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MARTIN MARIETTA

Oak Ridge Reservation Environmental Report for 1988

VOLUME 1: NARRATIVE, SUMMARY, AND CONCLUSIONS

OPERATED BY
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FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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OAK RIDGE RESERVATION ENVIRONMENTAL REPORT FOR 1988

VOLUME 1: NARRATIVE, SUMMARY, AND CONCLUSIONS

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ERRATA

The following corrections should be made to this 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.

EXECUTIVE SUMMARY

OVERVIEW OF 1988 ENVIRONMENTAL REPORT

This two-volume report, the *Oak Ridge Reservation Environmental Report for 1988,* is the eighteenth 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 and supporting 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) 1988. 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 1988 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 not just in absolute terms but also 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. Even more important for the long term is to provide a yardstick for measuring progress in implementing improved environmental management practices and in taking remedial actions to correct deficiencies in past practice. This includes active 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," not just to meet what may be acceptable or legally permitted limits.

From this perspective, the aim of the effluent and environmental monitoring program must be two-fold: (1) to serve as an effective *early indicator* that detects and provides the real-time 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 of up to 120 km (77 miles) to the north, south, east, and west of Oak Ridge;
- 6 meteorological towers;
- Over 400 National Pollutant Discharge Elimination System (NPDES) and surface-water-sampling stations;
- Over 330 on-site groundwater-monitoring wells;
- 96 on-site exhaust-stack monitors for detecting radionuclide releases;
- 3 river and stream points where fish are sampled;
- 46 locations where vegetation samples are taken;
- 40 locations where soil samples are taken;
- 8 stream sediment monitoring points;
- 6 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.

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); and the Atomic Energy Act. 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).

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 draft DOE Order 5400.xx, entitled "Radiation Protection of Public and Environment."

Summary Conclusion

Comprehensive environmental monitoring data for 1988 show a continuation of progress in

bringing the three major Oak Ridge installations into full compliance with permits and regulations issued by the bodies previously mentioned and with their advice and recommendations. The total environmental related costs associated with new construction and modifications to present facilities, as well as the day-to-day activities of staff environmental personnel, was about $425 million from 1984 through 1987. In fiscal year (FY) 1988 $142 million was spent, and a continuation of these efforts will require an FY-1989 expenditure of about $160 million.

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 1988 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 1988.

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.

Quantities of nonradiological chemical emissions are not included in this report this year. An addendum that will include the information will be published after the Superfund Amendments Reauthorization Act (SARA) Title III report is issued on July 1, 1989. When the addendum is published, probably in late July, a summary of the SARA Title III 313 Report will be included. The SARA report provides the community with the opportunity to learn about estimated quantities of certain toxic chemicals used at a facility that are routinely or accidentally released into the environment. The addendum that will be published after the SARA report will summarize the SARA report and is expected to include 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. The addendum will not be all inclusive but will provide emissions information on the major chemical emissions to the air, water, or land from processes at the facilities.

SUMMARY OF 1988 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 1988.

Radioactive Discharges to the Atmosphere

During 1988, 59,100 Ci of radionuclides were released to the atmosphere from Oak Ridge installations, in comparison with 71,400 Ci released in 1987, 92,600 Ci released in 1986, 59,000 Ci released in 1985 and 121,000 released in 1984 (see Fig. 1). This difference from year to year can be accounted for almost totally by tritium because of decreases in ORNL inventories. Two inert gases, xenon and krypton showed some increase in 1988 over 1987. These gases have little or no interaction with the terrestrial biosphere, including humans. The total curie discharges of tritium, xenon, and kryton are shown in Figs. 2, 3, and 4.

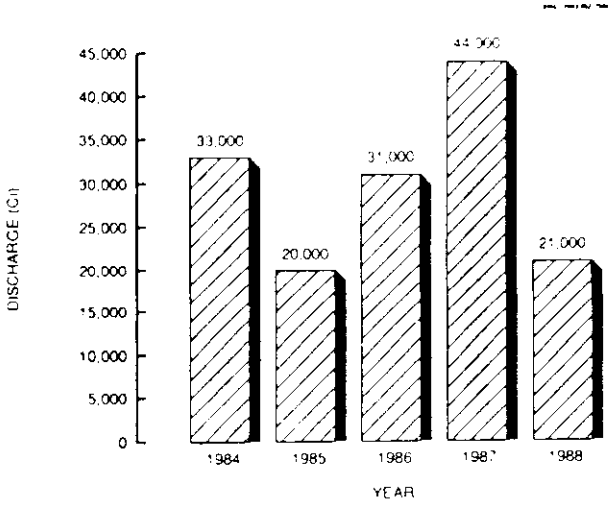

Fig. 2. Total discharges of tritium from ORNL to the atmosphere.

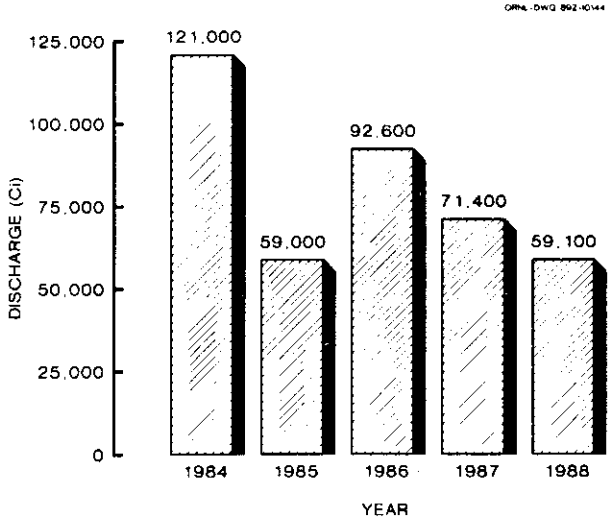

Fig. 1. Total curie discharges from the Oak Ridge Reservation to the atmosphere.

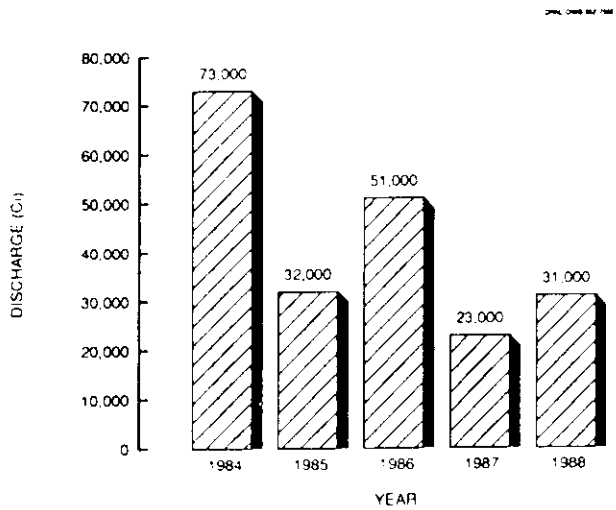

Fig. 3. Total discharges of ^{133}Xe from ORNL to the atmosphere.

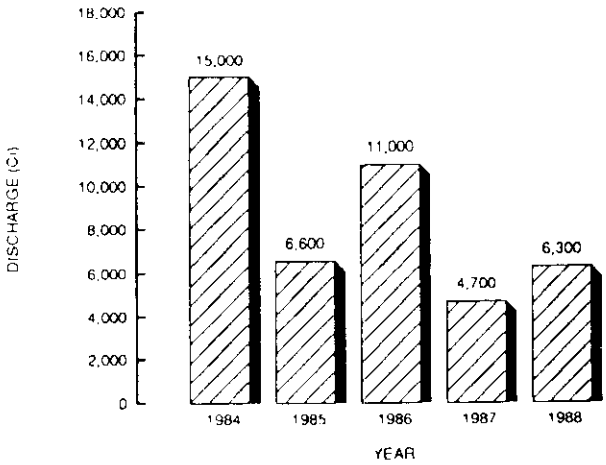

Fig. 4. Total discharges of ^{85}Kr from ORNL to the atmosphere.

Uranium is the primary radioactive element of concern at the Y-12 Plant. Uranium emissions were lower than in recent years at the plant. During 1988, 0.12 Ci of uranium were discharged from the Y-12 Plant in comparison with 0.14 Ci in 1987 and 0.19 Ci in 1986. After uranium isotope differences are considered, this correlates to 47.4 kg (104.3 lb) of uranium discharged in 1988 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 1984 through 1988. Figure 6 shows the comparable total mass of uranium emitted from the Y-12 Plant for the same years. This reduction in 1987 and 1988 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.

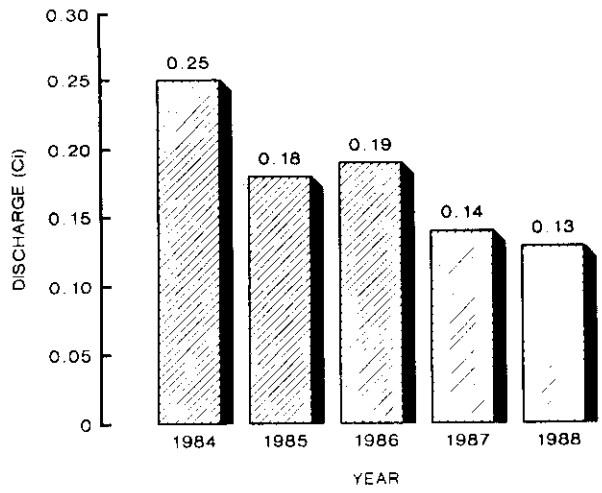

Fig. 5. Total discharges of uranium from the Y-12 Plant to the atmosphere (1984–1988).

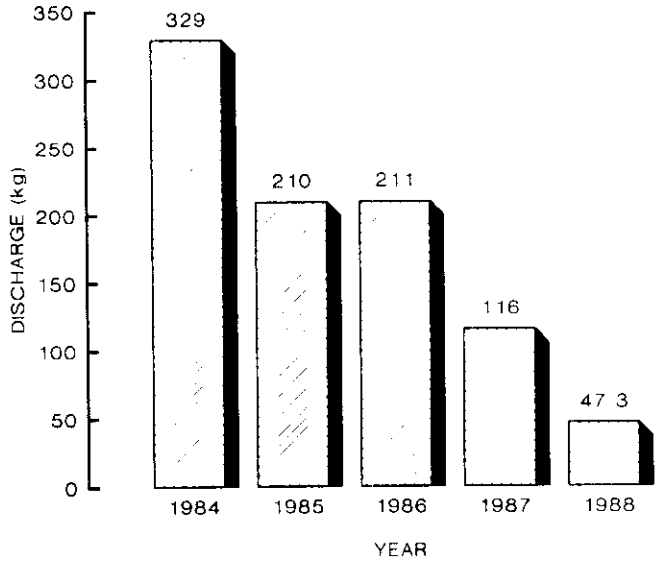

Fig. 6. Total kilograms of uranium discharged from the Y-12 Plant to the atmosphere (1984–1988).

