogen potency factor (CPF) was used to calculate an acceptable level of exposure using a 1 in 100,000 lifetime risk of developing cancer.
2. Munro, N. B., and C. C. Travis (1986). "Drinking-Water Standards," *Environmental Science and Technology* **20** (8): 768–769.
3. Hoffman et al. (1984). Preliminary Screening of Contaminants in Sediments. ORNL/TM-9370. Using EPA standard values and criteria as explained in Hoffman et al. (1984).
4. U.S. EPA (1986). Superfund Public Health Evaluation Manual. EPA/540/1-86/060.

acceptable levels of exposure for humans to each chemical. The methodology used for determining acceptable chemical exposure levels for humans is described.

3.2.1 Terminology

Chemicals gain access to the human body by inhalation, ingestion, absorption, and other routes. Whether or not these chemicals produce a toxic effect in the body is dependent on a number of factors. These factors include the physical and chemical properties of the compound, the exposure conditions (duration and frequency), and the susceptibility of the human. Lack of available environmental measurement data precludes an analysis of all pathways of concern for human exposure to chemicals. For example, no measurements of organics in air have been made, precluding an analysis of the inhalation pathway. However, a relevant and practical analysis of the ingestion pathway via drinking water is possible; therefore, a characterization of human exposure to chemicals via drinking water is provided. It is necessary to define pertinent terms. They are as follows.

Acceptable daily intake (ADI). Intake of a toxic chemical (measured in micrograms per day)

that is not anticipated to result in any adverse health effect following exposure. These are EPA-established values.

Calculated daily intake (CDI). Intake of a toxic chemical (milligrams per day) based on the assumption that humans drink 2 L of water per day (an overestimate).

Carcinogen potency factor (CPF). An estimate based on a lifetime probability that a carcinogenic chemical will cause cancer at a dose of 1 mg/kg/d. The actual risk is probably lower than the predicted risk or may even be zero.

National Pollutant Discharge Elimination System (NPDES). A permit that requires evaluation of area source discharges from within and around the facilities to determine their impact on water quality.

3.2.2 Methods of Evaluation

3.2.2.1 Airborne chemicals

The release of airborne chemicals into the atmosphere at ORR facilities is considered to be low. Air permits issued by the Tennessee Department of Health and Environment (TDHE), Air Pollution Control Board, do not require sampling or monitoring at any of the ORNL permission emission points except the steam plant. At other ORR facilities, emission sources may release permitted quantities of chemicals into the atmosphere. Further discussion can be found in Sect. 2.1.1.2.

3.2.2.2 Waterborne chemicals

Health criteria for water were set so that chemical intake from consumption of 2 L/d of water would not exceed the ADI for noncarcinogenic toxic chemicals. For carcinogenic chemicals, there is no accepted threshold limit. For the purposes of this document, a specific risk of developing cancer over a human lifetime of 1 in 100,000 was used to establish acceptable levels of exposure to carcinogens (Hoffman et al. 1984). The ADI for carcinogenic chemicals was derived using the formula:

$$ADI = \frac{1 \times 10^{-5} \times BW}{CPF} \qquad (1)$$

where

BW = 70 kg (reference adult, healthy male) and

CPF = carcinogen potency factor, which is the "upper limit" on the lifetime probability that the carcinogen will cause cancer at a dose of 1 mg/kg/d. The term "upper limit" means that the actual risk is probably lower than the predicted risk or may even be zero.

ADIs were derived primarily from the EPA Integrated Risk Information System (IRIS) data base, which contains updated ADIs for 1989. For those chemicals not included in the data base, the most current ADIs from other available sources were used and are referenced in Table 3.2.5.

The term ADI represents an allowable daily intake for both carcinogens and noncarcinogens. For example, in establishing water quality criteria for the chemicals of greatest concern, the EPA used the following relationship:

$$C_w = ADI / I_w \qquad (2)$$

where

C_w = Water quality criteria level (μg/L),

ADI = EPA-established value for an "acceptable daily intake" (μg/d), and

I_w = EPA-assumed value for daily water consumption (2 L/d).

A review of water quality criteria documents appears in Sittig (1980). Table 3.2.1 lists the CDI of chemicals from surface water on and off the ORR site. If the CDI/ADI ratio is >1, then an unacceptable level of risk would result from consumption of water from ORR discharge points. This means the chemical is designated as one that warrants further investigation. If the CDI/ADI ratio is expressed as less than (<) a particular numerical value, this is based on a "less than" concentration for the CDI because of the detection

limitations of the instruments used to measure for chemicals. Information compiled in Table 3.2.1 was obtained from the NPDES outfall data on surface water quality. If one NPDES outfall discharged into another NPDES outfall, only the applicable data associated with the second outfall were reviewed. Other chemical dose information is given in Tables 3.2.2 through 3.2.5.

Estimates of CDI are based on the assumption that total daily intake of drinking water (2 L/d) comes from the stream (which is unlikely). In reality, outfalls are generally located within areas of DOE facilities not readily accessible to the general public; thus, public consumption of water from the outfalls is highly unlikely. Further, as the pollutant moves downstream from the outfall and the volume of water increases, the concentration of the pollutant decreases. A dilution factor can thus be determined. For example, the flow rate at outfall 302 (Fig. 2.2.7) at the Y-12 Plant is 0.77×10^6 g/d. This flow rate is divided by the flow rate at East Fork Poplar Creek (2.13×10^7 g/d) and then multiplied by the CDI for arsenic of 0.40 mg/d. This calculation yields a new CDI for arsenic of 0.014 mg/d. A dilution factor of 29 is, therefore, determined. Thus, it is important to recognize that the values given in Tables 3.2.1 through 3.2.5 represent overestimates of the intake.

3.2.2.3 Chemicals in other environmental media

An important pathway of concern for human exposure to chemicals is through atmospheric deposition of the chemicals onto vegetation and subsequent transfer into beef and milk. Direct measurements for concentrations of organics in vegetation, beef, or milk in the vicinity of ORR facilities have not been made.

3.2.2.4 Direct exposure

Direct exposure to chemicals does not represent a likely pathway of exposure at the ORR facilities. For airborne releases, concentrations offsite are too small to be a problem through the dermal exposure pathway. For aquatic releases, outfalls are generally located within areas of DOE facilities that are not readily accessible to the general public. Public consumption of water from the outfalls is highly unlikely; however, ingestion of chemicals in water is addressed in Sect. 3.2.2.2.

3.2.2.5 Current year summary

To evaluate the public health implications posed by contamination at the ORR, the assessor must obtain and evaluate data and information on the site's history, the types and levels of contamination at the site, site-specific environmental transport pathways, routes of human exposure, and medical and toxicologic implications of the site's contaminants. This risk assesment includes five basic steps for acquiring the data and information necessary to evaluate the site's health risks.

1. Evaluate information on the site's physical, geographical, historical, and operational setting, and identify health concerns of the affected communities.
2. Determine the contaminants of concern associated with the site.
3. Identify environmental pathways.
4. Identify human exposure pathways.
5. Determine public health implications based on available medical and toxicological information.

Chemicals where the CDI/ADI ratio exceeds unity warrant further investigation. No chemicals at ORR met this criterion.

4. REMEDIAL ACTION PROGRAM

4. REMEDIAL ACTION PROGRAM

4.1 DESCRIPTION

4.1.1 Objectives

Past ORR practices in the storage, treatment, and disposal of hazardous materials/wastes have resulted in the release of hazardous wastes to the environment. To comply with Energy Systems policies to ensure protection of the public, environment, and company employees, the Energy Systems facilities established RAP to accomplish the following objectives.

- Identify and assess sites that may contaminate the environment with hazardous wastes.
- Develop and implement remedial actions to prevent, control, and minimize the release of hazardous wastes from the identified sites.
- Monitor the remediated sites to verify effectiveness of remediation.
- Comply with environmental laws and regulations.
- Obtain and manage funds for the remedial actions.

A general overview of the remedial action process is shown in Fig. 4.1.1. In addition to RAP, Energy Systems has established the Environmental Restoration Division (ERD) to help accomplish the above objectives. Also, an agreement between TDHE, DOE, and Energy Systems, the Federal Facility Agreements, is being put together to clarify TDHE's, DOE's, and Energy Systems roles and responsibilities in the remediation of ORR.

4.1.2 Regulatory Review

The RAP must comply with numerous environmental regulations as established by state and federal agencies. The five sets of regulations that have significant impact on the program are summarized in the following subsections. In addition, other environmental laws such as the Clean Air Act, Clean Water Act, and TSCA must be complied with in the implementation of the RAP.

4.1.2.1 Resource Conservation and Recovery Act

The RCRA, as promulgated by the EPA in 1976, contains closure and postclosure requirements for hazardous waste treatment, storage, and disposal (TSD) facilities that received hazardous waste after November 19, 1980. When operations at hazardous waste TSD facilities cease, each facility must be closed to control, minimize, or eliminate postclosure escape of hazardous wastes and hazardous constituents to protect human health and the environment.

4.1.2.2 Hazardous and Solid Waste Amendments

During 1984, the EPA promulgated the Hazardous and Solid Waste Amendments (HSWA) to the RCRA regulations. Sections 3004(u) and 3004(v) of HSWA require "corrective action for all releases of hazardous waste or constituents from any solid waste management unit at a treatment, storage, or disposal facility ... regardless of the time at which the waste was placed in the unit" to protect human health and the environment.

4.1.2.3 Tennessee Hazardous Waste Management Regulations

The TDHE administers the Tennessee Hazardous Waste Management Regulations (THWMR), which are equivalent to RCRA

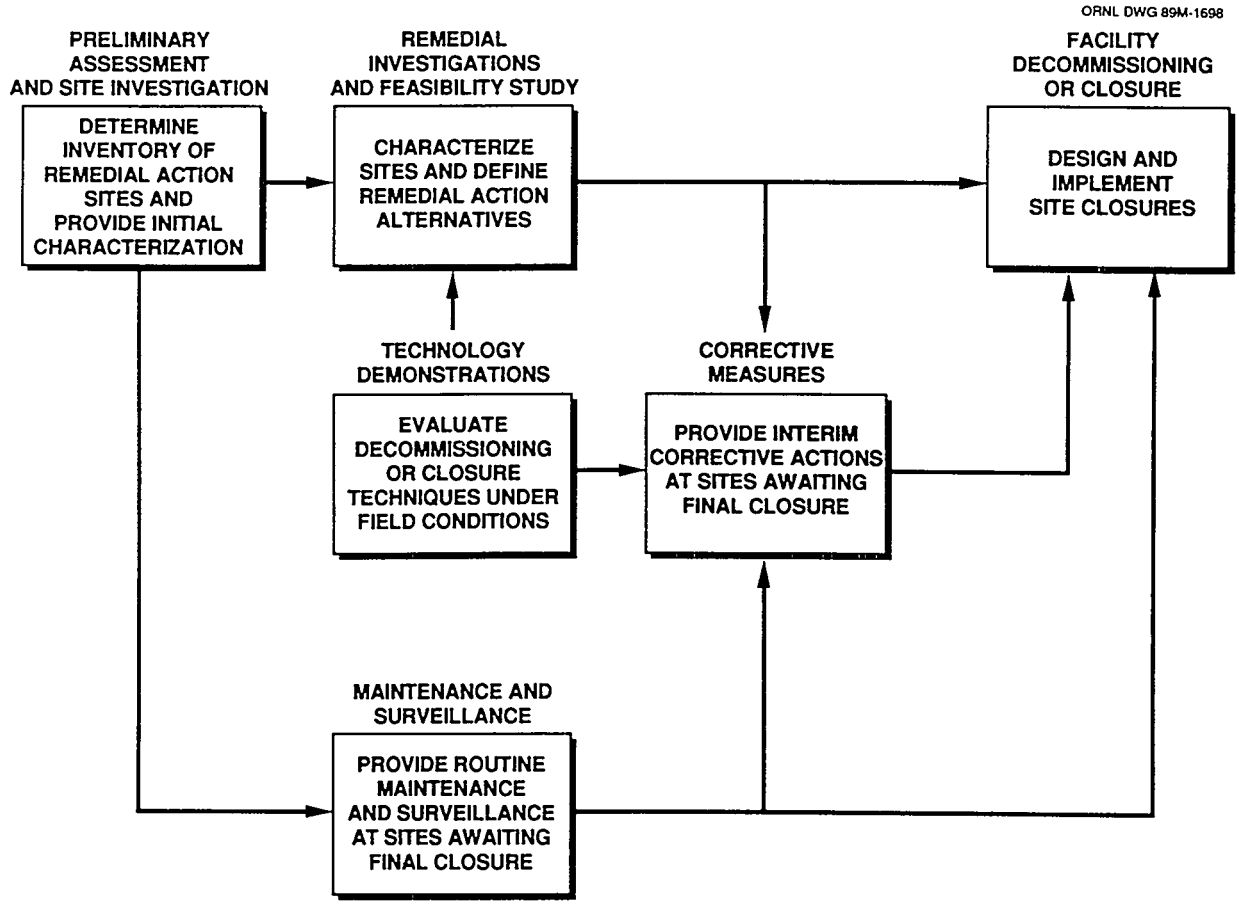

Fig. 4.1.1. Remedial action process flowchart.

regulations administered by the EPA. The THWMR also require closure and postclosure care of hazardous waste TSD facilities as previously described under RCRA.

4.1.2.4 Comprehensive Environmental Response, Compensation, and Liability Act

During 1980, CERCLA was enacted by Congress to require cleanup of releases of hazardous substances in air, surface water, groundwater, and land from new and abandoned facilities. During 1985, DOE issued DOE Order 5480.14 to define how CERCLA requirements should be implemented at DOE facilities.

The 1986 SARA required the EPA to evaluate all federal facilities for inclusion in the federal CERCLA program. In anticipation of coming under the federal CERCLA program, DOE Order 5480.14 was rescinded, and a new DOE CERCLA order, 5400.5, was issued. Federal Facility Agreement (FFA), which will establish the framework and schedules for the Environmental Restoration Program at ORR sites, is being finalized. The ORR was placed on the National Priorities List effective December 21, 1989.

4.1.2.5 Underground storage tank regulations

In September 1988, the EPA promulgated technical standards and corrective action requirements for owners and operators of underground storage tanks (USTs). These regulations govern USTs containing petroleum and chemical products and call for specific construction, installation, leak detection, inventory,

tightness testing, and closure requirements for new USTs. By 1998, existing USTs (installed prior to December 1988) must be retrofitted to comply with the EPA regulations or must be closed. As with many of the EPA programs, individual states may administer the UST regulations, providing that the state's regulations are at least as stringent as EPA's. The Tennessee Legislature has passed the Tennessee Petroleum Underground Storage Tank Act, and regulations are currently being developed.

4.1.3 Program Content and Strategy

The strategy of the RAP has been to identify all ORR sites with potential for releasing hazardous wastes/constituents; to prioritize remedial investigations and work; to examine and investigate the sites to determine the extent of contamination; to perform the necessary remedial actions to control, prevent, and minimize release of hazardous wastes from the site; and to monitor the sites to check the effectiveness of the remediation.

4.2 OVERVIEW OF SITES

4.2.1 Oak Ridge Y-12 Plant

The Y-12 Plant RAP is divided into two main components based on the organization having functional responsibility. Part of the RAP is managed by the newly created Energy Systems Environmental Restoration Division (ERD) and part by the Y-12 Plant Environmental Management Department (EMD) in the Health, Safety, Environment, and Accountability (HSEA) Division.

Other Y-12 Plant organizations that have important roles in the program are the Waste Treatment Operations Department; the Waste Transportation, Storage, and Disposal Department; and the Waste Management Engineering Department. Many other plant organizations provide significant contributions to the program, such as engineering support, laboratory support, health and safety support, plant operations, and development. When necessary, services are obtained from specialized consultants at ORNL, ORGDP, or private consulting firms.

A general overview of the remedial action process is illustrated in Fig. 4.1.1. The first step is to identify sites that have potential for releasing hazardous wastes to the environment. Next, an assessment or investigation is performed to determine if the groundwater, surface water, air, or soil influenced by the facility contains hazardous contaminants. If the investigation indicates that environmental media are not contaminated, the environment adjacent to the site is declared clean and the investigation work is documented. If the investigation indicates that the environmental media at the facility are contaminated, appropriate remedial actions are developed and implemented. After site remediation, maintenance and surveillance are performed to ensure the effectiveness of remediation.

The Y-12 Plant contains many facilities that have been used for treating, storing, or disposing of hazardous wastes. Examples include landfills, incinerators, drum storage areas, aboveground storage tanks, underground storage tanks, surface impoundments, and treatment facilities. The hazardous wastes that are treated, stored, or disposed of in the facilities include waste acids containing heavy metals, chlorinated solvents, and PCBs. The RAP has been set up to address these sites and the associated contaminants. Table 4.2.1 presents a summary of the projects that are currently included in the Y-12 Plant's RAP. Figure 4.3.1 presents a summary schedule for implementation of the program elements.

4.2.1.1 Y-12 Plant Remedial Action Program Categories

The following types of remedial actions are currently under way at the Y-12 Plant.

RCRA closures

This group consists of several facilities that have been used to store, treat, or dispose of hazardous wastes that are regulated under RCRA. Consequently, these sites will be closed under RCRA and THWMR. Closure of each facility will be conducted to control, minimize, or eliminate postclosure escape of hazardous waste to protect human health and the environment. In general, the

Table 4.2.1. Summary of remedial action projects at the Y-12 Plant

Project	Number
RCRA closures	
Incinerator	1
Drum storage areas	4
Treatment facilities	1
Storage tanks	1
Landfills	3
Surface impoundments	4
Land treatment	1
Total	15
3004(u) and (v) corrective actions[a,b]	
Drum storage area	1
Storage tanks	7
Landfills	4
Surface impoundments	2
Treatment facilities	1
Creek and floodplain studies	4
Scrap metal and material facilities	6
Total	25
CERCLA projects[c]	
Interactive underground storage tanks	17
Material usage areas	3
Drum storage area	1
Total	21
Line item project	
Disposal Area Remedial Action project	

[a]Some SWMUs are being grouped for purposes of the RFI.

[b]As a result of a meeting in August 1988 with EPA and TPHE, approximately 30 SWMUs will require further assessment to determine whether an RFI is necessary.

[c]The ORR was placed on the National Priorities List effective December 21, 1989.

closure process for each facility will consist of the following activities:

- Prepare and submit a facility closure plan to EPA.
- Receive approval of closure plan from TDHE or EPA.
- Perform closure activities as specified in the approved closure plan.
- Document and certify closure.
- Receive acceptance of closure from TDHE or EPA.

This group includes 15 facilities (e.g., New Hope Pond, S-3 Pond Site, Bear Creek Burial Grounds, and Oil Landfarm). A discussion on the current status of the RCRA closures is presented in Sect. 4.3.

3004(u) and (v) corrective actions

The second group in the ERBC consists of the facilities to be addressed under 3004(u) and (v) corrective actions of HSWA. Evaluation of each facility under 3004(u) and (v) consists of four phases:

- RCRA Facility Assessment (RFA). Preliminary assessment of each facility to identify releases or possible releases of hazardous wastes justifying in-depth investigation of the facility.
- RCRA Facility Investigation (RFI). Detailed investigation of each facility through sampling and physical examination of the facility to fully define whether the facility and/or the adjacent environment is contaminated with hazardous wastes.
- Corrective Measures Study. Evaluation of the data and information from the RFI to determine the need for and extent of remedial action at each facility.
- Corrective Measures Implementation. Selection and implementation of appropriate remedial action for each facility.

The first phase, the RFA, is ongoing at the Y-12 Plant and includes 187 SWMUs. Approximately 68% of the SWMUs have been determined to be uncontaminated or are being addressed by other programs and will not be investigated further under the 3004(u) program. Thirty SWMUs are to be carried into the RFI phase for additional investigation and evaluation. Because of the grouping of some SWMUs, there are 25 RFIs to be conducted, as shown in Table 4.2.1. Examples of facilities and sites to be

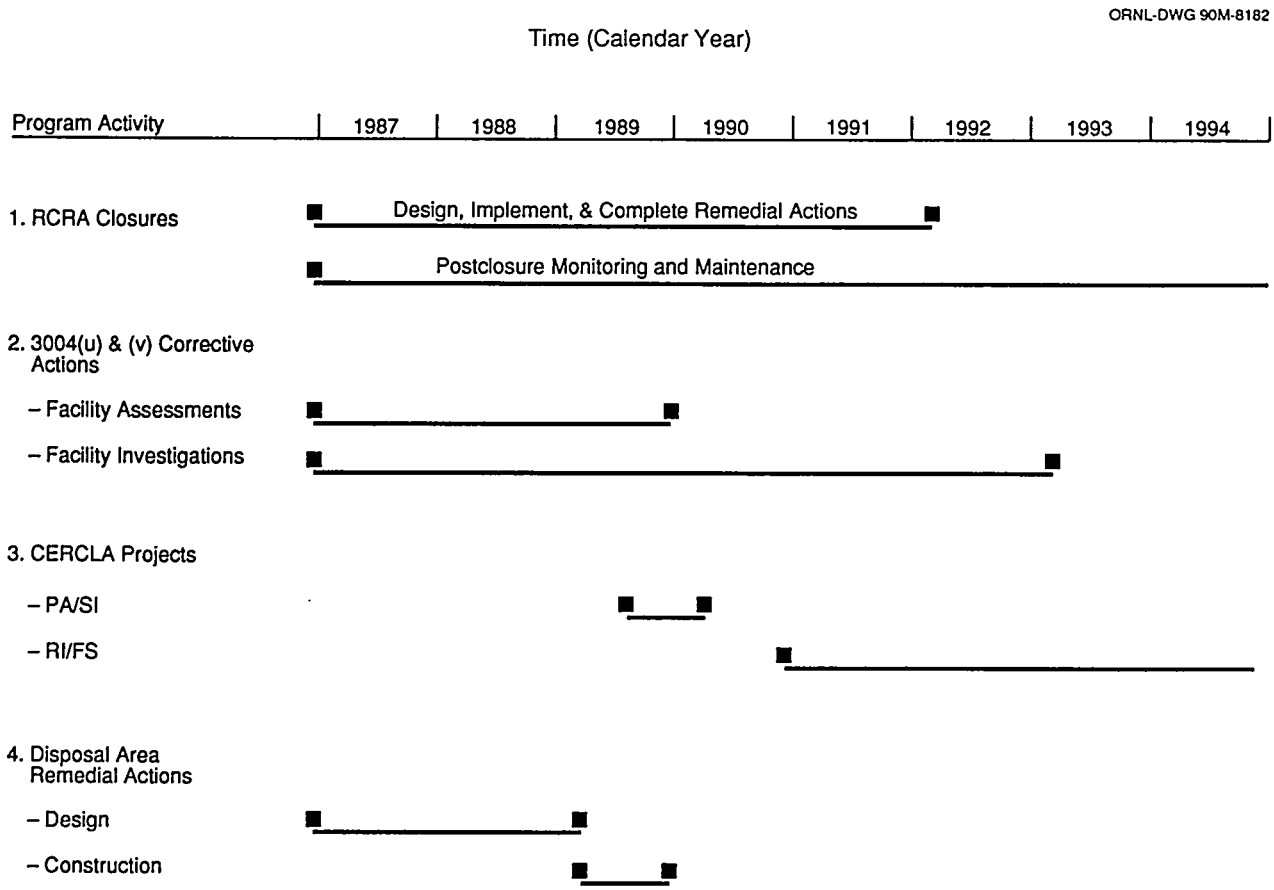

Fig. 4.3.1. Summary schedule of implementation of the Y-12 Plant remedial action program. (Future schedules for remedial action, construction, etc., will depend on results of assessments and investigations.)

investigated in this group are the S-2 Pond Site, Sanitary Landfills I and II, upper East Fork Poplar Creek, East Fork Poplar Creek, and Bear Creek. A discussion of the current status of the 3004(u) and (v) corrective actions is presented in Sect. 4.3.

CERCLA projects

The third group in the ERBC consists of facilities to be addressed under the CERCLA program. Investigation of each facility under CERCLA consists of five phases:

- Preliminary assessment/site inspection. Identification of past disposal sites that may pose a hazard to public health or the environment or have an adverse effect by its persistence in the environment.
- Remedial investigation. Definition and quantification, by preliminary and comprehensive environmental and/or ecological survey(s), of the nature and extent of contamination of confirmed hazardous waste sites. These studies are usually conducted in a staged fashion, with an appropriate risk assessment analysis completed between stages to ensure that the investigations are concluded in a cost-effective manner.
- Feasibility studies. Selection of effective remedial alternatives for confirmed hazardous waste sites through the development of detailed engineering feasibility and cost-sensitivity studies. The intent is to find the lowest-cost alternative that is technologically feasible and reliable and that effectively mitigates and

minimizes damage to, and provides adequate protection of, public health, welfare, and the environment.

- Remedial design. Preparation of detailed engineering construction documents necessary for safe and timely implementation of the recommended remedial alternative for a confirmed hazardous waste site.
- Remedial action. Implementation of the remedial design, evaluation of its effectiveness, and final disposition of the site(s).

The CERCLA program currently contains four sites for investigation: the Z-Oil Contaminated Areas at the Y-12 Plant, the 9720-2 Drum Storage Area, the Beryllium-Contaminated Area in Building 9766, and the Old Steam Plant (Building 9401-1). In addition, 17 inactive USTs have been proposed for inclusion in the CERCLA program. Preliminary assessments have been made on all of these sites. The current status of the CERCLA program is discussed in Sect. 4.3.

Line item project: Disposal Area remedial actions

As a result of waste oil disposal practices in the Bear Creek Burial Ground during the mid-1960s, waste oil seeped from downgradient portions of disposal trenches and entered two drainage ditches in BCBG. During 1971 and 1972, Oil Ponds 1 and 2 were constructed to intercept and collect the seeping waste oils, which were contaminated with PCBs and chlorinated solvents. The accumulated waste oils were removed from the ponds. The disposal area remedial action (DARA) project was established to remediate the two oil ponds and oil seeps. When completed, the DARA project will consist of the following elements:

- Ditches for diverting naturally flowing surface water away from the existing ponds.
- A Liquid Storage Facility to store water impounded in the two ponds. The water will be transferred to a facility for treatment and discharge through an NPDES discharge point.
- A storage vault for the PCB-contaminated soils and sediments to be excavated from the bottom of the ponds and the seep areas. The material will eventually be transported for disposal in the RCRA/TSCA incinerator at ORGDP.
- A surface seep collection system to collect contaminated leachate emanating from the trenches. The leachate will be pumped into the Liquid Storage Facility.
- A Groundwater Treatment Facility containing an air stripper to receive and process contaminated water transported from the Liquid Storage Facility. After processing, the wastewater will be transferred to an existing treatment facility for final polishing and discharged through an NPDES discharge point.

The current status of the project is discussed in Sect. 4.3.

Underground storage tanks

The new UST regulations contain provisions for response to releases from USTs. Should a leak be suspected or detected, the UST must be immediately removed from service and emptied of its contents, and the regulatory agency (TDHE or EPA) must be notified. Short-term abatement activities (e.g., product recovery) must be implemented as the facility owner/operator works with the regulatory agency on a Site Investigation Plan that will address soil, surface water, and groundwater contamination. The owner/operator will be required to remediate the site according to cleanup standards set forth by the TDHE/EPA.

A similar process will be required when a UST is permanently closed. The contents of the tank will be emptied, and the tank will be either removed from the ground or filled with an inert solid. Site assessment will require tank tightness prior to removal from service, soil sampling and analysis, or installation of groundwater monitoring wells. The closure plan must be submitted to the TDHE/EPA for approval.

The Y-12 Plant has approximately 20 remaining tanks that are subject to the UST regulations. As of the end of December 1989, 27 USTs had been inert filled or removed from the ground. The current status of the Y-12 UST program is discussed in Sect. 4.3.

Improved Water Management at Oil Retention Pond Closure Site

Oil Retention Ponds 1 and 2 were created in the early 1970s to serve as gravity separators for hazardous waste (primarily PCB-contaminated oils) that had seeped from Burial Ground A-North burial trenches.

The closure activities for these ponds are covered by two projects, DARA and Closure and Post Closure Activities (CAPCA). DARA consists of three subprojects: Groundwater Treatment Facility (GWTF), Support Facilities (SF), and Pond Closure (PC). SF consists of a Solids Storage Facility (SSF) and a Liquid Storage Facility (LSF). The CAPCA subproject is entitled Oil Retention Ponds (ORP).

The SFF will provide 3058 m^3 (4000 yd^3) of storage space for PCB-contaminated soils excavated from the ponds and portions of Tributaries 6 and 7 of Bear Creek. PC consists of the actual excavation of soils and installation of a seep-collection trench and drain line. The seep-collection trench will intercept concentrated waste where it is currently surfacing (upstream of Pond 1). The LSF will collect the seep water, which will be treated and discharged through an NPDES monitoring point by GWTF. ORP will provide for final closure by covering the excavated ponds, tributaries, and adjacent areas with a multilayer, engineered cap. Tributary 7 will be relocated to a new, clean course.

Closure plans have been approved by TDHE. The initial milestone of this closure was initiation of the discharge of water from ORP 1 by October 3, 1988. Actual discharge began on September 6, 1988. This discharge has been the source of numerous water management plan excursions (primarily, PCB levels slightly above the allowable limit of 1.0 ppb). Additionally, the inflow to the pond was greater than expected (1989 was wettest year in the last 16 years) and could not be handled by the interim treatment system established at the pond.

All surface diversions were completed by February 15, 1989, and the interim treatment system upgrade to 60 gpm was operational on March 13, 1989. A >90% reduction in excursions (from January 1989) was observed during the remainder of the project.

The SSF was completed in July 1989 and the LSF in September 1989. The GWTF is scheduled for completion in January 1990 and operation by mid-March 1990.

The seep-collection trench installation began on September 1 with initial seep-water collection on September 14, 1989. An interim seep-collection trench was in operation from September 14, 1988, to September 1, 1989.

Excavation of PCB-contaminated soils began on July 29 and was completed on November 4, 1989. The remaining soil in all areas, except a small area at the surface seep, was certified below 25 ppm PCB. The exception area excavated surface ranged from 100 to 1700 ppm PCB and was accepted by EPA- and TDHE-approved deviation.

Excavated and adjacent areas have been backfilled with clay and covered by a multilayer, engineered cap. Old Tributary 7 below Pond 1 was not capped but backfilled and mounded with clay as planned. All cap construction is scheduled to be complete by February 1, 1990, approximately 3.5 months ahead of schedule. Final seeding and mulching of the cap is scheduled for the spring of 1990.

4.2.2 Oak Ridge National Laboratory

After 45 years of research and development (R&D) activities associated with both civilian and defense uses of nuclear materials and technologies, a diverse legacy of contaminated inactive facilities, research areas, and waste management areas exists at ORNL; many are potential candidates for remedial action. Most attention is focused on waste management sites, which contain the bulk of the environmental contamination. A wide variety of liquid and solid wastes, primarily radioactive or mixed wastes, have been disposed of on-site in the past 45 years. The major ORNL sources of wastes (and surplus facilities) were: radioisotope production; experimental reactors; hot cells and pilot plants (chemical separations or fuel reprocessing); research laboratories (physical, chemical, and biological); accelerators; and

analytical laboratories. Solid wastes from other sites contributed a large fraction of both the material and the radioactivity buried in solid waste storage areas (SWSAs) during the period from 1955 to 1963 in which ORNL served as the Southern Regional Burial Ground of the Atomic Energy Commission.

In May 1986, the EPA elected to enforce regulatory requirements for remedial actions covering most ORNL sites through its RCRA authority [corrective action requirements; Sect. 3004(u)]. During FY 1989, the EPA placed the entire DOE Oak Ridge Reservation, including ORNL, on the National Priorities List. This will result in the superposition of CERCLA (SARA) requirements on the current RCRA regulatory framework. Both sets of EPA regulations require remedial investigations (RIs), differing in approach and nomenclature, followed by development of a program of remedial actions through remedial alternatives assessments [feasibility study (FS) under CERCLA; corrective measures study (CMS) under RCRA]. These steps provide the basis for determining the extent of contamination problems and the scope of needed corrective actions.

Implementation of the RAP at ORNL began with identification of sites requiring corrective actions and will end with final certification of facility closure or decommissioning activities designed to ensure long-term containment or disposal of residual radioactive or hazardous materials. Between these two milestones is a structured path of program planning, site characterizations, alternatives assessments, technology demonstrations, engineering designs, continued maintenance and surveillance, and, where necessary, interim corrective actions to stabilize the site prior to final disposition. Depending upon the priority established for a given site after characterization and assessment, one of three options will be implemented: (1) remedial actions will be deferred and the facility will be placed into a monitored protective-storage mode until closure or final decommissioning can be scheduled, (2) interim corrective actions will be carried out prior to placement into monitored protective storage, or (3) closure or final decommissioning will be undertaken to place each facility into a stabilized condition requiring only periodic monitoring. Project priorities and schedules will be established through an interactive process in which regulatory authorities, the DOE, and the public will be involved.

The ORNL RAP currently includes some 169 sites in 13 basic categories (Table 4.2.2). These sites vary in complexity from small ponds and waste storage tanks to large experimental reactors and waste disposal areas. The sites represent a heterogeneous mixture of technologies, containment, and contaminants, ranging from doubly contained cells inside secured buildings to 40-year-old, singly-contained USTs and to large areas of buried solid wastes and environmental contamination. Approximately 130 sites appear to require further evaluation and/or remedial action.

While the scope of hazardous chemical contamination at ORNL appears to be limited, a significant number of sites are highly contaminated with low-level radioactive waste (LLW) or mixed wastes, often accompanied by transuranic wastes and/or higher activity LLW. Most of these sites fall into only five of the Table 4.2.2 categories: (1) SWSAs, (2) LLW seepage pits and trenches, (5) LLW lines and leak sites, (10) radioactive waste facilities (LLW storage tank sludges), and (12) inactive hydrofracture injection sites (old and

Table 4.2.2. Potential ORNL remedial action sites

Category	Number
1. Solid waste storage areas	8
2. Low-level waste seepage pits and trenches	8
3. Process ponds	14
4. White Oak Creek watershed	2
5. Low-level waste lines and leak sites	39
6. Environmental research areas	37
7. Hazardous waste sites	5
8. Radioisotope processing facilites	12
9. Experimental reactor facilites	7
10. Radioactive waste facilities	18[a]
11. Research laboratories	7
12. Inactive hydrofracture injection sites	4
13. Other contaminated sites	8
Total	169

[a]Includes 39 underground low-level waste storage tanks, located at 16 sites.

new hydrofracture facility grout sheets). The SWSAs were used primarily for solid waste disposal via shallow-land burial. The LLW lines and storage tanks were part of the early liquid waste system (that is, for transferring, collecting, and storing liquids and sludges prior to disposal). The seepage pits and trenches were used for disposal of liquid wastes and sludges into ground, prior to ORNL waste injections into deep geologic formations by hydrofracturing. Collectively, these sites contain most of the waste inventory in the external environment at ORNL.

Unfavorable environmental conditions (high seasonal rainfall, shallow groundwater table, elevated levels of calcium and magnesium in water, complex hydrogeology) of the ORNL site complicate waste management and remedial actions. Because of the large number of RAP sites and the hydrogeologic complexity at ORNL, the strategy developed in response to regulatory requirements has been oriented toward Waste Area groupings (WAGs) rather than individual sites. The WAGs are generally defined by watersheds that contain contiguous and similar remedial action sites. Under the WAG concept, ORNL sites can be placed within 20 such groupings (Fig. 2.3.5 and Table 2.3.5); each represents distinct small drainage areas within which similar contaminants were introduced. In some cases, there has been hydrologic interaction among the sites within a WAG, making individual sites hydrologically inseparable. The use of groupings provides perimeter monitoring of both groundwater and surface water and the development of a response that is protective of human health and environment in an appropriate time period.

4.2.3 Oak Ridge Gaseous Diffusion Plant

The RFA requires that all solid waste management units (SWMUs) at the facility be identified regardless of when they were in operation. The ORGDP inventory of such facilities includes old burial gounds; process lines used to transport hazardous waste; abandoned storage tanks; shut-down treatment facilities; and RCRA treatement, storage, and disposal facilities. The 3004(u) requirements pertain to units that either were or are used to manage hazardous wastes. However, spills or releases of hazardous substances have occurred at ORGDP from non-waste management units such as gasoline storage tanks, abandoned laboratories, and recirculating water systems. These areas are, by definition, CERCLA units; however, for remedial action activities, they are being treated under the RFI program utilizing the same process as 3004(u) units.

Table 4.2.3 lists the types of SWMUs at ORGDP and the applicable regulation for each. Figure 4.1.1 summarizes the remedial action process for identifying, characterizing, and correcting releases at ORGDP.

The RFI requires that each SWMU be evaluated by collecting appropriate environmental data (i.e., soil, sludge, air, groundwater, and surface water samples) to determine if hazardous materials have been released from the unit. These data provide the information needed to determine the appropriate corrective measure for an SWMU. Table 4.2.4 lists the sites requiring RFI.

Based on the information currently available, three disposal sites at ORGDP are considered to have the highest priority in the RAP. These facilities include the K-1070-A contaminated burial ground, the K-1070-B old classified burial ground, and the K-1070-C/D classified burial ground. The K-1070-A contaminated burial ground is ranked as a high-priority unit because of the existing documentation of materials that were buried at the location during the 1960s, including radioactive materials consisting of approximately 14 Ci total activity and also containing various hazardous waste materials. Data to indicate that the burial ground is contaminating the environment are not available; however, it is considered a high-priority unit because of the potential for environmental contamination. The facility is being characterized for groundwater contamination to determine if buried materials are leaching. The first RFI plan prepared at ORGDP was for this facility.

The K-1070-B old classified burial ground is also given a high-priority ranking because of the potential for groundwater contamination. Unlike the K-1070-A burial ground, no data are available

Table 4.2.3. ORGDP solid waste management units

	Regulation			
	RCRA	3004(u)	CERCLA	Number
Burial grounds		7		7
Storage facilities	7	7	2	16
Treatment facilities	4	6		10
Process lines		4	6	10
Underground tanks	5	7	12	24
Surface impoundments	2	3		5
Accumulation areas	8	9	13	30
Other			8	8
Total	26	43	41	110

Table 4.2.4. ORGDP RCRA facility investigation (RFI) plan sites

K-1070-A contaminated burial ground
K-1064 burn area and peninsula storage
K-901-A holding pond
K-1407 waste area grouping
  K-1407-A neutralization pit
  K-1407-B holding pond
  K-1070-B classified burial ground
  K-1700 creek
K-770 scrap metal yard and contaminated debris
K-1410 neutralization pit
K-1420 mercury recovery room
K-1070-C/D classified burial ground
K-1401 acid line
K-1503 neutralization pit
K-1413 waste area grouping
  K-1413 neutralization pit
  K-1413 process lines
K-1232 treatment facility
K-1070-F old contractors' burial ground
K-1420 waste area grouping
  K-1420 process lines
  K-1420 oil storage
  K-1421 incinerator
K-725 beryllium building
K-1085 burn area
K-720 fly ash pile
Cooling towers and process lines
K-1070-G burial ground
K-1004-L vault
K-1004 area lab drain and K1007-B pond
K-1410 building
K-1099 Blair Road quarry
K-1095 waste paint accumulation area
K-1407-C holding pond
K-1031 waste paint accumulation area
Electrical switchyards
K-901 contractors' disposal area
K-901-A sanitary disposal area
K-1035 acid pits

to document the materials buried in the K-1070-B facility. Interviews with plant employees indicate that the burial ground was used for classified materials. Like the K-1070-A burial ground, this facility was operated before waste management procedures were implemented. Groundwater characterization is also being performed here to determine if groundwater is being contaminated. This unit is grouped with the K-1407-A neutralization pit and the K-1407-B surface impoundment to form the K-1420 WAG.

The K-1070-C/D classified burial ground is ranked as a high-priority unit based on the inventory of materials disposed of in the area. Groundwater monitoring wells have been installed at this unit to determine if materials are leaching from the area.

4.3 CURRENT STATUS

4.3.1 Y-12 Plant

The following discussion of the current status of the Y-12 Plant RAP is divided into sections according to the organization that is responsible for implementation.

4.3.1.1 Environmental Restoration Division Programs

RCRA 3004(u) and (v) corrective actions

The first phase of RCRA 3004(u) and (v) corrective actions, the RFA, is ongoing. Of the 187 SWMUs identified at the Y-12 Plant at the time, 127 have been determined to be uncontaminated and therefore need no further investigation. Thirty sites will be addressed in the second-phase RFI for additional investigation, and 30 additional sites require further assessment. During 1987, general documents and RFI plans for 9 of these 24 sites were developed and submitted to EPA and TDHE for review and approval. In 1988, ten additional RFI plans were submitted to EPA and TDHE for review and approval. The following RFI plans were submitted in 1989:

- Line Yard,
- SY-200 Yard,
- Nitric Acid Pipeline,
- Upper East Fork of Poplar Creek, and
- Mercury-contaminated areas.

Review of an RFI Plan by EPA and TDHE will be necessary before field sampling and investigation may be implemented as described in the plan. The information and data collected in the RFI fieldwork will be used to determine whether or not a particular site is contaminated and, if so, the extent of contamination present. From these data, appropriate remedial actions can be selected and implemented.

Three documents have been developed as reference documents for the Y-12 RCRA 3004(u) program. The *General Document* (Y/TS-352, Vol. I), which was developed in 1987, provides general RFI plan objectives, a list of the Y-12 SWMUs, and general information about the geography, the environmental setting, and the mission of the Y-12 Plant. The Quality Assurance Project Plan (Y/TS-352, Vol. II), which was written in 1988, contains information on the organization, procedures, and other aspects of the Y-12 3004(u) program as they relate to quality assurance. The Data Management Plan (Y/TS-352, Vol. III), which was also written in 1988, describes the procedures required for the proper control of data generated during an RFI.

An overview of the schedule for the RCRA 3004(u) and (v) corrective actions is shown in Fig. 4.3.1.

CERCLA projects

Nineteen Y-12 Plant sites were included in the initial CERCLA report in 1986. In 1987 and 1988, 15 of the sites were transferred to the RCRA 3004(u) and (v) program. Draft investigation plans for the remaining four sites have been prepared but were put on hold when DOE Order 5480.14, which defined how CERCLA requirements would be implemented at DOE facilities, was rescinded in anticipation of federal facilities being included in the federal CERCLA program. These four sites, along with 17 inactive USTs, were proposed for inclusion in the federal CERCLA program. In 1988 a document, *Assessment Information for Proposed CERCLA Sites for the Oak Ridge Y-12 Plant,* Y/TS-487, which provides documentation

equivalent to the RFA on these 21 proposed CERCLA sites, was prepared.

The Y-12 Plant was placed on the National Priorities List effective December 21, 1989, thus formally beginning the federal CERCLA process. A draft CERCLA interagency agreement (IAG) between EPA, TDHE, and DOE, which will establish the framework and schedules for CERCLA as well as the majority of the Y-12 Plant remedial action program, is in preparation.

RCRA closures

Three underground tanks, which are RCRA units, remain to be closed under the direction of ERD. These tanks were part of an on-site facility for servicing motor vehicles. This facility included a gas station with associated underground fuel tanks, underground piping, dispensing pumps, a building, and ancillary fixtures. The two tanks were previously used for storage of unleaded gasoline (a 20,000-gal tank) and leaded gasoline (a 10,000-gal tank). The tanks were subsequently diverted from their initial use to storage of waste oils containing the spent solvents perchloroethylene and Freon 113 and measurable quantities of PCBs and uranium. A third, now empty, tank in the same dirt emplacement with the two RCRA tanks contained waste oil, which was not considered hazardous under current regulations.

The tanks were removed and the surrounding soil was sampled in 1989. Completion of closure, including additional soil sampling and removal of contaminated soil, if required, will occur when the closure plan is approved.

Interim Drum Yard is an outdoor storage area for containerized hazardous and mixed waste in a covered, temporary containment system. Drums of waste are stored on wooden pallets. At the time of closure, all hazardous wastes stored in the yard will be moved to storage at ORGDP, to other interim status or permitted storage at the Y-12 Plant, or to commercial disposal. Closure, which is scheduled to begin in late 1990 or early 1991, will consist of soil sampling and analysis and, if required, removal of contaminated soil.

The 9409-5 Tank Storage Facility is a diked area that contained four storage tanks for bulk solvents and solvent-contaminated oils. The tanks have been emptied and removed and will be reinstalled at the plant, and a closure plan will be prepared. Closure will consist of sampling of the concrete dike and the underlying soil, decontamination and/or demolition of the concrete, and, if required, removal of contaminated soil.

Underground storage tanks

The Rust Construction Garage Area is the site of four USTs: a 12,000-gal diesel fuel tank, a 12,000-gal gasoline tank, an 8,000-gal gasoline tank, and an abandoned 1,000-gal tank. The site assessment began when the 12,000-gal diesel fuel tank failed a tightness test. Since then, the 12,000-gal tank has been identified as a probable "leaker," and a leaking gasoline transfer line has been discovered. Piezometers wells were installed at the site to monitor groundwater levels and the presence of floating product. Product (apparently gasoline) has been discovered in one piezometer well, and recovery operations are under way. Other preliminary assessment work included a soil gas survey (SGS) of the area and the collection of soil samples. An Environmental Assessment Plan (EAP) has been submitted to TDHE for approval. As of December 31, 1989, the tanks were being removed, and the site was being evaluated for contamination.

4.3.1.2 Y-12 Plant Health, Safety, Environment, and Accountability Division Programs

RCRA closures

From 1986 through 1989, the following RCRA closures were completed in accordance with TDHE-approved closure plans:

- final closure of Salvage Yard Oil Solvent Drum Storage area,
- closure of the Oil Landfarm,
- closure of Chestnut Ridge Sediment Disposal Basin,
- closure of Bear Creek Burial Ground A,
- closure of Chestnut Ridge Security Pits,

- closure of the Hazardous Waste Storage Area in the Old Steam Plant (Building 9401-1),
- closure of the Prenco Incinerator Facility,
- closure of the ACN Drum Yard,
- closure of the southern portion of the Interim Drum Storage Yard, and
- closure of the Waste Machine Coolant Biodegradation Facility (WMCBF).

Closure activities for the RCRA closure of the following eight major facilities were initiated in 1988.

1. The closure program for the S-3 Ponds began by treating residual water collected in the ponds. Contaminated stream sediments in the vicinity of the S-3 Ponds were excavated and deposited in the ponds. Bottom sludges and sediment were stabilized with rock to provide a firm base for the placement of an engineered cap, and cap construction was completed, except for the asphalt surface for a parking lot. As of December 31, 1988, closure activities were suspended at the S-3 Ponds pending resolution of a clay permeability problem and as of December 31, 1989, the permeability issue had not been resolved with the State of Tennessee.

2. Final closure of Oil Retention Ponds 1 and 2 in the Bear Creek Burial Ground area began by intercepting seepage of contaminated leachate entering the ponds. Liquids from the ponds began to be removed and treated prior to discharge through an NPDES monitoring system. The bulk of the contaminated soils will be removed and stored pending treatment in the TSCA incinerator at ORGDP. An engineered cap will be installed to isolate residual contaminants in the soil from the surface environment. This cap will also minimize the release of contaminants into the groundwater. As of December 31, 1989, construction of the engineered cap was complete for Oil Retention Pond 2 and approximately 75% complete for Pond 1. Closure certification for the Oil Retention Ponds will be submitted in early 1990.

3. At the Oil Landfarm, soils contaminated with PCB in excess of 25 ppm were excavated from the landfarm plots and stored in a vault pending treatment in the TSCA incinerator at ORGDP. The plots and the chemical storage area will then be covered with an engineered cap. Closure certification has been submitted to the State of Tennessee.

4. Closure of BCBG consists of placing an engineered cap over the disposal areas that are designated burial grounds A, B, C, D, E, and J and the Walk-In Pits. Closure of the Walk-In Pits, which contain unstable and shock-sensitive wastes, presents technical uncertainties and safety concerns that are being addressed. As of December 31, 1989, closure certification for BCBG A has been submitted to the State of Tennessee. The design and construction of caps for the remaining area are continuing.

5. Closure of New Hope Pond (NHP) consists of removal of liquids and treatment (if required), stabilization of sediments, and installation of an engineered cap. As of November 8, 1988, surface water inflow to NHP was terminated. As of December 31, 1989, closure certification was in process, with submittal of certification scheduled for early 1990.

6. Closure of the Chestnut Ridge Sediment Disposal Basin (CRSDB) consisted of placement of clay backfill and installation of an engineered cap. Closure certification has been submitted to the State of Tennessee.

7. The Chestnut Ridge Security Pits (CRSP) were closed by installing a multilayer cap. Closure certification has been submitted to the State of Tennessee.

8. A clean closure is planned for Kerr Hollow Quarry. A videotape survey has been made of the materials on the bottom of the quarry, and the tape has been evaluated to determine if the quarry can be closed without material removal. The quarry will be clean closed using a remote-operated vehicle (ROV). The ROV will breach suspect containers in this quarry to ensure that no wastes remain in KHQ. As of

December 31, 1989, the award of the closure contract was in process, with award to be completed in early 1990.

Disposal Area Remedial Actions

During 1987, the design criteria for the DARA project were finalized and the engineering design of the project and support facilities was initiated. As of December 31, 1989, construction of the Solid Storage Facility and defined Storage Facility was complete.

Underground storage tank program

The UST program at the Y-12 Plant has grown significantly in 1989; eight USTs were removed or inert filled in 1988, and ten were removed in 1989.

Tank 2080-U. This 560-gal gasoline tank formerly served as a fuel pump for fork lifts at Building 9996. The tank was removed from the ground on December 7, 1988. The site was investigated, and a release investigation report was submitted in 1990. The report concluded that the site is not contaminated above TDHE action levels; therefore, no further action is required on the site.

Tank 0134-U. Located east of Building 9204-2, this was a small (approximately 120-gal) UST that was used to supply gasoline to an emergency generator. The tank was excavated and removed in August 1988. Upon removal, soil samples were collected from the excavated material and from the resulting pit. Analyses of the samples for benzene, toluene, and xylene indicated that soil contamination was well below regulatory limits. See Table 4.3.1 for analytical results. However, a small-scale SGS of the site indicated contamination by volatile organics. A Phase II site-investigation plan was submitted to TDHE on February 5, 1990.

Gasoline tank east of 9201-1. In late Steptember 1998, this tank was tested by ET&I and failed. The 560-gal tank and its associated dispensing pump were immediately taken out of service. The tank has been removed, soil samples

Table 4.3.1. Analytical results for soil and water samples for Tank 0134-U site at Building 9204-2

Sample	Contaminant				
	Benzene	Toluene	Xylenes	Lead	Substituted benzene
	Soil (μg/g)[a]				
Tank pit					
1	0.010U[b]	0.079	1,90J[c]	8.7	2.40J
2	<0.010	0.068	1.00J	14	2.10J
3	0.010U	0.160	1.60J	37	2.40J
4	0.11	0.340	3.0J	31	11.0J
Excavated soil					
1	0.010U	<0.010	0.410J	9.7	1.70J
2	0.010U	<0.010	0.460J	9.7	1.90J
3	0.010U	<0.010	0.460J	13	1.40J
	Water (μg/L, unless otherwise indicated)[a]				
1	830	780	19,000J	380	38,000J

[a]μg/g = ppm; μg/L = ppb; mg/L = ppm.
[b]U—contaminant was not detected during the analysis.
[c]J—estimated value.

have been collected, and applicable reports are being prepared.

Building 9754-2 fuel facility. In June 1989, this site was determined to be a confirmed release site. The 20,000-gal gasoline and 10,000-gal diesel fuel USTs at 9754-2 have been removed, and a site investigation plan has been submitted for the 9754-2 and the adjacent 9754 site. The three abandoned 1,000-gal USTs at the 9754 site will be removed during further remediation.

Tank 2117-U. This 550-gal UST, located north of Building 9929-1, was used to supply a furnace in 9929-1 with fuel oil. It was removed in October 1988 as part of a construction project at the site. Although no leaks are suspected to have occurred, soil samples were collected and are being analyzed.

Tank 0713-U. This UST, used at the Y-12 Steam Plant to store fuel oil, was excavated and removed. With the Steam Plant's changeover to natural gas, fuel oil is no longer needed as a supplemental fuel. No indications (e.g., stained areas, holes) of leakage were visible on the exterior of the tank. Soil samples have been collected for the analysis of total petroleum hydrocarbons to confirm whether or not any releases may have occurred from the UST.

Tank 0928-U. This 200-gal tank, located near the northeast corner of Building 9204-3, was used to supply gasoline to an emergency generator in the area. The tank failed tightness testing by ET&I and was removed on May 23, 1989. The applicable reports were prepared and submitted.

Tank 2099-U. A 560-gal UST located at 9201-5 was used to supply gasoline to a dispenser serving Y-12 vehicles. The tank failed a Petrotite test on November 19, 1988. The tank was removed from service and excavated on July 22, 1989. Contamination at the site did not confirm a leak, and no further action was required.

Tank 2310-U. A 200-gal UST located at the Pine Ridge Repeater Station was removed on November 17, 1989. The tank was confirmed to have leaked, and applicable reports were prepared and submitted to the State of Tennessee. Remediation efforts are being evaluated.

Tanks 2063-U, 2328-U, and 2329-U. These tanks located at the Salvage Yard Drum Deheader were used to collect residual liquids from drums containing hazardous materials and wastes. The tanks were reported to be leaking on March 12, 1989, and were removed from service. The tanks were excavated on July 21–29, 1989, and applicable reports were prepared and submitted.

Tank 2315-U. This 64-gal UST provided fuel to a gasoline generator located at the Pine Ridge East Repeater Station. Because of its small size (<110 gal), the tank is not subject to federal UST regulations. The tank was removed on November 29, 1989. No indications of leakage (e.g., stained areas, holes) were discovered. Soil samples were collected for the analysis of benzene, toluene, and xylene to confirm whether or not any releases may have occurred.

Tank 0836-U. This 10,000-gal UST was used for storage of non-RCRA waste oil. The tank was located near the former Building 9754 and was removed from the ground on October 11, 1989. Soil samples have been collected for the analysis of total petroleum hydrocarbons to confirm whether or not any releases may have occurred from the UST.

4.3.2 Oak Ridge National Laboratory

4.3.2.1 Characterization and assessment

Characterization and assessment are required initial steps in defining the scope and magnitude of remedial actions. The RFA and its two Addenda, prepared in 1987, were reviewed by regulatory authorities, and a list of sites (WAGs) requiring RIs (see below) has been agreed upon. Review of existing information, environmental surveys, and additional field sampling are being conducted for a few sites to resolve regulatory questions about site status. Other major activities are directed at completion of the basic groundwater monitoring network for principal WAGs by FY 1990, studies of groundwater-contamination sources, subsurface storm flows, contaminant subsurface pathways tracing, groundwater dating, surface water flow and quality measurement, groundwater treatment reduction, and support for a comprehensive biological monitoring of the White Oak Creek system (Loar et al. 1987, 1988) for input into the RI/FS effort.

Development of a comprehensive groundwater monitoring system began in 1985. This has included installation and development of hydraulic head measuring stations (HHMS), piezometer wells, and GQM wells. The HHMS are well clusters that provide data required for evaluating the transition between shallow and deep groundwater systems and the nature of the deep system(s). Piezometer wells are exploratory wells used to characterize groundwater flow patterns to permit proper siting of GQM wells. A total of 330 piezometer wells for siting GQM wells have been installed to date. Installation of the WAG perimeter groundwater monitoring system consisting of 171 GQM wells will be completed in FY 1990. Additional characterization and GQM wells will be installed to meet the needs of the RI/FS activity.

The largest single RAP activity currently is the implementation of the comprehensive RI/FS, initiated in 1986. Thirteen WAGs (1 through 11, 13, and 17) are scheduled for RIs and/or alternatives assessments. A major support-subcontractor team was procured in 1987, and major documents related to quality assurance, health and safety, data base management, waste management, etc., have been completed. Draft plans for 11 WAG RIs (1, 3 through 10, and 17) have been completed and submitted for regulatory review. The RI plan for WAG 2 will be submitted to regulators in 1991. RI plans for WAGs 11 and 13 will be submitted for regulatory review in 1993. Plans completed to date cover the main plant area of ORNL, all SWSAs, the LLW pits and trenches area, and hydrofracture sites (i.e., all of the highly contaminated sites identified in Sect. 4.2.2). The RI schedule for WAG 6 is tied to commitments in the SWSA-6 Closure Plan approved by TDHE and EPA (see below); field activities associated with the WAG-6 RI were formally implemented in late 1988 and will be completed by the end of FY 1990. RI field activities were initiated in WAG 1 (main plant area); other WAGs will be addressed according to established priorities. The overall RI/FS phase of the ORNL RAP was originally envisioned to require a 5-year effort. With a better understanding of the magnitude of the problem and experience with budget reductions, it now appears that 10 years will be a realistic, if not optimistic, expectation.

4.3.2.2 Maintenance and surveillance

While the RI/FS activity is under way, RAP sites continue to be monitored and controlled through a comprehensive program. Site-specific surveys are conducted to define the scope of existing contamination and permit effective planning for the widely differing needs of existing sites. Routine facility repairs, improvements, and small-scale cleanup activities are also provided to ensure containment of residual contaminants until site decommissioning or closure can be accomplished. Examples include repair of asphalt caps and diversion ditches, repairs or containment upgrades to ensure facility integrity, construction of deer-control fences to limit access to contaminated areas, sealing of unused wells, removal of contaminated vegetation, general surface cleanup activities, and collection and treatment of contaminated groundwater in the main plant area.

4.3.2.3 Technology demonstrations

Coordinated demonstrations and evaluations of remedial action technologies are being conducted on a schedule compatible with future closures or corrective action needs. The test area for remedial actions (TARA), located in SWSA 6, is the focus of a waste-trench stabilization and closure demonstration of integrating dynamic compaction, in situ grouting, and capping techniques. Dynamic compaction of the TARA trenches was completed in 1988. As further tests at the TARA site evaluate the effectiveness of chemical grouting and cap performance, ORNL will be in a better position to select effective stabilization techniques for closure of its existing waste disposal sites. During the summer of 1987, a demonstration of in situ vitrification (ISV) was conducted on a 1/3-scale, uncontaminated model of a LLW seepage trench. ISV is a process for immobilizing a hazardous chemical and/or radioactive waste by melting an area of contaminated soil/wastes with an electrical current to form a leach-resistant glass. Evaluations of the demonstration in 1988 indicate

that the process may be useful in stabilization of some ORNL sites. The ISV technique is being further evaluated for remediation of the LLW pits and trenches area as well as LLW storage tanks. A pilot-scale demonstration of an ISV of a radioactive seepage trench will be conducted in 1990, and an in situ grouting of an underground storage tank will be demonstrated in 1991. Work on both the TARA and ISV projects is expected to be completed in the early 1990s. Activities in 1992 will include a hydrofracture well plugging and abandonment (P&A) demonstration.

4.3.2.4 Interim corrective measures

Interim corrective measures (ICMs) will be conducted to contain, remove, or treat contamination resulting from releases of hazardous constituents from solid waste management units to protect human health and/or the environment prior to completion of final site remediation/closure. Potential ICMs have been identified that are associated with inactive waste settling ponds, contaminated vegetation, tritium releases, buried transuranic wastes, mercury contamination, bathtubbing burial trenches, environmental research areas, and inactive scrap yards. Prioritization, implementation planning, and design will be performed in FY 1991 with implementation initiation in FY 1992.

4.3.2.5 Cleanup activities

Site cleanup will proceed as quickly as characterization and funding will allow. As with the RI/FS, activities will be implemented according to priorities and schedules negotiated with regulatory authorities. The magnitude of the effort for long-term management of ORNL sites can only be roughly approximated because site-characterization information is still quite preliminary, and current technology limitations make achievement of the ultimate objective problematic for some sites (e.g., those containing long-lived transuranic wastes). However, regulatory requirements under RCRA and the proposed FFA mandate early closure of SWSA 6, 33 underground LLW storage tanks, and several additional underground tanks (see below) used for storage of petroleum products/paint solvents. In addition, plugging and abandonment (P&A) of the hydrofracture injection and observation wells and of groundwater monitoring wells that penetrate the hydrofracture injection zone is likely to be under way in response to Safe Drinking Water Act (SDWA) regulations prior to completion of the WAG 10 RI/FS. Over 100 wells may require P&A, adding substantially to the effort associated with hydrofracture closure.

The disposal of lead and scintillation vials in the currently active solid LLW disposal area, SWSA 6, required closure of selected areas in accordance with a November 8, 1988, statutory deadline. A comprehensive closure plan has been approved that addresses interim corrective measures, RI/FS activities, and ultimate closure of the site. Installation of a plastic membrane cover over the RCRA areas of SWSA 6, accompanied by riprap drainage controls, has been completed. This was done to reduce releases from SWSA 6 until characterization and assessment of the entire area could be completed (prior to onset of substantial closure activities). Final closure is expected in September 1993.

Closure of inactive LLW storage tanks and tanks that are currently active but scheduled for deactivation will also require substantial resources over the next few years. During 1988 and 1989, a sampling campaign was conducted to characterize the contents of these tanks. Continued sample analyses, leak testing and structural analyses, risk assessments, waste treatability studies, and planning evaluation of potential interim corrective measures/closure alternatives will be conducted during FY 1990 and 1991. Alternatives for closure range from removal and processing of the contents and exhumation of the tanks, to in situ stabilization of both tanks and contents. Actual closure operations are expected to begin in the 1990s and will be integrated with the WAG RI/FS effort.

4.3.2.6 Decontamination and decommissioning

A major component of the total ORNL remedial effort, initiated in 1976, involves maintenance and surveillance (M&S) and,

ultimately, decontamination and decommissioning (D&D) of a large inventory of surplus radioactively contaminated facilities resulting from past research, development, or production activities involving radioactive materials. These facilities are currently being monitored and controlled while awaiting decontamination for reuse or decommissioning to remove the future risk to employees and the public. Examples include several experimental reactors (most notably the Molten Salt Reactor Experiment and the ORNL Graphite Reactor), isotope production facilities and storage sites, and hot-cell facilities used for a variety of production and research purposes. The majority have been inactive for 10 to 20 years and, because of this time lapse and the inactive status of the sites, structural deterioration has often occurred.

While a continued commitment to comprehensive M&S will ensure that these facilities do not become a major threat to health and safety, funding ultimately must be provided and actions must be taken to remove the existing hazards through D&D. The inactive facilities are located within WAGs undergoing RI/FS activities, and final decisions on D&D must also be considered in the context of RI/FS alternatives and decisions. FY 1990 D&D project activities include the removal and disposal of a curium-handling glove box and waste removal and in-cell survey of manipulator cells in the High Level Radiation Analytical Facility. Future scheduling of D&D activities is somewhat uncertain due to their low priority with the DOE environmental restoration program.

4.3.2.7 Underground storage tanks containing nonradioactive substances

Compliance with new requirements for USTs containing nonradioactive substances (e.g., petroleum products) regulated under RCRA Subtitle I (USTs) is being overseen jointly by the Environmental Monitoring and Compliance Section (EMC) of the Environmental and Health Protection Division and the RAP. The EMC has oversight responsibility for approximately 50 active USTs, and the RAP is providing resources and personnel to support site characterization, assessment, and closure of several inactive tanks. Integrity testing and corrective action in the event of leaks are integral components of the requirements for active tanks. Fieldwork in remediation of the remaining inactive UST sites will be performed through an existing support subcontract and is expected to be completed in 1991.

4.3.3 Oak Ridge Gaseous Diffusion Plant

ORGDP has been in the RFI phase of the RAP since 1988. The SWMUs located at ORGDP have been identified, and RFI plans are being prepared. One hundred and ten waste management units have been identified at ORGDP (Table 4.2.3). Twenty-one units are RCRA sites and 45 are RCRA 3004(u) sites. The remaining 34 units at ORGDP are considered to be CERCLA sites but will be evaluated using the 3004(u) program protocol.

The RAP developed for ORGDP will be scheduled according to three factors: (1) priority, (2) completion of characterization activities, and (3) funding schedules. The priorities were established by determining the probability of a site posing a threat to the public, employees, or the environment. The priorities for performing corrective measures may be changed from the current schedules depending on the information collected from the characterization activities. Any units found to be a threat to the public, employees, or the environment will be given highest priority.

5. SOLID WASTE MANAGEMENT PROGRAM

5. SOLID WASTE MANAGEMENT PROGRAM

5.1 DESCRIPTION

5.1.1 Purpose

The goal of the solid waste management program is to handle solid wastes according to procedures that protect the health and safety of on-site personnel and the public, protect the environment, and minimize long-term liability. To meet this goal, the potential for environmental release of wastes must be minimized. Hence, solid waste management activities are conducted in compliance with state and federal regulations and conform to good industry practices, which in some cases are more protective than the practices mandated by the regulations.

The solid waste management program encompasses treatment, storage, transportation, and/or disposal of nonhazardous, radioactive, infectious and hazardous solid wastes. The terms *solid* and *hazardous* are used as defined in the RCRA. A *solid waste* is a solid, liquid, or gas that is discarded, abandoned, or, in some cases, reused by recycling or burning for energy recovery. *Hazardous wastes* are a subset of solid wastes that RCRA designates and regulates as hazardous. Mixed wastes contain both hazardous and radioactive components.

5.1.2 Regulations and Guidance

This section describes the regulations that govern the management of solid waste and the DOE orders that implement these regulations.

5.1.2.1 Federal and state compliance

RCRA, enacted in 1976, is the prominent regulation governing solid waste management activities. RCRA regulates the generation, transportation, treatment, and disposal of hazardous wastes and regulates facilities that conduct these activities. Source materials, special nuclear materials, and by-product materials are excluded from RCRA. However, radioactive material mixed with hazardous wastes is regulated by both RCRA and the Atomic Energy Act (AEA). Hazardous wastes are defined in RCRA by specific source lists, nonspecific source lists, characteristic hazards, and discarded commercial chemical product lists. Other portions of RCRA pertinent to the Oak Ridge installations include standards for transporters of hazardous waste; standards for owners and operators of hazardous waste treatment, storage, and disposal facilities; permit requirements for treatment, storage, or disposal of hazardous wastes; inspections; federal enforcement; hazardous waste site inventory; and corrective action requirements.

To obtain compliance with RCRA, the Oak Ridge installations must submit permit applications to environmental regulators for each hazardous waste treatment, storage, or disposal facility. Part A permit applications (interim status) were submitted in 1984, and Part B permit applications (operating) are submitted for individual operating units. Treatment, storage, or disposal units obtain interim status through the Part A permit

application process and are required to meet the design and management standards for interim facilities set forth in RCRA. Facilities receive full permit status through the Part B Permit application and approval. Facilities with interim status could file for closure and cease operations instead of filing for a Part B permit application, which requires more stringent standards.

Additional RCRA Part A and Part B applications are submitted as new storage and/or treatment units are needed for the management of hazardous wastes. The TSCA governs the labeling, handling, and disposal of wastes or articles containing PCBs. The Clean Water Act (CWA) requires use of best management practices (BMPs) and compliance with the NPDES permit, and the Clean Air Act (CAA) requires compliance with air emissions standards.

5.1.2.2 DOE orders

Management of radioactive wastes, waste by-products, and radioactively contaminated facilities is governed by DOE Order 5820.2A, which applies to all DOE elements, contractors, and subcontractors that manage radioactive waste as defined in the AEA of 1954 (as amended). Guidelines are provided for characterization, storage, and disposal of high-level radioactive wastes, LLW, transuranic (TRU) wastes, wastes contaminated with naturally occurring radionuclides, and decommissioning wastes.

Hazardous and mixed waste management at the Oak Ridge facilities is conducted under DOE Orders 5400.1 and 5400.3, as well as the AEA, the RCRA of 1976, and its Tennessee equivalent, the Tennessee Hazardous Waste Management Regulations. DOE Order 5400.1 ensures that hazardous waste generated by DOE-funded activities will be managed in an environmentally acceptable manner. DOE Order 5400.3 provides the requirements for hazardous waste management programs implemented at DOE-funded installations. The AEA of 1954, as amended, dictates provisions for establishing regulations that govern processing and use of source, by-product, and special nuclear materials.

5.1.3 Compliance Activities

5.1.3.1 Y-12 Plant

To obtain compliance with RCRA, the Y-12 Plant submits applications to environmental regulators for each hazardous waste treatment, storage, or disposal facility. Each permit application has two parts: Part A permit applications (interim status), submitted in 1984, and Part B permit applications (operating), submitted since 1985. Facilities with interim status had the option of filing for closure and ceasing operations instead of filing for a Part B permit. Twenty Part B permit applications and six postclosure permit applications have been filed for the Y-12 Plant facilities.

Information required for a Part B permit application includes general facility description, waste characterization, and analysis plans; information on processes generating the waste; procedures to prevent hazards; contingency plans; and closure and postclosure plans. After negotiation and acceptance of Part B, the Y-12 Plant facilities will be fully permitted under RCRA and subject to stringent guidelines specified in 40 CFR Part 264. The facilities are inspected regularly by EPA, TDHE, DOE, and/or internal auditors to ensure RCRA compliance.

In CY 1989, five Y-12 Plant RCRA facilities have been closed or partially closed in accordance with TDHE-approved closure plans. These were the Chestnut Ridge Security Pits, Chestnut Ridge Sediment Disposal Basin, Oil Landfarm, Bear Creek Burial Ground Area, and Hazardous Chemical Disposal Area. Closure activities are under way on an additional four disposal areas as a part of the Closure and Post Closure Activities project. The four facilities include the S-3 Ponds, New Hope Pond, Kerr Hollow Quarry, and Oil Ponds.

Nonhazardous, nonradioactive, solid waste disposal sites are permitted in accordance with the Tennessee Solid Waste Disposal Act. To meet the requirements of the act, documentation that included construction drawings and design and operating plans was submitted to the regulators for approval; subsequently, permits were issued for the

Y-12 Centralized Sanitary Landfill II, the Y-12 Spoil Area I, and Industrial Waste Landfill IV. All regulated facilities are inspected quarterly by the regulators. Applicable discharges to surface waters are through monitored discharge points that comply with the plant's NPDES permit.

An Environmental Assessment (EA) for the Y-12 Steam Plant Ash Disposal Project is currently under preparation. The EA will evaluate alternatives for disposal of dewatered bottom ash as well as nonradioactive, nonhazardous, nonmetallic industrial and sanitary wastes generated at Y-12 Plant, ORGDP, and ORNL.

5.1.3.2 Oak Ridge National Laboratory

Waste treatment and disposal activities are regulated by TDHE and EPA through operating permits. ORNL operates (1) several hazardous waste treatment, storage, and disposal facilities under an interim-status RCRA permit and (2) the Hazardous Waste Storage Building (Building 7652), which operates according to a full RCRA Part B permit granted in October 1986. Chemical and mixed wastes are regulated through these permits. The contractor's landfill for the disposal of nonhazardous materials such as fly ash and construction debris operates under a permit from the TDHE Division of Solid Waste Management. Process wastes are treated on-site in the process wastewater treatment facility, which discharges to surface water through a monitored discharge point that must comply with ORNL's NPDES permit. The NPDES permit is regulated by TDHE and EPA. Radioactive waste disposal must comply with DOE orders: RCRA requires that the potential for environmental release of radioactive materials be investigated and corrective actions taken. Thus, all waste-handling activities are regulated and inspected for compliance by state and federal agencies as well as through internal audits.

TRU wastes generated at ORNL are being placed in retrievable storage. Current activities center around certification of contact-handled (CH) waste, planning/designing of a repackaging and certification facility for remote-handled (RH) wastes, and planning for shipment of wastes to the Waste Isolation Pilot Plant (WIPP) in New Mexico.

5.1.3.3 Oak Ridge Gaseous Diffusion Plant

To comply with RCRA, ORGDP submitted Part A permit applications in 1984 and Part B permit applications in 1985. These applications were revised in 1988. During 1988, ORGDP elected to file for closure and ceased RCRA operation of four facilities. The plant also filed a permit-by-rule request for two facilities. In September 1989, ORGDP received 11 permits from TDHE. Ten of these permits are for RCRA storage units, and one is for closure of 1407-B Pond. Because of appeals, the storage areas have reverted to interim status.

The TSCA regulations govern the labeling, handling, and disposal of wastes that contain PCBs. PCB wastes that contain radioactive contamination cannot be disposed of by commercial facilities. These wastes will be disposed of at the K-1435 incinerator.

Other environmental regulations also impact solid waste management activities. CWA requires the use of BMPs and compliance with NPDES. CAA requires permitting of air emissions.

5.1.4 Program Strategy

Overall corporate strategies for the management of radioactive, hazardous, and mixed wastes have been developed for Energy Systems. These strategies are based on the following guiding principles.

- Reduce the quantity of solid waste generated. Waste generation reduction can be accomplished through various waste management options, including segregation, material substitution, recycle and/or reuse, mechanical volume reduction, process innovation, and treatment. The waste minimization principle includes process changes or treatments that decrease the hazard of the waste (i.e., generating LLW vs mixed waste or conventional sanitary wastes vs LLW). Decreasing the hazard of the waste should produce a waste that is more easily managed.
- Minimize the amount of wastes stored on-site. This philosophy can be adhered to through waste minimization (discussed above) and through

treatment and disposal methods that permit waste to be disposed of off-site. No waste greater than 32 pCi/g is currently disposed of off-site.

- Characterize and certify the wastes prior to storage, processing, treatment, or disposal. Wastes must be characterized in order to determine whether or not they are LLW, TRU, mixed, or RCRA hazardous. The isotopes present and their activities should be known to ensure that the wastes are appropriately managed. The wastes should be certified to meet the acceptance criteria of the facility that will receive the waste. Completion and maintenance of quality assurance documentation and waste management records are an essential part of this process.
- Use on-site storage where this can be shown to be safe and cost-effective until a final disposal option is selected. Conventional warehouse storage techniques will be used to extend the life of existing disposal facilities.
- Utilize demonstrations to determine the effectiveness of promising technologies in the solution of local problems.
- Maximize the involvement of private-sector contractors in conducting technology demonstrations and in implementing successful technologies. Private-sector participation will be solicited not only in the execution of demonstrations but also in the concepts to be used. It is felt that by allowing industrial participants to propose concepts as well as execution, the most advanced practical technology will be made available for consideration. Additionally, industrial participation on a cost-sharing basis is being encouraged to permit practical demonstrations of new technology that will benefit both DOE and the industry. This minimizes the amount of DOE capital investment required. Cost-sharing demonstrations and the use of small-scale demonstrations prior to selection of final disposal technology are both in accordance with this principle. Sharing and coordinating the use of facilities will also reduce the required capital investment. Facilities should be centralized and coordinated as appropriate.

More specifically, the radioactive waste management program is based on the following technical assumptions.

- Waste will be segregated by half-life and hazard consistent with the overall waste management strategy.
- The level of containment required and, therefore, the type of treatment and/or disposal required will be a function of the half-life and hazard, including potential mobility, of the waste.
- Engineered features cannot be relied on to contain long-half-life wastes without surveillance, remediation, and long-term maintenance.
- Management of long-half-life wastes must rely on concentration limits, natural features, and institutional control/perpetual care to provide for the maintenance of engineered features and to protect against intrusion.

TRU wastes will be managed in accordance with the TRU Waste Program strategy, which relies on certification and packaging at the site and shipment to the Waste Isolation Pilot Plant (WIPP) for ultimate disposal. LLW will be managed in accordance with DOE Order 5820.2A, "Radioactive Waste Management." The general strategy for management of LLW has been defined through the LLWDDD program.

The primary goal of the LLWDDD strategy is the disposal of solid radioactive waste in a manner that protects the environment and public health and safety at all times. For the disposal of LLW, the strategy establishes dose-based performance objectives that protect the public, minimize releases, and reduce the probability for the need to do remedial actions after the disposal facilities are closed. The key components of the strategy are

- the dose-based performance objectives for disposal of LLW,
- a waste classification system for managing different wastes to meet the dose-based performance objectives,

- the planned use of engineered features and barriers,
- the waste acceptance criteria (WAC) for each disposal site for achieving the dose-based performance objectives for that specific site with appropriate engineered features,
- a waste certification program for ensuring that the wastes for disposal meet the applicable WAC,
- the use of pathways analysis modeling to establish radionuclide concentration limits for the WACs and to predict whether a selected site and technologies will achieve the performance objectives, and
- phased implementation.

Using this general strategy, Energy Systems has proposed five classes of LLW.

1. **Below regulatory concern (BRC) waste.** LLW that is suitable for disposal in a sanitary/industrial landfill and will not expose any member of the public to an effective dose equivalent of more than 4 mrem/year at the time of disposal.
2. **Class L-I waste.** LLW that is suitable for disposal using sanitary/industrial landfill disposal technology and will not expose any member of the public to an effective dose equivalent of more than 10 mrem/year at the time of disposal.
3. **Class L-II waste.** LLW primarily containing fission product radionuclides with half-lives of 30 years or less that is suitable for disposal in engineered facilities designed to isolate the waste from the environment and public for a period of time sufficient to allow for the decay of radionuclides to such a level that any member of the public will not be exposed to an effective dose equivalent of more than 10 mrem/year.
4. **Class L-III waste.** LLW consisting of radionuclides that have long half-lives and will be disposed of in facilities having permanent intruder protection.
5. **Class L-IV waste.** LLW not suitable for disposal on the Oak Ridge Reservation (ORR) and that would require either treatment to reduce the level of contamination to a level consistent with any of the other waste classifications or shipment to an off-site LLW disposal facility.

The general strategy to be followed for the management of hazardous and mixed wastes will ensure the continuation of present management operations while simultaneously initiating a technology development and demonstration program for current and future problem waste streams. Fundamental to this general strategy are the following components: (1) waste stream identification and evaluation; (2) waste minimization/reduction; (3) on-site storage/treatment, RCRA hazardous wastes; (4) on-site storage/treatment, mixed wastes; (5) technology demonstrations; (6) delisting, detoxification, and mobility reduction; and (7) waste disposal activities.

The Hazardous Waste Development, Demonstration, and Disposal (HAZWDDD) Program developed a general classification system based on the RCRA and TSCA regulations (Fig. 5.1.1). Treatment options are evaluated for each category of problem waste using process flowcharts. Where technology currently exists, preferred treatment options are identified. When proven technologies do not exist, studies, evaluations, or technology demonstrations will be conducted. In general, the preferred treatment option for categories A (ignitables), E (spent solvent), J (PCB wastes), L (medical/infectious waste), and M (combustibles) is incineration. For category D (EP-toxic wastes), the preferred option is stabilization (surface decontamination, followed by stabilization, for surface-contaminated wastes), and the preferred option for category F (sludges) is thermal treatment and/or stabilization. The preferred treatment option(s) for categories B (corrosives), C (reactives), K (poisons), U (unknown), and Z (hazardous, but not EPA-listed) depend on complete waste characterizations.

Mixed wastes are currently being placed in interim storage as new technologies for treatment

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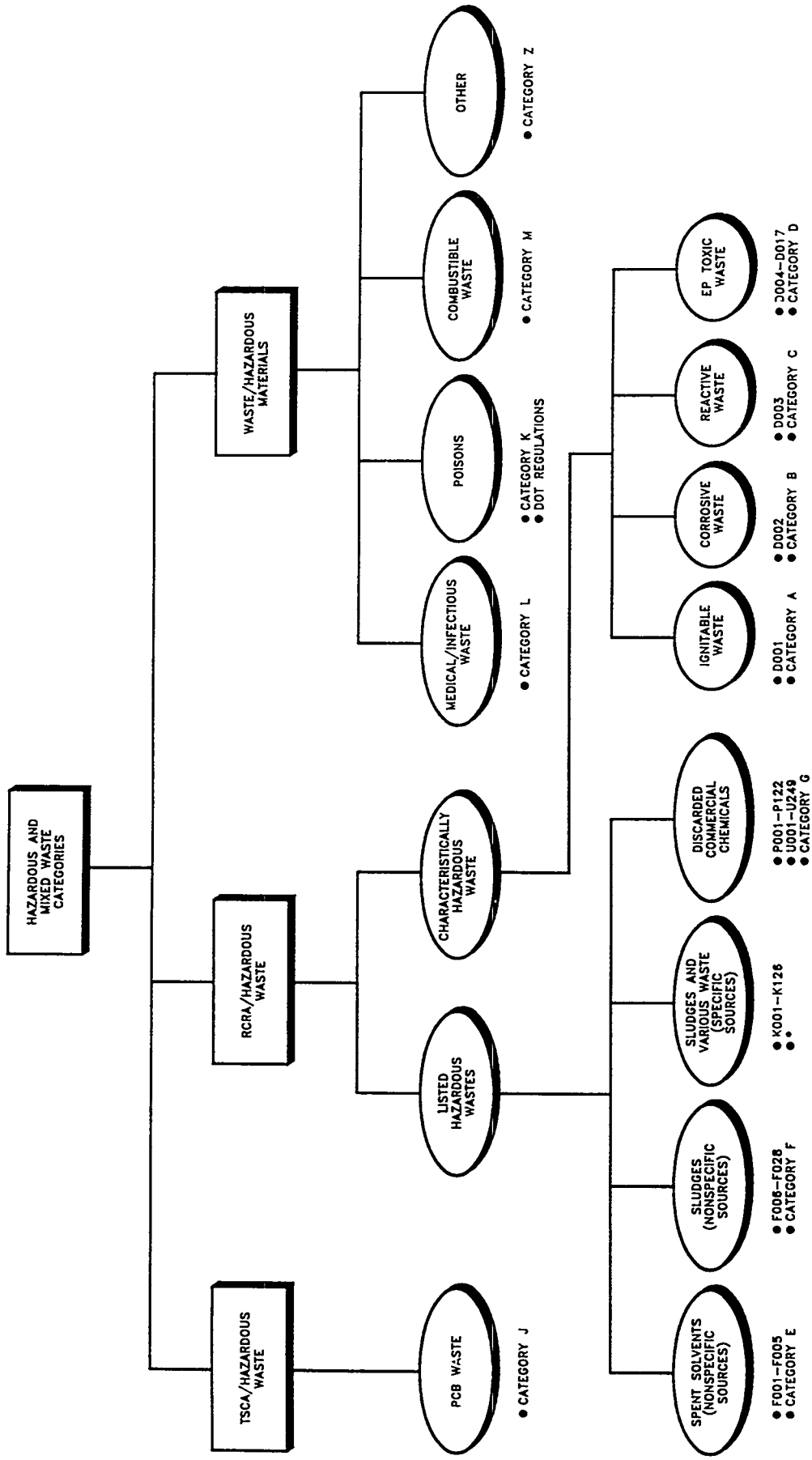

* NOT CATEGORIZED FOR HAZWDDD BECAUSE NONE OF THESE LISTED WASTES IS PRODUCED AT THE MMES SITES.