Atmospheric radionuclide emissions from ORGDP were confined to three sources in 1988. The total emissions were estimated at 1.7 kg (3.7 lb) of uranium with a ^{235}U assay of 1% and 0.54 g (0.02 oz.) of ^{99}Tc.

Discharges, as well as meteorological data, are input into dose models to predict the radiation dose to the maximally exposed individual and to the population within 80 km (50 miles) of the DOE Oak Ridge facilities. Dose equivalents to a maximally exposed off-site individual from airborne effluents are greatest from the Y-12 Plant: 0.0007 mrem to whole body, 0.68 mrem

effective, and 5.5 mrem to the lung. These are well within the dose limits (25 mrem to whole body and 75 mrem to any organ) specified in NESHAP. For the entire ORR, maximum individual dose equivalents are 0.14 mrem to whole body, 0.68 mrem effective, and 5.5 mrem to lung, well within the federal standards. The estimated collective committed effective dose equivalent to the approximately 870,000 persons living within 80 km (50 miles) of the ORR is 36 person-rem for 1988 airborne emissions. This represents about 0.01% of the 2.61×10^5 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 and/or sampled continuously by an air-monitoring network of 27 stations. The stations are divided into three groups. The ORNL perimeter air monitors are designed to evaluate the specific impact of ORNL upon 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 to 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 to 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, as compared to the remote station data. They are ^{60}Co, ^{228}Th, ^{230}Th, ^{234}U, and ^{235}U. Thorium-228 made the largest contribution to inhaled dose with an annual average of 0.85% 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 upon the local air quality. A similar comparison for the ORR perimeter air-sampling data shows that operations on the ORR are making a net contribution to the local airborne radioactivity. The impact upon inhaled dose from these isotopes ranges from <0.01% to 0.85% of the DCGs. No significant changes in the concentrations of these radionuclides were detected between 1987 data and the 1988 data for the remote stations. Therefore, based upon 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 because the fluoride emission sources were shut down. Of the approximately 590 ambient air fluoride measurements taken at the Y-12 Plant, none exceeded 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, 93 suspended particulate measurements were taken and all were in compliance with state standards.

Sulfur Dioxide Measurements

Continuous sulfur dioxide samples were taken and recorded hourly at the Y-12 Plant. All were

within both 24-h and 3-h standards. The highest level of the 24-h measurements was 21% of the Tennessee air quality standard. The highest level of the 3-h measurements was 15% 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 1988, the Y-12 Plant, with 248 noncompliances, was 97.0% in compliance with NPDES standards. ORNL had 149 noncompliances and was 95.4% in compliance. With 48 noncompliances, ORGDP was 99.8% in compliance.

The primary surface water areas monitored by all three installations include the Tennessee and Clinch rivers, White Oak Creek (WOC), Bear 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 Rinse Water Treatment Facility (PRWTF), 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 1988, its first full year of operation, the PRWTF treated over 30.3 million L (8 million gal) of plating rinsewaters. During 1988, the SPWTF was completed and began operating. As a result, about 178 million L/year (47 million gal/year) of acidic and caustic discharges from the Y-12 Plant coal yard and steam plant operations received treatment before release to East Fork Poplar Creek (EFPC).

Over the years, the Y-12 Plant has monitored both the influent at New Hope pond and the effluent of the Pond into East Fork Poplar Creek. Monitoring at these points ceased in 1988 when closure of New Hope Pond was initiated. As a replacement monitoring location, station 17, near the junction of Bear Creek Road and Scarboro Road, was selected. At this site, sampling for radiological and nonradiological parameters monitors East Fork Poplar Creek before it leaves the Y-12 Plant boundary.

Construction on the ORNL Nonradiological Wastewater Treatment Plant (NRWTP) continued throughout 1988. The NRWTP, which will treat numerous waste streams for removal of metals and organics, is scheduled for operation beginning in early 1990.

At ORNL and ORGDP, monitoring station upgrading projects were completed. These will enhance surface water monitoring capabilities. Construction of a new monitoring station on the WOC headwaters near ORNL was completed in 1988. This station is located north of the ORNL 7000 area and will provide background data for surface waters before they are influenced by the Laboratory.

At ORGDP, the NPDES sampling station upgrade project was initiated during 1987 and was completed in 1988. During 1987, the sample station platforms were replaced, and flow monitoring systems were installed. During 1988, refrigerated composite samplers were installed and linked to the flow-monitoring systems to allow flow-proportional sampling.

The NPDES compliance program at ORNL was the subject of intensive QA activities involving staff of the ORNL Quality Department and Energy Systems Central Staff as well as ORNL Environmental and Health Protection Division personnel. Significant improvements in areas of field monitoring, chain-of-custody, and laboratory analysis that were findings of an EPA Performance Audit Inspection Follow-Up in June 1988 were attributed to the QA efforts. The EPA revised its 1987 rating of the ORNL NPDES compliance program to a favorable one as a result of the 1988 findings.

ORNL submitted a Notice of Noncompliance to the TDHE in December 1988 for failure to completely meet the conditions of a Federal Facilities Compliance Agreement interim milestone

associated with construction of the NRWTP. Construction of NRWTP components required by November 1988 was 97% complete at that time. ORNL fully expects to meet the remaining milestones associated with the NRWTP.

Radionuclide Discharges to Surface Streams

At the Y-12 Plant and the ORGDP, radiological effluents were well within limits at all effluent locations. Effluent radionuclide concentrations were significantly reduced at several ORNL outfalls, including a tenfold decrease of ^{60}Co from the High Flux Isotope Reactor (HFIR) surface impoundment. The average ^{137}Cs concentration in the Process Waste Treatment Plant (PWTP) was above the DCG level for 1988; however, a PWTP upgrade project is expected to result in enhanced treatment capability at that facility in the future. In general, the radioactivity discharges to surface waters has declined over the past 5 years. Radionuclide discharges to surface streams are mainly emitted from ORNL to the Clinch River via White Oak Dam (WOD). Figures 7, 8, 9, and 10 pictorially represent this decline at the WOD monitoring station. The radioactivity discharged at WOD is shown for the four major radioactive elements for the years 1984 through 1988.

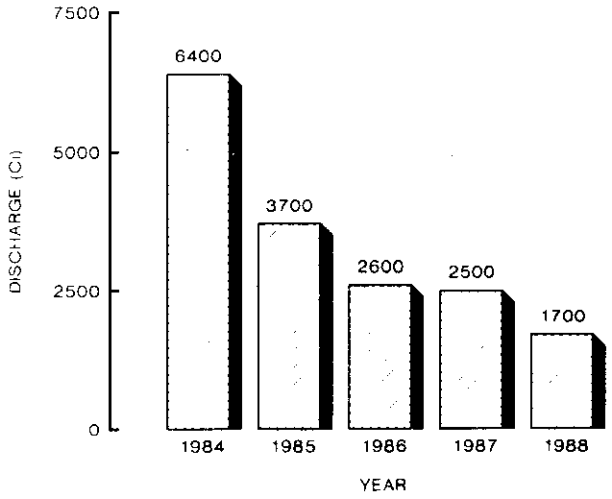

Fig. 7. Total discharges of tritium to surface waters, 1984 through 1988 (White Oak Dam).

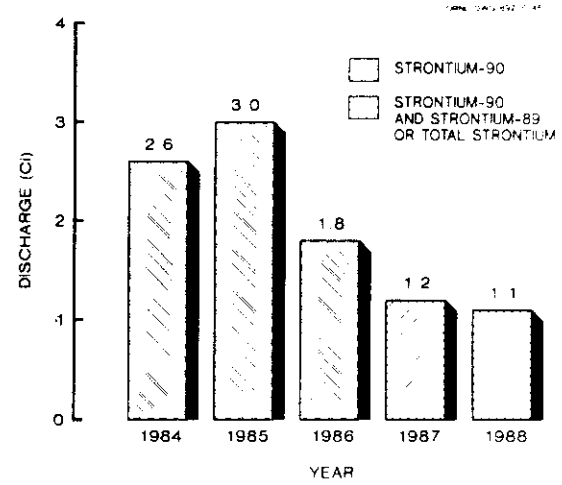

Fig. 8. Total discharges of radioactive strontium to surface waters, 1984 through 1988 (White Oak Dam).

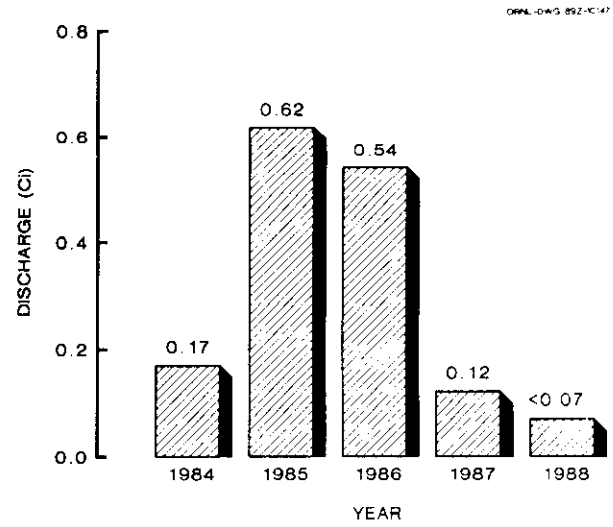

Fig. 9. Total discharges of ^{60}Co to surface waters, 1984 through 1988 (White Oak Dam).

GROUNDWATER

In 1988, 58 new on-site groundwater wells were installed on the ORR, and a total of 339 were sampled as part of an ongoing effort under RCRA to determine whether hazardous wastes have entered the groundwater and, if so, to define the extent of the problems. Over 150,000 laboratory analytes were measured in groundwater samples during 1988. Groundwater detection and assessment monitoring is under way at RCRA sites, and problem areas are being identified.

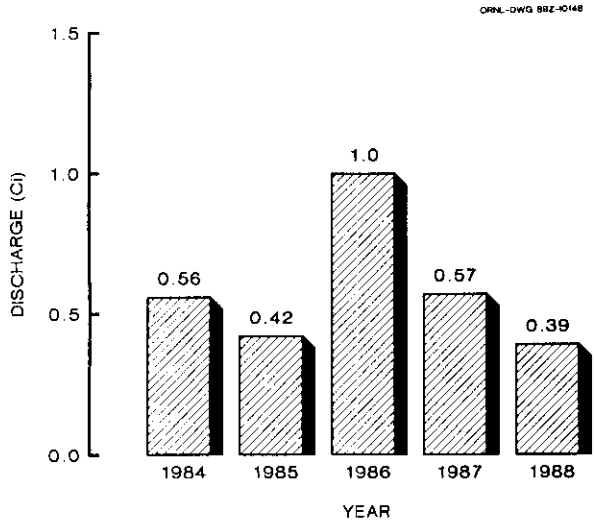

Fig. 10. Total discharges of ^{137}Cs to surface waters, 1984 through 1988 (White Oak Dam).