Fig. 5.1.1. Hazardous and mixed waste categories developed for the HAZWDDD Plan.

and disposal are identified and evaluated. Solid LLW, with the exception of some special case wastes, is currently placed in interim storage at ORGDP awaiting development of treatment/disposal facilities consistent with the LLWDDD strategy.

PCB waste is managed to ensure compliance with PCB regulations and to minimize the risk of CERCLA or civil liabilities. It is the policy to comply with the letter and spirit of the PCB regulations. In certain instances where the intent of the rule can clearly be met but where the letter of the rule may create substantial hardships, the EPA regional administrator may be petitioned for a waiver. Such petitions will be made through DOE.

At the present time, an Environmental Impact Statement (EIS) is being prepared that addresses the general waste management strategies and specific LLW disposal facilities on the ORR. DOE Order (5820.2A) for radioactive and mixed waste management was issued in September 1988. This new order is expected to have a significant impact on future radioactive and mixed waste management operations. ORGDP's implementation plan was submitted to DOE in April 1989, and the waste management plan was submitted in January 1990. These identify and implement the actions, schedules, and costs necessary to achieve full compliance.

5.1.4.1 Y-12 Plant

Current strategy for solid waste management consists of waste reduction, storage, treatment, delisting, and disposal. Each concept is an integral portion of the overall waste management strategy. Mixed waste storage is necessary to ensure compliance with environmental regulations while treatment and disposal techniques are identified and implemented and during the delisting process. Also, the proper identification, characterization, and classification of waste materials are essential to ensure that waste management activities are performed safely, efficiently, and in compliance with regulations and policies.

Solid wastes are categorized at the Y-12 Plant as follows: industrial and sanitary wastes, security classified wastes, low-level radioactive wastes, RCRA hazardous wastes, and mixed wastes. RCRA hazardous wastes are candidates for commercial recovery or disposal programs; mixed wastes, which contain both RCRA hazardous and radioactive components, are not candidates for commercial recycle or disposal.

Ideally, after strategy implementation, most solid wastes that are generated will be conventional sanitary/industrial wastes. When this is not possible, prudent management will minimize the amount of other wastes present. Six major waste-minimization options are available at the Y-12 Plant: segregation, material substitution, process innovation, mechanical volume reduction, recycle and/or reuse, and treatment. These options are not mutually exclusive and may be combined to suit the specific needs.

To properly characterize wastes and determine the appropriate storage or disposal modes, a comprehensive system of administrative controls, inspections, sampling, analysis, and monitoring is used. Sampling and analytical programs are in place for hazardous, nonhazardous, and mixed waste streams. In addition to characterization by sampling, low-level waste certification for bulk wastes is accomplished using external radiation monitors.

Also, to improve characterization of potentially low-level radioactive waste streams, the Y-12 Plant continues with procurement, installation, and testing of more effective waste certification equipment, including a crated waste assay monitor and waste curie monitors.

A variety of disposal options are available to manage the wastes generated at the Y-12 Plant. On-site treatment for disposal/storage includes oxidation of uranium machine turnings; batch physiochemical treatment of liquid wastes; biodenitrification of aqueous nitrate waste; and baling of solid, low-level radioactive wastes. On-site disposal capability includes shallow land burial for solid wastes and discharge through NPDES discharge points after treatment for aqueous wastes. Off-site disposal options include disposal of hazardous waste by commercial vendors. Long-term storage options include storage in warehouses, tanks, and vaults at the Y-12 Plant, as well as

storage of Y-12 Plant wastes in buildings at ORGDP. More detailed information on each of these options is presented in Sect. 5.3.2.

Several LLWDDD-related, Y-12 Plant-sponsored technology demonstrations have been completed, including supercompaction, shape alteration, and the laboratory characterization task of the Uranium Lysimeter Demonstration.

In addition, demonstrations that were well into the planning or implementation phases in 1988 included a BRC demonstration and the field task of the Uranium Lysimeter Demonstration. Other LLWDDD-related work included the characterization of an East Chestnut Ridge site for EIS review.

The HAZWDDD program has been established to identify valid treatment and disposal alternatives for hazardous and mixed wastes. Activities are currently planned through FY 1992. Technology demonstrations will be funded so that commercially available treatment processes can be tested on Y-12 wastes. Priority is being given to work on waste streams for which no disposal outlet has been identified. The program will include full-scale commercial treatment efforts pending the outcome of treatability studies. Soils contaminated with mercury and/or chlorinated organic compounds are wastes included in this program.

Demonstrations for removal of hazardous or radioactive constituents in soils are under way. Results of the demonstrations will be evaluated for further use in applying this technology to larger-scale treatment projects. A single demonstration has been completed to initiate an evaluation of incineration technology for LLW. Final results of the demonstration are due in early 1990.

A project is currently under way to evaluate the potential for delisting a sludge generated by wastewater treatment facilities at the Y-12 Plant. The preliminary sampling and analytical results were favorable and were sufficient to pursue a delisting petition. A contractor is assisting in preparing the necessary documentation for the submittal.

Two demonstrations have been scoped for pursuit in FY 1990. The demonstrations will evaluate hazardous and radioactive constituents in sludges from wastewater treatment facilities and from oils and solvents used at the Y-12 Plant.

5.1.4.2 Oak Ridge National Laboratory

Wastes are identified initially through their generating processes and can be grouped into the broad categories shown in Fig. 5.1.2. Although knowledge of the generating process helps in identifying the waste constituents, this depth of characterization is often not sufficient to allow for proper waste handling. Hence, more detailed waste characterization is often conducted before treatment or disposal. Wastes are analyzed using standard EPA and DOE-approved analytical methods. In addition, all wastes are checked for radioactive contamination.

It is ORNL policy to minimize all categories of wastes by reducing waste volume and/or toxicity, thereby reducing the need for waste treatment and disposal and their potential environmental consequences. This reduction can be achieved through process modification, segregation, minimization, or recycling.

One example of process modification that effectively reduces the amount of hazardous waste generated is a procedural change in the Analytical Chemistry Division. Many chemical analyses are now done on small-volume samples using small volumes of solvents for extractions, which reduces the total volume of waste solvent generated.

Waste segregation is used to minimize the generation of solid low-level radioactively contaminated wastes. By providing collection barrels for both radioactive and nonradioactive wastes, the volume of wastes that requires handling as radioactive waste has been reduced. Before these procedures were implemented, radioactive and nonradioactive wastes were discarded in the same barrel. This contaminated the nonradioactive portion and required special disposal of an inflated amount of waste.

ORNL's procurement policy is an example of minimization. In the past, researchers took advantage of the reduced cost of bulk purchasing; however, the excess purchased was often discarded as waste. By purchasing only the quantity of a chemical needed, less waste is produced.

Examples of recycling include making unneeded chemicals available to others rather than discarding them as wastes; using acceptable waste corrosives in a neutralization facility in place of

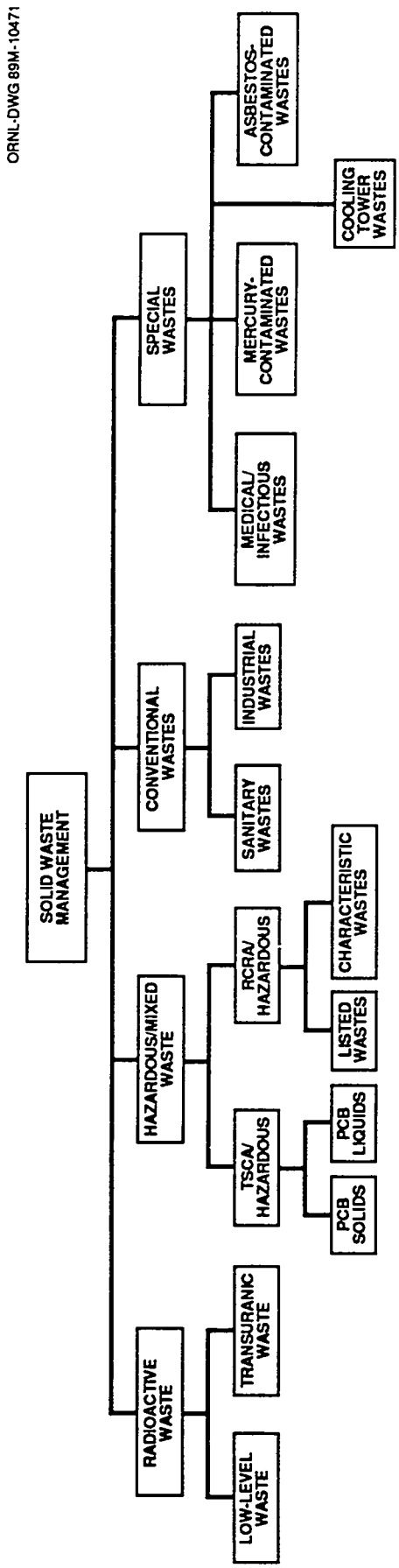

Fig. 5.1.2. Categories of solid waste sources and flow of mixed wastes.

new acids and bases; recovering used solvent through distillation so that it can be reused; and recovering silver from silver-bearing photographic wastes, thus rendering the waste nonhazardous.

Despite these efforts, some wastes will be produced. Minimizing the impact on public health and the environment is the goal of the waste management program. To achieve this goal, some wastes, such as sanitary wastes, are treated on-site while others, such as low-level solid wastes, are disposed of on-site in SWSAs. Off-site treatment is the best management option for many hazardous and PCB-contaminated wastes. Most hazardous laboratory and PCB-contaminated wastes are incinerated in permitted facilities. Although more expensive than land disposal, destruction by incineration is preferable for minimizing long-term liability. Transuranic waste and mixed waste are in long-term storage on-site until appropriate storage, treatment, or disposal options become available. Solid waste management strategies depend on the type of waste and are chosen because they are the most prudent approaches currently available.

5.1.4.3 Oak Ridge Gaseous Diffusion Plant

The solid waste management system includes all waste streams generated at ORGDP. Waste streams are evaluated using process knowledge and analytical waste characterization. Samples are collected and analyzed using EPA- and DOE-approved methods. Radioactive analyses are performed on an as-needed basis.

ORGDP policy mandates minimization of waste generated while achieving compliance with applicable environmental regulations. Five minimization options are used at ORGDP: segregation, material substitution, process innovation, mechanical reduction, and recycle/reuse.

ORGDP management supports the waste minimization program. An excellent example of the program at work involved a change in the procedure for procuring hazardous materials. In the past, hazardous materials were purchased in larger quantities to take advantage of the less expensive bulk rates. However, a hidden cost of this procurement method was the expense of disposal of the excess material. Current procedure for the purchase of hazardous materials requires the approval of the Plant Hazardous Materials Coordinator. This minimizes the purchase of excess hazardous materials and, thus, the need to dispose of excess quantities.

5.2 WASTE GENERATION

5.2.1 Types of Wastes Generated

5.2.1.1 Y-12 Plant

Following is a brief summary of the types of wastes generated at the Y-12 Plant.

Sanitary/industrial wastes. Industrial trash consisting of paper, wood, metal, glass, plastic, etc., coupled with large volumes of construction/demolition debris and small volumes of sanitary/food wastes from cafeteria operations. Also included in this category is fly ash from steam plant operations and other special wastes.

RCRA hazardous wastes. Solid wastes (including liquids) that are defined as hazardous by RCRA regulations as a consequence of being a listed waste or having a hazardous characteristic.

Mixed wastes. RCRA hazardous wastes that are also contaminated with low-levels of uranium.

PCB wastes. PCB oils or materials that have been contaminated with PCB.

PCB/uranium-contaminated wastes. PCB oils or materials that have been contaminated with PCB and also with low levels of uranium.

Low-level radioactive wastes. Solid wastes (including liquids) that are composed of isotopically depleted uranium metal or oxide or that contain low levels of uranium contamination.

Asbestos/beryllium oxide wastes. Solid wastes that have been contaminated with either asbestos or beryllium oxide, which classifies the waste as a special waste. The waste may also be contaminated with low levels of uranium.

Scrap metal. Derived primarily from demolition activities. The scrap may be either nonuranium contaminated or contaminated with low levels of uranium.

Classified wastes. Wastes that are classified because of their shape, composition, or both.

Medical wastes. Medical and infectious wastes consist of contaminated bandages, sharps, and cultures media.

Nonhazardous wastes. All other types of wastes (including liquids) that are nonhazardous or nonradioactive, or both.

Material access area (MAA) wastes. Wastes that are removed from MAAs include combustible and compactible materials (paper, wood, wipes, etc.) and noncombustible and noncompactible materials (dirt, concrete, block, rubble). The waste contains low concentrations of enriched uranium and has been monitored to verify that the uranium concentrations are below levels of concern for accountability, recoverability, and security control.

5.2.1.2 Oak Ridge National Laboratory

The general types of wastes generated at ORNL include radioactive, hazardous, mixed, and nonhazardous. Radioactive wastes include transuranic wastes and low-level solid and liquid wastes. Hazardous wastes include chemicals that are characteristically hazardous or listed by RCRA in 40 CFR 261.33. Asbestos, PCB-contaminated, and medical materials are "miscellaneous" regulated wastes managed at ORNL. Mixed wastes contain both radioactive and hazardous wastes. Asbestos and PCB-contaminated wastes can also be radioactively contaminated. The remaining wastes produced at ORNL are nonhazardous sanitary wastes, industrial wastes, and scrap metals.

5.2.1.3 Oak Ridge Gaseous Diffusion Plant

Seven broad categories of waste are generated at ORGDP. These include LLW, classified waste, hazardous waste, mixed waste, PCB waste, sanitary/industrial waste, and medical waste.

Low-level wastes. These include solids and liquids that contain radioactive materials. LLW are managed according to DOE Order 5820.2A and AEA.

Classified wastes. These include liquid and solid streams containing materials that, for security reasons, are restricted by DOE criteria. Classified wastes generated at ORGDP are managed in accordance with DOE Order 5632.1. These wastes could be contaminated with low levels of radioactivity.

Hazardous wastes. These are wastes that are regulated by the EPA RCRA. These wastes are managed in accordance with DOE Orders 5400.1 and 5400.3 and state and federal regulations.

Mixed wastes. These are wastes regulated as hazardous that are also radioactively contaminated.

PCB wastes. These are regulated by TSCA. These waste streams may or may not be radioactively contaminated. Radioactively contaminated waste cannot be disposed of through commercial disposal facilities. Any TSCA waste that is radioactively contaminated is placed in storage for future disposal at the K-1435 incinerator.

Sanitary wastes. This is regulated by TSWMA. This waste stream consists of paper, wood, construction debris, and fly ash. All sanitary waste is disposed of at the Y-12 Centralized Sanitary Landfill II.

Medical wastes. Medical and infectious wastes consist of contaminated bandages, sharps, and cultures media. These wastes are placed in biological disposal containers and autoclaved to destroy any biologically active organisms. The waste is then landfilled at the Y-12 Centralized Sanitary Landfill II.

5.2.2 Waste-Generating Activities

5.2.2.1 Y-12 Plant

Major waste-generating activities at the Y-12 Plant include construction/demolition activities that produce large volumes of contaminated and noncontaminated wastes, including lumber, concrete, metal objects, soil, and roofing materials. Wastes contaminated with hazardous materials are also generated by construction/demolition activities.

Machining operations use stock materials, including steel, stainless steel, aluminum, depleted uranium, and other metals to produce significant quantities of machine turnings and fines as a waste product.

The Y-12 Steam Plant produces steam by burning coal, which produces fly ash and bottom ash as a waste product.

During 1989, the Environmental Improvements–PCB Transformer Replacement line item project for the draining, removal, off-site disposal, and subsequent replacement of PCB-filled transformers was completed. (Replacement units are dry or filled with non-PCB fluid.) The units were located within and outside of plant buildings. Disposal of the drained carcasses and PCB fluid was provided by an off-site contractor as required under 40 CFR 761.

Industrial trash, both noncontaminated and uranium contaminated, is generated by daily operations throughout the plant. These operations include janitorial services, floor sweeping in production areas, and production activities.

In addition, plating waste solutions are generated by metal-plating operations around the plant, and reactive wastes and waste laboratory chemicals are generated from various laboratory activities.

Liquid process wastes are generated from multiple processes throughout the plant. Sludges are generated as a result of treating process wastes at multiple sites, and waste oils and solvents are generated from machining and cleaning operations.

Contaminated soil, soil solutions, and soil materials are generated from closure activities associated with RCRA closures (see Table 5.2.1 in Vol. 2).

These are only a few of the industrial-type activities at the Y-12 Plant that are generating waste streams at the site. A summary of waste generation for 1989 is given in Tables 5.2.1 and 5.2.2.

Table 5.2.1. Y-12 Plant waste generation summary for 1989

Waste	Quantity (kg)
Sanitary/industrial	6,308,000
Construction/demolition spoil	2,411,000
Fly ash	11,200,000
Asbestos/BeO	
Uncontaminated	200,100
Contaminated	9,000
Hazardous[a]	2,030,400
Mixed	5,140,700
PCB	46,600
PCB/uranium	1,090
Low-level contaminated waste[b]	2,670,000
Scrap Metal	
Uncontaminated	1,456,000
Contaminated	639,000
Classified	94,600
Nonhazardous liquids[c]	4,814,000

[a]This does not include Steam Plant regeneration waters.

[b]This category consists of industrial wastes.

[c]This category consists of waste oils, mop waters, and other nonhazardous liquids. Does not include the Steam Plant Wastewater Facility wastewater.

5.2.2.2 Oak Ridge National Laboratory

Because ORNL is a research facility, it has many diverse waste-generating activities, each of which may produce only a small quantity of waste. Isotope production, utilities, and support functions such as photography are additional sources of waste. A summary of waste generation for 1989 is given in Table 5.2.3.

Hazardous wastes are generated in laboratory research, electroplating operations, painting operations, descaling, demineralizer regeneration, and photographic processes.

Table 5.2.2. Y-12 Plant radioactive waste data for 1989[a]

Radionuclide	Activity (Ci)
^{235}U	0.33
^{238}U	25.6
^{232}Th	0
^{99}Tc	0
^{237}Np	0

[a]Does not include airborne emissions or effluent to waterways.

Table 5.2.3. 1989 ORNL waste generation summary

Waste	Volume (m^3)	Weight (kg)
Hazardous		69,000
Sanitary		
Radiological		3,400
Nonradiological	1,400	
Construction debris	930[a]	
Industrial		3,500
Mixed		3,100
PCB[b]		
Radiological		670
Nonradiological		29,000
Transuranic		
Contact handled	30	590
Remote handled	9	2,300
Low-level Wastewater		1,200,000
Asbestos		
Radiological	28	1,800
Nonradiological		7,700
Scrap metal		
Radiological		29,000
Nonradiological		1,000,000[c]
Miscellaneous nonhazardous		4,200
Miscellaneous radiological	0	0

[a]This construction debris is used at the Recontour Site around Building 1000. This volume was not reported in the Environmental Report for CY 1988.

[b]Martin Marietta Energy Systems policy defines any material with PCB contamination greater than 2.0 ppm as PCB waste.

[c]During the first 10 months of 1989, all scrap metal was transported to the Y-12 Plant scrap yard for auction; 905,142.86 kg were taken to the Y-12 scrap yard. In November a scrap metal contractor signed an agreement with ORNL to pick up accumulated scrap metal at ORNL on a monthly basis. The contractor, Southern Alloys and Metals, P.O. Box 688, Rockwood, TN 37854, picked up 114,793.65 kg of scrap metal during the last 2 months of the year.

Mixed wastes are generated by research projects and some facility operations. Facility renovation and demolition activities produce asbestos. Although the electrical system has been largely converted to a non-PCB system, PCB-contaminated wastes, including fluorescent light ballasts and capacitors, are still occasionally discarded. Additionally, Energy Systems policy requires that waste materials containing greater than 2 ppm PCBs be managed according to TSCA requirements.

Nonhazardous wastes result from ORNL maintenance and utilities. For example, the steam plant produces nonhazardous sludge. Scrap metals are discarded from maintenance and renovation activities and are recycled when appropriate. Construction and demolition projects also produce nonhazardous industrial wastes. All nonradioactive medical wastes are autoclaved to render them noninfectious and are sent to the Y-12 Plant Sanitary Landfill. Isotope production and research activities generate a variety of low-level radioactive and transuranic wastes, as shown in Table 5.2.4. Remedial action projects also produce wastes requiring proper management.

5.2.2.3 Oak Ridge Gaseous Diffusion Plant

Enrichment, maintenance, decontamination, and research and development (R&D) activities have generated a wide variety of waste at ORGDP. Until August 1985, the primary function of the site was the enrichment of uranium in the ^{235}U isotope. Uranium is the predominant radionuclide found in ORGDP waste streams.

Small quantities of ^{99}Tc, ^{237}Np, and ^{239}Pu have also been released in the waste streams because these radionuclides were present in UF_6 reactor return feed material that was shipped to ORGDP for enrichment.

Solid low-level wastes are generated by discarding radioactively contaminated construction debris, wood, paper, asbestos, trapping media, and process equipment and by removing radionuclides from liquid and airborne discharges.

Currently, low-level solid wastes are being stored at ORGDP for future disposal.

All contaminated scrap metal is stored aboveground at the K-770 scrap metal facility until further disposal methods are evaluated.

Sludges contaminated with low-level radioactivity are generated by settling and

Table 5.2.4. 1989 ORNL Radioactive waste data

Isotope	Curies
^{241}Am	1.3
^{243}Am	0.0085
^{39}Ar	0.0013
^{10}Be	0.0032
^{14}C	0.075
^{249}Cf	0.00021
^{252}Cf	0.063
^{243}Cm	0.000012
^{244}Cm	1.2
^{57}Co	0.011
^{58}Co	38
^{60}Co	2,200
^{51}Cr	0.015
^{134}Cs	86
^{137}Cs	370,000
^{64}Cu	20
^{152}Eu	490
^{154}Eu	310
^{155}Eu	10
^{55}Fe	0.052
^{59}Fe	1,300
^{153}Gd	1.7
^{68}Ge	0.061
3 H	620
^{125}I	0.072
^{131}I	1.1
^{192}Ir	28
^{40}K	0.0017
^{43}K	0.00083
^{85}Kr	0.024
MFP[a]	0.00033
^{54}Mn	33
^{22}Na	0.020
^{63}Ni	0.28
^{237}Np	0.074
^{191}Os	0.068
^{32}P	0.000002
^{210}Pb	0.017
^{103}Pd	2.4
^{147}Pm	0.51
^{195}Pt	0.0024
^{238}Pu	0.0081
^{239}Pu	41
^{240}Pu	4.8
^{241}Pu	0.055
^{226}Ra	0.0043
^{229}Ra	0.0032
^{106}Ru	0.00017
^{35}S	0.00094
^{119m}Sn	0.035
^{85}Sr	0.0030
^{90}Sr	1,000
^{179}Ta	0.10

Table 5.2.4 (continued)

Isotopes	Curies
^{182}Ta	12,000
^{99}Tc	0.41
^{228}Th	0.0013
^{229}Th	0.0077
^{232}Th	0.0011
^{204}Tl	0.050
^{232}U	0.011
^{233}U	4.2
^{234}U	0.00060
^{235}U	0.0028
^{236}U	0.000066
^{238}U	0.0086
^{188}W	0.0031
^{90}Y	0.044
^{95}Zr	0.000055
Total	390,000

[a]Mixed fission products.

scrubbing operations and have been stored in K-1407-B and K-1407-C ponds. The sludges have been removed, were fixed in concrete at K-1419, and stored aboveground at K-1417. These materials are considered mixed waste, and efforts are under way to have them delisted.

The primary generator of radioactively contaminated liquid waste is the uranium decontamination and recovery facility. This waste stream is currently being treated at the K-1407-H CNF.

Radioactive waste streams generated at ORGDP are managed according to applicable state and federal regulations and DOE orders. Several waste management facilities are already in place. Changing laws and regulations have made it necessary to upgrade several facilities and to design and construct new facilities that reflect the most recent environmental technology.

5.3 WASTE MANAGEMENT ACTIVITIES

5.3.1 Waste Management System

5.3.1.1 Y-12 Plant

Form UCN-2109, Request for Disposal of Hazardous Chemicals, Gases and Radioactive

Materials, is the primary method of documentation and waste tracking for wastes at the Y-12 Plant. Before the waste is moved, it must be adequately characterized. This is documented on the form. Additional forms are used to document special waste streams such as classified wastes, asbestos/beryllium oxide, and spoil materials.

All off-site shipments of wastes conform to U.S. Department of Transportation (DOT) criteria for such shipments. The criteria include packaging, manifesting, and shipping requirements.

Information concerning waste generation, storage, transportation, and disposal activities is maintained on computerized data bases. Data from Form UCN-2109 and other documentation are compiled to ensure compliance with all applicable state and federal regulations and to promote efficient waste management operations.

5.3.1.2 Oak Ridge National Laboratory

Form UCN-13698, Request for Disposal of Hazardous Waste Material, is filled out by the generator prior to pickup of hazardous waste. A Health Physics staff member surveys the waste for radioactivity. Waste generation is reduced by recycling and segregation whenever feasible. The Hazardous Waste Operation Group (HWOG) checks form UCN-13698 for accuracy, assigns a hazard class and the EPA hazardous waste number, and transports the waste to a hazardous waste management facility. HWOG maintains an inventory logbook for each storage facility.

The information on form UCN-13698 is entered into a computer data base to facilitate waste tracking and the generation of waste management reports. Hard copies of the form are kept on permanent file.

5.3.1.3 Oak Ridge Gaseous Diffusion Plant

Form UCN-12463, Request for Disposal/Storage of Waste Materials and Equipment, is the primary method of documentation and waste tracking for waste materials generated at ORGDP. Before the waste can be moved, it must be adequately characterized through chemical analyses or process knowledge. This information becomes part of the disposal package and is constantly maintained during the waste tracking procedures. All waste materials, including classified, LLW, hazardous, nonhazardous, and mixed, are tracked using form UCN-12463.

All incoming and off-site waste shipments conform to DOT criteria. These criteria include packing, manifesting, and shipping requirements.

Information concerning waste generation, storage, transportation, and disposal activities is maintained on a computer data base. Data from form UCN-12463 and the waste characterization information are compiled to ensure compliance with the applicable state and federal regulations and to promote efficient waste management operations.

5.3.2 Waste Management Facilities

5.3.2.1 Y-12 Plant

Nonhazardous

The Y-12 Centralized Sanitary Landfill II is a TDHE-permitted facility that became operational in 1983. It serves ORGDP, ORNL, the Y-12 Plant, and other DOE prime contractors and their subcontractors in the Oak Ridge area. Combustibles, decomposable materials, and other industrial wastes are permitted, as are certain special wastes such as asbestos, beryllium oxide, aerosol cans, fly ash, and others. These materials are disposed of in large trenches, and a clay cover is applied daily. This facility is operated as described in Report Y-EN 618, Design and Operating Procedures for the Y-12 Centralized Sanitary Landfill II.

The Y-12 Spoil Area I is a shallow land burial facility for the disposal of noncontaminated rubble and construction spoil, including asphalt, brick, block, brush, concrete, dirt, rock, tile, and other similar materials. This TDHE-permitted facility is operated in accordance with Report Y/IA-167, Design and Operating Procedures for the Y-12 Spoil Area I.

The Chestnut Ridge Borrow Area Waste Pile serves as a storage/disposal area for soils with low concentrations of mercury and is operated in accordance with Report Y/TS-62, Design and Operating Procedures for the Chestnut Ridge

Borrow Area Waste Pile. The facility is covered with a synthetic liner and has run-on and runoff protection.

The current plans are to seek closure of this site under TDHE Solid Waste Management rules for special wastes. Preparation of plans, specifications, and drawings is planned for 1990.

Lake Reality is a lined containment basin with a surface area of approximately 2 acres. The pond serves to enhance the water quality of EFPC downstream of the Y-12 Plant.

Industrial Landfill IV is a TDHE-permitted landfill for disposal of nonhazardous, nonradioactive wastes from the Y-12 Plant.

The Garage Oil Storage Tank is a 37,854-L (10,000-gal) UST that contains used, clean oil for sale to the public.

The salvage yard is used for the staging and public sale of nonradioactive, nonhazardous scrap metal.

Oil Storage OD6 is a 113,562-L (30,000-gal) tank that is used to collect clean oils before sale to the public.

Rogers Quarry is used for the disposal of fly ash from the steam plant.

The UNC Landfill is a surface storage area for nitrate-contaminated sludges and soils. Plans for closure of this facility have been approved. The closure activities are described in the Report Y/IA-200, *Closure Plan for the United Nuclear Corporation Waste Disposal Site.*

The Sludge Handling Facility (T-118) was designed and constructed to provide water filtration and sludge dewatering in support of a storm sewer cleaning and relining project. Filtered water was reused by the sewer cleaning contractor, and the dewatered sludge was stored in specially constructed containers for future disposal. The facility began receiving material during the winter of 1986 and was removed from operation at the end of the project during the fall of 1987.

The Plating Rinsewater Treatment Facility (PRTF) (T-036) provides neutralization, electrochemical reduction, chemical precipitation, carbon adsorption, and filtration to plating rinse waters from plating operations.

The Steam Plant Wastewater Treatment Facility (SPWTF) provides flow equalization, pH adjustment, chemical precipitation, clarification, and sludge dewatering to coal pile runoff, ion-exchange regeneration wastewater, boiler blowdown, and demineralizer waste.

RCRA hazardous/mixed

The East Chestnut Ridge Waste Pile is a lined, leachate collected waste pile used for the storage of contaminated soils and spoil materials.

Kerr Hollow Quarry was used for the disposal of water-reactive and shock-sensitive chemicals. The facility is currently being closed.

The RCRA Staging and Storage Facility is a compartmentalized warehouse used for the staging of RCRA wastes before off-site shipment.

The Salvage Yard Oil/Solvent Drum Storage Area (OD2) was a diked storage area where drums of oils and solvents were staged pending disposal.

Security pits are deep trenches used for disposal of classified wastes. Hazardous materials were disposed in this facility prior to 1984.

Building 9720-9 is a warehouse used for storage of nonflammable and flammable hazardous waste.

The Interim Storage Yard is a gravel storage yard used to store drums of hazardous waste pending final disposition. Half of the yard has been closed in accordance with a TDHE-approved closure plan.

The Biodenitrification Facility used biodenitrification reactors and recovery/feed tanks to biologically decompose uranium-contaminated nitrate wastes.

The Cyanide Treatment Facility is a batch facility for the destruction of cyanide in wastes. The destruction occurs in drums under an exhaust hood.

The Waste Coolant Processing Facility (WCPF) is a biodegradation and storage facility for waste coolants.

The West End Treatment Facility (WETF) uses pH control, metal precipitation, effluent polishing, sludge dewatering, and biodenitrification/biooxidation to treat uranium-contaminated nitrate wastes.

The Central Pollution Control Facility (CPCF) is a batch treatment facility that uses process reactors, settlers, filters, a mop water

treatment system, chrome reduction unit, hydrated lime system, sludge dewatering, and effluent polishing to treat nonnitrate wastes.

Building 9212 Tank Farm consists of tankage used to store acid and caustic wastes.

The Waste Oil/Solvent Storage Facility is a tank facility that provides 200,000 gal of bulk storage for uranium-contaminated oils and solvents and PCB-contaminated materials, as well as nonuranium contaminated materials.

The Liquid Organic Waste Storage Facility is a bulk and drum storage facility that provides 113,562 L (30,000 gal) of bulk storage and storage for about 300 drums of solvents.

PCBs and PCB/uranium

Oil Drum Storage Area OD3 has two 22,712-L (6000-gal) tanks, which were used to store PCB-contaminated oils. These tanks are part of a larger area that also contained drums. All of the site has been closed with the exception of the tanks.

The Garage Oil Storage Tanks are 37,854- and 75,708-L (10,000- and 20,000-gal) underground tanks that formerly contained PCB-contaminated oil. The tanks have been drained and removed from the ground as part of the closure plan initiated in 1989. Closure is continuing into 1990.

Building 9404-7 is a warehouse used to store drums of PCB- and PCB/uranium-contaminated wastes.

Building 9720-9 is a warehouse used to store PCB-contaminated waste pending off-site shipment.

The Environmental Improvements project funded the construction of a PCB Staging/Storage Facility to temporarily store drained carcasses and PCB fluid prior to off-site shipment for disposal. This facility consists of a diked concrete pad and pre-engineered roof structure. The facility was designed for compliance with PCB storage requirements as addressed in 40 CFR 761.

Low-level radioactive

Bear Creek Burial Ground, a shallow land burial facility, has been used primarily for the disposal of low-level uranium-contaminated waste, although it has received RCRA and TSCA wastes. During 1989, only low-level uranium-contaminated material (including asbestos and beryllium oxide), depleted uranium machine turnings, fines, laboratory samples, and miscellaneous uranium metal and alloys were disposed of in the burial ground. The facility is operated in accordance with Report Y/IA-169, *Design and Operating Plan for the Extension of Y-12 Plant Burial Ground A for the Disposal of Low-Level Radioactive Solid Waste.*

Closure activities began in November 1988 on many of the areas used for disposal of RCRA and TSCA wastes; these activities continued through 1989. In addition, a Best Management Plan, Y/IA-210 *Best Management Practices Plan for Waste Management Activities in the Bear Creek Burial Grounds*, has been prepared, and identified activities are being implemented. The objective of these actions is to eliminate disposals in BCBG. Some of these actions were initiated in 1987 and include volume reduction of some solid wastes and subsequent shipment to ORGDP for storage.

The Uranium Oxide Vaults (S-114) are two concrete vaults used for the storage of uranium oxide and metals.

The Waste Feed Preparation Facility is a compaction/baling facility that compacts solid, uranium-contaminated wastes into bales for interim storage at ORGDP.

The Trash Monitoring Facility is an external radiation monitoring facility that is used to select the proper disposal facility for bulk solid wastes.

5.3.2.2 Oak Ridge National Laboratory

RCRA-regulated and PCB wastes are managed in storage facilities until they can be shipped off site for treatment and/or disposal. Martin Marietta Energy Systems policy defines any material containing greater than 2 ppm PCB as PCB waste. Several facilities operate under interim status while permit applications are under review by TDHE. The Hazardous Waste Storage Facility, Building 7652 permit application was approved by TDHE in October 1986. PCB-contaminated hazardous wastes are temporarily

stored at Building 7507, and PCB-contaminated mixed waste is stored on the 7507W Storage Pad. TRU waste is stored in the TRU Retrievable Storage Facilities, 7855, 7834, and 7823.

Few hazardous wastes are treated and none are disposed of in on-site facilities. The Chemical Detonation Facility processes small amounts of wastes that would be dangerous to transport off-site. Explosives such as aged picric acid are detonated in the detonation facility.

Several recycle/reuse units are or have been in operation. The Elementary Neutralization Unit functions as part of the Process Wastewater Treatment Plant and uses approved chemicals (corrosives) that would otherwise be discarded. Photographic wastes that are hazardous only because they contain silver have previously been recycled for silver recovery in Building 7934 and are currently shipped to Silver Services in Gallatin, Tennessee, for recovery. The silver cake was then sold for its silver content. The silver recovery process was not operated during 1989 pending an NPDES permit. During this period, photographic wastes were shipped off site for silver recovery.

The landfill receives nonhazardous industrial materials such as fly ash and construction debris. SWSA 6 receives low-level solid radioactive waste, including radioactively contaminated asbestos. Asbestos and general refuse are managed in the Y-12 Plant Sanitary Landfill.

RCRA designates satellite accumulation areas as those at the site of small-quantity waste generation where wastes are accumulated by the generator to a sufficient quantity to be transferred to a permitted storage facility. Satellite accumulation areas may not receive wastes from other sources. Satellite accumulation areas are used throughout ORNL for hazardous and radioactive waste accumulation. Once a drum is filled, it is transferred to the appropriate storage or disposal facility within 3 days.

5.3.2.3 Oak Ridge Gaseous Diffusion Plant

The K-770 scrap metal storage facility consists of a 2.8-ha (6.9-acre) tract of land used for storing low-level radioactively contaminated scrap metal. Ferrous and nonferrous materials are generated at ORGDP and transported by truck to the storage yard.

The K-726 PCB storage facility is located inside the K-770 scrap yard. This facility consists of a diked concrete block building with approximately 225-m^2 (2430-ft^2) storage space and is used primarily for the storage of low-level uranium-contaminated PCB waste that also contains combustible liquids. These wastes will be disposed of at the K-1435 incinerator.

The K-306-1 PCB storage facility is a 288-m^2 (3110-ft^2) area used for radioactively contaminated PCB waste. These wastes also will be disposed of at the K-1435 incinerator. When the PCB waste is removed, this facility will be used for storage of RCRA waste sludges generated at the Y-12 Plant.

The K-311-1 container storage area provides storage for approximately 51 tons of lead wastes generated during previous Y-12 Plant operations. This facility is a 225-m^2 (2400-ft^2) enclosed building. Stored wastes include lead ingots, lead slag, and lead carbonate contaminated with low-level radioactive contaminants.

The K-1419 sludge fixation facility is used for mixing hazardous and mixed inorganic wastes with concrete to form a solid mixture that can be stored aboveground at K-1417. The facility consists of a storage tank area for wastes and a series of storage tanks for nonhazardous feed materials, feed tanks, and mixers. The waste sludges and liquids are mixed with cement and fly ash according to the fixation recipe to stabilize them. The fixation recipes are specific for each waste type.

The K-1417 casting and storage yard, which has a storage area of 1.2 ha (3 acres), is used for storage of drummed solidified sludges generated at the K-1419 facility. Casting activities can be performed either at K-1419 or in the casting area of K-1417. A truck and equipment washing system collects runoff and spillage from the casting area.

The K-306-1 vault 23A hazardous waste storage facility provides storage capacity for about 3000 208-L (55-gal) drums and is used primarily for storing sludges generated during treatment of Y-12 Plant wastewaters at either K-1232 or Y-12 Plant facilities. The drums are sealed, labeled, identified, and inventoried either before or immediately following transport to K-306-1, vault 23A.

The K-301-1 vault 4 hazardous waste storage facility has a storage capacity for 15,200 208-L (55-gal) drums and is used primarily for storage of sludges generated during the treatment of Y-12

Plant wastewaters at either K-1232 or Y-12 Plant facilities. K-301-1 is also permitted for storage of BMP acidic, basic, or organic solutions until they can be treated. The drums being stored are sealed, labeled, identified, and inventoried either before or immediately following transport to the facility.

The K-305-6 vaults 19 and 19B hazardous waste storage facility offers a storage capacity for 8050 208-L (55-gal) drums. This facility is also used primarily for the storage of sludges generated during the treatment of Y-12 Plant wastewaters at either K-1232 or Y-12 Plant facilities. The containers are sealed, labeled, identified, and inventoried either before or immediately following transport to K-305-6.

The K-1420-A flammable waste storage tank is a 113,562-L (30,000-gal) tank that was modified to store low-flash-point and high-vapor-pressure wastes. The waste types stored in this facility include flammable solvents, gasoline, and paint waste. Only drummed waste that has been identified can be stored at this facility. The waste will be disposed of at the K-1435 incinerator.

The K-1425 waste oil/hazardous waste/PCB storage facility consists of container and tank storage areas. The container storage building capacity is 480 208-L (55-gal) drums, and the tank storage area consists of four 85,275-L (22,500-gal) tanks in a dike. Wastes stored in this facility include oils, solvents, water, and organics. These are RCRA wastes, wastes that contain PCBs, or wastes that are radioactively contaminated and will be disposed of at the K-1435 incinerator.

The K-1435 TSCA Incinerator consists of storage tanks, dikes, and the incinerator. The maximum storage capacity for waste is 1040 208-L (55-gal) drums. The tank storage capacity is 3.48×10^5 L (0.9×10^5 gal). The incinerator system consists of a liquid, solid, and sludge feed system; a rotary kiln incinerator; and a secondary combustion chamber.

The wastes disposed of at this facility include oils, solvents, chemicals, sludges, aqueous waste, and solids. The waste cannot be disposed of by a commercial incinerator because of radioactive contamination. All waste sent to K-1435 for incineration must be fully characterized and identified. DOE has approved a chain-of-custody system for all waste received from off-site.

During 1988, the performance test of the K-1435 TSCA Incinerator was completed and shakedown testing was begun. These tests continued through 1989.

The K-1302 gas cylinder storage facility has been designated for storage of compressed gas cylinders. These gases are commercial products that are to be discarded or treated. The facility has a maximum storage capacity of about 100 ft^3 (2.8 m^3) of gas.

The K-1036-A storage dike is used for waste oil storage. These oils are not regulated by RCRA; however, radioactive contamination is present. This facility has a maximum waste storage capacity of about 5000 208-L (55-gal) drums. This waste will be disposed of at the K-1435 incinerator.

The K-303-5 low-level storage vault is used for storage of nonhazardous radioactively contaminated waste generated at ORGDP. The K-310-3 low-level storage vault is used for storage of nonhazardous radioactively contaminated waste generated at the Y-12 Plant. The K-310-2 low-level storage vault is used for storage of nonhazardous radioactively contaminated waste generated at ORNL.

The K-711 storage facility has a maximum storage capacity of about 1800 208-L (55-gal) drums. This waste, which will be disposed of at the K-1435 incinerator, consists of waste oils and solvents generated at the DOE facility at Fernald, Ohio, and other DOE facilities.

The K-1202 storage tank facility is used for storage of flammable or nonflammable RCRA regulated liquids that are radioactively contaminated.

The K-1025-C storage facility is used to store out-of-date or off-specification laboratory chemicals that will be disposed of through off-site commercial facilities.

K-310-1 vault in the K-25 building is used to store RCRA regulated sludges and ash from the operation of the K-1035 incinerator.

K-302-4 vault has been constructed for storage of future RCRA and mixed wastes.

5.3.3 On-Site Treatment

5.3.3.1 Y-12 Plant

Biodegradation of waste coolants is performed at the WCPF. Compaction/baling of solid, low-level, uranium-contaminated wastes is conducted at the Waste Feed Preparation Facility, and compaction of used drums was carried out at the Salvage Yard Drum Crusher.

Dewatering is available for storm sewer sediments at the Sludge-Handling Facility, for nonnitrate waste sludges at the CPCF, and for nitrate waste sludges at the WETF.

Until November 1988, treatment/disposal of water-reactive and shock-sensitive waste was performed at Kerr Hollow Quarry.

Biodenitrification of nitrate wastes is performed at the WETF and the Biodenitrification Facility. Additional treatment for nitrate wastes, including pH control, heavy metal precipitation, and effluent polishing, is performed at the WETF. Batch treatment for nonnitrate wastes, including filtration, settling, metal precipitation, chemical addition, dewatering, and effluent polishing, is performed at the CPCF.

Cyanide destruction by batch reaction under a hood is performed at the Cyanide Treatment Facility.

Oxidation of uranium machine turnings is performed at the Chip Oxidation Facility.

The on-site waste treatment quantities are shown in Table 5.3.1 of Vol. 2.

5.3.3.2 Oak Ridge National Laboratory

On-site treatment includes elementary neutralization and detonation facilities and mercury and silver recycle units. Quantities and types of wastes processed during 1989 are presented in Table 5.3.2 of Vol. 2.

5.3.3.3 Oak Ridge Gaseous Diffusion Plant

On-site treatment facilities at ORGDP include K-1407-N Central Neutralization Facility (CNF), K-1419 sludge fixation, K-1232 treatment, and K-900 bottle smasher. See Sect. 5.3.2.3 for descriptions of these treatment units. Quantities and types of waste treated at these facilities are shown in Table 5.3.1.

Treatment of the current inventory of contaminated scrap metal at ORGDP (as well as Portsmouth, Paducah, and Fernald DOE facilities) is expected to occur over the next 3 to 5 years as part of a comprehensive DOE Scrap Metal Program, to be managed through ORGDP. Under this program, the scrap metal will be processed for beneficial reuse where possible or size-reduced for disposal.

5.3.4 On-site Waste Disposal Activities

5.3.4.1 Y-12 Plant

On-site waste disposal quantities for the Y-12 Plant in 1989 are shown in Table 5.3.3 of Vol. 2.

5.3.4.2 Oak Ridge National Laboratory

The only on-site disposal units are the contractor's landfill and SWSA 6. Waste disposal in these units for 1989 is summarized in Table 5.3.4 of Vol. 2.

5.3.4.3 Oak Ridge Gaseous Diffusion Plant

The only on-site disposal unit in operation during 1988 was the K-1070-C burial ground for

Table 5.3.1. ORGDP on-site waste treatment data for 1989

Type	Quantity (gal)	Treatment	Residue type	Quantity (gal)
Nonhazardous	4.2×10^6	Neutralization	None	
Hazardous	2.0×10^7	Neutralization Metal precipitation	Hazardous sludge	340

classified, nonhazardous waste. This unit was closed in July 1989. The disposal of this waste is summarized in Table 5.3.5 of Vol. 2. Currently, there are no on-site disposal facilities being operated at ORGDP.

A new organization has been established at ORGDP to design, construct, and operate all new low-level waste disposal facilities for ORR. These new facilities will be developed in concert with the LLWDDD strategy and will serve waste generators from all three DOE facilities on the ORR. The Low-Level Waste Disposal Facilities (LLWDF) project will provide new disposal facilities at a new centralized location of the ORR for BRC, Class L-I, and Class L-II low-level wastes, with capacity up to 40 years to be available. The LLWDF will utilize state-of-the-art disposal technologies, including lined trenches with leachate collection treatment capabilities for BRC/Class L-I wastes and tumulus confinement disposal units for Class L-II wastes. As currently scheduled, these facilities are expected to be operational in 1996.

5.3.5 Off-site Waste Disposal

5.3.5.1 Y-12 Plant

Incineration is the preferred method for off-site disposal of wastes, particularly PCB wastes; however, landfills and other types of disposal are used as needed. For instance, PCB-contaminated transformer carcasses cannot be incinerated and must be sent to a landfill. All commercial sites are inspected by Energy Systems personnel before use. These inspections are used to examine processes and review management, permit, and insurance information. Inspections are repeated regularly.

Off-site disposal, as listed in Table 5.3.6 of Vol. 2, is arranged through the Y-12 Plant Transportation and Purchasing departments. Unless special circumstances warrant otherwise, all such disposals are awarded to the lowest qualified bidder. Commercial transporters or transportation provided by the disposal firm is used to move the waste from the Y-12 Plant site. All containers must meet DOT shipping requirements. Packages and vehicles are inspected and inventoried before shipment.

5.3.5.2 Oak Ridge National Laboratory

Consistent with DOE's policy to conduct operations in a safe and environmentally sound manner is the concern for minimizing long-term liability. To achieve this goal, ORNL uses the incineration method where possible, rather than disposal methods that allow potential future release to the environment. Nevertheless, some wastes cannot be destroyed through treatment and require land disposal.

Contracting only with approved commercial disposal contractors ensures safe and environmentally sound operations. Contractor approval is based on a site visit and evaluation that includes scrutiny of areas such as financial responsibility, operating procedures, regulatory compliance history, recordkeeping and reporting, training and qualifications, and security and emergency procedures. Each commercial contractor must be evaluated every two years.

Most of the wastes shipped off-site are discarded commercial chemicals from research activities. Oils contaminated with PCB or hazardous wastes are also shipped off-site for incineration. Table 5.3.7 of Vol. 2 lists the wastes shipped off-site and the disposal options used. In addition, several shipments of scintillation vials have been sent off-site for incineration. The vials are used in scintillation counters and contain the radioactive isotope in a mixture of xylene and toluene. With the exception of these scintillation vials, mixed wastes are stored rather than sent off-site for treatment. These scintillation vials were below the Nuclear Regulatory Commission's (NRC's) exclusion limit and are not considered radioactive.

5.3.5.3 Oak Ridge Gaseous Diffusion Plant

The K-770 clean scrap yard provides storage for nonradioactive scrap metal. ORGDP, ORNL, and ORAU use this facility. The scrap metal is stockpiled at K-770 before being sold to the public.

The K-1025-C storage building has a capacity of 80 208-L (55-gal) drums. This facility is used for commercially discarded products and chemicals.

Wastes stored at K-1025-C are not radioactively contaminated. The wastes are collected at this facility for packaging and disposal at an off-site disposal facility approved by DOE and the Energy Systems Office of Environmental and Safety Activities. The off-site facility must have been inspected within the past year. Quantities and types of wastes disposed of off-site during 1989 are shown in Table 5.3.8 in Vol. 2.

5.3.6 Waste Placed in Storage

5.3.6.1 Y-12 Plant

In some cases, wastes cannot be disposed of, either immediately or in the foreseeable future. Storage requirements at the Y-12 Plant fall into two categories, short-term storage for those wastes awaiting off-site shipment or treatment, and long-term storage for wastes, such as mixed wastes, that are being stored pending future disposal decision. Information on these wastes is given in Tables 5.3.9 and 5.3.10 of Vol. 2.

5.3.6.2 Oak Ridge National Laboratory

Wastes are stored on-site for several reasons. Recyclable materials such as mercury and silver-bearing photographic wastes are stored before recycling, while other hazardous wastes are stored until sufficient quantity is accumulated for an off-site shipment. Mixed wastes are stored until incinerator capacity is available locally to destroy them. Transuranic wastes placed in storage during 1989 are indicated in Table 5.3.11 of Vol. 2. Wastes remaining in storage at the end of 1989 are shown in Table 5.3.12 of Vol. 2.

5.3.6.3 Oak Ridge Gaseous Diffusion Plant

Several storage facilities exist at ORGDP, some of which are described in Sect. 5.3.2.3. Both long- and short-term requirements exist. Tables 5.3.13–5.3.15 in Vol. 2 indicate the types and quantities of waste stored at ORGDP. Many of these wastes will be burned in the K-1435 TSCA incinerator, now scheduled to begin operation in 1990.

6. SPECIAL STUDIES

6. SPECIAL STUDIES

Many environmentally related special studies are conducted on the ORR annually. This chapter includes those studies that are not directly associated with the annual environmental monitoring activities but may be of special interest to some readers. The studies were submitted for publication by the plant most directly involved with each study.

6.1 Y-12 PLANT

6.1.1 Investigation of Pentachlorophenol-Treated Wood at the Y-12 Plant

At the request of DOE/ORO (Spence 1989), a survey was conducted in June 1989 at the Oak Ridge Y-12 Plant to characterize the potential presence of dioxins resulting from the treatment of wooden cooling towers with a wood preservative containing pentachlorophenol (PCP). It also addressed how the preservative was used. These concerns arose from the discovery of dioxin contamination caused by treating wooden cooling towers with a PCP-containing wood preservative at the Paducah Gaseous Diffusion Plant.

Based on the history of the process, which shows the low concentration usage of a PCP-containing chemical in cooling towers at the Y-12 Plant, the potential for contamination by dioxins is extremely small. The results of the analyses agree with this assumption. However, the EPA's goal is to eliminate the presence of dioxins in discharges to public waters, and a discharge criterion of 0.013 parts per quadrillion has been set (Spence 1989). This criterion is obviously much lower than the detection limits used in the screening analyses and is not attainable with current analytical technology (Root 1988).

6.1.2 Alternate Concentration Limits Demonstration

The Alternate Concentration Limits Demonstration project was initiated to develop cleanup levels for groundwater at the S-3 Ponds Waste Management Area (WMA) in accordance with the TDHE regulations. Contaminant transport models were developed for four constituents detected in groundwater at the S-3 WMA located west of the DOE Y-12 Plant, Oak Ridge, Tennessee (Geraghty & Miller, Inc. 1989c). The S-3 WMA encompasses the former location of the S-3 Site Hazardous Waste Disposal Unit, a RCRA-regulated unit consisting of four unlined surface impoundments that received liquid waste from 1951 to 1984; it includes four nearby SWMUs: the Salvage Yard, the Interim Drum Storage Yard, the Rust Garage, and the S-2 Site.

Models were calibrated for nitrate, uranium, cadmium, and tetrachloroethene by estimating aquifer properties, source strength, and chemical transport parameters that provided the best match to the distribution of constituents measured in monitor wells screened at various depths throughout the site. The models were used to compute the three-dimensional concentration distribution for each constituent within the aquifer; produce plume maps for horizontal slices of the aquifer at the depths of the five model layers; and compute a mass balance for the modeled system, including an estimate of total contaminant mass discharged from the aquifer to two streams that flow away from the site. In addition to the development of the contaminant transport models, a site-specific risk evaluation was conducted for conditions at the S-3 WMA, Bear Creek, and East Fork Poplar Creek. The Alternate Concentration

Limit Demonstration and supporting documents were submitted to DOE and further transmitted to TDHE and EPA for review and comment.

6.1.3 Identification and Characterization of Storm Drain Outfalls and Processes That Discharge to Surface Waters

A number of outfalls on East Fork Poplar Creek (EFPC) are not specifically listed on the existing Y-12 Plant NPDES Permit and, therefore, are not routinely sampled. These outfalls were included in a list of Category III type outfalls (discharges from buildings and areas with possible process effluents) in a 1983 storm drain system characterization report submitted to the state and EPA as part of the 1985 NPDES permit application. All known sources of Category III type discharges have since been eliminated in the plant. An outfall sampling plan was initiated in June 1989 to recharacterize the discharges from these outfalls. The results from this sampling effort have been incorporated into the recent submittal of the new NPDES permit application. The results obtained indicate that the effluents from these outfalls are similar to a Category II type discharge (cooling water, condensate, precipitation, and building, roof, and foundation drains). A routine sampling program has been initiated for these outfalls, and results will be reported as an attachment to the monthly DMR.

Also, a number of discharges originate from testing and/or processing equipment used in the Y-12 Plant. As part of the recent effort to characterize more completely the miscellaneous source category of the existing NPDES permit, various sources of effluent discharges were identified and included in the NPDES permit application submittal. These sources include ultrasonic test gages and density testing baths used for nondestructive testing of metal parts, photographic units used for processing film, and vapor blasters used to clean metal parts.

Additional efforts are under way to identify any other miscellaneous outfalls that may be targeted for rerouting of water or alternate treatment and disposal. One major finding is that a number of sinks are tied to the storm drain system. In an effort to reduce the potential for accidental releases to EFPC, this study currently focuses on characterization and verification of drain routing for all sinks at the Y-12 Plant. The discharges from lavatory sinks are connected to the sanitary sewer, as are many nonlavatory sinks in over 400 buildings within the Y-12 Plant. However, some nonlavatory sinks are tied to the storm sewer system that discharges to EFPC.

Currently, administrative controls in place at the Y-12 Plant prevent disposal of chemicals in sinks. Each division at the Y-12 Plant has at least one Environmental Officer who trains the employees in the proper use and disposal of chemicals and wastes. Polytanks and/or other containers are now required for routine disposal of chemicals. In addition, substitutions are made whenever a less-toxic chemical can be used to minimize potential effects resulting from spills or inadvertent disposal. The goal of the sink identification project is to identify sinks on building drawings, characterize possible discharges from those sinks, and determine the appropriate routing and/or treatment for that discharge. This major effort will result in all sinks being separated from EFPC.

6.1.4 Rogers Quarry Effluent Quality

Rogers Quarry has been used for the disposal of coal fly ash and bottom ash from the Y-12 Steam Plant since 1965. As discussed in Sect. 6.1.6 of the 1988 ORRER (Rogers et al. 1989), the Y-12 Plant is implementing alternative coal ash disposal methods to eliminate the discharge of ash slurry to McCoy Branch (upstream of Rogers Quarry) and Rogers Quarry. In 1989, these methods included the interim measure of burning 80% natural gas instead of coal at the steam plant and the extension of the ash sluice pipeline directly to Rogers Quarry, thereby bypassing McCoy Branch. The pipeline went into operation in November 1989.

The interim measure of burning less coal was expected to result in some improvement in the effluent quality of Rogers Quarry, especially concentrations of sulfate, arsenic, and selenium that may be released from coal ash. Average

concentrations of these constituents decreased significantly in the quarry effluent between 1988 (see Table 2.2.18 in Vol. 2 of 1988 ORRER) and 1989 (see Table 2.2.19 in Vol. 2 of this report). Figure 6.1.1 displays the temporal pattern in the concentrations of these constituents in 1989. The rapid decrease in sulfate, arsenic, and selenium between January and April represents the flushing of these constituents from the quarry after the switch to natural gas in late 1988. The peaks in sulfate, arsenic, and selenium near the end of April correspond with initiation of aerator operation in the quarry, which would have increased mixing of deeper quarry water into surface water and discharge via the monitored overflow. Unseasonably cold air temperatures in December 1989 required increased use of coal for fuel at the Y-12 Steam Plant; therefore, the concentrations of ash-derived constituents in the effluent also increased. However, the significant, rapid overall improvement in effluent quality observed in 1989 reflects the type of recovery to expect when fly ash disposal in the quarry is completely eliminated in 1990 and bottom ash disposal (less than 20% of total ash production) is eliminated in 1993.

Monitoring of the effluent of Rogers Quarry will continue as progress on the complete elimination of the ash slurry is made. In addition, water balance monitoring (see Sect. 6.2.14 of the 1988 ORRER) will be continued. Biological monitoring of McCoy Branch, both upstream and downstream of Rogers Quarry, was begun in 1989 to document recovery.

6.1.5 Y-12 Plant Airborne Mercury Monitoring Program

The on-site airborne (ambient) mercury monitoring program at the Oak Ridge Y-12 Plant was established in July 1986 to provide a historical data base of mercury concentrations in ambient air and to demonstrate protection of the environment and human health from releases of mercury to the atmosphere. Airborne mercury at the Y-12 Plant primarily results from vaporization of mercury in soils, releases from the burning of coal at the Y-12 Steam Plant, and fugitive exhaust from Building 9201-4, a former lithium isotope separation facility that is contaminated with mercury.

During 1989, as in 1988, six ambient mercury sampling stations were operational (i.e., stations on the east and west ends of the plant, two stations near Building 9201-4, a station at New Hope Pond, and a control site on Chestnut Ridge). At each of these stations, airborne mercury is collected by pulling ambient air through a Teflon filter followed by a flow-limiting orifice and an iodated charcoal sampling tube. The charcoal tubes, which absorb mercury vapor, are changed every 7 days, and Teflon filters for particulate mercury are changed every 28 days. Average air concentration during the sample collection period is calculated by dividing the total quantity of mercury collected on the charcoal and filters by the total volume (uncorrected to STP) of air sampled during the sampling period.

Table 6.1.1 shows the maximum, minimum, and average concentrations of airborne mercury vapor recorded during 1989 for the six sampling stations. In general, with the exception of the Ambient No. 8 station at the west end of the plant and the New Hope Pond site at the east end of the plant, average air mercury concentrations for 1989 agreed well with the results from the 1986 through 1988 period, being approximately equal or slightly lower. As expected, the control site (Rain Gage 2) continued to have very low average concentrations (0.005 $\mu g/m^3$) of mercury vapor. After operating 20 months and establishing a data base of background concentrations for mercury vapor, the Rain Gage 2 station was shut down in 1989. The monitoring sites located southwest and southeast of Building 9201-4 continued to show relatively high average concentrations in comparison to background levels; however, concentrations in 1989 for both these sites did show a reduction of approximately 25% over 1988 levels. A possible explanation for the decrease in mercury vapor levels at these two sites is the switch from burning coal to burning natural gas at the Y-12 Steam Plant, which is adjacent to these monitoring sites. As in the past, seasonal trends in ambient air concentrations of mercury were apparent, especially at the two stations located near Building 9201-4, with average weekly concentrations of mercury vapor gradually increasing throughout the summer and early fall and decreasing in the

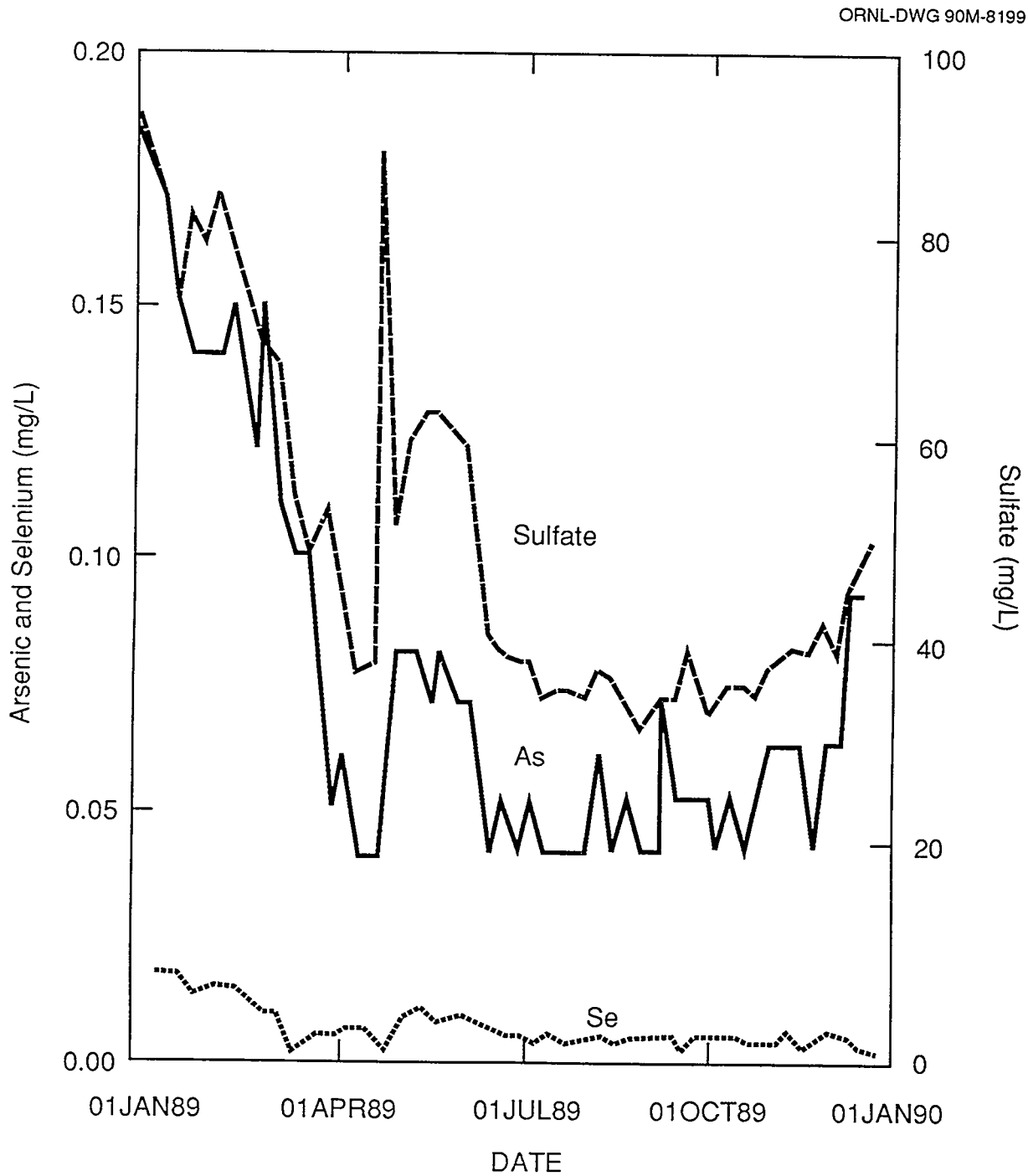

Fig. 6.1.1. Effluent quality of Rogers Quarry.

Table 6.1.1. 1989 Results of the Y-12 Plant airborne mercury monitoring program

Site	Sampling period	Mercury vapor concentration ($\mu g/m^3$)		
		Max	Min	Av
Ambient No. 2 east end of Plant	12/27/88–12/27/89	0.012	0.003	0.007
Ambient No. 8 west end of Plant	12/27/88–12/27/89	1.185	0.006	0.145
Building 9404-13 SW of Building 9201-4	12/27/88–12/27/89	0.250	0.029	0.101
Building 9805-1 SE of Building 9201-4	12/27/88–12/27/89	0.207	0.017	0.071
New Hope Pond 100 m NE of pond	12/27/88–9/19/89[a]	0.009	0.002	0.004
Rain Gage 2 Walker Branch watershed	12/27/88–10/31/89[a]	0.014	0.001	0.005

[a]Site discontinued.

winter. Particulate mercury concentrations continued to be very low at all six sites (less than 0.001 $\mu g/m^3$).

Two monitoring stations show significant differences in mercury vapor concentrations in 1989 when compared with earlier data: the New Hope Pond station and the Ambient No. 8 station. Mercury vapor concentrations at the New Hope Pond site, which showed a threefold increase in 1988 over 1987 partially as an artifact of different seasonal sampling periods, decreased to background levels in 1989. Reduction in the average mercury concentration at this site may be a result of the capping of the pond in 1989 as well as an artifact of the relocation of the site approximately 100 m northeast of the original location because of closure activities. The New Hope Pond station was permanently abandoned in mid-September because of loss of electrical power to the site. The annual average mercury vapor concentration for the Ambient No. 8 site increased dramatically and unexpectedly from 0.039 $\mu g/m^3$ in 1988 to 0.145 $\mu g/m^3$ in 1989. The highest weekly average concentration (1.18 $\mu g/m^3$) recorded since the establishment of the monitoring program in 1986 was recorded for this site for the second week of October 1989. The 30-d average for the month of October for the site was 0.563 $\mu g/m^3$, approximately one-half the National Emission Standard for Hazardous Air Pollutants (NESHAP) limit. Concentrations dropped to levels more typical of 1988 levels in November and December. The reason for the dramatic increase in mercury vapor concentration at this site is unknown but may be related to the increase in earth-moving activities at the west end of the Y-12 Plant.

The 1989 results indicate that on-site airborne (ambient) mercury concentrations continued to be below the NESHAP guideline for mercury in ambient air of 1 $\mu g/m^3$ (30-d average) and the industrial hygiene standard of 50 $\mu g/m^3$ (10-h workday).

6.1.6 Leak Test Procedures for Uranium Stack Samplers

In a letter dated April 25, 1988, the EPA Region IV approved the operation of the Y-12 Plant Uranium Chip Oxidation Facility (UCOF). As one condition of that approval, the EPA required that (1) a protocol for a study to

characterize typical leakage rates experienced by an emission monitor be developed and (2) a determination be made if a quarterly leak test was adequate to maintain sample system integrity. The EPA specified the maximum allowed leak rate as 4% of the average flow rate through the sample line.

In this study, a leak test procedure was developed and laboratory tests were conducted to characterize leakage rates in simulated operating conditions. Two types of systems are used to sample the Y-12 Plant stacks: continuous stack samplers (CSS) and uranium breakthrough monitors (BTM). The leak test apparatus was designed for use on both types of stack monitors. Because the CSS is a simpler system in design, a CSS was used to perform the leak test study in the laboratory; however, the design of the filter holder and its sealing mechanism is similar in both the CSS and the BTM.

The leak test apparatus consisted of a 3.0-L standard volume with associated valve and a MKS, Inc., Baratron pressure indicator with a 0 to 1000 mm Hg pressure-sensing element. The pressure resolution of this indicator was 0.1 mm Hg. The volume container and the pressure indicator/recorder will be a portable unit that can be transferred between stack sites. The stack monitors will be modified by the addition of two ball valves to the sample line to perform the leak test.

To conduct this laboratory study, a CSS was set up in the laboratory and modified to allow for leak testing. To simulate operation, before each leak test the filter holder was removed and replaced to simulate changing the filter paper. In the Y-12 Plant, CSS filters are changed at least once a week and as many as five times a week, depending on the location. Therefore, the filter change cycle was repeated 195 times to simulate a minimum of three quarters of operation. For stack monitors that have filters changed once a week, this number represents approximately 3 years and 9 months of operation. This number of leak tests is therefore sufficient to characterize the leakage rate experienced by a stack monitor system in operation. The o-ring seals on the filter holder were not changed during testing.

The maximum allowed leak rate is 4% of the average flow rate through the sample line. The average flow rate is approximately 1 cfm. The maximum allowable leak rate is therefore approximately 0.04 cfm. Of the 195 consecutive leak tests performed in the laboratory, no leaks greater than 0.04 cfm occurred.

Based on the laboratory tests, it is concluded that the design of the filter holder seals is adequate to prevent excessive leakage into the sample line of the stack monitor during continuous use over a minimum period of three quarters. This conclusion will be confirmed in the field tests currently being conducted on the UCOF and the Uranium Oxide Storage Vault stack monitors.

6.1.7 Sanitary Sewer Study at the Y-12 Plant

Elevated levels of uranium were reported in the Oak Ridge city sewer sludge in October 1988. Although it was established that the elevated levels were the result of emissions from another business in Oak Ridge and not from the Y-12 Plant, this excursion generated interest in the Y-12 Plant emission levels. As a result, a daily sampling plan for uranium on the Y-12 Plant and industrial park sewers was initiated to characterize uranium effluents from the Y-12 Plant.

Daily samples were taken from the Y-12 Plant east pipe starting in November 1988. These samples were continued for 10 months through September 1989. The data gathered from these daily samples showed no abnormalities in the Y-12 Plant uranium effluents. Sample results generated at ORNL on each load of solids delivered from the city sewer verify this finding. Monthly samples of the Y-12 Plant effluents are taken by the Y-12 Plant Environmental Management group. Sample results are maintained on file for all sampling at both plants.

6.1.8 Predicted Effects of Post-Closure Remedial Actions at the Y-12 Plant Burial Grounds and Oil Landfarm Waste Management Areas on Ecological Conditions in Bear Creek

Past disposal of wastes, including oils, solvents, PCBs, and metals, at the Y-12 Plant burial grounds and oil landfarm waste

management areas has resulted in the contamination of Bear Creek. In some cases, contaminated groundwater infiltrates Bear Creek and its tributaries; in others, surface seeps of PCB-contaminated oil has caused contamination. Closure of the sites is mandated by the RCRA and requires evaluation of various postclosure remedial actions. Proposed alternatives included in the evaluation of these sites were (1) no remedial action, (2) capping the sites to prevent further infiltration of rainwater, and (3) capping combined with the installation of groundwater wells to withdraw and treat the most contaminated subsurface plumes and to prevent their further dispersal.

Because these remedial measures have the potential to sustain or cause adverse ecological effects in Bear Creek, an evaluation of the ecological consequences of the proposed actions was conducted by staff in the ORNL Environmental Sciences Division and the Health and Safety Research Division. Chemical and ecological monitoring data and results of toxicity tests on Bear Creek surface water were used in conjunction with estimates of the effects of remedial actions on surface flow and solute concentrations to estimate likely environmental changes in Bear Creek.

No adverse ecological effects in Bear Creek currently exist as a result of contaminant transport from these sites. However, in the no-action scenario, continued expansion of contaminated groundwater plumes at both sites was predicted to result in (1) marginally toxic concentrations of VOCs in Bear Creek near the burial grounds several decades from now and (2) detectable but nontoxic concentrations near the oil landfarm. Capping and excavation of PCB-contaminated surface soil was predicted to keep VOCs from reaching toxic levels in Bear Creek at both sites and to eliminate PCB inputs to Bear Creek. The groundwater withdrawal option at both sites was predicted to reduce further migration of VOCs but without any ecological benefits. Reduction of stream flow associated with this option would be expected to result in a small loss of aquatic habitat. As was the case at the S-3 pond site, the option of capping the site without operating a groundwater recovery and treatment system was considered the alternative most likely to protect ecological conditions in Bear Creek.

6.1.9 Ecological Effects of Contaminants and Remedial Actions in Bear Creek

Past waste disposal operations in Bear Creek Valley west of the Y-12 Plant have resulted in the contamination of surface water and groundwater. To identify contaminant sources, prioritize them based on their ecological effects, and evaluate the effectiveness of remedial actions, ecological monitoring of Bear Creek and selected tributaries was initiated in 1984 and continues currently. The monitoring program consists of (1) instream sampling of benthic invertebrate and fish communities in Bear Creek to characterize spatial and temporal patterns in distribution and abundance and (2) laboratory bioassays of water samples from Bear Creek and selected tributaries to identify potential sources of toxicity to biota.

Chemical water quality of Bear Creek is not typical of affected streams in the region because of high concentrations of dissolved salts (primarily calcium, magnesium, sodium, and potassium nitrate, chloride, bicarbonate, and sulfate) resulting from the infiltration of contaminated groundwater in the vicinity of the S-3 pond site at the headwaters of Bear Creek. Concentrations of these major constituents in Bear Creek downstream from the uppermost sampling site at Bear Creek kilometer (BCK) 12.36 roughly approximate those expected from the dilution of flow at the uppermost site with uncontaminated groundwater and surface flow from tributaries. Trace ions (ammonia, barium, beryllium, cadmium, cobalt, copper, manganese, lead, nickel, silver, uranium, and zinc) are elevated in the uppermost reaches of Bear Creek but decline to background or below detection limits within a short distance downstream.

Nine ambient (instream) toxicity tests with fathead minnow (*Pimephales promelas*) larvae were conducted on water from various sites in Bear Creek, several tributaries of Bear Creek, and Grassy Creek, a small, nearby reference stream, between June 1984 and March 1989. Toxicity of

water samples from six sites in Bear Creek was also evaluated in March 1988 and 1989 using survival and reproduction of the microcrustacean, *Ceriodaphnia dubia*, as toxicity endpoints. Results of these ambient toxicity tests showed that water at BCK 12.36 was toxic to fathead minnows on six of nine test dates, but no consistent pattern of toxicity was observed at any sites further downstream. Similarly, in situ bioassays with snails (*Elimia clavaeformis*) conducted at four sites in Bear Creek in 1986–1987 showed an increase in the percentage of dead or stressed snails with increasing proximity to the S-3 pond site. Bear Creek water that was not toxic to fathead minnow larvae was toxic to *Ceriodaphnia* at BCK 12.36 and BCK 11.83 in March 1988, when stream flow was higher and solutes were more dilute than usual, and again in March 1989, when stream flow was normal. Preliminary results from concurrent water quality analyses suggest that metals (e.g., nickel) were the most likely toxicants in the latter test. Moreover, the *Ceriodaphnia* test appeared to be at least a factor of two to three times more sensitive than the fathead minnow test in detecting toxicity in Bear Creek water.

Nineteen species of fish were found in semiannual quantitative sampling of the fish community in Bear Creek. Much of the stream has a limited fish fauna (low species richness) characterized by robust population parameters (high densities and biomass). There is no stable, resident fish population at BCK 12.36, where the water is commonly toxic to fathead minnow larvae in laboratory bioassays and contains high levels of dissolved salts as a result of inputs of contaminated groundwater from the S-3 pond site. Downstream at BCK 11.83 and BCK 11.09, fish density and biomass were low in 1984 but showed recovery the next year. No impacts on the fish fauna of Bear Creek were evident in the vicinity of inputs from the burial grounds (BCK 9.91 and BCK 9.40), even though no fish were found in most qualitative surveys of the tributaries draining that site. Lower Bear Creek (BCK 3.25) has a diverse assemblage similar to that in Mill Branch, a larger reference stream and tributary of EFPC; the middle to upper reaches (except site BCK 12.36) contained a fauna similar to that of Grassy Creek. The extended drought that occurred from 1985 to 1987 had no long-term adverse impacts on the fish communities in Bear Creek partly because of several springs that stabilize flows during low-flow periods and moderate temperature extremes.

No endangered or threatened fish species have been found in Bear Creek. However, the Tennessee dace, which was formerly classified as the mountain redbelly dace (*Phoxinus oreas*) (Starnes and Jenkins 1988), is a major constituent of the fish population at every site above the NPDES monitoring station (BCK 4.55) and in at least four tributaries. The fish is listed as a species in need of management, and its habitat is protected by the state of Tennessee.

The benthic invertebrate fauna of Bear Creek showed a pattern of increasing density, biomass, taxonomic diversity, and species richness with increasing distance downstream from BCK 12.36. The paucity of benthic invertebrates in the upper reaches of Bear Creek contrasted sharply with reference sites (unaffected streams of similar size), which had relatively diverse and abundant invertebrate assemblages. No threatened or endangered species of aquatic invertebrates has been collected in Bear Creek. Although evidence of adverse effects on the fish communities of Bear Creek was not noted at sites downstream from BCK 11.83, the benthic fauna appear to be more sensitive, with clear differences in faunal composition from unaffected reference streams at all sites except BCK 3.25, where no impact was evident. Species intolerant of pollution (mayflies, stoneflies, and caddisflies) were absent in the upper reaches and became more common downstream. Mayflies, which are particularly sensitive to toxic metals, were virtually absent at all sites except BCK 3.25. Unlike the fish data, which provide evidence of ecological recovery in Bear Creek between 1984 and 1985, the benthic invertebrate data did not show a similar trend during the same period or even several years later. These results are consistent with those obtained from the toxicity tests in demonstrating the greater sensitivity of invertebrates to water quality degradation.

6.1.10 Y-12 Spill Report

The Y-12 Plant had a total of 105 recorded spills or releases of various types of materials

during CY 1989. This compares with 153 spills or releases recorded during CY 1988. As in CY 1988, many of these spills involved petroleum products (Fig. 6.1.2). Each recorded spill event was investigated by a Y-12 Plant Spill Coordinator to determine the potential environmental impact caused by the spill, assist with the cleanup of the spill, and suggest ways to prevent the same type of spill from reoccurring. Cleanup operations were generally performed by trained staff members of the Y-12 Plant Waste Transportation, Storage, and Disposal Department. All cleanup operations and disposals of cleanup materials were handled according to Y-12 Plant standard operating procedures. The Y-12 Plant EMD reports spill events to various levels of Y-12 management, DOE, and other governmental agencies as appropriate.

A Spill Prevention Committee composed of representatives of manufacturing, product certification, maintenance, and other organizations within the plant was proposed in CY 1989 and will be organized in CY 1990. The procedures for tasks in which spills may be more likely to occur were reviewed in CY 1989, and many will be revised in CY 1990. Further efforts to reduce the number of spills in the Y-12 Plant continue.

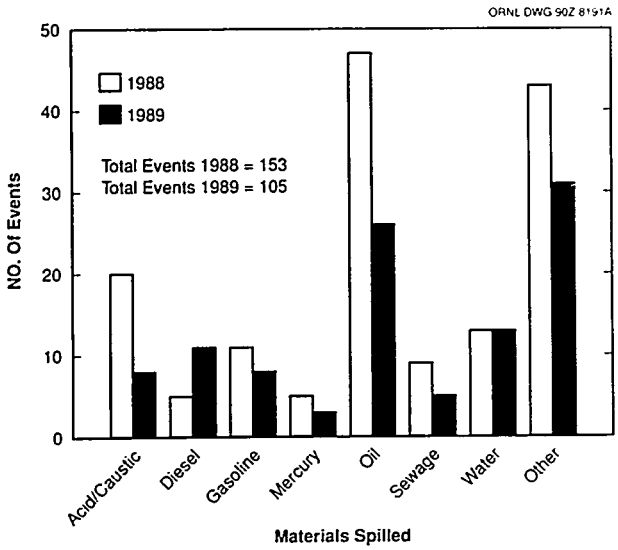

Fig. 6.1.2. 1989 Y-12 Plant spills summary.

6.1.11 East Fork Poplar Creek Area Source Pollution Assessment and Control Program

The Y-12 Plant NPDES permit requires evaluation of area source discharges from within and around the plant to determine their impact on the water quality of EFPC. Area source discharges, also referred to as nonpoint source pollution, result when uncontaminated surface water or groundwater flows over or through contaminated surfaces and results in the transfer of poilutants to a receiving stream. To characterize area source discharges into EFPC and to develop a plan for its control, the Y-12 Plant has developed an area source pollution assessment and control plan for EFPC with the assistance of Camp, Dresser, and McKee, Inc.