At the Y-12 Plant, 51 additional groundwater-monitoring wells were installed in 1988. Forty-one of these wells were installed to supplement existing monitoring programs and to fill previously identified gaps in data. Five wells were installed at a new facility to establish baseline groundwater quality, and five additional wells were installed at a site previously identified under RCRA 3004 (u) provisions.

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, while 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 the concept of Waste Area Groupings (WAGs) has been developed to evaluate potential sources of releases to the environment. In each WAG, scientists have grouped multiple sites into geographically contiguous and/or hydrologically defined areas. Twenty WAGs have been identified at ORNL. About 250 water quality monitoring wells will eventually be installed around the perimeter of the WAGs that are determined to have a potential for the release of contaminants. In 1988, groundwater monitoring began at two ORNL WAGs, WAG 6 (30 wells) and WAG 1 (25 wells). Over 18,000 analytical results were obtained from wells in these two WAGs during the third and fourth quarters of 1988. Results indicate that the most widespread contaminant in WAG 6 is tritium. The other primary contaminants in WAG 6 are volatile organic species that are in wells close to the waste trenches in WAG 6. The perimeter well with the highest levels of volatile organics is a shallow, 7.2-m (23.5-ft) well along the northeastern boundary of WAG 6. Volatile organics present in this well that are above the federal drinking water standards include trichloroethane, 1,2-dichloroethane, and carbon tetrachloride. Levels of organic species in all the other perimeter wells were less than 1 mg/L. In addition to these contaminants, the internal site characterization wells also contained benzene, toluene, xylene, and vinyl chloride in one or more of the wells. Maximum organic concentrations were between 1 and 2 mg/L in the internal WAG 6 wells. Only one quarter of the data were available for WAG 1 in 1988. Additional sampling is necessary to determine the contaminants and concentrations present within the ORNL main plant area (WAG 1). Based on the limited data available, it appears that radioactive strontium and organics may be the major contaminants of concern in the groundwater in the main Laboratory area.

The ORGDP Groundwater Protection Program includes 140 monitoring wells at 42 sites. Eighty wells at 13 of these sites were actively monitored for groundwater contamination during 1988, requiring more than ~42,000 laboratory analyses. The two RCRA sites (K-1407-B and K-1407-C Ponds) have undergone false-positive

assessments, which indicated that they were not contaminating groundwater with hazardous materials.

All 11 remedial action sites, however, exhibit some level of contamination. Four sites (K-1070-F, K-1085, K-1099, and K-1407-C Upgradient Area) show limited contamination at very low levels. Two sites (K-770 and K-1232) show contamination from a small number of constituents, but at levels which warrant additional investigation. The remaining five sites (K-1064-G, K-1070-A, K-1070-C/D, K-140 WAG, and K-1413 WAG) show numbers of constituents and levels of contamination that require further investigation. Monitoring, to date, has been used to detect the presence of contamination at remedial action sites and is not adequate to determine exact sources or to define plumes. Further investigations based on the data generated will be conducted.

OTHER MONITORING

Biological Monitoring (Fish, Milk, Deer, and Vegetation)

Fish-sampling results in 1988 are comparable to, or are generally lower than, data for previous years (see Figs. 11 through 15). Samples were collected for the purpose of measuring concentrations of mercury, polychlorinated biphenyls (PCBs), ^{60}Co, ^{137}Cs, and total radioactive strontium in bluegill collected from the Clinch River. The average mercury concentration

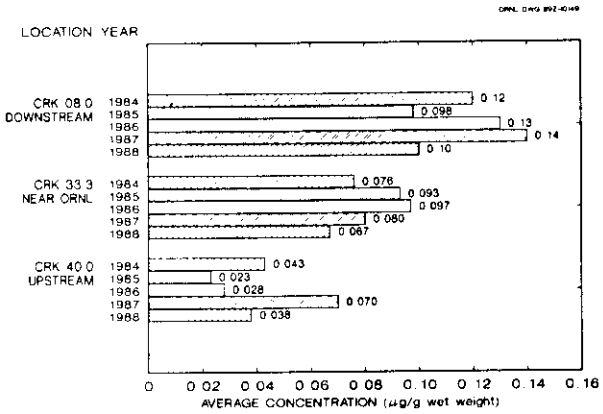

Fig. 11. Annual average mercury concentrations in bluegill at three Clinch River locations, 1984 through 1988.

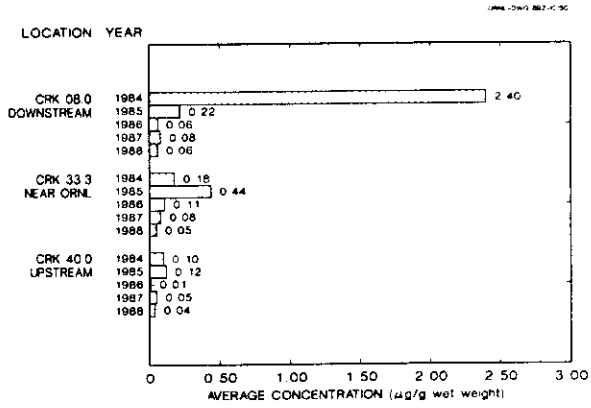

Fig. 12. Annual average PCB concentrations in bluegill at three Clinch River locations, 1984 through 1988.

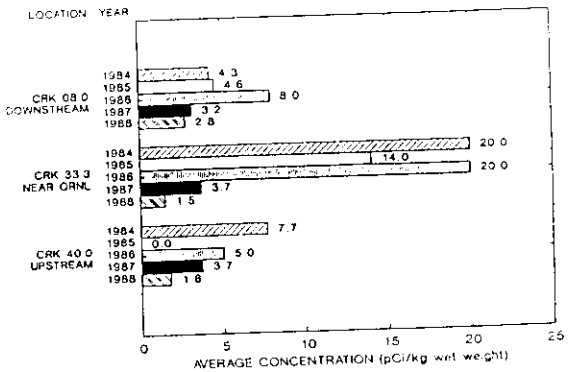

Fig. 13. Annual average ^{60}Co concentrations in bluegill at three Clinch River locations, 1984 through 1988.

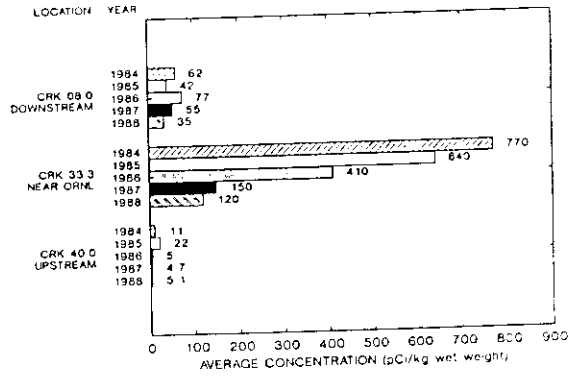

Fig. 14. Annual average ^{137}Cs concentrations in bluegill at three Clinch River locations, 1984 through 1988.

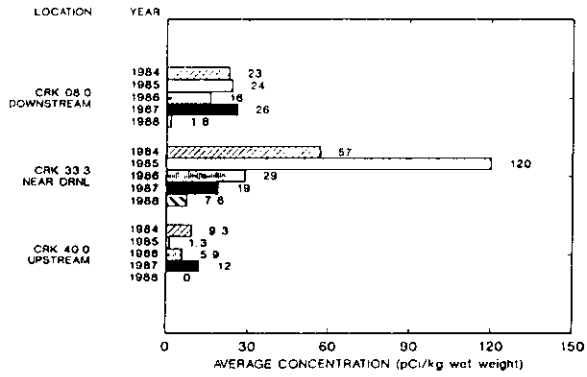

Fig. 15. Annual average total strontium concentration in bluegill at three Clinch River locations, 1984 through 1988.

for 1988 was 6.9% of the U.S. Food and Drug Administration (FDA) guideline. For the PCBs, the percentage of the guideline in 1988 was 2.5%. No guidelines exist for radionuclide concentrations in fish. However, dose calculations were made based on concentrations of radionuclides in fish and assumed consumption rates. These data are included in the results in Sect. 3.1 of this report. To put these doses from waterborne radionuclides further into perspective, the nearest population (Kingston) exposed to these radionuclides would receive a committed effective dose equivalent of 0.3 mrem/year from drinking water and eating fish. This represents about 0.1% of the annual dose from background radiation.

Milk samples were collected from eight 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.

During the 1988 deer hunts, 507 deer were harvested on the ORR in October, November, and December. Each hunter's deer was analyzed for a select group of radionuclides. Thirteen deer had levels of 30 pCi/g or greater of ^{90}Sr in bone, which is the confiscation level. These deer were retained and buried on-site at ORNL. The highest ^{90}Sr concentration in retained deer in 1988 was 250 pCi/g.

Annual ORR deer hunts have been conducted each fall to minimize the number of deer/vehicle collisions in the Oak Ridge area. The number of collisions was rapidly increasing in the 1982–1985 timeframe, as shown in Fig. 16. Deer hunting, under the management of the Tennessee Wildlife Resources Agency (TWRA) began in the fall of 1985 and the number of deer/vehicle collisions has declined as shown in the same figure.

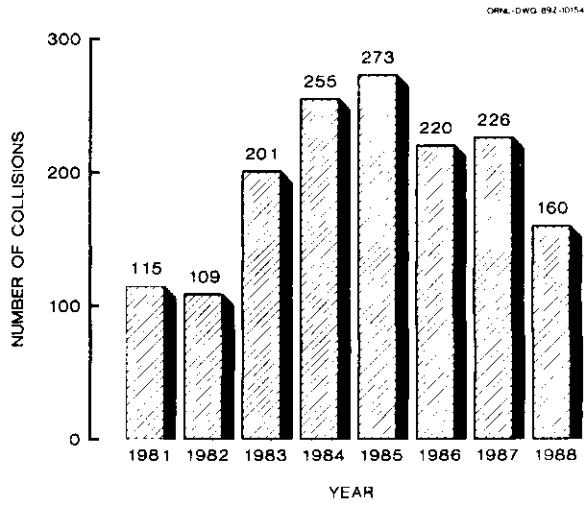

Fig. 16. Number of deer-vehicle collisions by calendar year (1981 through 1988).

Grass samples were collected at 40 locations, both on the ORR and off-site. Analyses are conducted for ^{60}Co, ^{137}Cs, ^{239}Pu, ^{238}Pu, ^{234}U, ^{235}U, ^{238}U, and total radioactive strontium at 27 locations by ORNL personnel. Figures 17–24 depict the available trend information in grasses during the period 1984 through 1988 at the perimeter stations, the ORR stations, and the remote stations.