During the preliminary sampling phase of the EFPC area source pollution assessment program, it was determined that nonpoint source pollution has a significant impact on instream water quality. To quantify pollutant transport into EFPC from area source discharges and to locate sources of these discharges, a comprehensive sampling program was conducted from September 1988 to April 1989. The major goals of this program are to identify locations of potential area source discharges, to determine pollutant loadings from these sources, and to identify appropriate corrective actions. The comprehensive sampling program consisted of flow monitoring and water quality sampling at 12 sites within the Y-12 Plant and within the EFPC drainage basin. Sampling intervals include a number of storm events ("wet weather" samples) as well as sampling during normal flow periods ("dry weather" samples). By comparing the wet weather and dry weather water quality, sources and impacts of nonpoint source pollution can be evaluated. The analysis of samples and evaluation of data are currently being conducted.

6.1.12 Building 9215 Stack Emission Incident

A stack in Building 9215 experienced a very unusual emission problem in July and August of 1989. The stack exhaust included a high concentration of moisture sufficient to be seen as a visible mist and to flood the continuous stack sampler. The wet stack samples were analyzed by

the laboratory in the usual manner, and when the results were converted to emissions, the estimated release rate was quite high. Considering the condition of the samples, Y-12 Plant personnel felt that these particular samples were not indicative of the actual emissions, especially since no process operations had occurred for over a month. An investigation of the event was conducted.

The stack serves a Mill Area and also serves as ventilation exhaust for the equipment pits and general area. All operations in this area were shut down in June 1989 for extensive cleaning and repainting. Cleaning operations were conducted using high-pressure water spray; the runoff was collected in the pit areas below the process equipment. Ventilation piping from the pits feed into the main exhaust system, which runs underground through a tunnel to a stack. The pits and the tunnel were flooded. Water was pumped from the pits prior to the restart of the ventilation system on July 28, 1989, but the tunnel remained flooded. When the fan was restarted, the high velocity of air moving over the water in the tunnel picked up uranium-contaminated water droplets and carried the material up and out the stack. The sampler picked up the water through the probe and was subsequently flooded also.

The investigation of the event resulted in several recommendations, and the following actions were taken:

1. Water was pumped from all pits, the ventilation tunnel, and the stack basin. Administrative controls, new pumps, and level-indicating instruments were put in place as needed to ensure that these areas remained pumped.
2. System changes had already begun to reroute some water sources that had formerly gone to the pit and tunnel. Other changes were suggested that would reduce the waste water, such as recycling some through a cooling tower.
3. As a result of the variation of stack flow measured at different levels of water in the tunnel and the lack of routine verification of stack flows throughout the plant, a quarterly velocity check of all stacks on the sampling program was implemented in the fall of 1989. Results of these quarterly measurements will be evaluated after one year to determine the variability of stack flows and the frequency at which further velocity checks are needed.

Since corrective actions were initiated, the emissions have been within the normal operating level of other depleted uranium areas.

6.1.13 Treatment for Category IV Discharges

Category IV-type discharges are process wastewaters, as listed on the current NPDES permit, that discharge to EFPC. Many of these discharges have already been eliminated. The remaining Category IV discharges are scheduled to be treated or eliminated during 1990. Studies have been conducted for each of these discharges to determine the most appropriate form of treatment and disposal.

Currently, efforts are in progress to discharge photographic rinsewaters to the City of Oak Ridge Sanitary Treatment Plant, where this discharge (rinsewaters only) can receive the biological treatment appropriate for this type of wastewater. Dye penetrant wastewater will be collected and treated at an existing Y-12 Plant wastewater treatment facility. The Plasma Torch wastewaters will be reduced through recycle and treated at an existing Y-12 Plant wastewater treatment facility. The nitric acid still overheads will be used as makeup to a cooling tower, utilizing the acidic properties of this flow for pH adjustment.

A new NPDES permit application has been submitted for the lithium process steam condensate. Improvements to this process are scheduled that include discharge recycle and pH adjustment. These improvements (scheduled for 1993) will allow for the elimination of this Category IV from EFPC, when completed.

6.1.14 Building 9212 Emission Incident

A stack serving the Building 9212 caustic scrubber exhaust system experienced an emission problem on Monday, June 26, 1989. The sample collected from the continuous stack sampler on that day indicated an emission rate higher than the DOE administrative reporting level of 10 g enriched uranium per day over the weekend. Although this

emission level is higher than expected from this process, it was still well within any regulatory limits.

An investigation team was formed to determine the cause of the emission. Because this is a wet scrubber system, there is no paper filtration for the exhaust. Operations personnel cleaned out the exhaust system in an attempt to correct the problem. Several test runs were conducted; they indicated that the emissions problem still existed. Further attempts by operations to identify and correct the cause resulted in the complete disassembly and rebuilding of the caustic scrubber and its associated pumps and piping. Operational procedures were reviewed, and the process was carefully observed and controlled. Finally, an alarmed stack sampler, or breakthrough monitor, was installed in place of the continuous stack sampler (which is not an alarmed sampler). With the assistance of the continuous monitoring capability, the operations personnel have been able to keep the emissions within the Y-12 Plant control level by administrative controls and more stringent operational management.

This process system will be part of the Air Emissions Control (AEC) project, under construction. When the AEC system comes on line, this exhaust, with several others, will pass through a large filter bank prior to entering the environment.

6.2 OAK RIDGE NATIONAL LABORATORY

6.2.1 Reservation-Wide Geologic and Hydrologic Investigation

A detailed investigation of the the geology and hydrogeology of the Oak Ridge Reservation (ORR) is currently under way. An important element of this work is the construction of a modern detailed geologic map of the ORR that will show the distribution of all rock units and contain a large amount of information on the structure. Understanding the geologic framework of the ORR is essential to many current and proposed activities related to land use planning, waste management, and remedial action.

A major long-term goal of geologic investigations in the ORR is to determine what correlations exist between bedrock fracture systems that provide the plumbing for the fluids that may be present. Understanding the geology and structure of the entire ORR and surrounding area can help formulate a structural-hydrologic model that integrates geologic and hydrologic data. For the first time, this will enable prediction of the movement of groundwater and other subsurface fluids on the ORR. Understanding the structural setting and its controls on fluid flow at depth should be the first step in developing a model for groundwater movement in this area, one that should be applicable anywhere in the world in a similar setting. Geophysical studies (mostly seismic reflection) will be conducted over the next several years to help refine projections of structural data into the subsurface. Development of a state-of-the-art geologic and geophysical framework for the ORR is therefore essential for formulating a generic structural-hydrologic model.

The ORR is located in one of the classic foreland fold and thrust belts in the world, the Appalachian Valley and Ridge. The basic structural style here has been compared to that in the Canadian Rockies and to the Moine thrust zone in Scotland. The Tennessee portion of the Appalachian Valley and Ridge is characterized by the presence of a number of faults that were active some 250 million years ago and produced a series of overlapping sheets inclined to the southeast. They were eroded to produce the northeast-trending linear ridge structure of East Tennessee. About ten major thrust faults constitute the Valley and Ridge at the latitude of the ORR. Two of these major faults, the Copper Creek and Whiteoak Mountain faults, are exposed in the ORR. The contrasting geometry and deformational style of these two faults provide a unique opportunity within the ORR for generic kinematic and mechanical studies of the contrasting behavior of foreland thrusts.

The bedrock geology of the ORR consists of a heterogeneous assemblage of sedimentary rock types ranging in age from Early Cambrian to Early Mississippian (500 to 350 m.y.), including carbonate rocks (limestone and dolostone), shale,

sandstone, and chert. The total thickness of section in the ORR is on the order of 9500 ft (3 km). The mechanical properties of each rock type determine the response of each to forces in the earth and control the formation of both large and small structures here. These differences produce a slightly different scheme of fracture properties in each rock type, which ultimately affects the plumbing system and the way fluids are transmitted through it.

A number of site-specific geologic and hydrogeologic studies have been conducted by ORNL staff as part of past and proposed waste disposal activities. These site-specific geologic investigations represent greatly detailed studies of small areas within the ORR; however, until recently little emphasis has been directed toward investigating details of the geology and hydrogeology of the entire ORR and synthesizing the existing data into a unified geologic/hydrogeologic framework of the ORR. To develop a conceptual and quantitative geologic (and hydrogeologic) model of the ORR, it is imperative that the region studied be of the same scale as the geologic processes responsible for the observed geologic characteristics.

The most pervasive geologic structure in the region is fractures. Fractures refer to all surfaces of discontinuity in a rock mass and form as products of the elastic strain experienced by a rock mass through time. If the relative age can be ascertained, fractures are useful for inferring the stress-orientation history of large thrust sheets during emplacement. From a practical standpoint, they are probably the most important factor controlling the plumbing and direction of groundwater flow in this region. Therefore, an understanding of fracture orientation, mechanics of formation, and timing of development is needed. By examining fractures at different scales and determining the origin of different fracture systems, the hierarchy of fracture networks might be used to predict preferred fluid migration paths.

During 1989, work included geologic field activities, principally mapping and efforts to revise the subdivisions for sedimentary rock units. To date about 40% of the geology of the S-16A ORR map has been completed. It is expected that the map will be completed by 1994. A preliminary report on the geology and hydrogeology of the ORR will be produced during 1990.

6.2.2 Aerial Radiological Survey of the ORR

DOE maintains an aerial radiological surveillance capability, the Aerial Measuring System (AMS). Since its inception in 1958, the AMS has been used in a nationwide program to map the terrestrial gamma radiation environment of nuclear power plants, processing plants for nuclear materials, and research laboratories. The AMS is currently operated and maintained by EG&G Energy Measurements (EG&G/EM), Inc., under contract to DOE. The aerial surveys provide data for assisting in effective environmental management at nuclear facilities and provide radiological background templates for repeat surveys in the event of a large-scale radioactive release.

During the period September 12–29, 1989, an aerial radiological survey of the ORR, city of Oak Ridge, and the surrounding area was conducted. The survey encompassed an area of 170 mile^2, which included the Y-12 weapons production plant, ORGDP, and ORNL. The objectives of the survey were to measure the terrestrial gamma radiation, derive exposure rates, and identify the man-made radioisotopes. The radiation data will be presented in the form of a template that, when superimposed on a TVA map of the ORR, will give the spatial distribution of gamma exposure rates attributed to natural and man-made radioisotopes. In addition to the above survey, DOE requested special flyovers of (1) the railroad tracks leading from the Y-12 Plant through the city of Oak Ridge and (2) an area in south Knoxville containing several scrap metal yards.

A draft report of the aerial survey results will be available for review beginning in the summer of 1990 from DOE, Nevada Operations Office. The results of the special flyovers will also be made available in a separate, informal, brief report.

The aerial radiological survey was conducted over the ORR and surrounding area (10 by 17 miles) as defined by the TVA map S-16A. The rectangular survey area was divided into a grid

pattern consisting of 105 parallel lines 17 miles long and 500 ft apart. The aircraft was flown at a constant altitude of 300 ft above ground level and a speed of 70 knots.

The special flyovers were conducted at an altitude of 125 ft. Over the 8-mile length of railroad tracks leading from the Y-12 Plant through the city of Oak Ridge, four passes were made to search for ^{137}Cs. In the south part of Knoxville where several scrap metal yards are located, a 1 by 2 mile^2 area was surveyed to search for uranium metal.

The aircraft used for the low altitude survey was a twin engine Messerschmitt-Bolkow-Blohm BO-105 helicopter. The helicopter was equipped with two detector pods, each containing four 2 × 4 × 16 in. sodium iodide detectors and a radiation and environmental data acquisition and Recorder (REDAR IV) system. The position of the helicopter was continuously monitored using an ultra-high frequency ranging system and a radar altimeter. To assist in navigation, the grid parameters were programmed into the REDAR IV system and displayed via a steering indicator to the aircraft pilot.

The gamma ray spectral and nonspectral data were acquired at 1-s intervals and recorded on magnetic tape. The spectral data consisted of dual 1024-channel gamma energy spectra (0–4 MV). The nonspectral data included the temperature, pressure, aircraft position, and altitude. Following each flight, the data acquired on the REDAR IV system were transferred to a radiation and environmental data analyzer and computer (REDAC) system housed in a mobile laboratory for processing.

Using the REDAC system, the radiation data for each flight were processed using an extensive library of data reduction routines. The radiation data were then integrated with the position coordinates and compiled with the existing data to produce a radiation map, or template. A large-scale hard copy of the radiation template was generated and superimposed on the TVA map to show the spatial distribution of the gamma activity.

The radiation data will be presented in terms of total gamma exposure rates extrapolated to 1 m above ground level. The exposure rates derived from the aerial measurements are verified with ground-based ionization chamber and soil sample measurements. In addition to the total gamma exposure rates, the spectral data will be analyzed to determine the relative abundances of man-made radioisotopes. From the aerial survey conducted in 1989, the prominent man-made radioisotopes detected were ^{60}Co, ^{137}Cs, and ^{234m}Pa (which is indicative of depleted uranium). Using a series of spectral stripping techniques, the relative yields of these radioisotopes, along with any other man-made radioisotopes identified, will be determined.

6.2.3 Biotransformations of Mercury in East Fork Poplar Creek

Microorganisms play a significant role in the transformation processes affecting mercury, especially at sites with a history of anthropogenic exposure to mercury such as EFPC. Biotic reduction of mercuric ion and demethylation of methylmercury have been characterized in this creek and in the Clinch River upstream of the DOE facilities with radiotracer techniques. The frequency of bacterial genes coding for these reactions (*mer* genes) in gene pools of active microbial communities living in the streams has also been determined by gene probe screening of DNA extracted from stream water.

Biotic reduction of mercury varied seasonally and accounted for up to 90% of total reduction in samples from EFPC. Reduction proceeded rapidly without a lag period in samples from EFPC but exhibited a lag period of 12 to 24 h before the biotic component of reduction was expressed in samples from the Clinch River. The *merA* gene sequences, which code for mercuric ion reduction, were 46 times more abundant in the microbial community from EFPC compared with the Clinch River. Demethylation of methylmercuric chloride added to water samples from both sites consistently exhibited a lag period of 1 to 2 d before demethylation was initiated but was typically greater than 90% complete after 5 d. The Clinch River exhibited a lower threshold concentration of methylmercury above which no demethylation occurred in 5 d as compared with EFPC. The

Clinch River also exhibited a threshold concentration of methylmercury below which demethylation was not induced in 5 d. No such lower threshold or induction concentration was observed for EFPC. The abundances of *merB* gene sequences, which code for the organomercurial lyase enzyme, were relatively low and similar for both EFPC and the Clinch River.

The high relative abundance of *merA* genes in the microbial community in EFPC suggests that reduction and volatilization of mercury via the mercuric reductase enzyme may be a more important detoxification mechanism at this site than demethylation. Thus, unexpectedly low concentrations of methylmercury observed in water at this site may be partially the result of rapid elimination of the substrate for methylation, mercuric ion, rather than rapid demethylation of methylmercury. Collaborative research with the EPA Biotechnology Laboratory and the University of California-Irvine is in progress to determine if beneficial biotransformations (e.g., demethylation) of mercury compounds can be stimulated in the indigenous microbial community in EFPC.

6.2.4 Miscellaneous ORNL Spills

During 1989, ORNL had a total of 91 spills or releases of various types of materials (Figs. 6.2.1 and 6.2.2), compared with 109 for 1986, 92 for 1987, and 119 for 1988. ORNL has defined a spill as any material outside of its containment vessel. A spill is not necessarily a release to the environment; it may be to the floor, a laboratory bench, or a secondary containment structure. Emphasis is placed on spill reporting and investigation to prevent any environmental releases. Members of the Environmental Monitoring and Compliance Department of the ORNL Environmental and Health Protection Division investigated each spill or release to determine the environmental impact, to provide input for reducing any harmful effects, and to assist with cleanup efforts. Cleanup activities were conducted by staff members of the ORNL Hazardous Waste Operating Group. All cleanup materials were disposed of according to ORNL procedures.

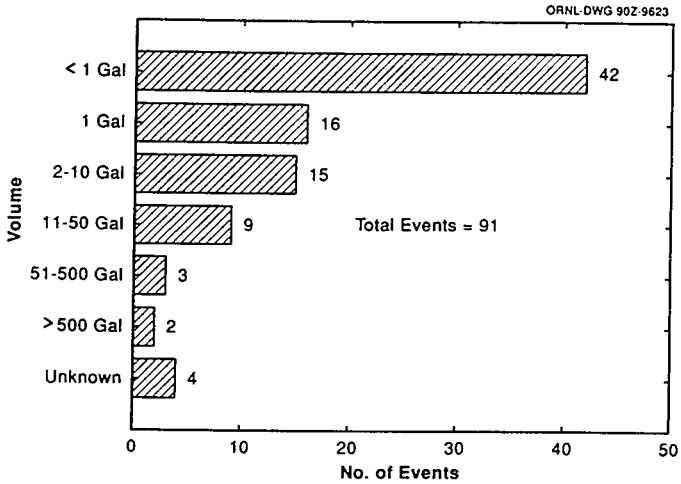

Fig. 6.2.2. 1989 ORNL spills summary (volume).

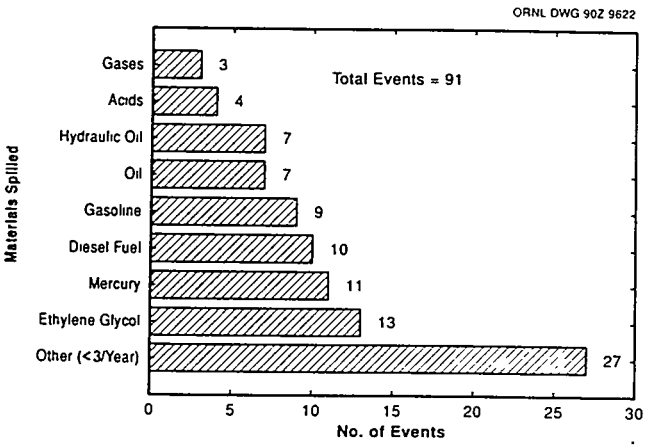

Fig. 6.2.1. 1989 ORNL spills summary (material frequency).

ORNL reports all spills via the electronic mail system to various levels of ORNL management and DOE officials as soon as possible after the spill; updates are provided as necessary. This reporting system has resulted in an increased awareness of spills by ORNL staff members.

As in 1986, 1987, and 1988, many of the spills involved petroleum products. Efforts to enhance spill prevention, especially of petroleum products, included training for more than 900 ORNL Plant and Equipment Division personnel and increased monitoring of construction activities and storage areas where these types of spills often occur. The

monitoring and site assessment activities, conducted by field interface staff, also provided an opportunity to detect and prevent other potential environmental problems. Over 1200 site assessments were conducted, and the site assessment reports were distributed throughout ORNL. Of the 91 spills, 42 were less than a gallon in quantity, and only 2 were greater than 500 gallons.

6.2.5 Survey of Cooling Tower Wood for the Presence of Pentachlorophenol and Sodium Pentachlorophenate

At the request of DOE/ORO a survey of the cooling towers at ORNL was conducted to determine if PCP or Na-PCP fungicide treatment had been used to preserve the wood components. These chemicals are of environmental concern because byproducts and degradation associated with their manufacture and use are known to contain dioxins and furans (Spence 1989). The survey also addressed the maintenance, operation, and disposal of the cooling towers, with emphasis on determining the potential for PCP or Na-PCP introduction from these sources to the environment.

ORNL personnel contacted and questioned about the possibility of PCP or Na-PCP contamination in the wooden cooling towers included environmental, engineering, and waste disposal staff. In addition, outside vendors, builders, and maintenance firms associated with the cooling towers were contacted and questioned about their knowledge of past and present fungicide treatments. The following brief summary is based on the information obtained from these sources.

ORNL staff members identified 28 cooling towers ranging in capacity from 200 to 170,000 gal. Twenty-three of these cooling towers are of wood construction, and five are constructed of metal. The metal cooling towers were eliminated as possible sources because of their construction. The survey then focussed on the remaining 23 wooden cooling towers. The builders of 20 of these towers have been identified: 16 were constructed by Marley Cooling Tower Company; 2 by Havens Cooling Towers; 1 each by Lilie-Hoffmann Cooling Towers, Inc., and Ecodyne Cooling Tower Services. Contact was made with representatives of each of these companies, except for Lilie-Hoffmann Cooling Towers, Inc. (After numerous attempts to locate Lilie-Hoffmann Cooling Towers, Inc., it has been concluded that the company is no longer in business.) Discussions with representatives of the other companies indicated that neither PCP nor Na-PCP had been used to treat wood used in the construction of the cooling towers they had built. The builders of the three remaining cooling towers have not been identified; however, contacts at ORNL indicated that steam sterilization instead of a chemical treatment was used on these towers.

Investigation of the maintenance of the cooling towers determined that the Ferguson Equipment Company has always been the contracting firm used for maintenance of the cooling towers at ORNL. Discussion with personnel there indicates that neither PCP nor Na-PCP has ever been used in the maintenance of the cooling towers. Therefore, long-term maintenance activities have not introduced PCP or Na-PCP to the environment.

Disposal practices for wood from cooling towers suggest that in most cases wood removed from the towers was disposed of at the Y-12 Centralized Sanitary Landfill II. No indication of wood being sold to the public or reused in other projects was found. A recent project (CY 1988) determined that cooling-tower wood subjected to the Resource Conservation and Recovery Act (RCRA) test for the presence of metals [Extraction Procedure Toxicity (EP tox) and Toxicity Characteristic Leaching Procedure (TCLP)] indicated that no metals were present in levels above RCRA action limits. One case of elevated radiation was found in which cesium-137 was twice the background radiation level. Based on this information, team members concluded that cooling-tower wood has never been disposed of as a hazardous waste. Currently, testing of cooling-tower wood is mandated by As-Low-As Reasonably Achievable (ALARA) Memoranda or Activity Description Memoranda written for cooling-tower demolition projects. This procedure results in appropriate sampling and disposal of all cooling-tower wood.

In summary, the survey has indicated that none of ORNL's cooling-tower wood has been treated with PCP or Na-PCP and that additional testing for contaminants associated with these fungicides, such as dioxins and furans, is unwarranted at this time. In addition, both current and past practices used for operation, maintenance, and disposal have been appropraite and responsible.

6.2.6 Historic Airborne Emissions of Radionuclides from ORNL—1943 to 1960

In 1989, DOE/ORO asked ORNL to review the available information on historical airborne releases of radionuclides from the site. Prior attempts to quantify these releases had not been successful. In response to this request, a report was prepared that used various technical reports generated by the health physics and operations organizations during the early years of the laboratory's operation. These reports from the period did not contain sufficient information to estimate total site releases, but they did contain more information on historical releases than had previously been assembled.

Information found on the Oak Ridge Graphite Reactor (OGR), which commenced operation on November 4, 1943, showed a daily release of 470 Ci of argon-41. Other radionuclides were released from the rupture of uranium slugs during the reactor's initial years of operation. By November 1948, a filter house had been designed, constructed, and placed in operation for the OGR, which was estimated to have reduced the airborne activity from the ruptures by at least a factor of ten. A total of 50 slug-ruptures occurred in the OGR prior to the installation of the filter house. The quantity of radionuclides released during the ruptures is unknown.

Of all the chemical processing that was conducted at ORNL, the separation of radioactive lanthanum (RALA Process) was the major source of chronic airborne emissions. A total of 68 RALA runs were conducted. Filtration of the cell ventilation system was installed after the 28th run. There was an estimated emission of 6 Ci of gamma emitting particulates for each of the first 28 runs. With filtration, the release/run was reduced to 3.3 Ci. (Other ORNL chemical processes appear to have been minor compared to RALA.)

In 1950 a central gas-handling system was installed to provide filtration and scrubbing for miscellaneous process air streams (including RALA) prior to release to the atmosphere through the main ORNL stack. (Separate stacks were used for emissions from the OGR and the Building 3019 Pilot Plant.) A 1953 study quantified the RALA emissions as 30 Ci of radioiodine and 100,000 Ci of noble gases per run. Due to the release height of this material, the primary source of ground-level contamination was from the vent of a liquid-waste tank during jetting and sparging operations associated with the RALA run.

Three accidents occurred during this time period that also released airborne radionuclides, none of which were thought to have significant offsite impact. On April 29, 1954, a batch of uranium slugs being dissolved in Building 3026-D overheated resulting in a release of radioactivity that contaminated buildings in the area. On November 11 and 12, 1959, releases of 0.3–15 Ci of particulate Ru-106 occurred from the main stack and caused contamination of site areas, which required cleanup. A few days later, on November 20, 1959, a chemical explosion occurred in the Building 3019 Pilot Plant that released plutonium from the building.

A limited amount of monitoring data was found. Data covering the period 1956–1960 showed the total airborne activity at ORNL to be about 2.5 times greater than at remote monitoring sites, and radioactive particulate concentrations at ORNL were about twice as high than at the remote sites. Unfortunately, this was not the time period of primary interest. Direct radiation measurements at ORNL from 1950–1962 were higher than 1943 levels; however, it is unlikely that those increases were primarily due to airborne releases.

6.3 OAK RIDGE GASEOUS DIFFUSION PLANT

6.3.1 K-1515-C Holding Lagoon Fish Kills

The K-1515 Sanitary Water Plant processes water pumped from the Clinch River to be used as

potable water for ORGDP. The K-1515-C holding Lagoon is a small (<1-ha) shallow pond that receives chlorinated discharges resulting from filter backwashing and settling basin overflows at the K-1515 Sanitary Water Plant. It also receives nonchlorinated overflows from the facility's raw water storage tank as well as some natural runoff. In addition, the lagoon is utilized as a settling basin for (1) sludge from the water plant effluents resulting from aluminum sulfate used as a flocculating agent and (2) solid material from the Clinch River water. An NPDES monitoring station is located at the lagoon outlet prior to its discharge to the Clinch River, and the effluent is monitored for aluminum, sulfate, chemical oxygen demand, and total suspended solids weekly. Daily field readings for flow, pH, and temperature are also obtained. A 100% compliance rate was maintained at this NPDES outfall during 1989 with the exception of one aluminum exceedance that occurred during heavy rainfall and was attributed to the washing of soil particles into the lagoon.

A fish kill occurred on March 27, 1989, when the lagoon was drained to begin installation of a new weir gate at the NPDES monitoring location. During an EPA Performance Audit Inspection conducted in 1987, the weir structure was cited as not meeting EPA requirements, and subsequently the weir gate was undergoing replacement to comply with these requirements. Water levels in the Clinch River were very low at the time the lagoon was drained, and fish that exited the lagoon during the draining process were stranded in the shallows and mud flats of the Clinch. An immediate rescue operation of the stranded fish was conducted, and fish that could be netted were relocated to deeper water. The estimate of dead fish was 500 to 1000, consisting primarily of small young sunfish and mosquitofish and some carp and golden shiners. The weir installation was completed on March 29, 1989, and the lagoon was refilled. Repopulation of the lagoon by fish was observed within several weeks of the incident.

Another fish kill occurred on November 27, 1989, and an intensive investigation by ORGDP Environmental Management and ORNL Environmental Sciences Division (ESD) personnel was initiated immediately to determine the magnitude and cause of the kill. Daily surveys of the lagoon were conducted by ORNL ESD personnel for the next 3 weeks, and small numbers (two to three) of freshly dead fish were observed each day. Large numbers of living fish were observed in the lagoon during each of the surveys. The numbers of dead fish continued to decline over the next several weeks until no dead fish were observed; the surveys were terminated on January 15, 1990. At this time the total number of dead fish collected during the fish kill was 175, consisting primarily of young-of-the-year sunfish, adult mosquitofish, and gizzard shad. Water quality data were obtained from the lagoon during the period when the surveys were conducted, and a sampling study to characterize the five influent streams to the lagoon was conducted from December 1 to December 22, 1989. The pH and dissolved oxygen content of the influent streams were found to be within acceptable limits for fish; however, the total residual chlorine (TRC) concentrations in two of the influent streams were found to be at levels high enough to be acutely toxic to fish, while concentrations in another of the streams were high enough to result in chronic toxicity. Although mean temperatures of the influent streams were often 5 to 6°C higher than those of the lagoon, the lagoon temperatures were within tolerance limits for those species inhabiting the pond. Fish, particularly young-of-the-year sunfish, are attracted to warmer water during the fall and winter and in this case may have been exposed to toxic levels of TRC in the influent streams. This fish kill was very similar to a fish kill that was first observed at this location on December 14, 1988, and a comparative study of the two incidents was conducted by ORNL ESD personnel. TRC concentrations in the December 1988 incident were also found to be high enough to be toxic to fish. Another striking similarity between the two incidents was that they both occurred at approximately the same time of the year, late fall or early winter, when the shallow lagoon cools much more rapidly than the water withdrawn by the K-1515 Sanitary Water Plant from the larger Clinch River. This may result in

incomplete mixing of the lagoon and influent waters, resulting in the warmer, lower-density influent water that contains high levels of TRC overlaying the cooler, denser lagoon water. This warmer surface layer may trap very small, young-of-the-year fish that usually inhabit the shallower areas of the pond. Based on this comparative study and the investigation conducted for this incident, which included the evaluation of data collected during the influent stream characterization, it was concluded that high TRC levels were the most probable cause of the fish kill. Seasonal changes that result in substantial differences in temperature between the influent waters and the lagoon were probably a major factor influencing the time of occurrence and magnitude of the initial kill. As a result of the investigation, an engineering study was initiated to determine facility modifications necessary to continue operations at the K-1515 Sanitary Water Plant without discharging to the lagoon.

6.3.2 Study of Rainfall Infiltration to the ORGDP Sewer System

A study to identify sources of rainfall infiltration to the ORGDP sewer system was conducted during 1989. This infiltration contributes to hydraulic overload conditions that occur during periods of heavy rain and result in diversions from the extended aeration unit of the sewage treatment facility to the Imhoff holding tanks. During these diversions, solids from the sewage plant effluent are settled into the Imhoff tanks, and the effluent is then disinfected with chlorine. Following a dechlorination step, the effluent is discharged through the normal NPDES monitoring station. Two noncompliances with the NPDES permit occurred in 1989 when diversions to the Imhoff tanks were occurring. The infiltration study will be completed in June 1990, and funds to refurbish the sewer system have been allocated in the FY 1991 budget. Procedure reviews and additional personnel training were completed during 1989 to minimize the impact of these diversions. Interim measures that include continuous coverage at the facility during heavy rainfall to ensure all possible preventive actions to avoid permit exceedances are taken, and installation of additional flow capacity from the Imhoffs to the chlorine contact basin have been implemented until the infiltration can be corrected.

6.3.3 K-1435 Toxic Substances Control Act Incinerator

The K-1435 TSCA Incinerator, which was built to thermally destroy PCBs and other organic hazardous wastes, has undergone another series of testing to meet the requirements of the RCRA. RCRA testing done in 1988 proved to be inconclusive; therefore, the Tennessee Department of Health and Environment (TDHE) required a retest.

An outside contractor was hired to perform the sampling and analytical activities for the RCRA retest; these were conducted in June 1989. Results from the tests were submitted to the TDHE and the EPA for approval in September. The TDHE/EPA reviewed the results and gave approval in November. The TDHE plans to modify the RCRA permit to include the conditions that were demonstrated during the trial burn. Current plans are to issue the final permit sometime in April 1990.

During the RCRA trial burn, a catastrophic failure of the induced-draft fan occurred. The incinerator was shut down while a Type B investigation was done to try to determine the cause of the failure. A new fiberglass fan has been installed, and final approval from DOE is being sought for restart.

Current plans are to complete the required TDHE air compliance tests for lead, beryllium, and nitrogen oxide emissions. After these tests are completed, all permitting requirements will be fulfilled and full operation can begin. This should be in the fall of 1990.

6.3.4 Closure of K-1407 B and K-1407 C Ponds

The K-1407 B and K-1407 C Ponds are currently being clean-closed under RCRA. The hazardous sludge from both K-1407 B and K-1407 C Ponds has been removed, and verification

activities are under way to determine if any contamination still exists in the ponds. During these sampling activities, radioactive contamination was encountered in the samples submitted for analysis. Because radionuclides fall under the jurisdiction of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the appropriate personnel were notified and site RCRA closure activities were halted.

Working in conjunction with the EPA, TDHE, and DOE, ORGDP has proposed a strategy to determine the nature and extent of the radionuclide contamination. Closure of the ponds will be postponed until a remedial investigation in accordance with CERCLA can be conducted and the threat posed by radioactive contamination to human health or to the environment can be determined. The closure plans have been modified to include the proposed strategy and will be submitted to the EPA and TDHE for approval.

6.3.5 ORGDP Spill Report

A total of 45 spills occurred at ORGDP during 1989. Each spill was investigated by the ORGDP Environmental Management Department to review cleanup activities. Only one reportable quantity for spilled material was exceeded during 1989. The various types of spill and the associated frequencies are shown in Fig. 6.3.1.

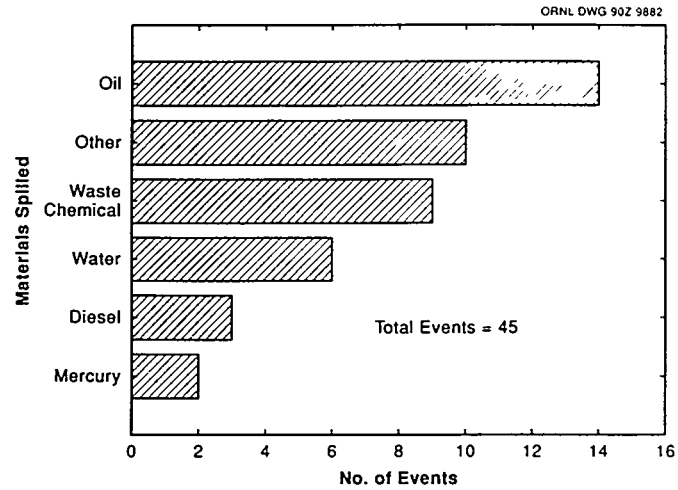

Fig. 6.3.1. 1989 ORGDP Plant spills summary.

6.3.6 Dioxins from Pentachlorophenol-treated Wood—ORDGP

In the past, the cooling towers at ORGDP were treated by the Martreat process, steam sterilization, microbiotreatment, or a phosphate-based method. The Martreat process used a metallic salt and arsenic acid in the first stage and a chromate application in the second stage. The steam sterilization primarily consisted of steam cleaning the cooling towers. A microbiotreatment process was used at the centrifuge facility cooling tower. The phosphate treatment process is the method now being used at the K-1037 cooling tower. During the survey, it was discovered that a pentachlorophenol (PCP) was also used for treatment in the early 1960s. Since it was discovered that PCP treatment was used at ORGDP, a sample was collected from the K-901-A Holding Pond, which received blowdown from the process cooling towers, to determine if decomposition products from PCPs, such as dioxins and furan compounds, were present in the pond sediments. The sample consisted of a composite of five core samples taken in a profile across the pond. Each core sample consisted of approximately 3 ft of sludge.

The results of this sample indicate that the concentration of dioxins and furan compounds was very low. This information was provided to ORNL's Environmental Sciences Division personnel for their evaluation. After their review of the data, the following conclusions were submitted to ORGDP.

Analysis of the K-901-A pond sediment found very low concentrations of octachlorodibenzodioxin (OCDD), heptachlorodibenzofurans (heptaCDF), and octachlorodibenzofuran (OCDF). These are major impurities in commercial PCP and thus are not unexpected in a pond receiving blowdown from PCP-treated cooling towers. Sediments from the C-616-E pond at the Paducah Gaseous Diffusion Plant (PGDP), which also received such blowdown, contained substantially higher concentrations of

these substances; 36,600 vs 440 parts per trillion (ppt) OCDD, 3000 vs 610 ppt OCDF, and 1400 vs 1000 ppt heptaCDF at PGDP and ORGDP, respectively. The substances detected do not have high toxicity relative to 2,3,7,8-tetrachlorodibenzodioxin (2,3,7,8-TCDD), the notoriously toxic "dioxin." OCDD and OCDF do not exhibit enough toxicity in tests to be given Toxicity Equivalence Factors (TEFs), which estimate toxicity relative to 2,3,7,8-TCDD. HeptaCDF has a TEF of 0.001.

If sediment concentrations are used to estimate concentrations of these substances in fish, a 1:1 correspondence is a good approximation. Thus, 1000 ppt heptaCDF (the worst-case substance detected in K-901-A sediment) suggests a likely concentration of 1000 ppt in fish from that site. This would be toxicologically equivalent (using the TEF) to 1 ppt 2,3,7,8-TCDD in fish. The Federal Drug Administration's recommended limit in fish for human consumption is 25 ppt.

The ratios of TCDD, pentachlorodibenzodioxins (PCDD) tetrachlorodibenzofurans (TCDF), and pentachlorodibenzofurans (PCDF) to OCDD found in treated wood at PGDP were used to estimate the concentrations of these more toxic substances that might be present in K-901-A sediments, based on the measured OCDD concentration. Estimated concentrations by this procedure were 0.1 and 1 ppt for TCDD and PCDD, and 0.4 and 6 ppt for TCDF and PCDF, respectively. All are toxicologically equivalent to less than 1 ppt 2,3,7,8-TCDD in sediments.

Thus, although it appears as though PCP leachate and/or wastes have entered K-901-A pond, dioxin concentrations do not approach levels warranting concern.

It is not believed that biotic sampling is needed, given the results of the sediment analysis and the absence of a continuing source of PCP leachate to the pond, as well as the relatively minor changes in water level associated with the weir modifications.

The K-901-A Holding Pond is a Solid Waste Management Unit for which a RCRA Facility Investigation will be performed. Additional samples will be collected at that time on a statistical basis for this unit. The current information has been given to the Office of Risk Analysis at ORNL to determine if the data are sufficient to perform a risk assessment or if more data will be needed to make an assessment.

During the survey, an effort was also made to determine where cooling tower debris may have been disposed of in the past. In reviewing the information and discussing this with employees (as well as retired employees), the areas of disposal are as follows:

K-1064 Burial Area/Peninsula Storage
Poplar Creek Disposal Area (Roane Substation Site)
K-1099 Blair Quarry
K-770 Scrap Metal Yard
K-1070-F Contractors Burial Ground (Potential)

All of these units except for the Poplar Creek Disposal Area (Roane Substation) belong to the Tennessee Valley Authority and are being addressed under the Remedial Actions Program at ORGDP.

Based upon the information currently available, it is believed that the past use of PCPs to treat cooling tower wood has not caused an environmental issue, as indicated in the laboratory data. The cooling towers and the K-901-A Holding Pond will be sampled in detail as part of the characterization for the remedial action characterization process.

The cooling towers that are now in use and the treatment method used are as follow:

Cooling tower location	Treatment method
K-1004-L	Chlorine
K-1006	Chlorine
K-1580	Chlorine
K-801	Chlorine and Betz 562, Betz 35A[a]
K-822	Chlorine and Betz 2020, Betz 2060A[a]

[a]Treatment chemicals contain proprietary information.

These cooling systems may also be treated with a biocide if the bacteria levels are not adequately controlled with chlorine. The cooling system at K-1007, although not a cooling tower, receives a Betz 508 slimicide treatment for bacteria control.

The only waste that is generated from the treatment of these cooling towers would be in the blowdown that is discharged through a monitoring location. These cooling towers or any others at ORGDP that may be repaired or torn down and generate wood for disposal will be sampled for dioxins and furan compounds prior to disposal.

6.4 BIOLOGICAL MONITORING AND ABATEMENT PROGRAM (BMAP)

6.4.1 Bioaccumulation Studies

Biological Monitoring and Abatement Programs (BMAP) mandated by NPDES permits at the Y-12 Plant, ORNL, and ORGDP each contain tasks concerned with monitoring the accumulation of contaminants in the biota of receiving waters. The primary objectives of these studies are (1) to identify substances that accumulate to undesirable levels in biota as a result of discharges from DOE facilities, (2) assess the significance of those discharges relative to other sources in determining contaminant concentrations in biota in receiving waters, and (3) to provide a baseline measure of biotic contamination to use in evaluating the effectiveness of any future remedial measures.

Elevated concentrations (relative to local reference sites) of mercury and PCBs in biota are associated with NPDES-regulated discharges at all three facilities. Concentrations of these substances in redbreast sunfish (*Lepomis auritus*) have been monitored twice yearly since 1985 at five sites in EFPC downstream from the Y-12 Plant (Fig. 6.4.1). A clear trend of decreasing mercury concentrations in sunfish with increasing distance below the New Hope Pond/Lake Reality discharge is apparent (Fig. 6.4.2), and the mean concentrations of mercury in fish at specific sites have not exhibited an increasing or decreasing trend relative to concentrations observed in 1984 in the Oak Ridge Task Force Study (TVA 1985). Mean mercury concentrations have continued to approach or exceed the FDA action level of 1 $\mu g/g$ at sites in the upper third of EFPC. A similar pattern of decreasing concentration with distance downstream is apparent for PCBs in redbreast sunfish (Fig. 6.4.3). After increasing during 1986–1987, PCB concentrations in EFPC sunfish appear to have returned to the levels observed in 1985.