The average 1988 results for total radioactive strontium, ^{137}Cs, and ^{239}Pu were higher than previous years for Group L (ORNL Perimeter Stations) because of the inclusion of a new station near the Process Waste Treatment Plant. The observed concentrations in the samples biased the annual average results high, probably because of an overflow into the grass from a nearby pond. Average concentrations of ^{60}Co and ^{137}Cs were near the analytical detection limits.

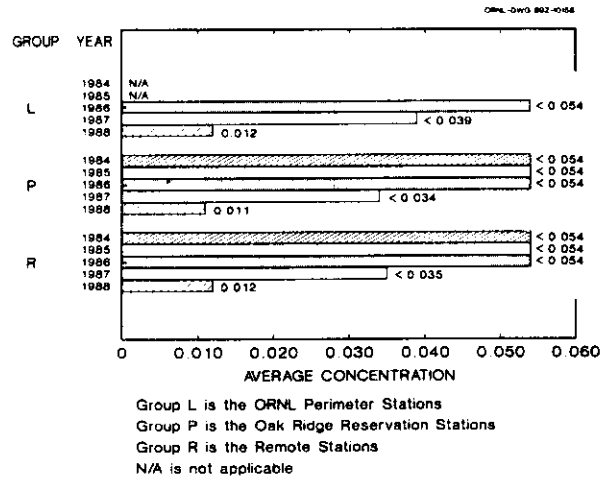

Fig. 17. Cobalt-60 concentrations (pCi/g ash weight) in grass.

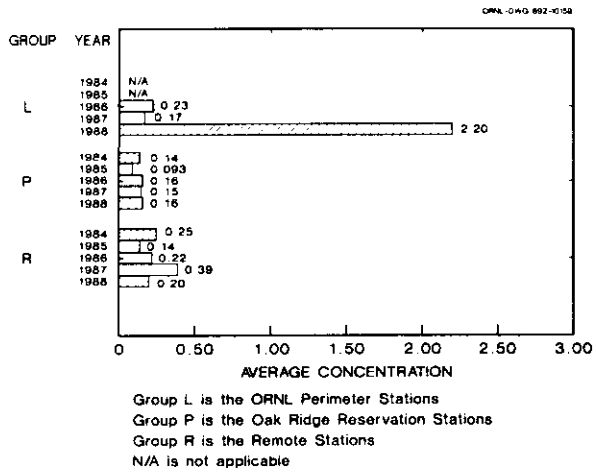

Fig. 18. Total radioactive strontium concentrations (pCi/g ash weight) in grass.

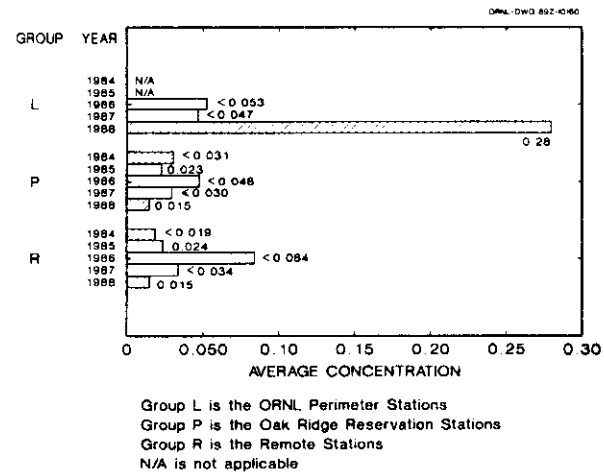

Fig. 19. Cesium-137 concentrations (pCi/g ash weight) in grass.

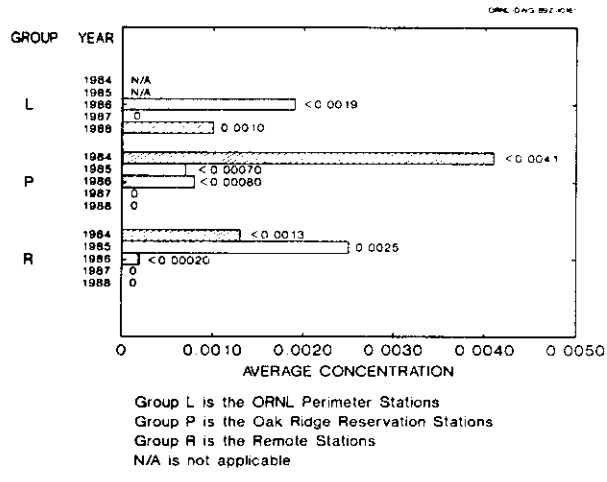

Fig. 20. Plutonium-239 concentrations (pCi/g ash weight) in grass.

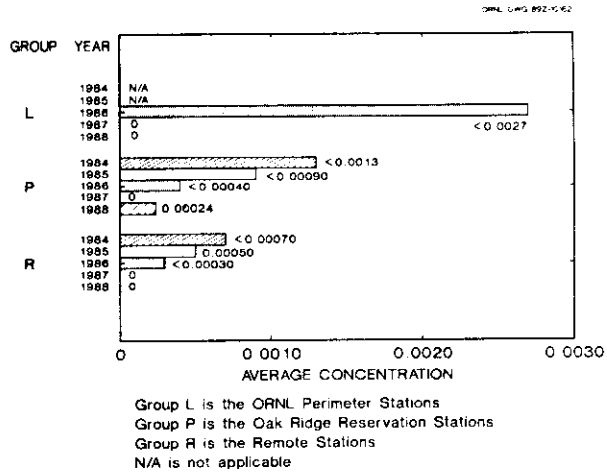

Fig. 21. Plutonium-238 concentrations (pCi/g ash weight) in grass.

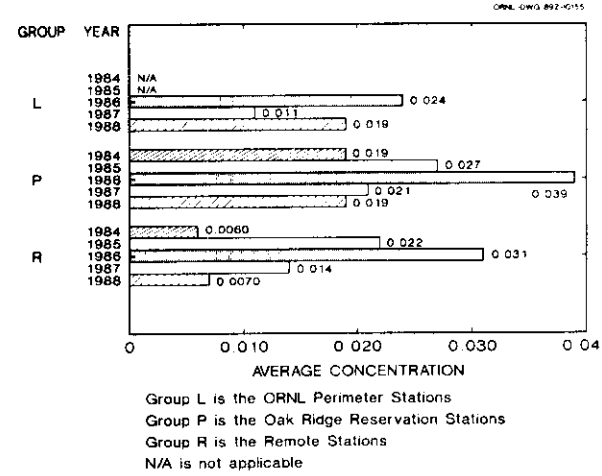

Fig. 22. Uranium-238 concentrations (pCi/g ash weight) in grass.

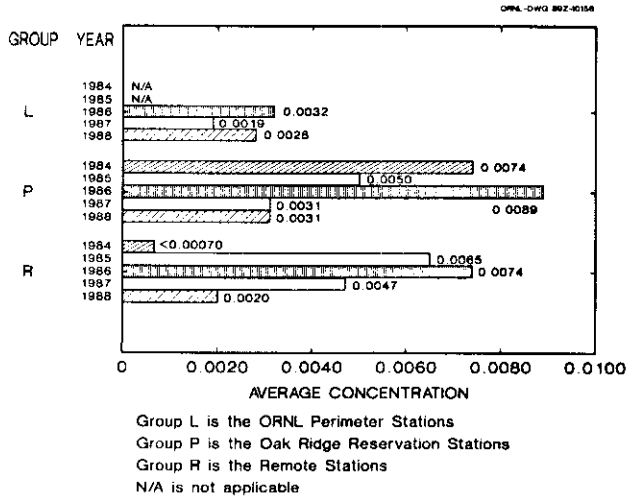

Fig. 23. Uranium-235 concentrations (pCi/g ash weight) in grass.

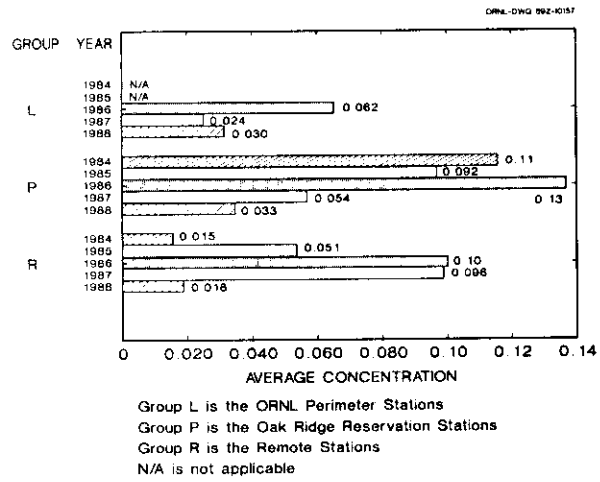

Fig. 24. Uranium-234 concentrations (pCi/g ash weight) in grass.

Concentrations of uranium were about twice those of background levels near the Y-12 Plant site. Analysis was conducted by ORGDP personnel for fluorides, total uranium, and ^{99}Tc on grasses at 13 locations and on pine needles at 6 locations. Pine needles were analyzed because they are sensitive to fluoride. Fluoride levels in grass at all sampling locations were below the 30-μg/g level, which is considered to produce adverse effects when ingested by cattle with average grazing intakes (AIHA 1969). The uranium concentrations in grasses are slightly higher than at other sampling locations at the on-site contaminated scrap yard, and the technetium concentrations are two orders of magnitude higher at the same location. These concentrations are to be expected considering the specific locations from which these samples were taken.

Soil Sampling

Soil samples from noncultivated areas provide a measure of the quantity of radioactivity or other pollutants that have been deposited from the atmosphere.

Soil samples are routinely collected at the ORNL perimeter stations, the ORR stations, and the remote stations.

Figures 25–32 depict the available trend information in soil for ^{60}Co, ^{137}Cs, ^{238}Pu, ^{239}Pu, total radioactive strontium, ^{234}U, ^{235}U, and ^{238}U during the period 1984 through 1988 at the ORNL perimeter stations, the ORR stations, and the remote stations.

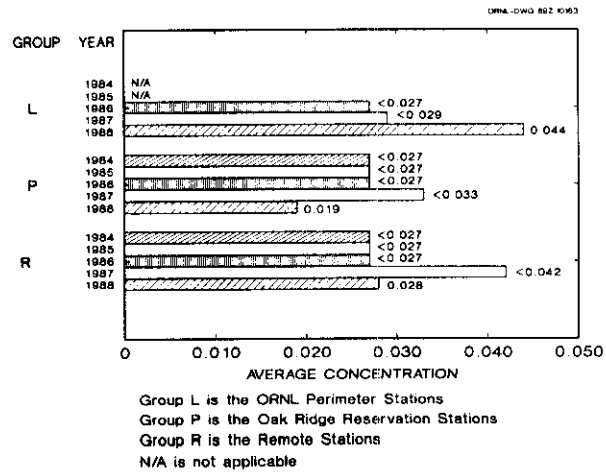

Fig. 25. Cobalt-60 concentrations (pCi/g dry weight) in soil.