Bluegill sunfish (*Lepomis macrochirus*) were collected in the fall of 1988 at sites near discharge sources and in the Clinch River/Watts Bar Reservoir to substantiate the 1987 finding that mercury and PCB inputs from upstream sources were barely discernable in this species in those larger bodies of water downstream from DOE facilities (Figs. 6.4.4 and 6.4.5). Elevated concentrations of mercury were clearly evident in fish from EFPC, Poplar Creek, Bear Creek, Mitchell Branch, and White Oak Creek (WOC). Fish from the Clinch River below the mouth of Poplar Creek contained slightly higher concentrations than fish from the reference site or fish from sites in the Clinch River upstream from the mouth of Poplar Creek. The mean mercury concentration was highest at East Fork Poplar Creek kilometer (EFK) 23.4 below the outfall of New Hope Pond/Lake Reality but did not exceed the FDA limit at any site. Bluegill from the Clinch River several kilometers downstream from the mouth of Poplar Creek had a mean mercury concentration that was only slightly higher than that in fish from the reference stream (0.14 vs 0.09 $\mu g/g$ wet wt, respectively).

The pattern of PCB contamination observed in this study closely resembles that of mercury (Fig. 6.4.5). The highest mean concentration was found at Mitchell Branch at the ORGDP, and PCBs were elevated in fish from WOC, EFPC, lower Poplar Creek, and Bear Creek. PCB concentrations in bluegill from sites in the Clinch River below ORNL and below the mouth of Poplar Creek were not higher than those in fish from the reference site.

Sunfish serve as good indicators of PCB contamination, particularly in small streams close

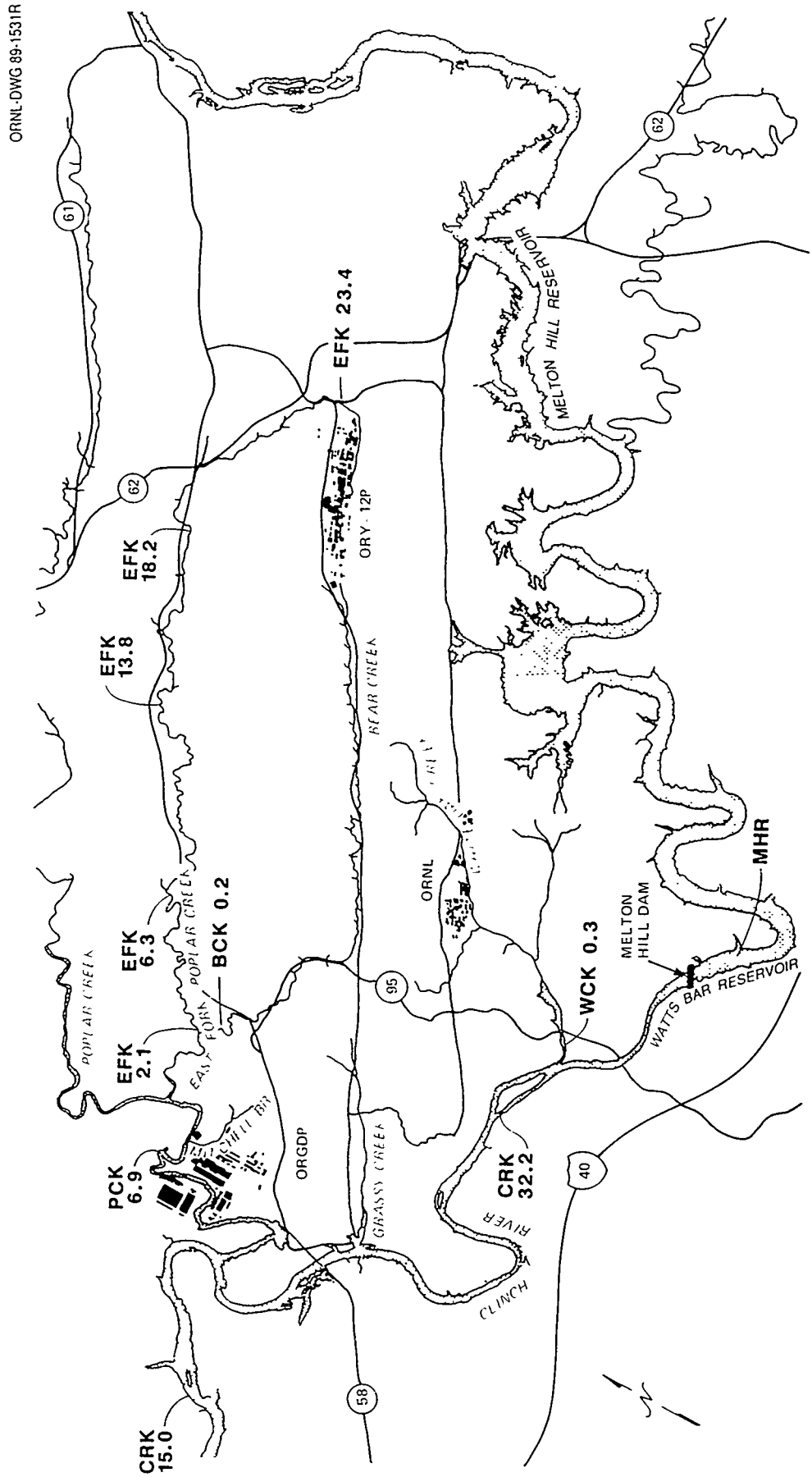

Fig. 6.4.1. Locations of channel catfish and redbreast sunfish collection sites for BMAP bioaccumulation studies.

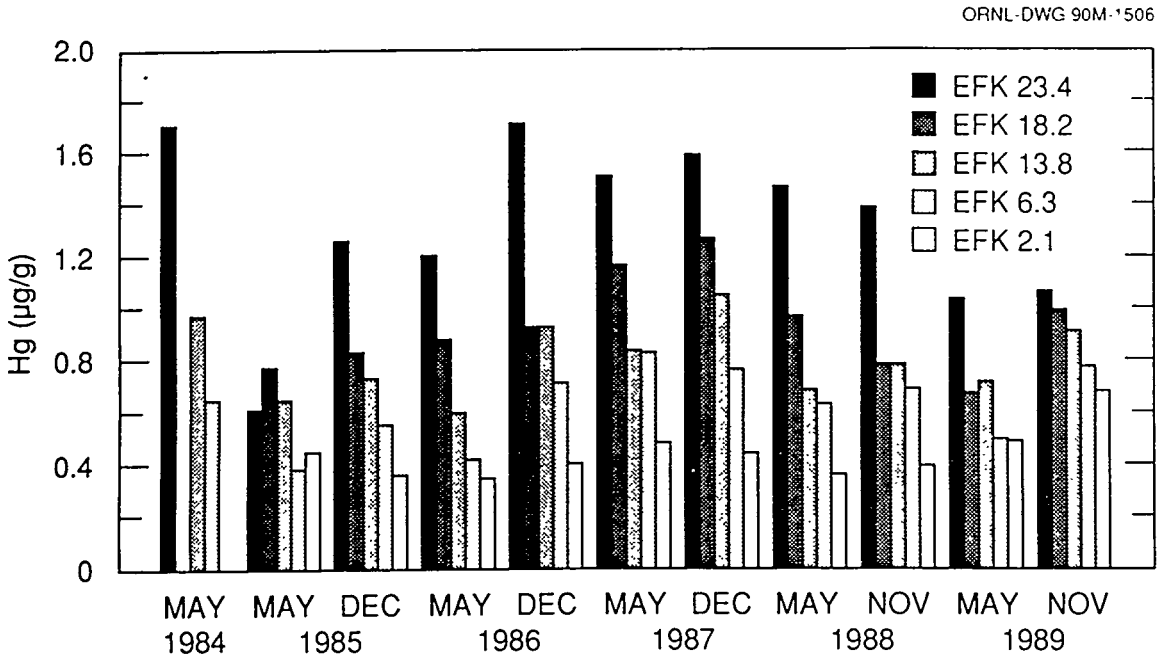

Fig. 6.4.2. Average concentrations of mercury in redbreast sunfish (n = 8) collected at sites in East Fork Poplar Creek, 1984–1989. The 1984 data are from the Oak Ridge Task Force study. *Source:* Tennessee Valley Authority, *Instream Contaminant Study, Task 4: Fish Sampling and Analysis,* Report to DOE, Oak Ridge Operations Office, Tennessee Valley Authority, Office of National Resources and Economic Development, Knoxville, Tenn., 1985.

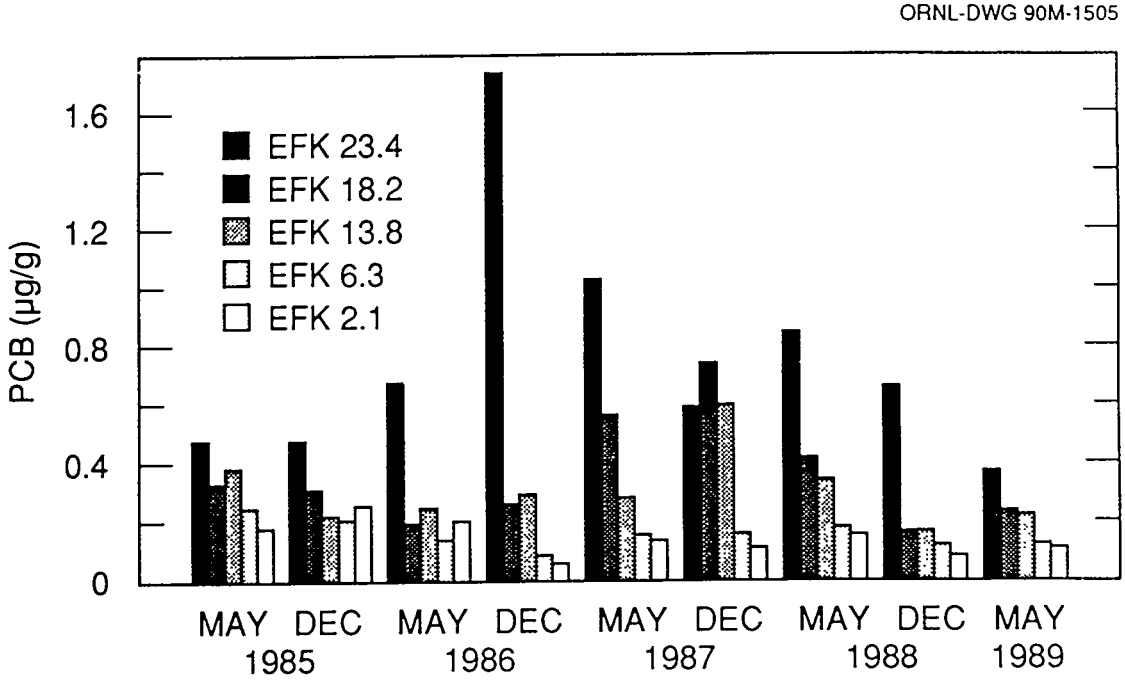

Fig. 6.4.3. Average concentrations of PCBs in redbreast sunfish (n = 8) collected semiannually at sites in East Fork Poplar Creek, 1985–1989.

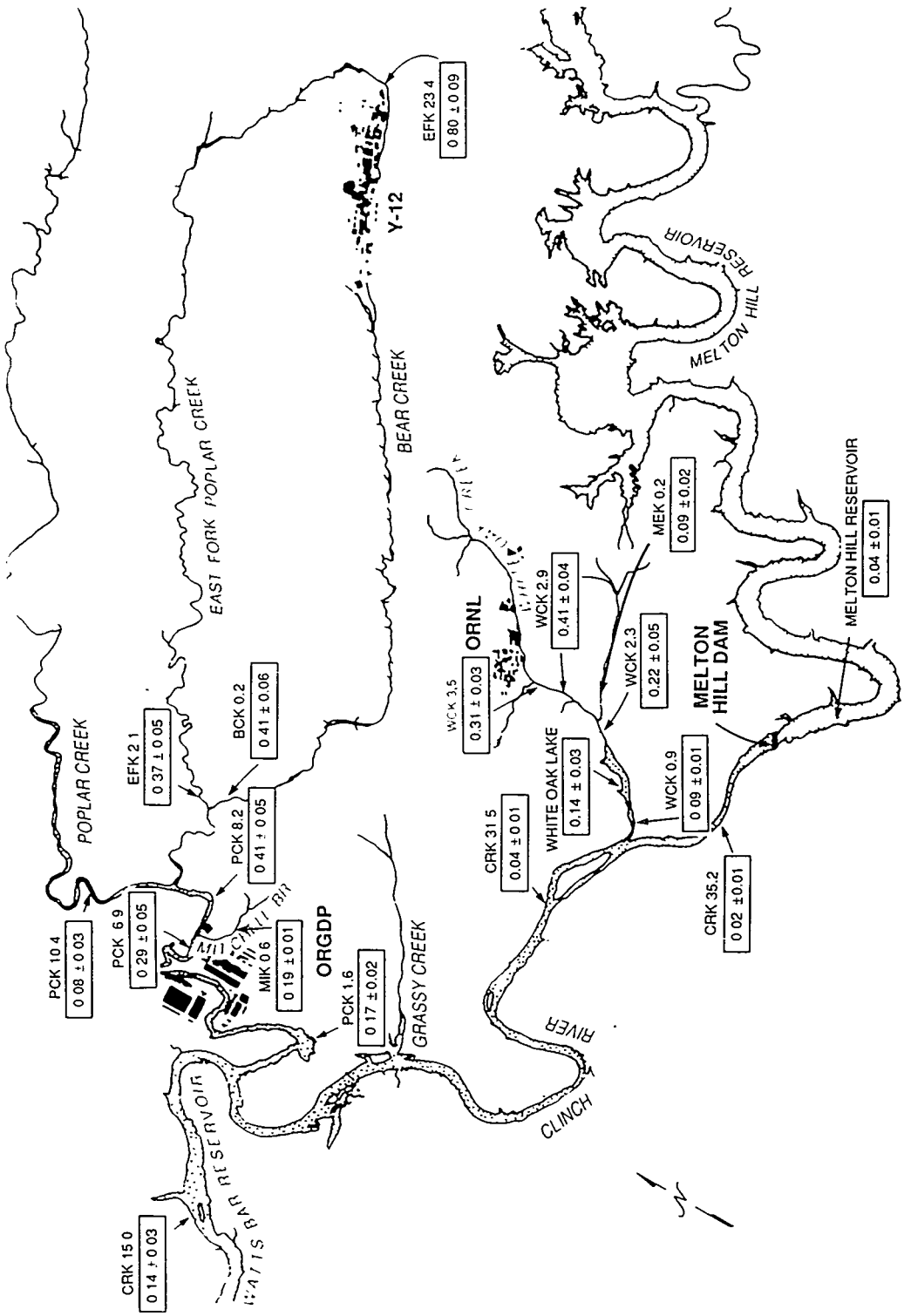

Fig. 6.4.4. Average concentrations (± 1 SE) of mercury (μg/g, wet wt) in bluegill collected in fall/winter 1988 at sites on the Oak Ridge Reservation. Fish at MIK 0.2 and BCK 0.2 were mixed sunfish species (*Lepomis auritus* and *L. macrochirus*) and rock bass (*Ambloplites rupestris*), respectively.

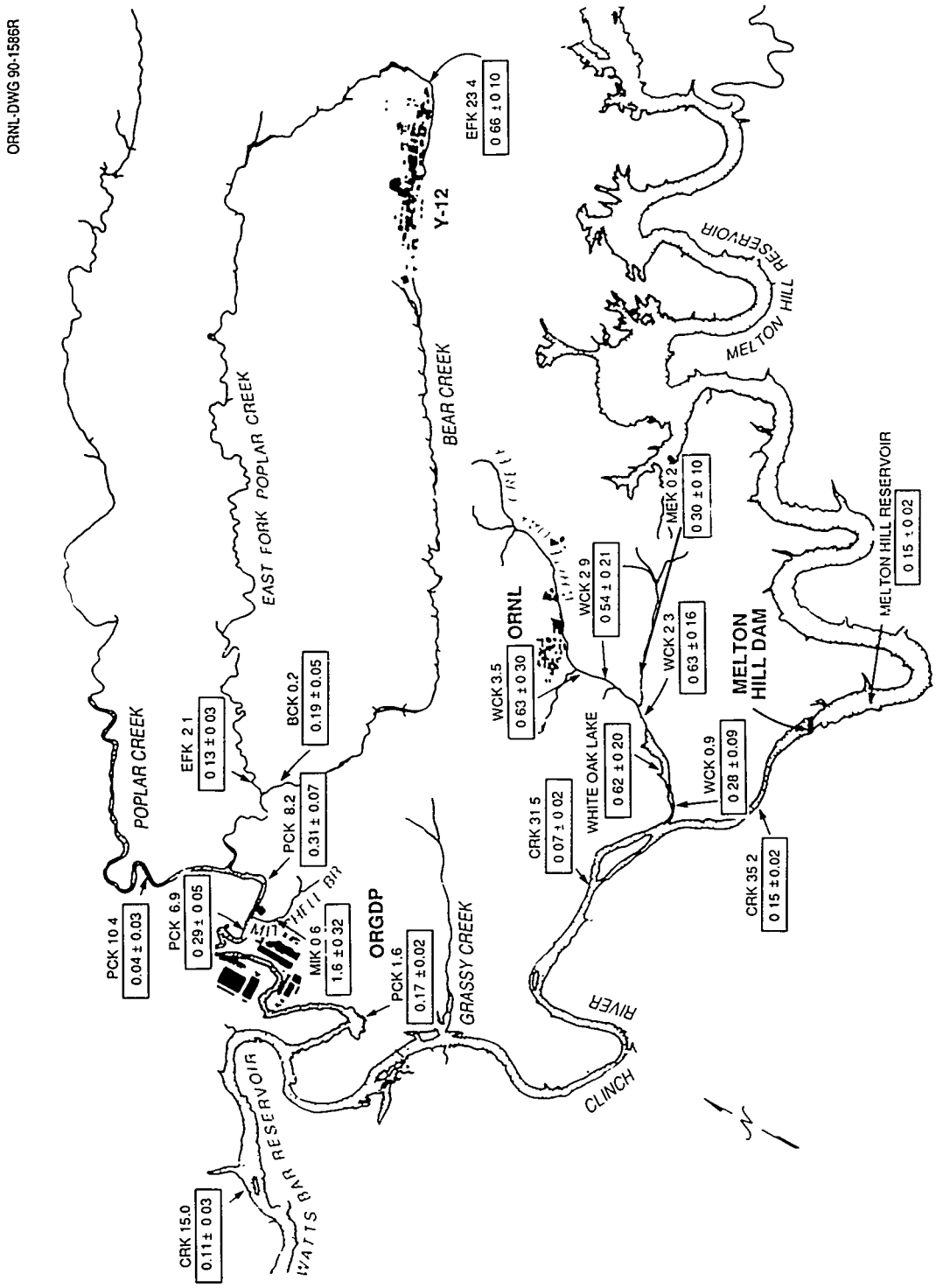

Fig. 6.4.5. Average concentrations (±1 SE) of PCBs (μg/g, wet wt) in bluegill collected in fall/winter 1988 at sites on the Oak Ridge Reservation. Fish at MIK 0.6 and BCK 0.2 were mixed sunfish species (*Lepomis auritus* and *L. macrochirus*) and rock bass (*Ambloplites rupestris*), respectively.

to specific sources, but they do not accumulate PCBs to the extent that longer-lived, fattier fish like catfish and carp do. Channel catfish (*Ictalurus punctatus*) have been found to contain PCBs approaching the FDA limit (2 μg/g) in several reservoirs in East Tennessee, including Watts Bar Reservoir (TVA 1985). As a result of finding that PCB concentrations exceeded the FDA limit in all channel catfish collected in WOC embayment in 1984 by the Oak Ridge Task Force, annual PCB monitoring in this species was initiated in 1986. Routine collection sites (Fig. 6.4.1) were selected to assess the relative contributions of PCB sources in the WOC and Poplar Creek drainages to PCB concentrations in Clinch River catfish. Results of this monitoring in 1986–1989 are presented in Table 6.4.1. PCB contamination was evident in catfish at all sites in 1989 as was the case in previous years. The highest mean concentrations occurred in WOC embayment and the Clinch River near the mouth of WOC, but the concentrations in 1989 were within the ranges observed at both sites previously. PCB concentrations in catfish collected in 1989 from lower Poplar Creek and the Clinch River near ORGDP were slightly lower than those found near ORNL, but they were nevertheless high enough to support the Precautionary Fish Consumption Advisory issued by TDHE for the Clinch River arm of Watts Bar Reservoir. Although fish from Melton Hill Reservoir contained lower concentrations in 1989 than in previous years, they continue to indicate that a significant portion of the PCB contamination in catfish in the Clinch River near ORNL and ORGDP may come from upstream sources.

Chlordane contamination was detected in clams placed in cages in WOC at ORNL in 1988 and was confirmed by additional sampling of clams and sediment in 1988 and 1989. The contamination appears to originate between the 6000 and 7000 areas, with the highest concentration in clams associated with a small tributary entering WOC from the south at White Oak Creek kilometer 5.4. Chlordane contamination was not found in fish collected from WOC in 1989. Channel catfish from the Clinch River near ORNL contained detectable levels of chlordane; however, the concentrations (approximately 0.05 μg/g) were relatively low and did not differ from concentrations found in catfish from Melton Hill Reservoir upstream.

6.4.2 Waterfowl on the Oak Ridge Reservation

Resident or migratory waterfowl can be found on ponds and settling basins on the ORR. Waterfowl utilizing these waste disposal ponds and

Table 6.4.1. Changes in the mean concentrations of PCBs (μg/g wet wt) in channel catfish during 1986–1989 and fraction of fish exceeding the Food and Drug Administration (FDA) limit of 2 μg/g

Sampling site[a]	PCBs				Fraction over FDA limit			
	1986	1987	1988	1989	1986	1987	1988	1989
WCK[b] 0.3	1.30	1.59	0.96	1.54	3/12	2/8	2/8	4/8
CRK[c] 32.2	1.01	1.61	0.58	1.20	0/8	2/8	1/8	1/8
Melton Hill Reservoir	0.46	0.81	0.52	0.28	0/6	1/7	0/10	0/8
PCK[d] 6.9			0.71	1.07			0/8	1/8
CRK 15.0			0.50	0.79			0/9	1/8

[a]Site locations are shown in Fig. 6.4.1.
[b]WCK = White Oak Creek embayment.
[c]CRK = Clinch River.
[d]PCK = lower Poplar Creek.

settling basins are capable of accumulating radionuclides and migrating off the ORR, where they may be harvested and consumed by hunters. It has generally been assumed that (1) most of the waterfowl frequenting these ponds and settling basins are migratory and only remain there for a few days or weeks, (2) the amount of radioactivity they accumulate in their tissue is insignificant, and (3) the number of waterfowl using these contaminated ponds is so small that the probability of a hunter harvesting more than one bird that had spent some time on these ponds is very small.

A weekly waterfowl census of 11 sites at ORNL was initiated in October 1987. Observations at locations near the ORGDP and at the Y-12 Plant were initiated in October 1988 and February 1989, respectively. Since 1987, more than 16,000 observations of waterfowl have been recorded at designated locations on the ORR. The waterfowl species observed on the ORR are listed in Table 6.4.2. The species observed most frequently and in the greatest abundance included Canada geese, wood ducks, black ducks, gadwalls, and mallards.

Table 6.4.2. Species of waterfowl observed on the Oak Ridge Reservation

Common name	Scientific name
American black duck	*Anas rubripes*
American coot	*Fulica americana*
American widgeon	*Anas americana*
Blue-winged teal	*Anas discors*
Canada goose	*Branto canadensis*
Gadwall	*Anas strepera*
Greater scaup	*Aythya marila*
Green-winged teal	*Anas carolinensis*
Hooded merganser	*Lophodytes cucullatus*
Lesser scaup	*Aythya affinis*
Mallard	*Anas platyrhynchos*
Pied-billed grebe	*Podilymbus podiceps*
Ring-necked duck	*Aytha collaris*
Wood duck	*Aix sponsa*

6.4.2.1 Transient waterfowl

Approximately 9500 observations of waterfowl have been made at ORNL since October 1987; White Oak Lake (WOL) and the Swan Pond were the sites most frequently used by waterfowl. Canada geese and mallards nested on the Swan Pond, and wood ducks nested in the vicinity of WOL. The waterfowl population on WOL fluctuated throughout the year, ranging from 0 to 200 birds per census (Fig. 6.4.6). Transient mallards, black ducks, gadwalls, American widgeons, mergansers, blue- and green-winged teal, and Canada geese have been observed on WOL.

Transient waterfowl species collected from WOL averaged 234 Bq/kg of ^{137}Cs in breast tissue; the maximum concentration was 340 Bq/kg. Higher concentrations were observed in the gastrointestinal tract and gizzard contents; however, liver concentrations approximated those of breast tissue. If an individual consumed 160 g of contaminated tissue at the maximum concentration of ^{137}Cs observed in breast tissue, the potential effective dose equivalent would be 0.73 μSv (73 μrem). To attain a dose of 1 mSv (100 mrem), 218 kg of such tissue would have to be consumed.

6.4.2.2 Canada geese

Canada geese use many of the small ponds on the ORR for nesting purposes. A pair of geese that were using a former waste disposal basin (Basin 3524) were collected in March 1989 and analyzed for ^{137}Cs and ^{90}Sr. Although the geese only used the pond area for approximately 1 month, the concentrations of ^{137}Cs in the breast tissue of the two geese were 150,000 and 106,000 Bq/kg (Table 6.4.3). The potential dose commitment to humans from consuming approximately 1400 g of breast tissue from the goose with the maximum concentration of ^{137}Cs would be 2.68 mSv (268 mrem).

The waterfowl census conducted in 1989 indicates extensive use of ORR aquatic systems by Canada geese. Approximately 6000 observations of geese were recorded for census sites at or near ORGDP. The most frequently used sites were Poplar Creek, K-1007 Holding Pond, and the grassy areas throughout the ORGDP environs.

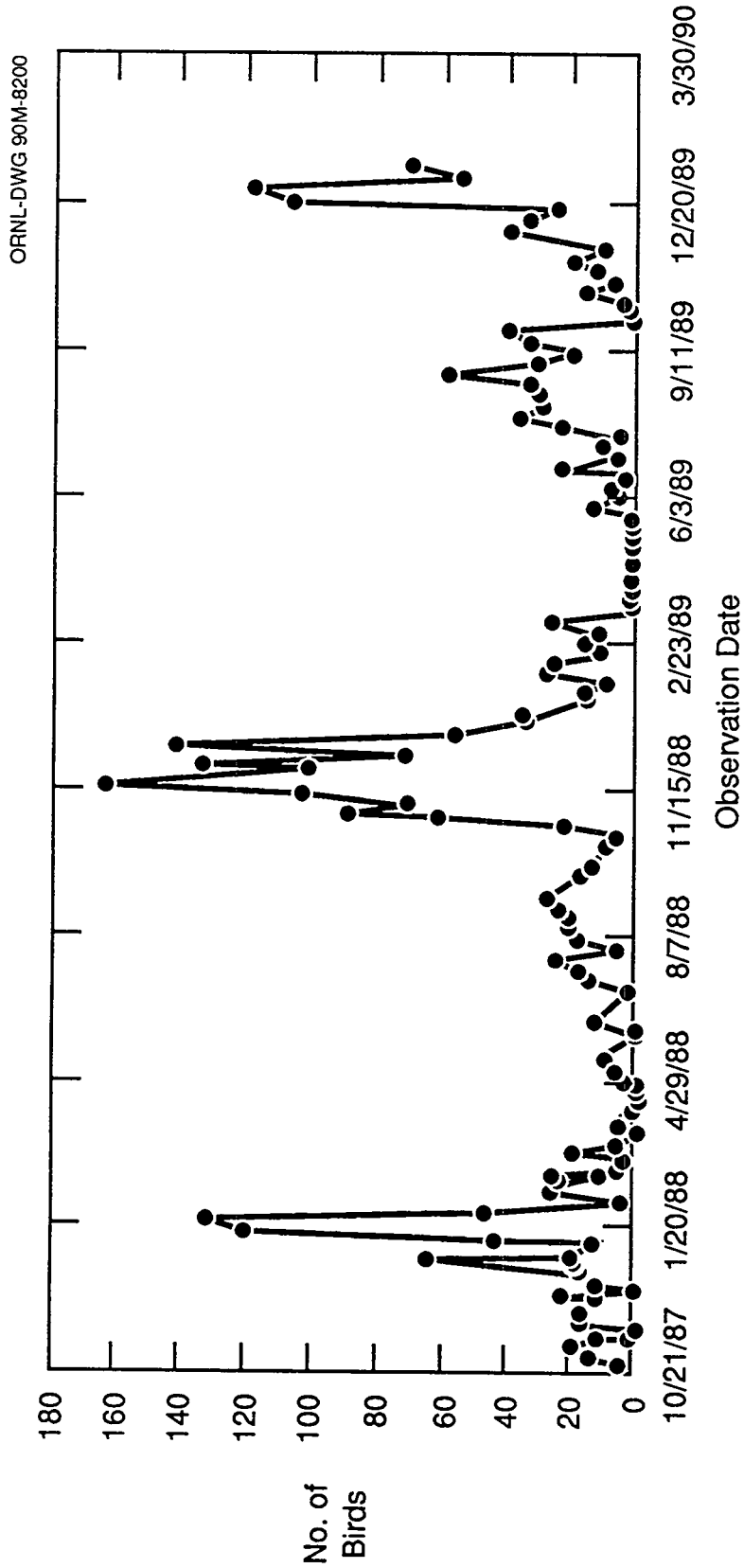

Fig. 6.4.6. Total number of waterfowl observed on White Oak Lake during weekly census from October 1987 to January 1990.

Table 6.4.3. Cesium-137 concentrations in tissues of Canada geese collected on Pond 3524 within the ORNL compound

Goose identification	Concentration (Bq/kg)			
	Breast tissue	Liver	Gizzard contents	Bone
1	150,000	15,000	55,000	21,000
2	106,000	24,000	66,000	27,000

Most of the geese at ORGDP are probably of a resident population; however, transients used the aquatic systems as resting areas or wintering grounds. Some of the resident geese also use these areas for nesting sites. At the Y-12 Plant, approximately 1500 sightings of geese were recorded in 1989. The maximum number of geese observed during one census at this location was approximately 200. At ORNL, geese have been observed on the Swan Pond, WOL, and throughout the ORNL compound.

Because of the extensive use of the ORR by Canada geese, a study to determine their movement patterns and interactions with other local flocks was initiated in 1989. In cooperation with the Tennessee Wildlife Resources Agency, a total of 283 Canada geese were fitted with both leg and neck bands during June 1989, at locations on and near the ORR. Provided by the U.S. Fish and Wildlife Service, the neck bands consisted of white plastic collars with numbers and letters large enough to be identified with binoculars or a spotting scope so individual geese could be identified without capture.

Although many of the geese banded at ORGDP still use the area, movement to other areas has been observed. Groups of geese observed at the Y-12 Plant included birds that had been banded at the Y-12 Plant, Solway, and Clark Center Park. Flocks on Melton Hill Reservoir have included individuals from numerous banding sites, and geese banded at ORNL have been observed at Melton Hill Dam. These observations demonstrate that potentially contaminated geese move off the reservation to public areas. See Sect. 6.4.5 for further discussion.

6.4.3 Growth and Survival of Introduced Clams in East Fork Poplar Creek

Results from in situ bioassays with the fingernail clam *Sphaerium fabale* in 1988 showed that both growth and survival were reduced in upper EFPC near the Y-12 Plant compared to several local reference streams and a downstream site in EFPC. These results implied that this and other equally or more sensitive invertebrate species may not be able to grow or survive in upper EFPC. Instream sampling of the benthic invertebrate community in EFPC supports this hypothesis; the invertebrate community in upper EFPC is depauperate, and only a few pollution-tolerant taxa can survive there. A follow-up study was conducted to (1) further assess the utility of this method as an alternative biomonitoring tool and (2) investigate whether or not improvements in the water quality may have occurred that would support the growth and survival of this species in upper EFPC.

The sites included in the 1989 study were the same as those used in 1988: two sites on EFPC (EFK 23.4 just below Lake Reality and EFK 13.8 just above the city of Oak Ridge Wastewater Treatment Facility) and one site on each of three minimally impacted reference streams (Brushy Fork, Hinds Creek, and Bull Run). Four trays, each containing 15 individually marked and measured (length) clams, were placed at each of the five sites. At approximately 3-week intervals,

mortality was noted and lengths were taken of all surviving individuals. The trays of clams were exposed at each site for approximately 150 d (mid-June–November).

Survival of clams at EFK 23.4 over the 5-month study was considerably lower than that observed at EFK 13.8 and the three reference sites. Only 52% of the clams placed at EFK 23.4 survived the first 3 weeks of exposure, and only 32% were alive at the end of the study. Survival after 5 months was 75% at EFK 13.8, which was similar to the observed survival rate of 75–80% at the reference sites. Considerable differences were also found in growth of clams between the reference and EFPC sites. By the end of the study, the incremental increase in length of clams placed at the three reference sites was approximately 2.5 and 1.5 times greater than that at EFK 23.4 and EFK 13.8, respectively; length increases by the end of the study ranged from 1.34 to 1.42 mm at the reference sites compared with 0.52 and 0.91 mm at EFK 23.4 and EFK 13.8, respectively.

The results of this study suggest that during the initial exposure period, clams at EFK 23.4 may have been exposed to a toxic concentration of a contaminant that eliminated the most sensitive individuals. The slow growth of the surviving individuals at EFK 23.4 compared with the reference sites suggests that chronically toxic conditions or elevated temperatures may adversely affect clam survival and growth below Lake Reality. Although some downstream improvement occurred at EFK 13.8, the reduction in clam growth there compared to the reference sites is indicative of adverse ecological conditions due to either Y-12 Plant operations, urbanization, or both.

Although insufficient replication in the 1988 studies precluded direct statistical comparisons between the two years, the trends in survival and growth between years for a given site and between sites within each year were generally similar. However, major differences between years were noted in survival at EFK 23.4 and growth at EFK 13.8. Clams placed at EFK 23.4 appeared to survive better in 1989 than in the previous year. Although this trend may possibly be indicative of improved water quality at this site, it may also be the result of insufficient replication in the 1988 bioassays, which prevented the detection of possible tray/handling effects. Growth of clams at EFK 13.8 was similar to that of clams at the reference sites during the first 65 to 70 d of both the late 1988 and the 1989 study. In the most recent bioassay, however, differences in growth between these sites were not detectable until after approximately 90 d, suggesting the need for a longer exposure period. The ability of this bioassay to detect clear trends and obtain reproducible results suggests that this method may be a valuable tool for assessing the effects on aquatic invertebrates of chronic exposure to contaminants.

6.4.4 Use of an Index of Biotic Integrity to Assess Temporal Changes in Fish Communities of BMAP Receiving Streams

The BMAPs for the three DOE facilities on the ORR include a task to assess the impacts of plant operations on fish communities in the receiving streams, and a major component of this task is application of the Index of Biotic Integrity (IBI). Biotic integrity is defined as "the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region."

The IBI is an impact assessment methodology that incorporates data on fish species richness and composition, trophic composition, and abundance and condition. Twelve individual metrics within these three categories are ranked on a scale of 5, 3, or 1 and then summed to provide a numerical index that rates the biotic integrity of the fish community from excellent to very poor. Because the IBI was developed for use on streams in the Midwest, several metrics were modified to represent expected conditions for streams in East Tennessee. In addition, data on fish species richness and abundance at numerous sites on minimally disturbed streams in the Hinds Creek

watershed northeast of Clinton, Tennessee, were plotted as a function of watershed area to estimate maximum IBI metric values.

When the fish communities in EFPC were analyzed for the period 1985–1988 by using the regionally modified IBI, both temporal and spatial improvements in the IBI ratings were observed (Fig. 6.4.7). The two sites closest to the Y-12 Plant (EFK 23.4 downstream of Lake Reality and EFK 18.2 just below the Route 95 bridge at Jefferson Avenue in Oak Ridge) had the most ratings of very poor (values ≤ 22). Sites further downstream were usually rated higher but never exceeded the reference stream (Brushy Fork), which was generally rated fair (values of 40 to 44). An increase in the IBI rating at the site closest to the Y-12 Plant corresponded in time with the startup of a major new wastewater treatment facility. The improvement was attributable to an increase in species abundance but was not supported by increases in species richness or trophic composition. Temporal improvements in all major categories were also observed at downstream sites, suggesting a broader recovery. These patterns of change in the IBI rating indicate that a gradual and consistent recovery is occurring in EFPC. However, the fish community in EFPC remains more affected than the fish assemblages that inhabit other local streams in watersheds with similar levels of agricultural and urban development.

Use of the IBI to monitor long-term responses of the fish community in EFPC will provide one of the best assessments of the effectiveness of

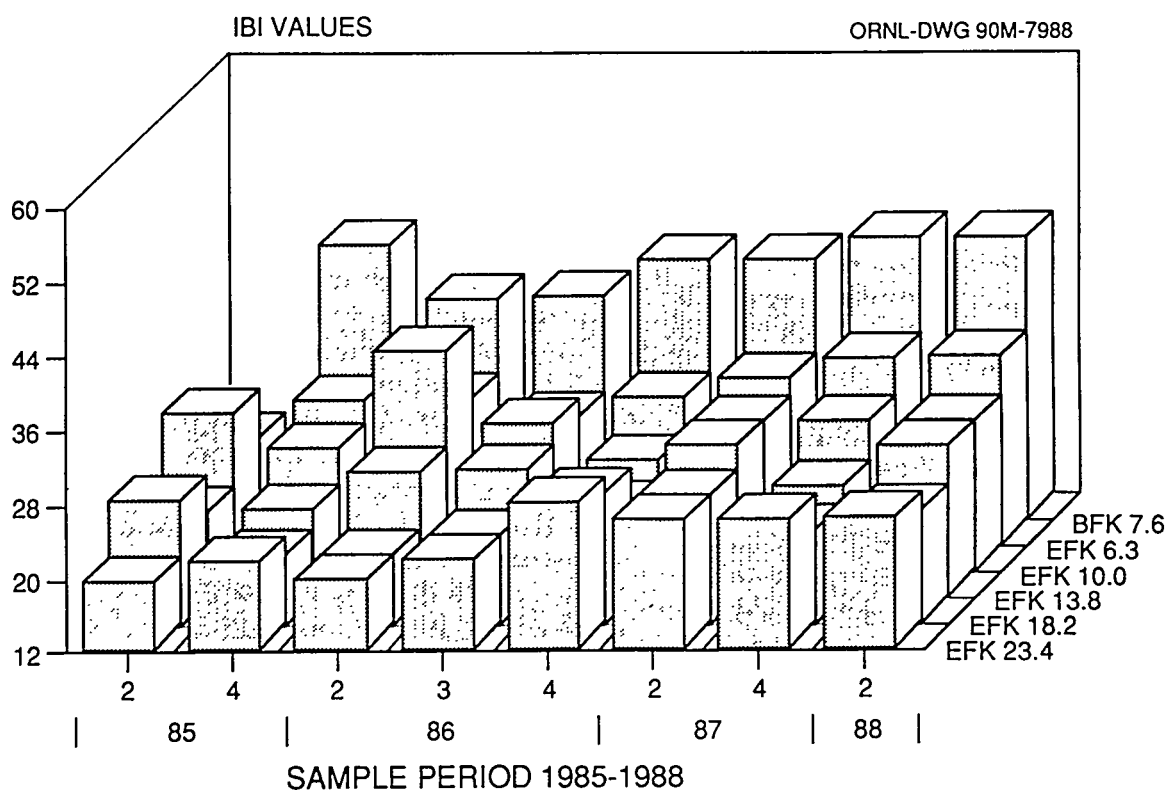

Fig. 6.4.7. Index of Biotic Integrity (IBI) values for fish communities at sites in East Fork Poplar Creek (EFK) and a reference stream, Brushy Fork (BFK), north of Oak Ridge for the 1985–1988 sampling period. IBI values can range from a minimum of 12 to a maximum of 60. The numbers associated with the sampling site designation refer to the distance (km) above the mouth of the stream.

pollution abatement measures and remedial actions. Because the IBI integrates information from several levels of biological organization, ranging from the individual to the ecosystem, it provides a sound ecological basis for assessing water quality. Applications of the IBI will be expanded to examine temporal trends in receiving streams that are included in the BMAPs at ORNL and ORGDP.

6.4.5 Radiological Survey of Canada Geese

The population of resident Canada geese on the ORR has increased over a period of several years. To determine the movement of these geese to plan for hunting season and locations, the Environmental Sciences Division in cooperation with the Tennessee Wildlife Resources Agency conducted extensive tagging of the geese at six locations during mid-June. At that time of year, the birds undergo molting and can be rounded up much like a cattle drive. After capture, the geese were tagged with standard leg bands and loose-fitting throat collars that are visible (with binoculars) at some distance. Several hundred geese were tagged and collared during this study.