Radionuclide concentrations at the ORNL perimeter stations and ORR stations were similar to those at the remote stations in 1988, with the following exceptions. Concentrations of ^{60}Co, ^{137}Cs, ^{239}Pu, and total radioactive strontium (^{89}Sr + ^{90}Sr) were about one order of magnitude greater than typical values for those respective isotopes at a perimeter station that is very close to the PWTP.

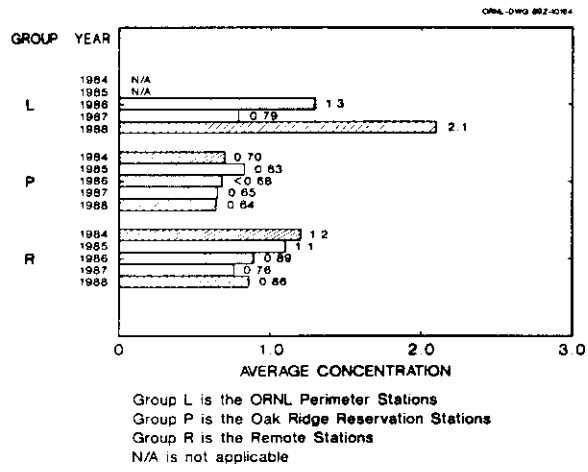

Fig. 26. Cesium-137 concentrations (pCi/g dry weight) in soil.

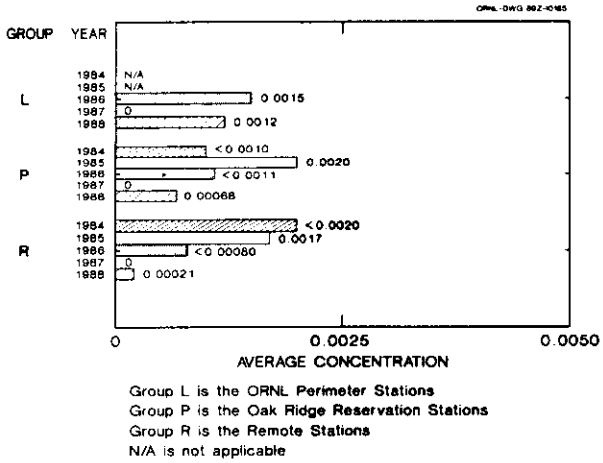

Fig. 27. Plutonium-238 concentrations (pCi/g dry weight) in soil.

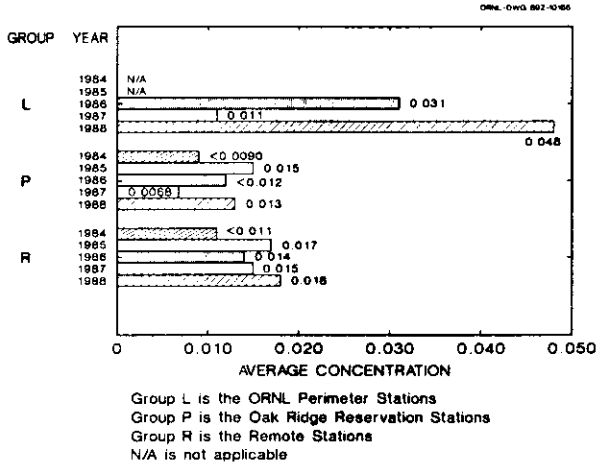

Fig. 28. Plutonium-239 concentrations (pCi/g dry weight) in soil.

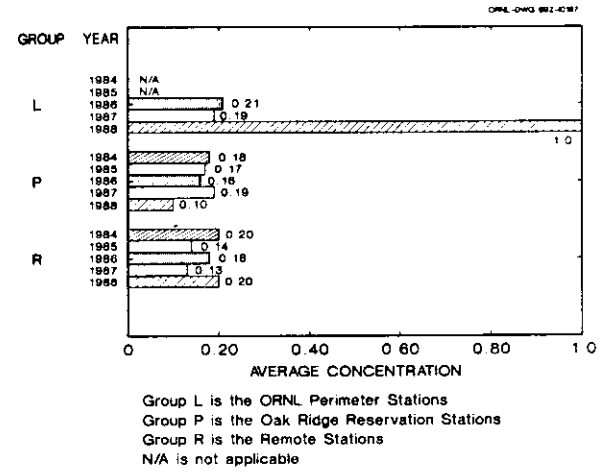

Fig. 29. Total radioactive strontium concentrations (pCi/g dry weight) in soil.

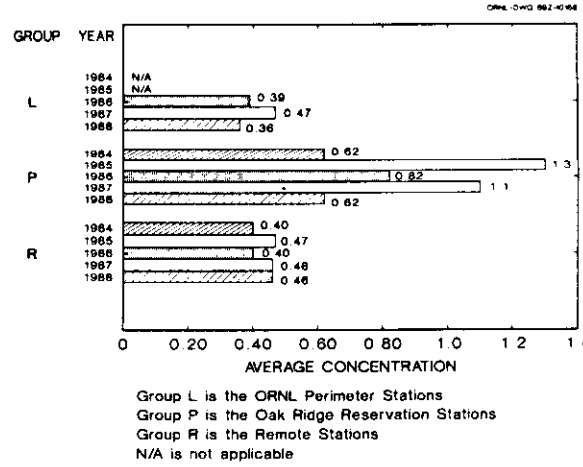

Fig. 30. Uranium-234 concentrations (pCi/g dry weight) in soil.

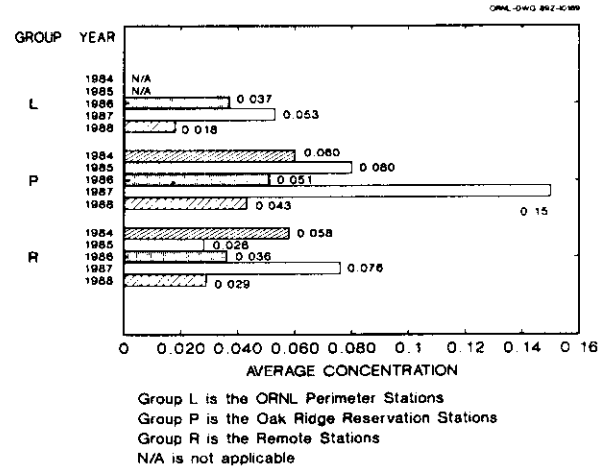

Fig. 31. Uranium-235 concentrations (pCi/g dry weight) in soil.

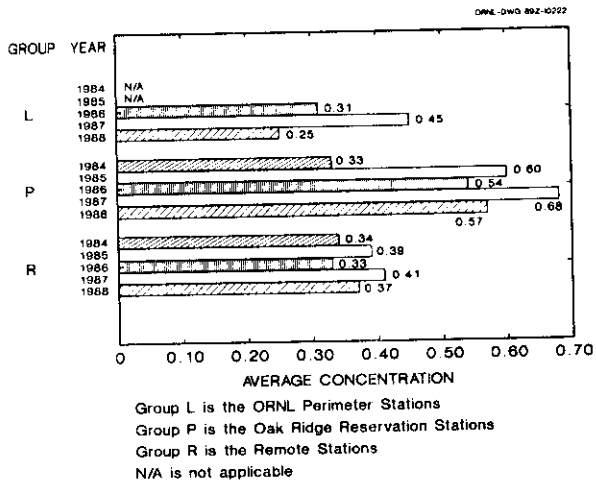

Fig. 32. Uranium-238 concentrations (pCi/g dry weight) in soil.

High concentrations of certain radionuclides would be expected at this location. This station was included in the sampling program for the first time in 1988, thus biasing the average results high for Group L.

Total radioactive strontium concentrations in 1988 were above average (for the perimeter network) at a perimeter station south of ORNL and included an anomalously high (maximum) value.

Concentrations of uranium isotopes in the soil at the ORNL perimeter stations were generally about equal to or less than the average concentrations at the remote sites. Uranium isotopes were generally highest at stations near the Y-12 Plant.

Samples were collected semiannually from 13 locations in and around ORGDP. Fluorometric analysis is used to determine uranium levels, and a fluoride-selection-ion electrode is used to determine fluoride levels.

The fluoride-in-soil concentrations in 1988 ranged from 227 μg/g to 875 μg/g. No consistent upward or downward trend is evident. In 1987 the fluoride concentrations ranged from 120 μg/g to 1050 μg/g. The concentration of fluoride in the soil is almost two orders of magnitude higher than that in grass. Uranium concentrations have not changed significantly since 1985. The concentration of uranium in the soil is generally one order of magnitude higher than the amount in grass.

Stream Sediment Sampling

The stream-sediment-sampling program consists of six sampling locations on Poplar Creek and two locations in the Clinch River. These samples are collected semiannually 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 1984 are shown in Figs. 33–38 for six

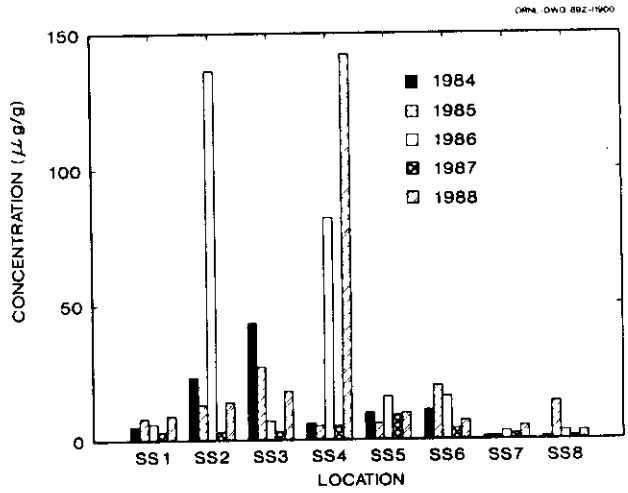

Fig. 33. Average uranium concentrations (μg/g dry weight) in sediment.

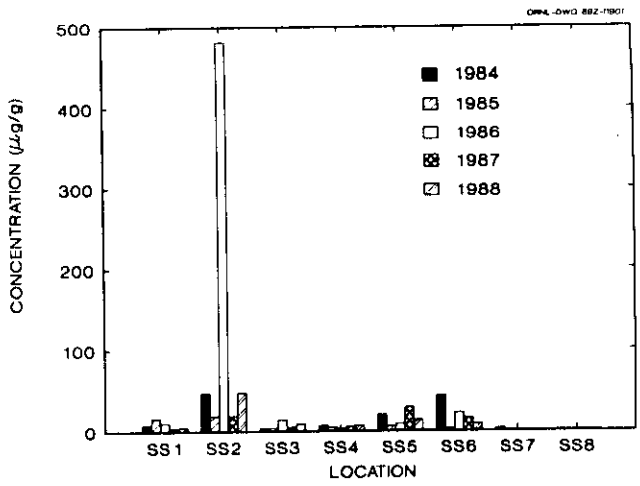

Fig. 34. Average mercury concentrations (μg/g dry weight) in sediment.

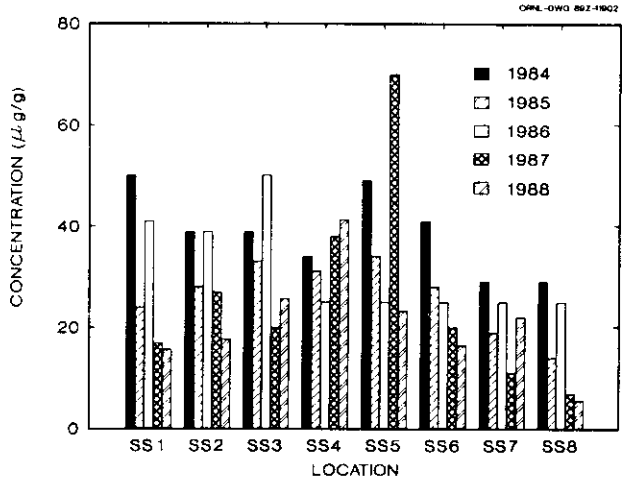

Fig. 35. Average lead concentrations (μg/g dry weight) in sediment.

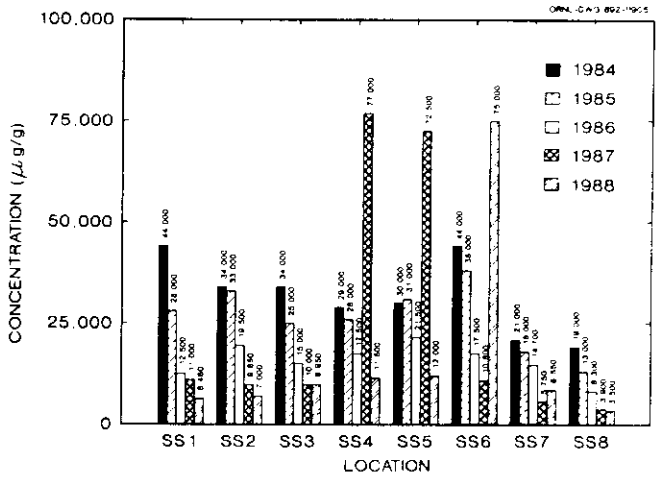

Fig. 38. Average aluminum concentrations (μg/g dry weight) in sediment.

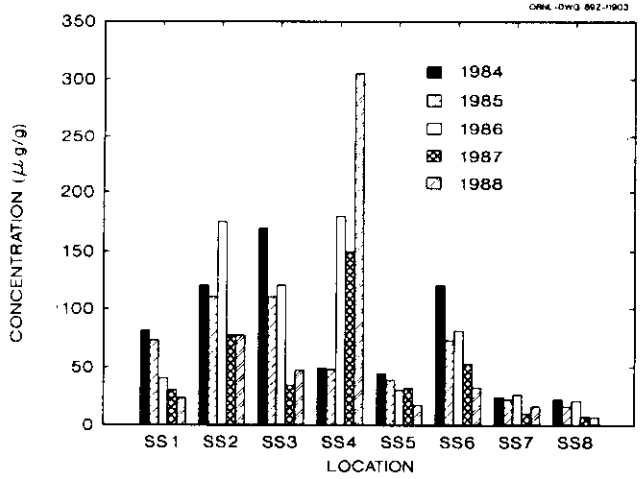

Fig. 36. Average nickel concentrations (μg/g dry weight) in sediment.

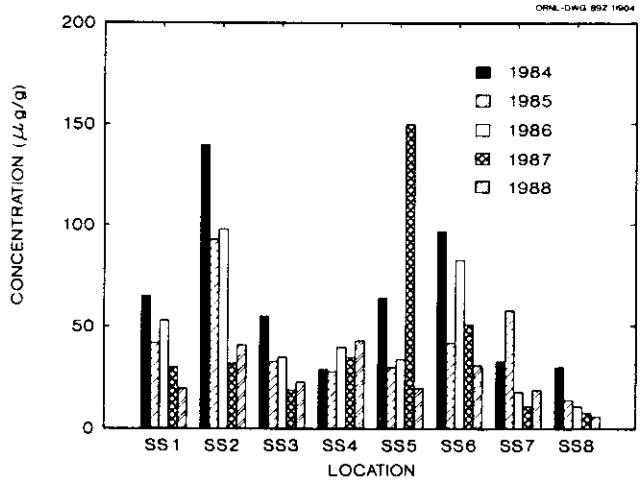

Fig. 37. Average chromium concentrations (μg/g dry weight) in sediment.

of the most prominent metals: uranium, mercury, lead, nickel, chromium, and aluminum. In most locations, the concentrations have been decreasing since 1984. Samples taken at the mouth of Mitchell Branch (SS4) in 1988 showed concentration increases of all the metals except aluminum and manganese. Samples taken at the mouth of EFPC (SS5), have shown decreases in all the metal concentrations. 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 total exposure (collective 50-year committed effective dose equivalent) of the entire population within 80 km (50 miles) of the three installations is given in Fig. 39. For the entire ORR, the maximum individual dose equivalents depend on the dose equivalent of interest. Maximum whole-body and thyroid doses are attributable to releases from ORNL; maximum effective, lung, and endosteal bone dose equivalents are attributable to the Y-12 Plant. The total collective dose commitment from ORR operations during 1988 is estimated to be 36 person-rem. This collective dose could produce a fatal cancer risk of ~0.0045/year, based on fatal cancer risk of 0.000125/rem of effective dose equivalent. In other words, as a result of operations on the ORR, the

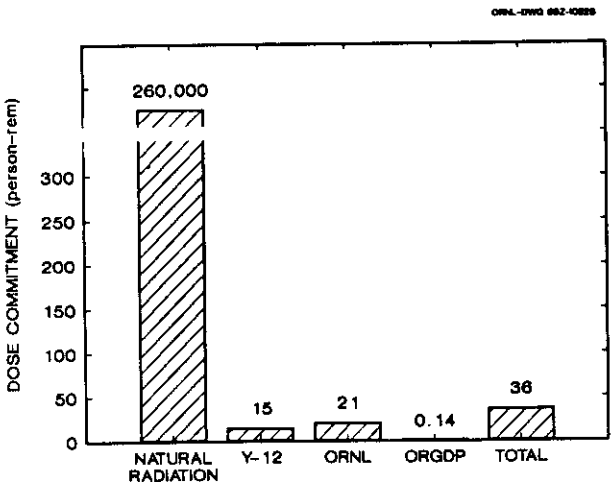

Fig. 39. The collective 50-year committed effective dose equivalent of the entire population within 80 km (50 miles) of the three installations.

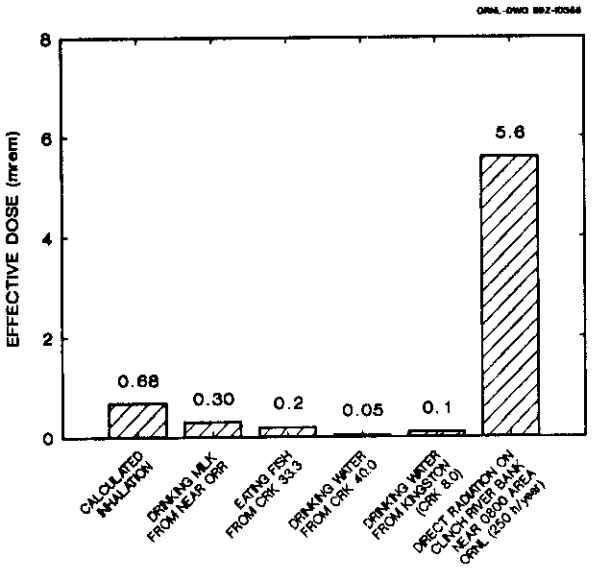

Fig. 41. The 50-year committed effective dose equivalent from various pathways from ORR discharges during 1988.

chance of one cancer developing in the population of about 850,000 living within 80 km (50 miles) of the reservation is less than 1 out of 200. The dose equivalent from natural radiation for this same population is also shown in Fig. 40. The whole-body, effective, and target organ doses from various pathways are shown in Figs. 40–42.

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

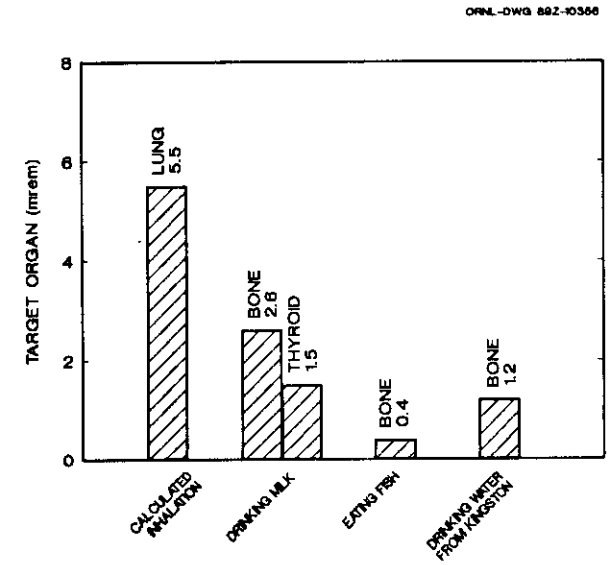

Fig. 42. The 50-year committed dose equivalents to selected organs from various pathways from ORR discharges during 1988.

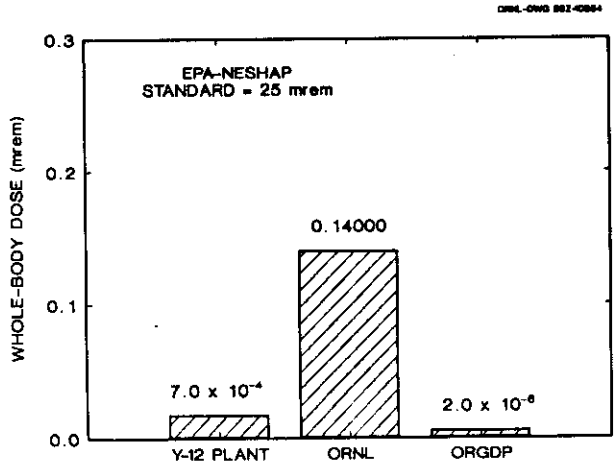

Fig. 40. The committed whole-body dose from inhalation pathway from ORR discharges during 1988.

the environment and to develop and implement remedial actions to control and minimize the release of these contaminants from the sites. To date, 340 sites have been identified as requiring investigation: 61 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 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. Much of the current groundwater monitoring efforts now under way on the ORR are being conducted to assess the groundwater near these hazardous waste sites.