A similar roundup was conducted in 1988, but throat collars were not used. Twenty-six selected geese from the 1988 roundup were assayed in a whole-body counter containing a 15- by 15-cm NaI(Tl) detector housed in a massive lead shield. The detection limit for ^{137}Cs in this counter was determined to be approximately 1 pCi/g. To further characterize the ORR geese, a similar program of radiological measurements was performed on 8 to 10 birds from each capture location during the 1989 roundups, with the exception of the Y-12 site (operational difficulties prevented radiological measurements on the few birds tagged here). Thus, 52 geese from ORGDP, Clark Center Park, CARL, Solway Park, and the ORNL Swan Pond were assayed. The gamma-ray spectrum from each whole-body count was examined for the presence of gamma-emitting radionuclides. A special search was concentrated on the photopeak region where ^{137}Cs would be found (this nuclide was the major contaminant in geese captured near ORNL ponds).

None of the 52 geese from the 1989 roundup or the 26 from the 1988 collection yielded ^{137}Cs whole-body concentrations exceeding the detection limit of 1 pCi/g. These measurements indicate that the off-site transport of contamination from ORNL operational areas by Canada geese is of low probability.

The entire flock from the ORNL Swan Pond (13 geese) was collared and assayed in mid-June. The birds were released at the capture location following the measurements. A week or two following the mid-June roundup, these collared geese and an equal number of untagged birds were observed inside the main ORNL enclosure. Plans were initiated to capture the entire flock for subsequent measurements. Three weeks after the initial capture at the Swan Pond, 21 geese, including 11 that were collared earlier, were captured near the aeration pond of the Sewage Treatment Facility. These geese were assayed in the whole-body counter that was set up at the Deer Checking Station on Bethel Valley Road. All of the birds showed measurable uptake of ^{137}Cs, but the concentrations in the untagged geese were only one-third to one-half those of the 11 collared ones that had shown no ^{137}Cs 3 weeks earlier. This indicates that the new birds joined the Swan Pond flock some time after the Swan Pond birds entered the Laboratory. Several of the geese containing higher levels of ^{137}Cs were sacrificed for subsequent laboratory measurements by Environmental Sciences Division personnel. The remainder of the collared birds were returned to the Swan Pond and released. Those geese have been observed to continue residence in the vicinity of the Swan Pond (as of the end of September).

This latter collection shows a potential for off-site transport of radionuclides by Canada geese if such birds are allowed to reside within the ORNL enclosure for any appreciable length of time.

7. QUALITY ASSURANCE AND GENERAL REVIEWS

7. QUALITY ASSURANCE AND GENERAL REVIEWS

An adequate quality assurance (QA) program for environmental monitoring requires the identification, quantification, and control of all sources of error associated with each step in the monitoring program and shall ultimately lead to the prevention of errors. Factors to consider as sources of error or variance include those associated with sample collection, sample handling and preparation, analysis, data reporting, and record keeping. Thus, QA requires systematic control of all phases of the monitoring process.

Energy Systems installations participate in both internal and external quality control (QC) programs. Internally, QC is maintained through procedures and checks that include the following practices:

- use of standardized surveillance procedures,
- use of standard operating procedures (SOPs) for sample collection and analysis,
- use of chain-of-custody and sample tracking procedures to ensure traceability and integrity of samples and data,
- instrument calibration and verification,
- background measurements at sample source and in the laboratory,
- resolution checks and detector alignment for determination of gamma emitter radionuclides,
- yield determinations for radiochemical procedures,
- duplicate analyses for precision checks,
- use of standards to determine accuracy,
- technician and analyst training and qualification, and
- spiked and surrogate sample analysis to determine matrix effects.

Preparation of SOPs is a continually evolving process. In 1988, these procedures for sampling activities were compiled, reviewed internally, and submitted to Region IV EPA for review and comment. The document, entitled "Environmental Surveillance Procedures Quality Control Program," has been revised to reflect the EPA comments. EPA has approved this document for use by Energy Systems. Sample collection procedures addressing each of these areas are generally in place within each Energy Systems installation. While much work has focused on the development of sampling plans containing proper design and collection procedures, additional efforts are needed. Methods and technologies are changing rapidly, and evaluation and incorporation of these must continue.

Each installation maintains SOPs, which are reviewed and updated periodically for the collection and analysis of environmental samples. The analytical laboratories use certified standards from the U.S. EPA or DOE or materials traceable to the National Institute of Standards and Technology (NIST) to establish accuracy, calibrate instruments, determine yields for radiochemical procedures, and standardize methods.

QA and QC officers are appointed to work with the analytical laboratories to monitor the quality of analytical data. The QA/QC officers administer a program that generates QC samples of known composition, and these samples are submitted to the laboratories on an established periodic basis. These samples are prepared using EPA, NIST, or other reliable materials and are submitted as samples of unknown value to the analyst. Additionally, organizations responsible for collecting environmental samples submit blank, equipment rinse, standard, and spiked samples with environmental samples to confirm the integrity of the samples and/or to validate analytical results.

These internal programs form the basis for ensuring reliable results on a day-to-day basis and facilitating the programs for training sampling technicians and laboratory analysts.

In addition to internal QC programs, analytical laboratories at Energy Systems installations participated in several external QA programs in 1989 (see Sect. 7.2).

7.1 FIELD SAMPLING AND MONITORING

7.1.1 Basic Concepts and Practices

Concentrations of contaminants cannot be measured at all locations within a particular area of interest. Therefore, samples must be taken that are representative of the entire area. Any aggregate of sampling units into which an area is divided is called the population of sampling units. For example, if contaminants in pond sediments are of interest, then the population is the entire bottom sediment of the pond. If the bottom sediments are then divided into sampling units of equal size, the sampling units collectively constitute the entire population. Each action of a sampler removes media from one sampling unit; the size of the sample depends on the type of sampler used. A group of sampling units selected from the entire aggregate as representative of the whole population forms a sample (if they are composited) or a set of samples. The units forming a composite sample are typically of equal size, are taken within a defined period of time, and are usually selected at random from the whole population of sampling units.

To make accurate estimates of the population, sampling design and collection procedures must yield samples representative of the population. These designs and procedures must be based on clearly defined objectives. Establishment of standardized procedures for sample collection can reduce overall variability.

Proper and cost-effective application of QA/QC cannot be accomplished without knowing the objectives of the program and the precision and confidence levels expected of the data. Once adequate sampling designs and collection procedures are in place, the quality objective is to collect the sample according to the specified procedure without altering the true nature of the sample.

Because of the changing technologies and regulatory protocols, training of field personnel is a continuing process. To ensure that qualified personnel are available for the array of sampling tasks within Energy Systems, training programs by the EPA as well as private contractors have been used to supplement internal training. Topics addressed include

- planning, preparation, and record keeping for field sampling;
- well construction and groundwater sampling;
- surface water, leachate, and sediment sampling;
- soil sampling;
- stack sampling;
- decontamination procedures; and
- health and safety considerations.

Field quality control samples are collected to evaluate and validate sampling data. These control samples generally include field preservative blanks, equipment rinses, and duplicate samples. Tables 7.1.1 and 7.1.2 in Vol. 2 provide examples of these types of field QC samples.

7.1.2 Air Monitoring

7.1.2.1 Y-12 Plant

Air sampling methods written for the Y-12 Plant detail the preparation of sample filters and air sampling for ambient monitoring of TSP, uranium, and fluorides and procedures for continuous sampling of stack emissions. Continuous flowmeters for stack sampling are in a recall program for calibration certification by the Y-12 Maintenance Department. Meteorological tower sensors are calibrated quarterly by a subcontractor. The flowmeters for TSP samplers are calibrated quarterly by the Y-12 Plant Maintenance Department. Samplers for sulfur dioxide are checked daily by technicians, certified by Maintenance, and subjected to quarterly audits by the state. Field blanks and spiked samples are routinely submitted with each set of fluoride samples.

An additional ambient air sampler for uranium particulates has been added near a new

decontamination facility. Upgrades to the stack monitoring program are addressed in Sect. 2.1 of this report.

7.1.2.2 Oak Ridge National Laboratory

ORNL has SOPs for sampling airborne emissions and ambient air. These procedures include chain-of-custody, analytical requests, recording field data, disposition of forms, collecting sampling media, and reporting system failures and are controlled by the Environmental Sampling Group. Calibration of flow measuring and totalizing instrumentation is conducted every 6 months. Routine maintenance is performed annually. Calibration and maintenance of the meteorological monitoring system is performed quarterly. Calibration and maintenance procedures are controlled by the Environmental Monitoring Group. Both groups are members of the Environmental Monitoring and Compliance Section in the Environmental and Health Protection Division.

7.1.2.3 Oak Ridge Gaseous Diffusion Plant

The ambient air monitoring program at ORGDP has procedures in place for monitor maintenance, sampling, and analysis for each parameter of interest. These procedures are in the Environmental Management Department's *Operating and QA Manual*, which is reviewed and updated as determined by Environmental Management in conjunction with the Maintenance Division and Analytical Chemistry Department.

Procedures that address the requirements for emission monitoring for each operational stack at ORGDP are complete. All stack sampling at ORGDP is conducted according to EPA procedures or modifications of those procedures developed by the ORGDP Quality and Technical Services Organization. Modifications are developed only if the original EPA procedures cannot be used for a particular application or have not been developed for a specific parameter. Such modifications are based on best available information in the field of emissions monitoring for a particular situation.

7.1.3 Water Monitoring

7.1.3.1 Y-12 Plant

Water samples are collected in accordance with EPA guidelines and protocols for appropriate containers, preservation techniques, and chain-of-custody requirements (40 CFR Pt. 136, July 1, 1987). Sampling methods are continually being upgraded to provide the best available techniques and equipment (e.g., automated samplers, flowmeters, and real-time monitoring of specific parameters in various wastewater streams). Field blanks, field replicates, and rinse waters from equipment decontamination are routinely submitted to the laboratory to validate the reliability of a sampling technique. SOPs have been written that document the sample collection methods and ensure that appropriate techniques for installation, calibration, decontamination, and maintenance of sampling equipment are addressed.

7.1.3.2 Oak Ridge National Laboratory

ORNL has SOPs for the collection of NPDES and other surface water samples. Chain-of-custody procedures and sample tracking are used for all NPDES and other surface water samples. Field water-quality instruments are standardized daily and calibrated every 2 weeks, or more frequently if needed. Sample containers, preservation methods, and holding times conform to 40 CFR Pt. 136 requirements.

7.1.3.3 Oak Ridge Gaseous Diffusion Plant

A QA/QC manual is being developed by the Environmental Management Department that will include water monitoring activities at ORGDP. This manual will cite procedures and activities that must exist within the plant laboratory, maintenance, and operation groups to ensure the overall quality of the program. Monitoring descriptions will be separated for NPDES and perimeter surface water and for radiological and nonradiological monitoring. Chain-of-custody procedures are used on all samples collected. Laboratory sampling and instrument maintenance

and calibration procedures are used to maintain control of monitoring activities.

7.1.4 Groundwater Monitoring

7.1.4.1 Y-12 Plant

Sampling and analysis (S&A) plans for the Y-12 groundwater monitoring programs adhere to EPA protocols and guidelines. Procedures for sampling methods (i.e., bailing, Bennett pumps, bladder pumps) have been written that address necessary QA concerns such as field instrument calibration, decontamination methods, and sample custody. Field replicates, field blanks, equipment rinses, and laboratory spikes are used to validate the precision and accuracy of field and laboratory techniques.

Groundwater quality assessment plans have been developed for five sites at the Y-12 Plant. In each plan, the appropriate methods to sample and analyze the wells and evaluate the data are specified. These procedures were reviewed and accepted by TDHE and EPA personnel during their respective audits of the program.

7.1.4.2 Oak Ridge National Laboratory

ORNL has SOPs for the collection of groundwater samples from water quality monitoring wells. Chain-of-custody procedures and sample tracking are used for all groundwater quality monitoring wells. All compliance groundwater monitoring at permitted and interim status facilities is performed in compliance with the requirements set forth by EPA in 40 CFR Pt. 264/265 and Tennessee rule 1200-1-11-.05(6). Sample containers, preservatives, maximum allowable holding times, and collection methods are based on acceptable procedures as outlined by EPA (1986a, 1986b). *Technical Enforcement* Guidance (EPA 1986a) is the preeminent RCRA guidance document for groundwater monitoring.

7.1.4.3 Oak Ridge Gaseous Diffusion Plant

Sampling and analysis plans for the ORGDP Groundwater Protection Program adhere to EPA protocols and guidelines. Sampling methods (i.e., bailing, Bennett pumps, bladder pumps) have been written to address necessary QA/QC concerns such as field instrument calibration, decontamination methods, and sample custody. Field replicates, field blanks, equipment rinses, and laboratory spikes are used to validate the precision and accuracy of field and laboratory techniques. All compliance monitoring at RCRA interim status facilities is performed in accordance with the requirements set forth by EPA in 40 CFR Pt. 264/265 and by Tennessee rule 1200-1-11-.05(6). The ORGDP groundwater sampling procedures are reviewed by both the EPA and TDHE during their respective audits of the program.

7.1.5 Biological Monitoring

Although much literature and numerous regulatory requirements apply to the collection of certain types of samples (i.e., surface water and groundwater samples), standard protocols for the collection of most biological samples do not exist. Careful consideration must therefore be given to each type of sampling to be performed. Standard collection procedures using accepted QA/QC techniques have been developed, documented, and followed to ensure data of reproducible and known quality.

ORNL has developed SOPs for the collection of milk and fish samples at all the Oak Ridge facilities. Milk samples are collected on a monthly basis, and three composites of six to ten fish are collected at each location during each sampling period to estimate confidence limits based on statistical considerations.

An ORGDP QA manual contains the procedures for the sampling and field chain of custody of vegetation, soil, and stream sediments in the surrounding area. These procedures are reviewed yearly and revised as needed. The QA/QC for the analysis of the biological monitoring samples is handled by the internal laboratory QA program described in Sect. 7.2.

7.1.6 Soil and Sediment Sampling

Soil/sediment sampling is another area in which considerable variability exists in the way sampling plans are designed and samples are collected. The type of soil/sediment to be sampled,

the objective of the sampling effort, the parameters of concern, and many other considerations must be taken into account before an adequate sampling plan can be developed.

7.1.6.1 Y-12 Plant

As noted in Sect. 7.1.1, samples must be taken that are representative of the entire area and which address the regulatory and scientific objectives of the plan. Hence, the Y-12 Plant adheres to the fundamental statistical sampling concepts outlined by EPA (1986b). A statistician reviews the sampling approach to verify that the resulting data will meet the intended objective. For RCRA closure activities, detailed S&A plans have been developed. Field blanks, field replicates, and equipment rinses are routinely submitted to the laboratory; additional personnel are being trained in soil and sediment sampling techniques.

To ensure proper documentation of field activities in support of impending RFI studies at the Y-12 Plant, current sampling methods have been documented by the Energy Systems Environmental Surveillance Procedures Quality Control Program and approved for use by EPA Region IV. In addition, an RFI-specific Quality Assurance Project Plan (QAPP) has been prepared. EPA's comments on this plan are pending.

7.1.6.2 Oak Ridge National Laboratory

EPA provides guidance in the collection of soil samples for potential hazard evaluation and presents QA considerations that apply to soil sampling. ORNL uses these documents and many others when developing sampling plans and procedures for the collection of soil and sediment samples. SOPs are used for routine soil sampling such as collection of soils around the ORNL perimeter air monitoring stations.

7.1.6.3 Oak Ridge Gaseous Diffusion Plant

ORGDP has a QA manual that contains the procedures for the sampling and field chain of custody for soil around the facility. These procedures are reviewed yearly and revised as needed. QA and QC for the analysis of the soil samples are handled by the ORGDP analytical laboratory QA program described in Sect. 7.2.

7.1.7 Solid Waste Monitoring

Each Oak Ridge installation uses SOPs and EPA manual methods for the collection of solid waste samples. These procedures incorporate unified, up-to-date information on sampling and analysis related to compliance with RCRA regulations; detailed sampling and testing methodology approved by the EPA Office of Solid Waste for use in implementing the RCRA regulatory program; and guidance in the development of collection, custody, and documentation procedures.

7.2 ANALYTICAL QUALITY ASSURANCE

The Energy Systems analytical laboratories have well-established QA/QC programs, and the highly trained and well-qualified staffs are provided with excellent equipment and facilities. Current, approved analytical methodologies employing good laboratory and measurement practices are used routinely to ensure analytical reliability. The laboratories have always been involved in the handling and analysis of hazardous materials of high purity, for which strict accountability is required. The analytical laboratories conduct extensive internal QC programs, participate in several external QC programs, and use statistics to evaluate performance. QA and QC are thus a daily responsibility of all employees.

7.2.1 Internal Quality Control

QC is a key feature in analytical QA. Analytical activities are supported by the use of standard materials or reference materials (e.g., materials of known composition that are used in the calibration of instruments, methods standardization, spike additions for recovery tests, and other practices). Certified standards from NIST, EPA, or other DOE laboratories are used for such work. The laboratories operate under

specific criteria for QA/QC activities documented at each installation. Additionally, separate QA/QC documents relating to the analysis of environmental samples associated with regulatory requirements are consulted (see Tables 7.2.1 through 7.2.5 in Vol. 2).

State-of-the-art computer systems and programs, such as the "AnaLIS" program developed by employees in the ORGDP laboratory, are used to report and track data and manage QC activities. This system provides for the recording of internal control data on known standards and the calculation of spike recoveries while ensuring that personnel have been certified before performing an analysis.

Analyses are performed using EPA, American Society for Testing and Materials (ASTM), Standard Methods for the Examination of Water and Wastewater, or other approved procedures. Analysis methods and minimum QA requirements are dictated by State and EPA regulatory requirements, DOE orders, and established laboratory QA programs.

Radionuclide monitoring, an important responsibility for the Oak Ridge plants, is supported by analytical measurements generally derived from state-of-the-art methods and instrumentation. High-purity germanium and lithium-drifted germanium detectors with standard counting configurations are used for identification of gamma-emitting radionuclides in environmental samples. Alpha-emitting radionuclides are identified with surface barrier alpha detectors, and gross alpha and beta activities are measured with proportional counting systems.

Quality control is ensured by using standard materials from NIST or other reliable sources for calibration, yield/efficiency determinations, spike recoveries, isotopic dilution, and other techniques. Backgrounds are measured periodically for corrections, and instrument responses and efficiencies are routinely established.

Nonradiological and classical wet chemical analysis methods are used to analyze environmental samples. Routine calibration and standardization, replicate analyses, spike additions, and analysis of blanks all support the internal QC efforts.

These internal programs are the mainstay of analytical QC and are the basis for ensuring reliable results on a day-to-day and batch-to-batch basis. The total effort in these programs is at least 10 to 20% of the laboratory effort (in accordance with EPA expectations).

QA/QC measurement control programs external to the sample analysis groups have single, blind control samples submitted to the analytical laboratories to monitor performance. Reliable suppliers such as NIST, EPA, and DOE are the sources for these standards. The results of such periodic measurement programs are statistically evaluated and reported to the laboratories and their customers. Most reports are issued quarterly, and some laboratories compile annual summary reports. These reports assist in evaluating the adequacy of analytical support programs and procedures. If serious deviations are noted by the QC groups, the operating laboratories are promptly notified so that corrective actions can be initiated, and problems can be resolved. QC data are stored in an easily retrievable manner so that they can be related to the analytical results that they support.

7.2.2 External Quality Control

In addition to the internal programs, all Energy Systems installations are directed by DOE and by EPA regulators to participate in external QC programs. These programs generate data that are readily recognizable as objective packets of results. These packets give participating laboratories and government agencies a periodic view of performance. The sources of these programs are laboratories in the EPA, DOE, and commercial sector.

Currently, three national certification/qualification programs exist for analytical laboratories: the Contract Laboratory Program (CLP) for Superfund work, the Drinking Water Supply Program, and the National Institute for Occupational Safety and Health (NIOSH) Program for Industrial Hygiene Analyses. Each of the ORO installation laboratories participates in one or more of these programs. The ORGDP laboratory participates in all three. Additionally, the ORO installation laboratories all participate in

the annual EPA Discharge Monitoring Report QA Study.

7.2.2.1 Radiological Quality Control

Energy Systems laboratories participated in several external radiological QC programs in 1989. Each installation has provided results from its participation in these programs.

EPA Intercomparison Radionuclide Control Program

The EPA Radionuclide Control Program is administered by the EPA Environmental Monitoring System Laboratory at Las Vegas (EMSL-LV). The state of Tennessee requires participation in this control program for drinking water laboratory certification of radionuclide analysis. These samples consist mainly of water and air filters. Results are furnished to the state of Tennessee for evaluation relating to drinking water laboratory certification. Failure to obtain an overall satisfactory rating leads to the removal of a laboratory from the certified status.

Results for each of the laboratories participating in this program are shown in Tables 7.2.6 through 7.2.8 of Vol. 2. The EMSL program calculates a normalized standard deviation for each laboratory based on all reported results. Based on their criteria, any reported value above three deviations is considered unacceptable. The Y-12 laboratory had 24 results rated as acceptable and 6 results rated as unacceptable. Fifty-two of the 53 values for ORNL were acceptable. The one unacceptable result was for the water analyses of H^3 due to a hardware system failure. Based on ORNL's performance in this program, the state of Tennessee granted certification to the Environmental Radiochemical Analysis Laboratory through September 12, 1992. One result for ORGDP was determined to be unacceptable for ^{137}Cs. This was due to the laboratory reporting the result with the decimal in the wrong place.

DOE Environmental Measurements Laboratory (EML) Radionuclide Quality Assessment Program

A Radionuclide Quality Assessment Program is administered by DOE's EML in New York. Various matrix samples, such as soil, water, air filters, and vegetation, are submitted semiannually for an analysis of a variety of radioactive isotopes, with a statistical report submitted by EML for each period. Results for each of the laboratories participating in the program in 1989 are shown in Tables 7.2.9 through 7.2.14 of Vol. 2. All matrices, except filters, are actual materials obtained from the environment at a DOE facility. Results for each of the laboratories generally compared well with the accepted value, except in a few instances, such as when results were reported improperly (e.g., wrong units, etc.).

The detection limits and precision depend on the counting equipment at each lab. These samples are usually near the detection limits; thus, results with ratio values of 0.5 to 1.5 as compared with reference values are acceptable data.

The parameters measured vary among laboratories because of the equipment at each laboratory. ORGDP tests for all parameters that the existing radionuclide equipment can detect.

For the Y-12 Plant laboratory, 25 results were acceptable, and 10 were unacceptable. Corrective actions for the unacceptable results are now being implemented. ORNL had two unacceptable results, one in April and one in September. All other results were acceptable. ORNL/EML ratios were between 0.17 and 2.00 for 1989.

7.2.2.2 Nonradioactive Quality Control

DOE-ORO installation laboratories participated in several external nonradiological QC programs in 1989. Each installation has provided results from its participation in these programs.

Proficiency Environmental Testing (PET) Program

In 1989, all Energy Systems analytical laboratories participated in the PET Program. Control samples were supplied by Analytical Products Group, Inc., a commercial supplier. Energy Systems analytical laboratories and WMCO at Fernald, Ohio, analyze samples at two concentration levels (a high and a low concentration denoted as level 1 and level 2) on a monthly basis. All data are reported to the supplier from each of the six laboratories.The commercial

supplier provides a report of the evaluated data, which includes a percent recovery of the referenced value, deviation from the mean of all reported data, and other statistical information. Investigators at each laboratory analyze only those parameters required on the installations' NPDES permit or parameters analyzed on a routine basis.

The vendor for the PET control program also provides a "corporate" (i.e., six-laboratory) report that compares the data from laboratories within the corporation with those of other corporate laboratories. As part of the purchase contract, the data from the six laboratories within the DOE-ORO complex (five Energy System plants and the Feed Materials Production Center laboratory) are evaluated, and a report is issued to each of the laboratory QA/QC managers. This management summary report shows problems encountered by specific laboratories.

The laboratories were statistically evaluated by PET to determine acceptability of analytical data. Data within 1.96 standard deviations are acceptable, data between 1.96 and 2.58 standard deviations are marginal, and data of more than 2.58 deviations are unacceptable.

Tables 7.2.15 through 7.2.20 of Vol. 2 show results for each of the three Oak Ridge laboratories. Data for two unknown concentrations (QC samples) or levels are reported. In Y-12 Plant laboratory testing, 488 of 505 results on the level 1 samples were acceptable, 10 were above the warning limits, and 7 were unacceptable. For the level 2 samples, 494 of 507 results were acceptable, 5 were above the warning limits, and 8 were unacceptable. An investigation was performed on each result that was at or above the warning limit.

Of the 324 level 1 results reported by ORNL, 315 were acceptable, 5 were marginal, and 4 were unacceptable. No parameter yielded more than one unacceptable result. Of the 342 level 2 results reported by ORNL, 337 were acceptable, 4 were marginal, and one was unacceptable.

Of the 516 level 1 results for ORGDP, 497 were acceptable, 9 were marginal, and 14 were unacceptable. Of the 516 level 2 results for ORGDP, 487 were acceptable, 12 were marginal, and 4 were unacceptable.

The number of unacceptable results for each of the facilities is about 1% of the total results in each case. This is expected, given that the acceptable and warning limits represent 99% of the statistical distribution by design.

EPA Discharge Monitoring Report Quality Assurance study

EPA conducts a national QA program in support of the NPDES program. All holders of major NPDES permits are required to participate. EPA furnishes the QC samples and evaluates the results. The state of Tennessee receives the results from the Energy Systems Oak Ridge laboratories participating in this study for evaluation, and the Oak Ridge installations are required to inform the state of Tennessee of any necessary corrective actions. Tables 7.2.21 and 7.2.22 of Vol. 2 show the results for Y-12 and ORNL. ORGDP did not receive their sample; therefore, there are no results. Of the 29 measurements by the Y-12 laboratory, the arsenic result was unacceptable. Investigation revealed that a dilution value had been incorrectly transferred from the instrument readout chart to the workcard where calculations are made. Two results from ORNL were unacceptable, one for As and the other for Cd. The QA/QC coordinator and laboratory supervision investigate any parameters found to be unacceptable.

Water Supply Laboratory Performance Quality Control Program

The Y-12 Plant and ORGDP laboratories are certified by the state of Tennessee for drinking water analysis. To maintain its certification, a laboratory must meet a specified set of criteria relating to technical personnel, equipment, work areas, QA/QC, operating procedures, and successful analysis of QC samples. The state also performs an on-site audit at a set frequency. The samples are furnished by EPA-Cincinnati, and the results are evaluated by EPA-Athens (Region 4) and furnished to the state of Tennessee. To maintain the qualified status, the laboratories must satisfactorily analyze the QC samples furnished on a routine schedule.

The Y-12 laboratory performed 80 measurements. Not all were required for certification purposes. Several measurements represent two separate concentration levels for a given parameter. Seventy-one measurements were rated as acceptable, and nine were rated as unacceptable. The laboratory performs a follow-up investigation on each unacceptable result. As a result of this evaluation, the calcium was downgraded to provisional certification. As a result of water study 24, the lindane and turbidity went to provisional status, and the filterable residue went to decertified status (Table 7.2.23 of Vol. 2).

In 1989, ORNL and ORGDP participated in the multilaboratory study for the analysis of water pollution samples that is administered by EPA's EMSL-LV. ORNL analyzed one set of samples, WP-023 (Table 7.2.24 of Vol. 2), in 1989. All results were acceptable, except for one fluoride analysis, two Kjeldahl-nitrogen analyses, two total phosphorus analyses, and two total organic carbon analyses.

ORGDP analyzed two sets of samples, WP-022 and WP-023 (Tables 7.2.25 and 7.2.26 of Vol. 2), in 1989. All results on both sets of samples were acceptable.

During 1989, the ORGDP laboratory received results from WS-023, which was submitted in 1988. In 1989, sets WS-024 and WS-025 were analyzed. Data for the three sets are shown in Tables 7.2.27, 7.2.28 and 7.2.29 of Vol. 2. In the WS-023 set, toxaphene received a provisional rating and there were no decertifications. The WS-024 set reinstated toxaphene and had no decertifications. All results in the WS-025 set were acceptable, except for turbidity and free Cl_2.

Analytical environmental support programs

These programs involve the coordination and implementation of environmental analytical and field activity QA and QC for the investigation and remediation of potential hazardous waste sites at government installations. The group has worked closely with the HAZWRAP organization in their implementation of remedial activities on Air Force bases in relation to QC. The Analytical Environmental Support Group (AESG) is the Navy representative for integration of QA/QC at Naval installation remedial investigations, and it also provides support to other DOE facilities in their remedial efforts. AESG has recently started working with the Army at Rocky Mountain Arsenal (RMA) in similar supporting roles.

The program involves several aspects related to analytical chemistry, sample collection, and field geology. The group has identified QC program requirements and developed detailed program plans for both HAZWRAP and Navy organizations. It has initiated external proficiency sample evaluation for laboratories subject to approval by each of these programs. It has implemented a comprehensive audit program of laboratories for each organization, which is capable of cross utilizing the information obtained for both programs. AESG provides complete review services for all program documents including work plans, sampling plans, laboratory QA plans, project QA plans, final reports, and deliverables. The group has developed and is currently implementing comprehensive field surveillances for HAZWRAP projects and will initiate these activities for RMA in the future.

In support of these programs during 1989, AESG has conducted the following activities:

- Evaluated 65 laboratories across the country. This process included
  - — laboratory QA plan reviews;
  - — preparation, submittal, and evaluation of PE samples; and
  - — on-site laboratory audits.
- Reviewed more than 700 project-related documents including project work plans, project QA plans, sampling plans, site investigation reports, final project reports, and decision documents.
- Conducted 26 field sampling activity surveillances/audits.
- Initiated analytical QA/QC support activity with RMA.
- Initiated analytical QA/QC support activity with Energy Systems Paducah Operations.

7.2.2.3 Environmental Protection Agency Contract Laboratory Program

The CLP is administered by the EPA CLP–Sample Management Office at Alexandria, Virginia, in cooperation with the EPA EMSL–LV and EPA regions. The program qualifies laboratories for the determination of organic and inorganic contaminants in aqueous and solid hazardous waste materials and enforces stringent QA protocol requirements for laboratory operation. This protocol is the only acceptable protocol for investigative, remedial, and monitoring studies of Superfund sites.

The ORGDP laboratory has been qualified by EPA for CLP work since 1985, and ORNL began operating under the protocol in 1987. Analysis of quarterly performance samples is mandatory for certification. Results of laboratory performance are shown in Tables 7.2.30 through 7.2.33 of Vol. 2. At ORNL, the average score for the inorganic laboratories was 85.3% and the average score for the organic laboratories was 79.6%. At ORGDP, the average score for the inorganic laboratories was 93.8% and that for the organic laboratories was 71.3%. Scores are based on a maximum 100 point system. The average score for all CLP laboratories participating in the program in 1989 was 82.5% for the inorganics and 75.5% for the organics.

7.3 AUDITS, REVIEWS, AND ASSESSMENTS

7.3.1 Y-12 Plant

7.3.1.1 External regulatory

Regulatory agencies conducted several reviews at the Y-12 Plant during 1989 (Table 7.3.1 in Vol. 2). Reviews conducted by TDHE included RCRA inspections, Compliance Evaluation Inspection (CEI) of the groundwater monitoring program, quarterly QA audits of ambient sulfur dioxide monitoring stations, an air pollution control compliance survey, solid waste management compliance inspections, and inspections of erosion control activities. In addition, EPA conducted a Compliance Monitoring Evaluation of the groundwater monitoring program and a Performance Audit Inspection of the NPDES program. No major findings or areas of concern were identfied during the inspections. Action plans have been developed to address any findings noted during the inspections.

From December 29, 1988, through January 11, 1989, the National Academy of Sciences (NAS) Interim Oversight of DOE's Non-Reactor Nuclear Facilities was conducted at the Y-12 Plant. This technical evaluation covered chemical safety; fire safety; criticality safety; occupational safety/fitness for duty; equipment integrity, adequacy, and maintenance; QA/QC; training, health physics and health programs; waste management; environmental monitoring; and general management and safety analysis. A report of NAS findings has not been received.

7.3.1.2 Department of Energy

Activities are continuing to address findings identified during the DOE Headquarters Environmental Survey. The preliminary report of findings was received from DOE Headquarters in December 1987, and an action plan to address the findings was submitted to DOE-ORO in February 1988. In addition, a quarterly report is issued to DOE-ORO updating the status of on-site activities related to the survey findings.

DOE-ORO conducted an Environmental, Safety, Health, and QA appraisal of the Y-12 Plant in June 1989. The appraisal report indicated that a competent environmental program exists at the Y-12 Plant; however, a few areas were identified as needing improvement. In their report, the appraisal team noted 31 environmental findings. Action plans have been developed to address these findings.

The Tiger Team Compliance Assessment of the Y-12 Plant was conducted from September 25 to October 20, 1989. During the assessment, 61 environmental findings were identified. As indicated in the Tiger Team's draft report, none of the problems identified were of a nature that indicated that continued operation of the facility would present an undue risk to public health or the environment. Of the 61 findings, 18 were identified as possible areas of noncompliance with federal or state regulations, six were identified as

noncompliances with DOE order requirements, and 37 were related to best management practices (BMPs). Action plans have been developed for these findings.

Some of the laboratory analytical data in the *1988 Environmental Surveillance Report* for gross alpha and gross beta activities were significantly higher than the summation of the specific radionuclide results. This was presented as a finding in the Tiger Team final report.

The normal procedure for alpha and beta activity analysis involves a preconcentration step to obtain the desired minimum detectable activity (MDA). Because of large sample loads and time constraints in reporting results to the customer at that time, in some instances the laboratory omitted this preconcentration step. Since only specific, small amounts of sample can be loaded on the counting planchet, the absence of the concentration step resulted in a higher minimum detectable activity than usual. This caused a poor correlation between the gross activities compared to the summation.

After being made aware of this inconsistency, the laboratory at that time reinstated the concentration step for all samples. The gross alpha and beta radiochemical data in the 1989 report reflects this change.

7.3.1.3 Internal

The Y-12 Environmental laboratory has a program for internal audits of methods, programs, and procedures. Audits during 1989 were done in the following areas: phenol, biochemical oxygen demand, sulfite, methylene blue active substances, inductively coupled plasma, and laboratory logbooks (Table 7.3.1, Vol. 2).

In 1987, a subcommittee of the Five-Plant Environmental Analysis Committee was established to eliminate all the discrepancies in the systems of nomenclature that exist in our facilities. The problem has been compounded by EPA's practice of calling a compound by different names in various references—for example, tetrachloroethene and tetrachloroethylene. This has led to much confusion for lay readers of technical reports. The subcommittee continued its efforts at standardizing the names of organic and inorganic analysis parameters in CY 1988. The list of organic parameters with associated CAS numbers has been greatly expanded to cover all monitoring programs. The list of inorganic parameters has been reviewed and amended several times. Both lists have been finalized to the point where they will be recommended for adoption by the five sites in CY 1989.

7.3.2 Oak Ridge National Laboratory

In 1989, ORNL experienced numerous audits/inspections and reviews related to environmental sampling and data management, sample analysis, waste management, and/or QA. These audits and reviews consisted of external audits by outside regulatory agencies such as the EPA and TDHE; audits and reviews by DOE Headquarters in Washington or DOE-ORO; and internal audits by Energy Systems.

7.3.2.1 External Regulatory

Table 7.3.2 of Vol. 2 summarizes the major environmentally related audits and reviews of ORNL by outside regulatory agencies. The major audits for the year were a Groundwater Monitoring Compliance Evaluation Inspection conducted by the TDHE and an NPDES Compliance Sampling Inspection conducted by the EPA. No deficiencies or noncompliances were identified by the TDHE audit, and two deficiencies were reported in the EPA audit. These deficiencies have been corrected.

7.3.2.2 Internal

In addition to the EPA, state of Tennessee, and DOE audits and reviews, Energy Systems and ORNL organizations external to the divisions and groups responsible for environmental concerns at ORNL performed numerous audits and reviews of the environmental program at ORNL.

These audits and reviews focused on the environmental program, recordkeeping, health and safety, QA, chemical and biological analysis, contingency plans, and storage of toxic and hazardous waste. In many cases, these audits and

reviews led to improved operating procedures and management practices.

7.3.3 Oak Ridge Gaseous Diffusion Plant

7.3.3.1 External Review

Table 7.3.3 of Vol. 2 summarizes the major environmental audits and reviews of ORDGP. The EPA conducted a review for Groundwater Compliance in March 1989. Several items concerning sampling procedures and laboratory analyses were addressed and corrected. The EPA conducted an NPDES Compliance Sampling inspection in April 1989. This evaluation was favorable, and no findings were reported.

Also in April 1989, the TDHE reviewed the Air Compliance Program and reported no findings or recommendations. In May 1989, the TDHE inspected the RCRA facilities and issued a Notice of Violation (NOV) because three waste streams were being collected at a satellite area and had exceeded the 208 L (55-gal) capacity. This was corrected by reclassifying the area as an accumulation area.

In August 1989, the EPA conducted a Compliance Evaluation of the RCRA facilities. Concerns cited by the evaluation team were unlabeled drums, a leaking drum, and several open drums. All items were corrected. The TDHE conducted a review of the Groundwater Compliance in September 1989 and reported no findings.

7.3.3.2 Department of Energy

DOE-ORO conducted on Environmental Protection Appraisal May 22–26, 1989. The appraisal team recommended various programs within the Environmental Management Department. These recommendations included identifying the persons responsible for assuring the proper disposal of asbestos, providing DOE with the results of quality investigations initiated by NPDES noncompliances, including all required elements in the next revision of the Spill Prevention, Control, and Countermeasures (SPCC) plan, and assembling a set of procedures for incident reporting. Action plans have been developed to address the recommendations made by the appraisal team.

DOE also reviewed the Asbestos Program in May 1989 and issued no findings.

7.3.3.3 Internal

In addition to the EPA, TDHE, and DOE audits and reviews, Energy Systems and ORGDP organizations perform audits and reviews of the environmental programs at ORGDP. These audits and reviews focus on record keeping, laboratory and sampling procedures, and storage of hazardous materials and waste. These have led to improved operating procedures and management practices.

APPENDIXES

Appendix A

GENERALIZED STRATIGRAPHIC AND STRUCTURAL DESCRIPTIONS OF GEOLOGIC FORMATIONS IN THE ORR

A.1 STRATIGRAPHY

Rome Formation

The Cambrian Rome Formation underlies Haw Ridge and Pine Ridge and is the basal decollement for the Copper Creek (CC) and WOM thrust faults. The Rome Formation consists of massive to thinly bedded, maroon to gray-green sandstones interbedded with greatly subordinate amounts of thinly bedded, silty mudstones; shales; and dolomite.

The Rome Formation consists of massive to thinly bedded, maroon to gray-green sandstones interbedded with greatly subordinate amounts of thinly bedded, silty mudstones, shales, and dolomite. The upper portion of the section contains a distinctive gray to gray-green sandstone, and the lower section is much more heterogeneous (Haase et al. 1985). Locally, the Rome Formations contains a significant dolostone component, which represents coeval and interbedded deposition of Shady Dolomite and the Rome Formation. Hence at the ORR, the Shady Dolomite is a stratigraphic equivalent of and does not lie underneath the Rome Formation (McReynolds 1988). Maximum stratigraphic thickness of the Rome Formation in the ORR is about 300 ft. However, because the Rome Formation is the basal décollement for the major thrust faults in the area, apparent thickness values vary considerably because of structural duplication or removal of intervals.

A.1.1 Conasauga Group

The Cambrian Conasauga Group underlies Melton and Bear Creek valleys. In this area of eastern Tennessee, the Conasauga Group is divided into six formations of alternating shale and carbonate-rich lithologies (Fig. A.1). From oldest to youngest these are: the Pumpkin Valley Shale, the Rutledge Limestone, the Rogersville Shale, the Maryville Limestone, the Nolichucky Shale, and the Maynardville Limestone. Descriptions of the units are primarily derived from Haase et al. (1985) and King and Haase (1987) and are included in Appendix A. As a whole, weathering of the Conasauga Group forms fractured saprolite as much as 12 m (40 ft) thick that is covered by a fairly thin veneer of soil.

Pumpkin Valley Shale [79.2–106.6 m (260–350 ft)]

The Pumpkin Valley Shale consists of massive to thinly bedded, maroon-brown to gray mudstones and shales interbedded with thinly bedded to laminated glauconitic siltstones. Two members can be identified, with the upper one being more shale- and mudstone-rich than the lower one. The lower member contains abundant zones of mottled, bioturbated shaly siltstones interbedded with thinly bedded shales and siltstones.