During 1986, 1987, and 1988, the following RCRA closures were completed at the Y-12 Plant in accordance with TDHE-approved closure plans:

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

RCRA closure and postclosure activities of the following eight major facilities at the Y-12 Plant were initiated in 1988:

- the S-3 Ponds,
- Oil Retention Ponds 1 and 2,
- Oil Landfarm,
- Bear Creek Burial Ground,
- New Hope Pond,
- Chestnut Ridge Sediment Disposal Basin,
- Chestnut Ridge Security Pits, 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 165 Solid Waste Management Units (SWMUs) identified at the Y-12 Plant at the time, 123 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). 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.

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 RFIs and/or alternatives assessments. 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 11 WAG RIs have been completed and submitted for regulatory review; the remainder will be completed by the end of 1989. 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 RI schedule for WAG 6 is tied to commitments in the SWSA-6 Closure Plan approved by TDHE and EPA; the WAG-6 RI was formally implemented in late 1988. Work is scheduled to begin in WAG 1 (main plant area) and WAG 10 (hydrofracture injection wells and

grout sheets) 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 the 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, the 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 about 30 audits or inspections and reviews during 1988 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
- 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.

CONTENTS

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 mandated by 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 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. Most major gaseous chemical emissions are included in this report; however, some additional information will be available when the Superfund Amendments and Reauthorization Act (SARA) Title III 313 Report is finalized in July 1989. An addendum to the Oak Ridge Reservation Environmental Report for 1988 will be issued subsequent to the SARA Title III 313 Report. The addendum will summarize the contents of the SARA report and include some additional information pertaining to chemical emissions to the environment.

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 on the past calendar year, this report shows trend analyses over several years, when possible, to indicate increases and decreases in either concentrations or discharges 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 1988 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 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 Turbulance Diffusion Laboratory-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 Oak Ridge 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

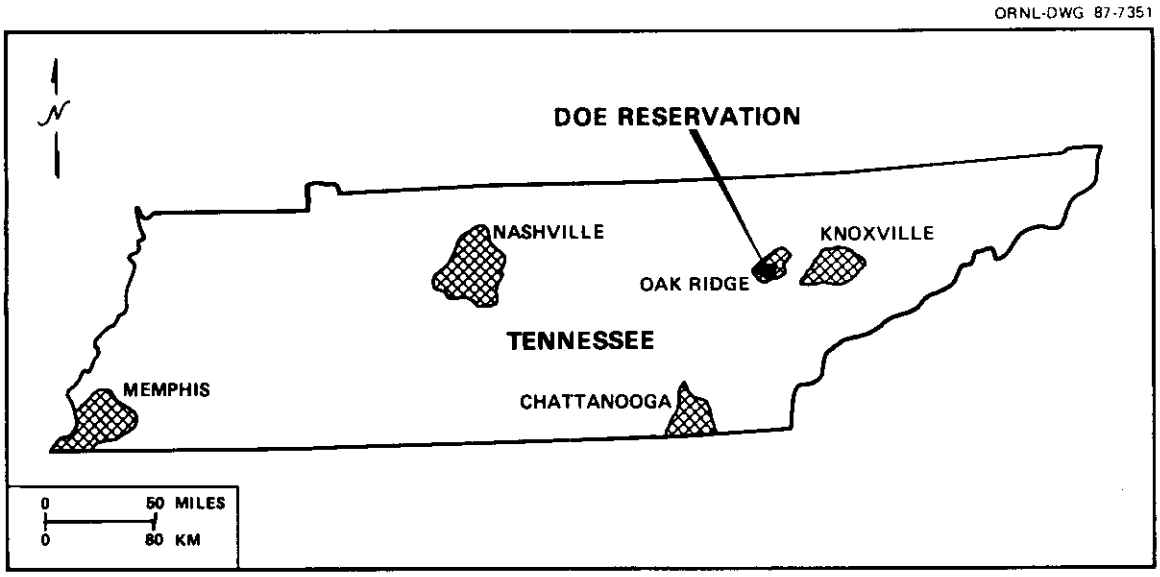

Fig. 1.1.1. Map showing the location of the Department of Energy's Oak Ridge Reservation in the state of Tennessee.

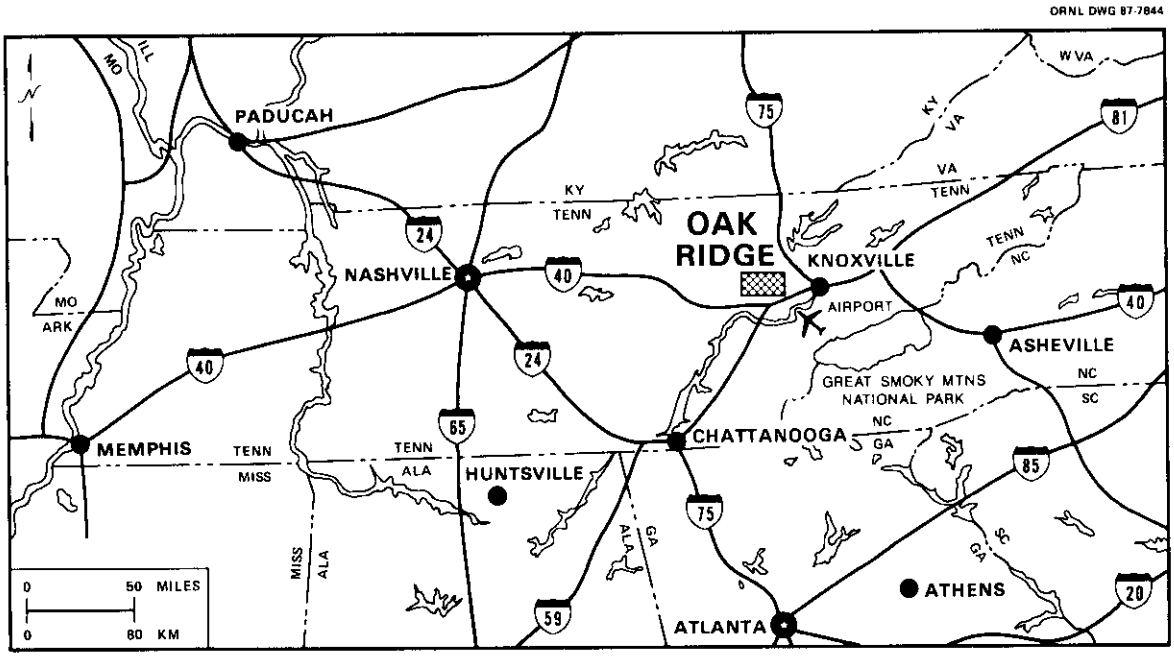

Fig. 1.1.2. Map showing location of Oak Ridge in relationship to geographic region.

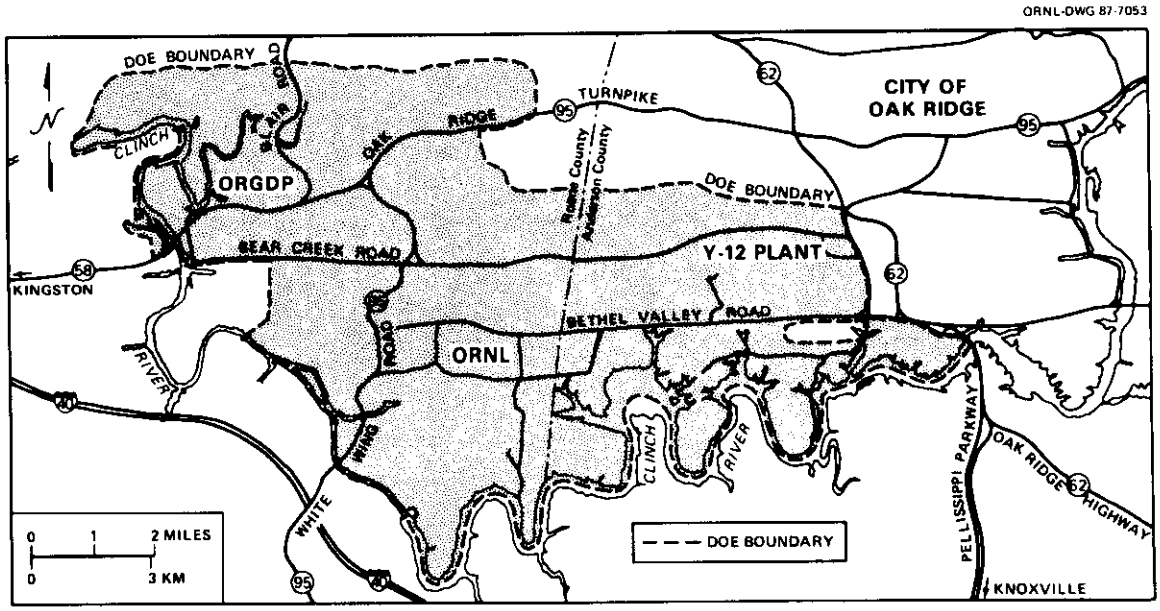

Fig. 1.1.3. Map showing the Department of Energy's Oak Ridge Reservation and the location of the three major installations.