Rutledge Limestone [27.4–42.6 m (90–140 ft)]

The Rutledge Limestone consists of light-gray to white, medium to thinly bedded limestones and shaley limestones interbedded with medium to dark gray, thinly bedded to laminated, calcareous mudstones and shales. A persistent 1.5- to 3.0-m (5- to 10-ft) thick interval of maroon to maroongray mudstone occurs toward the base of this formation and serves as a marker bed within the lower Conasauga Group throughout Bear Creek Valley.

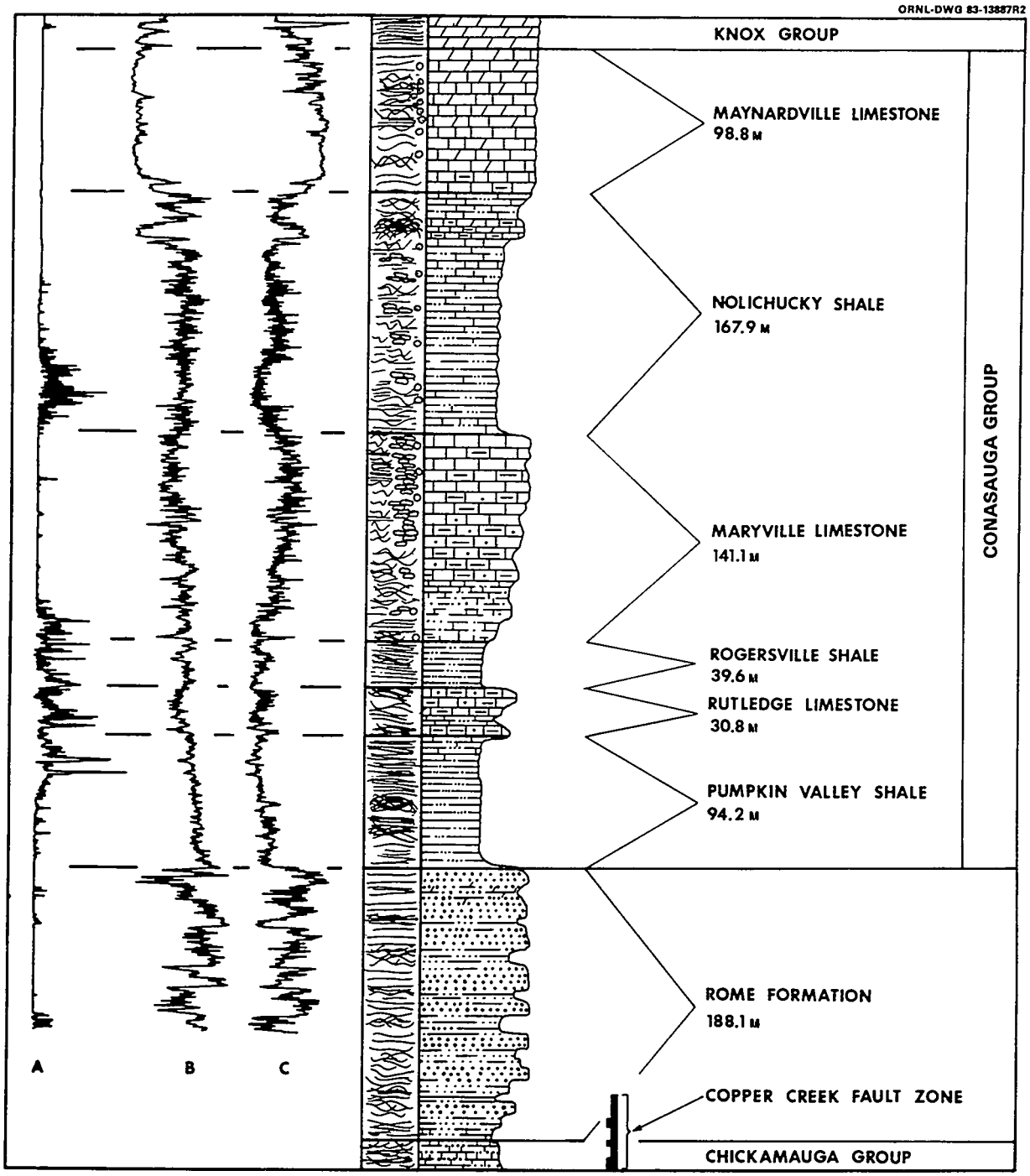

Fig. A.1. Conasauga Group stratigraphy.

Rogersville Shale [27.4–42.6 m (90–140 ft)]

The Rogersville Shale is composed predominately of massive to medium bedded, gray to maroon mudstones interbedded with medium to very thinly bedded, gray to maroon-brown shales. The shales and mudstones contain subordinate amounts of thinly bedded, glauconite-rich, locally calcareous siltstone. Within the middle and upper portion of the shale, a locally stromatolitic (Hasson

and Haase, 1988) carbonate unit, the Craig Limestone Member, of variable thickness is observed. It consists of mottled fine-grained limestone and dolostone to coarse-grained intraclastic and oolitic limestone (Walker and Simmons 1985).

Maryville Limestone [103.6–141.1 m (340–463 ft)]

The Maryville Limestone consists of light to dark gray, fine to coarsely crystalline limestone interbedded with subordinate amounts of dark gray, medium to thinly bedded calcareous shales and shaley siltstones. The Maryville Limestone can be divided into two members (Haase and Tank 1985), with zones of limestone-pebble conglomerates and ooid-rich beds being locally abundant in the upper member. The lower member consists of medium to thinly bedded calcareous shales and siltstones with subordinate amounts of crystalline limestones. Limestone-pebble conglomerates and ooid-rich beds are rare to nonexistent in the lower member (Haase and Tank 1985).

Nolichucky Shale [128–167.6 m (420–550 ft)]

The Nolichucky Shale can be divided into three members: the Upper Shale, the Bradley Creek, and the Lower Members (Hasson and Haase 1988), although identification of these members in Bear Creek Valley is not straightforward. The formation consists of maroon-brown to rare green-gray, massive to very thinly bedded, locally calcareous mudstones and shales interstratified with thinly bedded, medium-gray limestones and calcareous siltstones. The maroon-brown color of the shales is characteristic of the Nolichucky Shale. The interbedded limestone typically contains limestone-pebble conglomerates and ooid-rich beds similar to those occurring in the underlying Maryville Limestone. Throughout much of the Nolichucky Shale, mudstone/shale and limestone lithologies alternate on a scale of 0.3 to 0.9 m (1 to 3 ft), giving the formation a thickly bedded appearance.

Maynardville Limestone [97.5–137.1 m (320–450 ft)]

In the ORR, the Maynardville Formation shows a gradational lower contact with the Nolichucky Shale (King and Haase 1987). The Maynardville Limestone is composed of light gray to tan, massive to thinly bedded limestone with subordinate amounts of dolostone. This formation can be divided into members on the ORR (Haase et al. 1985). The uppermost Chances Branch member consists of medium- to thin-bedded buff and light-gray dolostones, ribbon-bedded dolostones/limestones, and thin-bedded medium-gray limestones. The lower Low Hollow member is principally wavy to evenly thin-bedded (oo)microsparite, with alternating horizons of dolomite-bearing, ribbon-bedded microsparite and calcarenite. The Low Hollow Member and the lower portion of the Chances Branch Member are oolitic, and soft sediment deformation fabrics have been observed (Geraghty and Miller 1987). Both members are locally stylolitic.

A.1.2 Knox Group

The Cambrian-Ordovician Knox Group underlies Copper Ridge, Chestnut Ridge, McKinney Ridge, and Blackoak Ridge. In eastern Tennessee, the Knox Group can be divided into five formations of dolomite and limestone. At the ORR, all five have been identified by field surface mapping (Hatcher, personal communication), and unit descriptions listed in Appendix A are derived from field mapping at other locations in eastern Tennessee (Hatcher and Bridge 1973). Detailed thickness measurements of the individual units have not been made on the ORR; however, the entire group is estimated to be approximately 731 m (2400 ft) thick (Lee and Ketelle 1989). In ascending order, the formations in the Knox Group are the Cambrian Copper Ridge Dolomite, the Ordovician Chepultepec Dolomite, the Longview Dolomite, the Kingsport Formation, and the Mascot Dolomite. Identification of lithologic contacts in fresh core is not as direct, and thus discrepancies exist between field and core studies. The Knox Group weathers to a thick [up to 45 m (150 ft)], orange-red clay residuum that commonly contains abundant chert. Primary structural fabrics generally are not preserved in the residuum. Significant portions of the areas underlain by the Knox Group are characterized by karst features.

Copper Ridge Dolomite

The Copper Ridge Dolomite is a resistant ridge former. It consists of thin- to thick-bedded olive-gray, grayish-black, and yellow-brown dolomite that is microcrystalline to coarsely crystalline. Freshly broken surfaces give off fetid odor, particularly in the lower part of the formation. Beds in the lower part of formation are thinner and finer grained than in the upper part of the formation. The contact between the Copper Ridge Dolomite and the Maynardville Limestone is drawn below a thin, fine-grained quartz sandstone containing white oolitic chert. The top of the formation is above a 0.9- to 2.4-m (3- to 8-ft) dolomite matrix sandstone. This sandstone is very persistent in float.

The Copper Ridge Dolomite weathers to clay residuum containing abundant black, medium- to coarse-grained oolitic chert; black cryptozoan chert; light-colored chert in blocks as much as 0.9 m (3 ft) in diameter; and some blocks of fine- to medium-grained quartz sandstone with dolomite cement.

Chepultepec Dolomite

The Chepultepec Dolomite is less resistant and occupies relative topographic lows in ridges comprised of the Knox Group. It consists dominantly of dolomite and limestone. The dolomite is finely crystalline, light gray and pinkish brown to light brown, thick-bedded, with numerous dolomite-cemented sandstone beds and some silica-cemented sandstones. The limestone is olive gray and brownish black and weathers to light gray with silty mottling on its surfaces. It is cryptocrystalline to very fine-grained, thick-bedded, and contains quartz geodes. Sandstone beds as much as 3 m (10 ft) thick with fine to medium rounded quartz grains are common in the lower part of formation. A bed of fine-grained, white, siliceous ooids occurs 9.1 m (30 ft) above the Copper Ridge/Chepultepec contact. White oolitic chert is abundant in the formation.

The formation weathers to a dark-orange clay residuum that contains nodular, varicolored, porous, and ropy chert. Sandstone in the lower part of the formation weathers to loosely cemented cherty blocks.

Longview Dolomite

The Longview Dolomite is a resistant ridge former that consists of both dolomite and limestone. The dolomite is siliceous, light to very light gray, finely to coarsely crystalline, thin to thick bedded, with rounded quartz grains throughout the unit. The limestone is light-bluish-gray, dense to fine grained, and medium to thick bedded, and it constitutes as much as half of the upper part of the formation.

The formation weathers to a light-ash-gray clay residuum containing massive, chalcedonic porcellaneous, dead-white to light-pink, brown, and gray chert blocks 0.6 m (2 ft) to more than 1.5 m (5 ft) in diameter. The chert is jointed and easily fractured and includes sparse oolitic chert.

Kingsport Formation

The Kingsport Formation is a less resistant dolomite and limestone. The dolomite is light gray and yellowish gray and weathers to a very light gray to white color. It is fine to coarsely crystalline, thin to medium bedded, and locally laminated. The limestone is light-olive-gray and medium-gray, cryptocrystalline to crystalline, and medium to thick bedded. The formation contains beds of chert nodules about 2.54 cm (1 in.) thick, medium-rounded quartz grains, and sandstone beds 2.54 cm (1 in.) or less thick. The top of the formation is more dolomitic than the bottom, and the lower contact with the Longview Dolomite is characterized by a significant decrease in chert.

The formation weathers to a clay residuum that contains oolitic, nodular chalcedonic, varicolored, and white porous chert, and local thin, dolomite-cemented sandstone fragments.

Mascot Dolomite

The Mascot Dolomite is a resistant unit that consists of dolomite with lesser amounts of limestone. The dolomite is siliceous and locally cherty; medium gray to medium dark gray or olive

gray; cryptocrystalline to fine crystalline, locally laminated, and thin to medium bedded. The limestone is olive gray and medium dark gray, cryptocrystalline, and medium to thick bedded with some silty partings, and it commonly shows a conchoidal fracture. A continuous "chert matrix" sandstone or quartz sandstone occurs at the base of the formation.

The formation weathers to a clay residuum that contains chalcedonic chert, nodular chert, porous white chert, and sandstone fragments with a dolomite matrix.

A.1.3 Chickamauga Group

The Ordovician age Chickamauga Group underlies East Fork Valley, the ORGDP area, and Bethel Valley. These rocks comprise the footwall immediately below the major thrust faults in the ORR. The Chickamauga Section has been described from two areas within the ORR: (1) at the eastern boundary of the Reservation near Solway Bridge (Weiss 1981) (Fig. A.2) and (2) at ORNL site (Lee and Ketelle 1988). The sections are approximately 10 km (6 miles) apart and both are located on the WOM thrust sheet. In general, the Chickamauga Group consists predominantly of limestones with interlayered carbonate-rich shales. Although descriptions of the two sections use different nomenclature schemes, it is possible to derive a rough correlation between parts of the two sections, based on narrative rock descriptions and geophysical logs acquired at the ORNL site.

Lower Chickamauga Group [91.4–96 m (300–315 ft)]

In this part of East Tennessee, the lower Chickamauga Group consists of the Blackford and Lincolnshire Formations, which were deposited on the Upper Knox unconformity. These units are tentatively correlated with unit A of Stockdale (1951) and Lee and Ketelle (1988). Lithologic and thickness differences between measured sections of the Lower Chickamauga Group may be attributed in part to local relief on the Knox unconformity. The Blackford Formation consists of maroon and olive-gray dense limestone and mudstone that is partially dolomitized. The top of the formation shows thin to medium laminations. The lowest member of the Lincolnshire Formation, the Eidson, is characterized by a shaley calcareous siltstone that contains bedded or nodular black chert. The unit is commonly thin and wavy bedded with limestone partings. The Hogskin Member of the Lincolnshire Formation is poorly exposed at Solway and is presumed to be correlative to X-10 units A3–A5, which are maroon calcerous siltstones with limestone beds and chert-rich limestones.

Middle Chickamauga Group [259–314 m (850–1030 ft)]

The transition between the Lower and Middle Chickamauga Group is marked by a significant increase in shale/mudstone content (Weiss 1981). This is inferred from the weathering profile at the Solway section and observed in core and geophysical logs at X-10 (Ketelle and Lee, 1988). The lowest formation of the Middle Chickamauga Group, the Benbolt Formation, is characterized at its base by a thick shale that grades into a more resistant siltstone and limestone at the top and is provisionally correlated with X-10 units B and C. Immediately above the Benbolt, the lower Wardell Formation is comprised of a light gray, medium-grained, dense crystalline calcarenite. Bedded and nodular chert and birdseye micrite are common, and fossils occur in patches or in sharply defined beds.

Middle Chickamauga Group correlations between Solway and X-10 are not straightforward above the lowermost section of the Wardell Formation. The Middle Chickamauga/Moccasin Formation contact has been defined by the introduction of maroon argillaceous limestones above the Witten Formation and is provisionally placed at the X-10 G/H contact. Using these correlations, the remainder of the Middle Chickamauga Group (the upper Wardell, Bowen and Witten; see Fig. 1.3.5) shows a doubled stratigraphic thickness at the X-10 site in comparison to the Solway site. In addition, rock descriptions and detailed thicknesses do not directly match between the two sites, and five 0.9- to 1.5-m (3- to 5-ft) deformation zones have been

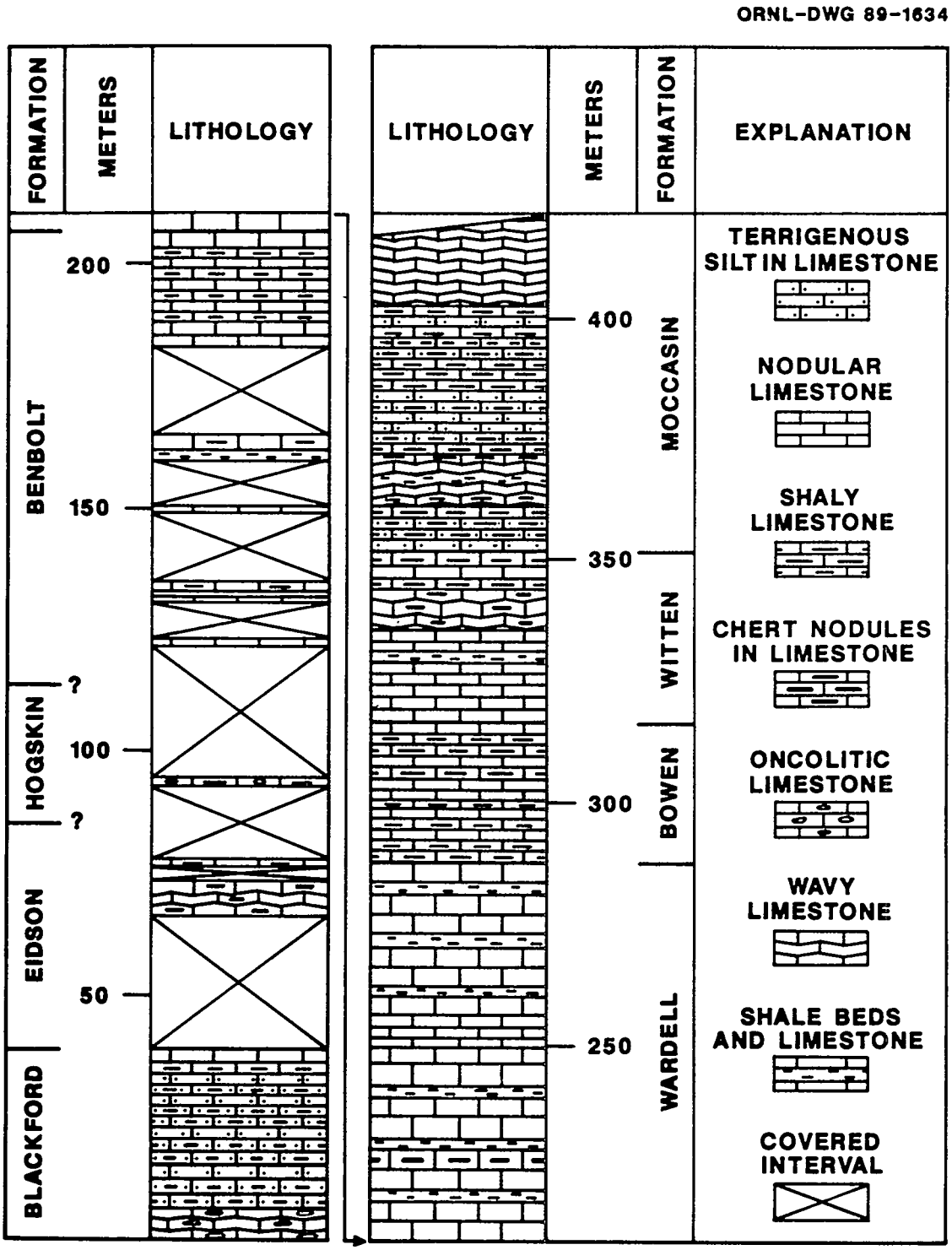

Fig. A.2. Chickamauga Group—Solway section.

reported from these rocks at the X-10 site. The thickness discrepancies between the two sites can be caused by an abrupt stratigraphic thickening or, as suggested by the presence of local deformation zones, by structural duplication.

Moccasin Formation [67 m (220 ft)]

The Moccasin Formation is characterized by maroon, argillaceous limestone and mudstone that overlies the Witten Formation. The lower contact is marked by a color change from dark or light gray to a pale maroon color and a gradational change from a wavy, interbedded, nodular, and ribbon limestone to a calcareous siltstone interbedded with fine-grained limestone (Lee and Ketelle, personal communication). True stratigraphic thicknesses of the Moccasin Formation are not exposed at the ORR because the formation is truncated by the Copper Creek Fault.

Post-Chickamauga Rocks

Units younger than the Chickamauga Group are only observed in the core of two strike parallel synclines north of the WOM Fault. These units consist of Upper Ordovician to Lower Mississipian limestones, shales, and siltstones.

A.2 STRUCTURE

Faults and Folds

Three regionally extensive thrust faults crop out on the ORR. They are the CC, WOM, and Kingston (K) faults. All of these faults extend from the surface to the geologic basement at approximately 426 m (1400 ft) (Fig. 1.3.3), trend parallel to regional strike (N55E), and show displacement of at least of several kilometers. The WOM Fault dips steeply (45°) to the southeast (King and Haase 1987) and is characterized by complex deformation (Figs. 1.3.2 and 1.3.3). A sequence of cross-cutting imbricate splay faults repeatedly stack the Rome Formation in the hangingwall, and slices of the Knox Group and Chickamauga Group have been complexly stacked, rotated, and folded in the footwall to the WOM Fault. In contrast, the CC Fault in the ORR shows a shallow dip (0–25°) and displays a relatively simple outcrop pattern, although portions of the Chickamauga Group in the footwall of the CC Fault may be structurally duplicated. Locally, the CC fault zone ranges in thickness from 0–23.5 m (0–77 ft) (Haase et al. 1985; Stockdale 1951). Thickness information for the other fault zones is not available.

On a smaller scale, the thrust sheets are cut by (1) high-angle tear faults that form as a result of differential movement of the thrust sheet and (2) minor thrust faults that form as a result of thrust movement over a curved surface. The existence of the tear faults has been inferred by local offset of topographic ridges, prominent topographic depressions, stream patterns, and is indicated by discrepancies in lithologic contacts as determined from borehole data (Dreier and Leat 1988). The majority of these features show a consistent northward trend that is oblique to the regional strike. Because they are tear faults, these structures probably show minor displacement 0–100 m (0–328 ft). Nevertheless these faults should have associated fracture zones.

Thrust faults have been identified from core, geophysical logs, topographic linements, and surface folding characteristics. The most consistent zone of thrusting appears to occur in the middle to upper portions of the Maryville Limestone and in the lowermost Nolichucky Shale (Haase et al. 1985; Lee and Ketelle 1989; Dreier and Leat 1988). These horizons may be a zone(s) of inherited deformation that has been passively transported by regional thrust faults and locally reactivated by local perturbations in fault geometry. Displacement along these thrust faults has not been measured. However, geologic constraints suggest that maximum displacement does not exceed 25 m (82 ft). Nevertheless, fracture zones up to 10 m (33 ft) are associated with these features (Dreier and Leat 1988). Tight, locally overturned folds with wavelengths that

range from centimeters to several meters are commonly associated with these minor faults.

Fractures

Fracturing is pervasive throughout all rock units in the ORR. Because permeability and porosity of bedrock are strongly influenced by secondary-fracture permeability and porosity, studies have recently been initiated to investigate fracture characteristics in sections of the ORR. Detailed investigations of Conasauga Group core from Bear Creek Valley show that five fracture sets occur consistently throughout the core. One set is parallel to bedding and the other four are generally perpendicular to bedding. Assuming a regional strike of N55E, the strikes of the high angle sets are approximately N55E (strike-parallel), N75W, N15E, and N20W. The bedding-parallel fractures are mainly release joints that may have formed in situ or as a result of coring. Studies elsewhere in the Appalachians suggest that release joints can form at depths up to 1 km (0.6 mile). In Melton Valley, field studies in waste management areas show a slight difference in the orientation of the high-angle fractures with respect to those measured in Bear Creek Valley. Here, there are prominent strike-parallel and strike-perpendicular sets with associated shear fractures (Dreier et al. 1987; Mares 1988).

Although the rock units are highly fractured, most fractures at depth are sealed by mineral precipitates (predominantly calcite) and do not contribute to secondary permeability. Open fractures are most common within 45 m (150 ft) of land surface and in deformed massive shale units (Dreier et al. 1988), although exceptions to this generalization do exist. Open fractures usually occur as a function of depth below land surface, lithology, and degree of deformation.

Karstification, or solution enlargement of existing fractures, is common in the more carbonate-rich units and is present in the Knox Group, the Chickamauga Group, the Maynardville Limestone, and carbonate-rich portions of the Nolichucky Shale. Cavities generally range in thickness from <30 to 91 cm (<1 to 3 ft), although cavities from 2.4 to 3.4 m (8 to 11 ft) thick exist (Rothschild 1984). The cavities commonly parallel bedding planes.

Appendix B

STATISTICAL TREATMENT OF RANDOM UNCERTAINTIES

As described in Sect. 2, random uncertainties are those that can be treated by statistical methods and are derived from an analysis of replicate observations of a random or stochastic process. The information in this appendix has been taken directly from *Upgrading Environmental Radiation Data,* EPA 520/1-80-012, prepared by the Health Physics Society Committee, 1980. Only a small amount of background information is presented here.

Before proceeding, definition of some terminology is necessary. The term variate (or random variable) is used to denote the quantity that may take on any of the observed values. The aggregate of these observations is termed a sample of some parent population and may be described by a frequency distribution. This distribution of the population is a specification of the way in which the number of observations (frequencies) are distributed according to the values of the variates. The parameters of a population are the descriptive measures of the distribution. The mean (μ), a measure of the center or location of the distribution, and the standard deviation (σ), a measure of the spread or scatter of the distribution, are examples of parameters. The mean (μ) is also termed the first moment of the distribution, and the square of the standard deviation (σ^2), called the variance, is the second central moment. In the absence of an infinite population, one must make estimates of the parameters from finite populations (the sample of observations). A sample statistic is this estimator of the population parameter. The values of sample statistics are computed entirely from the sample and are the basic measures of the central tendency (location) and dispersion (variation). The mean ($\bar{x}$) and standard deviation (s) are widely known examples of statistics. Unfortunately, the distinction between population parameters and sample statistics is frequently ignored, and the two are often confused and incorrectly referred to interchangeably. The following diagram is an attempt to clarify the distinction.

Statistics	→	Parameters
Calculated from sample (e.g., $\bar{x}$ and s^2)	used to estimate	for the population (e.g., μ and σ^2)

In practice, the parameters of the population are denoted by Greek alphabetic characters, and the corresponding estimators of these parameters (the statistics) by Roman alphabetic characters. Table B.1 lists a number of commonly used parameters and statistics.

The population distribution must be known before one can proceed with the treatment of random uncertainties. A rigorous analysis would require confirmation that the sample of observations is a normal or some other known distribution. Numerous statistical tests, such as the χ^2-, t-, and F-tests, are available for this use. Standard statistical sources may be consulted for details. These tests are not always practical, particularly because they are not very applicable with samples of less than about 30 observations. With fewer observations, a normal (or Gaussian) distribution, which is completely characterized by the mean and variance, is assumed. For some

Table B.1. Commonly used population parameters and sample statistics

Population parameters	Sample statistics (Estimators of parameters)
μ_x (mean—first moment)	$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$
σ_x^2 (variance—second central moment)	$s_x^2 = \frac{1}{n-1}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2$
σ_x (standard deviation of x about μ_x)	$s_x = \sqrt{s_x^2}$
$\sigma_{\bar{x}}$ (standard error of the mean, or standard deviation of the average)	$s_{\bar{x}} = \frac{1}{\sqrt{n}} s_x$
$\sigma_{xy} = \sigma_{yx}$ (covariance)	$s_{xy} = s_{yx} = \frac{1}{n-1}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)\left(y_i - \bar{y}\right)$
$\frac{\sigma}{\mu}(100)$ (coefficient of variation, or relative standard deviation, expressed in percent)	$v_x = \frac{s_x}{\bar{x}}(100)$

other distributions, further parameters, such as skewness (third central moment) or peakedness (fourth central moment), may be necessary. The justification for this assumption of normality is based on precedent. The normal distribution can be viewed as a mathematical result empirically shown to be valid for a large number of different experimental situations. It is still only an assumption, and it is well worthwhile to make a visual examination of the data for any marked departures from normality. There are some simple procedures to do this. They include construction of a histogram or graphical test using probability paper. The discussion of random uncertainties that follows assumes that a normal distribution is justifiable. It can be shown that this subsequent treatment is not absolutely dependent on a normal population distribution. The Central Limit Theorem states this, provided the departures are not too great, and further predicts that the convolution or folding-together of nonnormal distributions tends to form normal distributions. The probabilities for some typical intervals in the normal distribution are provided in Table B.2. As stated before, an analysis of the observed values will be used to estimate μ and σ^2.

Table B.2. Probabilities for same typical intervals in normal distribution

Interval $(\mu - \zeta\sigma_x)$ to $(\mu + \zeta\sigma_x)$ (ζ)	Percentage of the population within this interval (%)
0.6745	50
1.000	68.269
1.960	95
2.000	95.450
2.576	99
3.000	99.73

Sample Mean and Standard Deviation

For n measurements of x, the best estimate of the parameter μ is obtained from the mean ($\bar{x}$) of the sample: and the best estimate of σ^2 from the variance (s_x^2), where

$$\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i \rightarrow \mu . \tag{1}$$

and

$$s_x^2 = \frac{1}{n-1} \sum_{i-1}^{n} \left[x_1 - \bar{x}\right]^2 \rightarrow \sigma_x^2 . \tag{2}$$

The sample standard deviation is the square root of the variance, or the quantity s_x. It refers to the standard deviation computed from a sample of measurements.

Standard Error of the Mean

Any mean $\bar{x}$ is determined from a finite number of measurements. If the determination is repeated, one can obtain a series of slightly different $\bar{x}$ values. According to the Central Limit Theorem, for large n, the distribution of these $\bar{x}$ values will be close to normal for any distribution of x that has at least two finite moments. Thus, a standard deviation of this distribution could be obtained from repeated determinations of $\bar{x}$. It may, however, also be estimated from just the measurements used in a single determination of x. This estimate of the precision on the mean is termed the standard error of the mean ($s_{\bar{x}}^2$), which is given by

$$s_{\bar{x}}^2 = \frac{s_x^2}{n} = \frac{1}{n(n-1)} \sum_{i=1}^{n} \left[x_i - \bar{x}\right]^2 . \tag{3}$$

The quantity $s_{\bar{x}}^2$ is termed the variance of the mean. The standard error of the mean ($s_{\bar{x}}$) must not be confused with the sample standard deviation (s_x). The standard deviation s_x is only dependent on the measurement precision, whereas $s_{\bar{x}}$ depends on both the precision and the number of observations.

Appendix C

CHEMICAL RELEASE APPENDIX FOR THE OAK RIDGE RESERVATION FACILITIES 1989 ENVIRONMENTAL REPORT

INTRODUCTION

In addition to indicating the concentrations of various chemicals present in the environment near DOE facilities, in recent years the annual Environmental Reports have contained an estimate of the quantities of certain chemicals being emitted to the environment. This appendix contains an expanded list of chemicals with information regarding the types of releases, the estimated quantities released, the major processes contributing to the releases, and a brief description of the basis of estimates for calendar year (CY) 1989. Radiological chemical releases for CY 1989 are not included in this appendix; they are reported in the applicable chapters of this report.

DISCUSSION

Three categories of chemical releases at each DOE facility are reported in this appendix: (1) SARA 313, (2) Other Large Inventory Chemicals, and (3) Steam Plant Emissions. The SARA 313 chemicals are summarized from the information currently being compiled for the SARA Title III, Section 313 report, required by SARA 1986. This report is submitted on July 1 of each year for the previous calendar year and contains chemicals on the EPA toxic substance list. Currently, 309 specific chemicals and 20 chemical categories must be reviewed and possibly reported under SARA Section 313. If any of these chemicals were manufactured in excess of 25,000 lb, processed in excess of 25,000 lb, or "otherwise used" in excess of 10,000 lb at a facility during CY 1989, the chemical must be reported. In many instances, the estimate of quantities released was obtained via material balance calculations, monitoring data, or engineering calculations. In some cases, no quantitative monitoring data, inventory estimates, or emission factors were readily available, and release estimates were based on "best engineering judgement." Best engineering judgement was the principal method used to derive "Quantity released." Information obtained from air permits, rate of operation, quantities used, and known treatment efficiencies were used to estimate quantities released into the environment. Typically, assumptions based on best engineering judgement were required to perform the calculations when all variables were not known. Considerable manpower was expended reviewing chemical inventory information and estimating the quantities released to the environment. Information contained in this appendix may not coincide with the information to be reported for all chemicals under SARA, Title III, Section 313. The SARA 313 report must be submitted to the EPA and the TDHE no later than July 1, 1990. The information for this appendix was generated in the March/April timeframe, and some additional refinements were in progress. It is imperative that the additional 2 months

(May–June) be used to ensure compliance under SARA Title III, the Community Right-to-Know law.

The second category of chemicals reported in this appendix is "Other large inventory chemicals." This listing is included to provide the reader with additional chemical information not reportable under SARA 313. Note that this is not a complete listing of all chemicals that may have been released at a site. This list was developed to better inform the reader of additional chemicals used and released at each site that may be of interest to the general public.

The third category, "Steam plant emissions," is release estimates of certain chemicals from the coal- and/or gas-fired steam plants located at each site.

Chemical release information is included for the Oak Ridge Y-12 Plant (Table C.1), ORNL (Table C.2), and ORGDP (Table C.3).

Table C.1. Y-12 Plant chemical release information, 1989

Chemical name	Type of environmental release	Quantity released (lb/kg)	Major release sources	Basis of estimate
		SARA 313		
Acetonitrile	Air: point	4,000/1,800	Solvent usage	Material balance
Chlorine	Air: fugitive	1,900/880	Cooling towers	Material balance
	Air: point	170/80	Stack emissions	Engineering calculation
	Water: East Fork	1,500/680	Once-through cooling	Monitoring
Freon 113	Air: fugitive	47,000/21,000	Cleaning	Material balance
	Air: fugitive	16/7	Spills	Material balance
	Air: point	130,000/60,000	Stack emissions	Material balance
Hydrochloric acid	Air: point	1,100/500	Stack emissions	Engineering judgment
	Land	10/5	Spills	Material balance
Hydrogen fluoride	Air: point	14,000/6,300	Stack emissions	Material balance
Methanol	Air: fugitive	2,500/1,200	Spills: chilled water	Material balance
	Air: fugitive	51,000/23,000	Cleaning/cooling	Material balance
	Air: point	18/8	Stack emissions	Engineering judgment
	Water: East Fork	210/95	Spills: chilled water	Engineering judgment
Methyl chloroform	Air: fugitive	8,300/3,800	Cleaning: machine coolant	Engineering calculation
	Air: fugitive	3/1	Spills	Material balance
	Air: point	40,000/18,000	Stack emissions	Material balance

Table C.1 (continued)

Chemical name	Type of environmental release	Quantity released (lb/kg)	Major release sources	Basis of estimate
	Water: East Fork	100/48	Cleaning	Material balance
Nitric acid	Air: point (emitted as NO_x)	75,000/34,000	Cleaning and processing aid	Air permit
	Land	32/15	Spills	Material balance
Perchloro-ethylene	Air: fugitive	170/76	Solvent spill: machine coolant	Engineering judgment
	Air: point	36,000/16,000	Solvent: degreasing	Material balance
	Water: East Fork	200/54	Cleaning	Monitoring
PCBs	Water: East Fork	6/3	Ancillary use	Monitoring
	Land	<1/<1	Spill	Material balance
Sulfuric acid	Air: point	22/10	Processing aid	Engineering judgment
	Land	76/35	Spill	Material balance
		Other large inventory chemicals		
Freon 11	Air: fugitive	16,000/7,300	Refrigeration systems	Material balance
Freon 12	Air: fugitive	5,600/2,600	Refrigeration systems	Material balance
Freon 22	Air: fugitive	3,600/1,600	Refrigeration systems	Material balance
Freon 114	Air: fugitive	750/340	Refrigeration systems	Materia balance
Mercury	Water: East Fork	36/16	Stormwater runoff	Monitoring
Acetic acid	Air: fugitive	13/6	Wastewater treatment	Engineering judgment
		Steam plant emissions		
Sulfur dioxide	Air: point	1,300,000/580,000	Stack emissions	Emission factors
Nitrogen oxide	Air: point	1,700,000/790,000	Stack emissions	Emission factors
Carbon monoxide	Air: point	92,000/42,000	Stack emissions	Emission factors
Particulates	Air: point	14,000/6,200	Stack emissions	Emission factors

Table C.2. ORNL chemical release information, 1989

Chemical name	Type of release	Quantity released (lb/kg)	Major release sources	Basis of estimate
		SARA 313		
Ethylene glycol	Water: White Oak Creek	3,400/1,500	Chilled water system	Other[a]
	Soil: leak	29,000/13,000	Chilled water	Engineering calculations
Nitric acid	Air: point	65/29	Nitric acid tank vents	Engineering calculations
Sulfuric acid	Air: point	<1/<1	Sulfuric acid tank vents	Engineering calculations
Lead	Air: stack	14/6	Lead furnace—lead shop	Engineering calculations
		Other large inventory chemicals		
Freon 11	Air: fugitive emissions	8,800/4,000	Refrigeration systems	Other[a]
Freon 12	Air: fugitive emissions	2,900/1,300	Refrigeration systems	Other[a]
Freon 22	Air: fugitive emissions	6,700/3,100	Refrigeration systems	Other[a]
Freon 113	Air: fugitive emissions	3,000/1,400	Refrigeration systems	Other[a]
Sulfur hexafluoride	Air: fugitive emissions	7,400/3,300	Accelerator cooling	Other[a]
		Steam plant emissions		
Sulfur dioxide	Air: stack emissions	2,400,000/1,100,000	Fossil fuels combustion	Emission factors[b]
Nitrogen oxide	Air: stack emissions	300,000/140,000	Fossil fuels combustion	Emission factors
Carbon monoxide	Air: stack emissions	162,000/74,000	Fossil fuels combustion	Emission factors
Particulates	Air: stack emissions	18,000/8,000	Fossil fuels combustion	Stack test[c]

[a]Best engineering judgment.
[b]Based on AP-42 emission factors and 1989 ORNL steam plant coal usage/analysis records.
[c]Based on stack test conducted in 1981 in accordance with applicable EPA methods.

Table C.3. ORGDP chemical release information, 1989

Chemical name	Type of release	Quantity released (lb/kg)	Major release sources	Basis of estimate
		SARA 313		
Chlorine	Air: fugitive emission	34,000/15,000	Neutralization	Material balance
	Water: Poplar Creek	68/31		Monitoring
	Water: Clinch River	210/94		Monitoring
Sulfuric acid	Air: fugitive emissions	<1/<1	Neutralization/ storage	Other[a]
Methanol	Air: stack	<1/<1	K-1435 Toxic Substances Control Act (TSCA) Incinerator tests	Monitoring
1,1,1-Trichloroethane	Air: stack	14,000/6,200	Degreasing	Material balance
Carbon tetrachloride	Air: stack	<1/<1	K-1435 TSCA Incinerator tests	Monitoring
Hydrochloric acid	Air: stack emissions	250/110	Cleaning/pickling/ neutralization	Other[a]
	Air: fugitive emissions	<1/<1	Neutralization	Other[a]
	Water: Poplar Creek	340/150	Spill	Other[a]
		Other large inventory chemicals		
Freon 11	Air: fugitive emissions	12,000/5,400	Refrigeration/ systems cooling	Other[a]
Freon 22	Air: fugitive emissions	2,200/1,000	Refrigeration/ systems cooling	Other[a]
		Steam plant emissions		
Particulates	Air: stack emissions	13,000/5,800	Fossil fuels combustion	Emission factors[b]
Sulfur dioxide	Air: stack emissions	28,000/13,000	Fossil fuels combustion	Emission factors[b]
Nitrogen oxide	Air: stack emissions	70,000/32,000	Fossile fuels combustion	Emission factors[b]
Carbon monoxide	Air: stack emissions	12,000/5,600	Fossil fuels combustion	Emission factors[b]

[a]Based on best engineering judgment.
[b]AP-42, "Compilation of Air Pollutant Emission Factors."

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ERRATA

The following corrections should be made to the 1988 report.

Volume 1

Page 46, Table 2.1.11. The Max, Min, and Av values for ^{3}H at ORNL PAMs should be 70,000, −320,000, and −9,800, respectively. The Max, Min, and Av values for ^{3}H at Reservation PAMs should be 540,000, −350,000, and −17,000, respectively.

Page 162, Table 2.5.2. The units of measure should be pCi/g dry wt, rather than pCi/kg dry wt.

Page 169, Table 3.1.2. The value for ^{239}Pu in endosteal bone should be 7.59×10^{1}, rather than 7.59×10^{-1}.

Page 176, Table 3.1.10. The value for effective dose at CRK 8.0 should be 0.05. The values for effective dose and endosteal bone at CRK 40.0 should both be 0.01. The effective dose given in line 5, column 2 of the text should be 0.05 mrem.

Volume 2

Page 139, Table 2.3.14. The number of values exceeding reference for ^{60}Co, ^{137}Cs, gross alpha, total radioactive strontium, and total radium should all be 0.

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