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

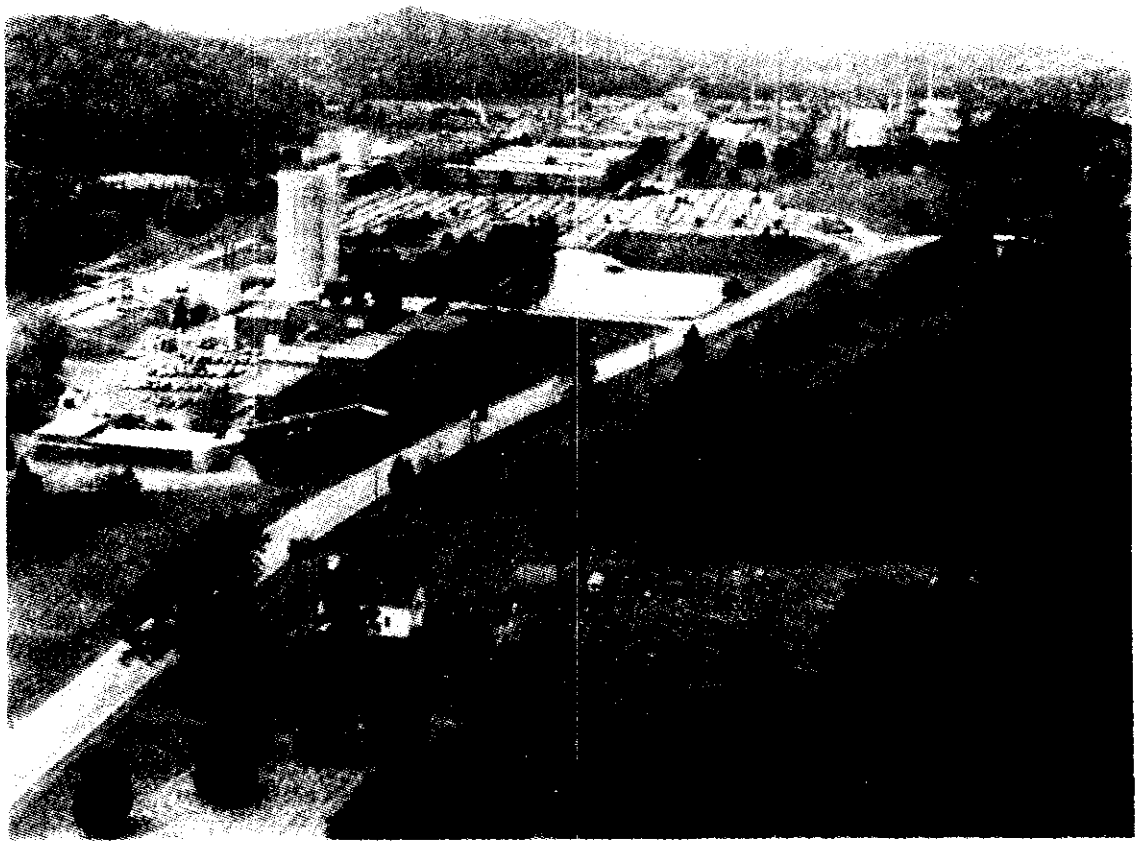

Fig. 1.1.5. ORNL (view looking west).

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, and support facilities. The Oak Ridge National Environmental Research Park is managed by ORNL. All of ORNL's reactors were shut down in 1986 and have not operated since that time. This was because of an effort to improve operating procedures and safety standards for the facilities. The ORNL Biology and Fusion Energy divisions are located at the Y-12 Plant.

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. Since that time, the decision to permanently shut down the gaseous diffusion cascade has been made.

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

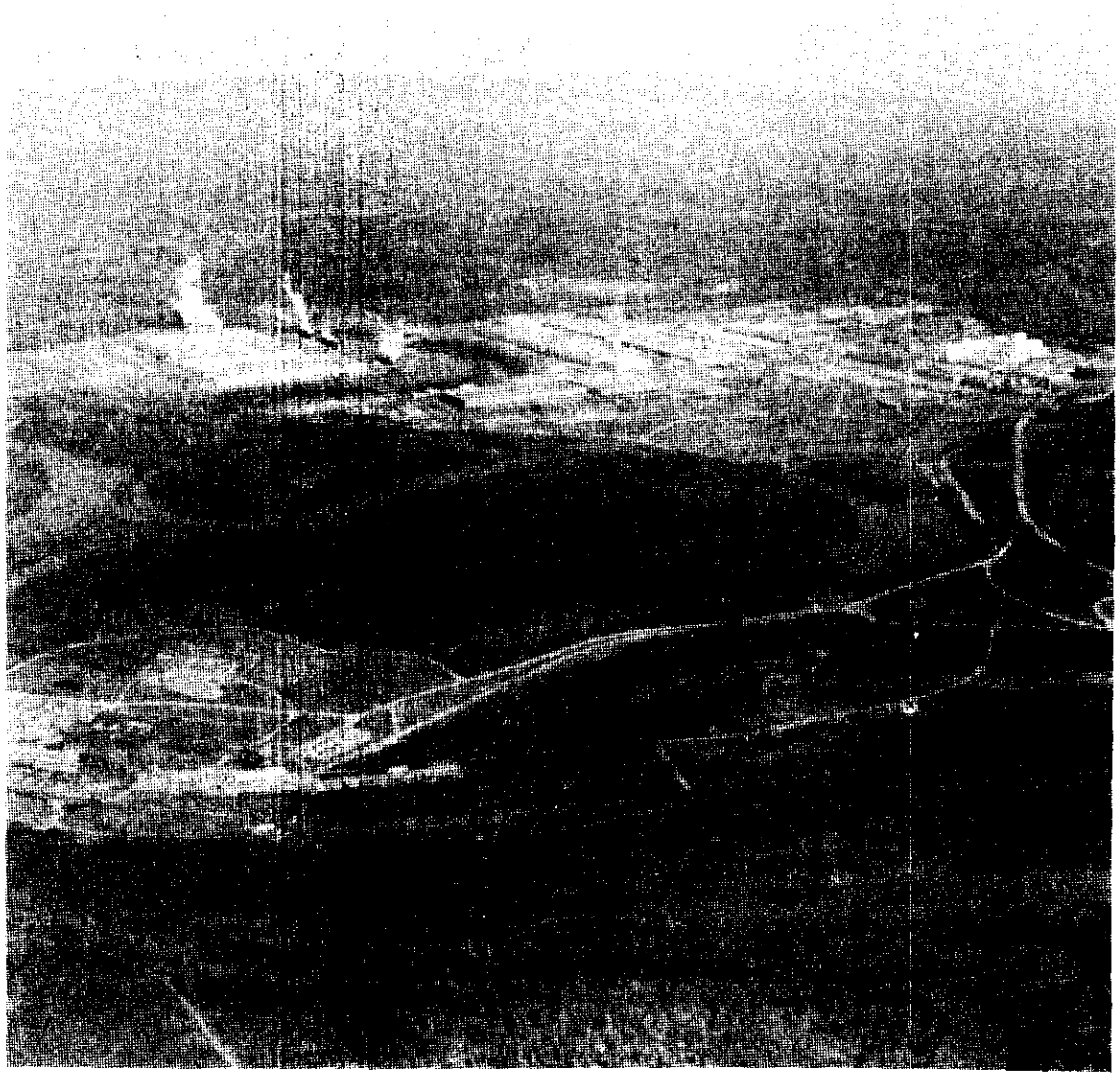

Fig. 1.1.6. ORGDP (view looking northeast).

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, 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 future incineration in the new 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 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 concentrated and 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. These 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. 5300), 16 km (10 miles) to the northeast; Lenoir City (pop. 5400), 11 km to the southeast; Kingston (pop. 4400), 11 km 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

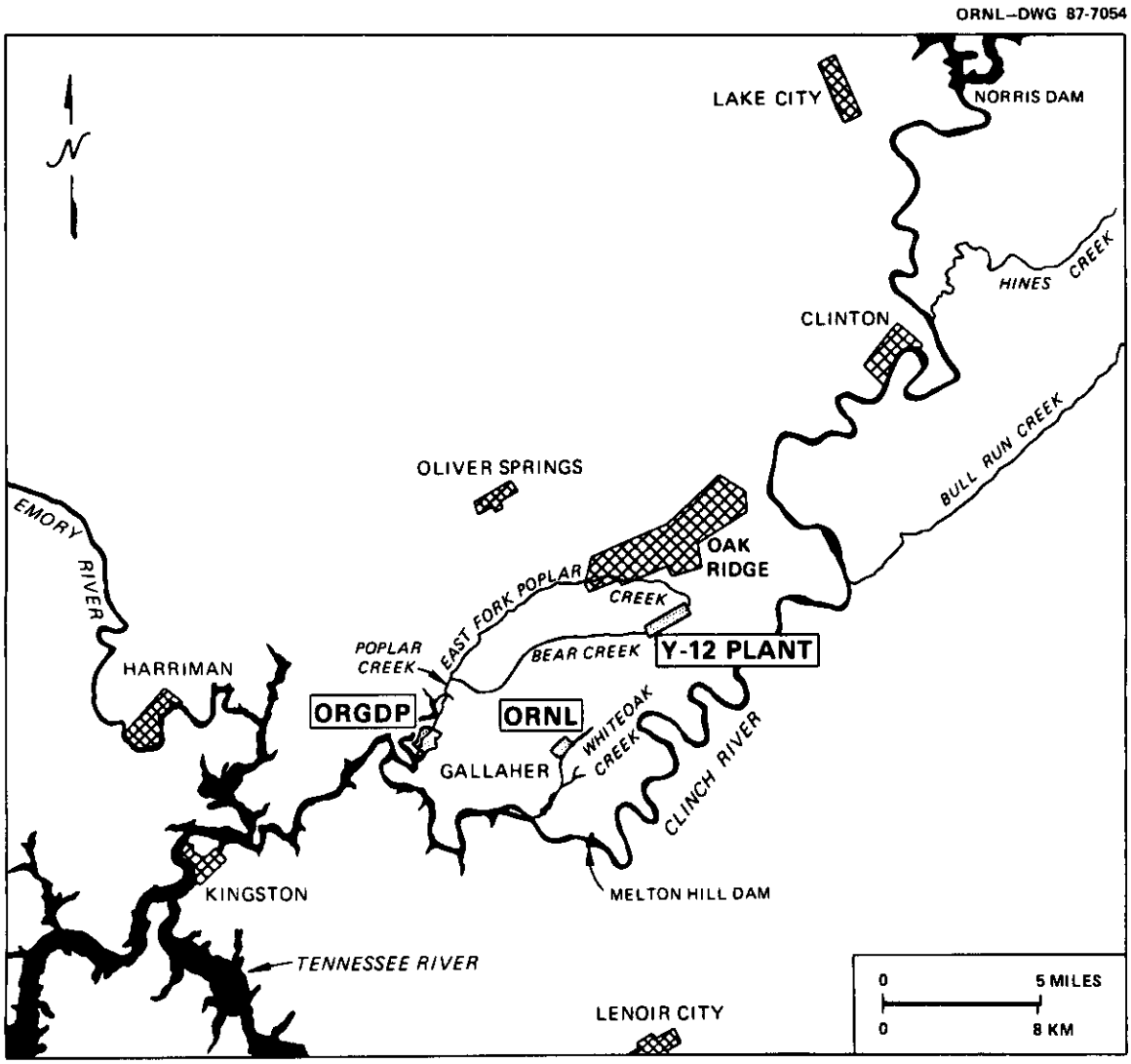

Fig. 1.2.1. Location map of towns nearest the ORR.

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.

1.3 GEOLOGY

The ORR is located in the Tennessee Valley and Ridge Province, part of the Southern Appalachian fold and thrust belt (Fig. 1.3.1). The area is characterized by a succession of northeast-trending thrust faults that structurally stack and duplicate the Paleozoic rocks of this area (Figs. 1.3.2 and 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.

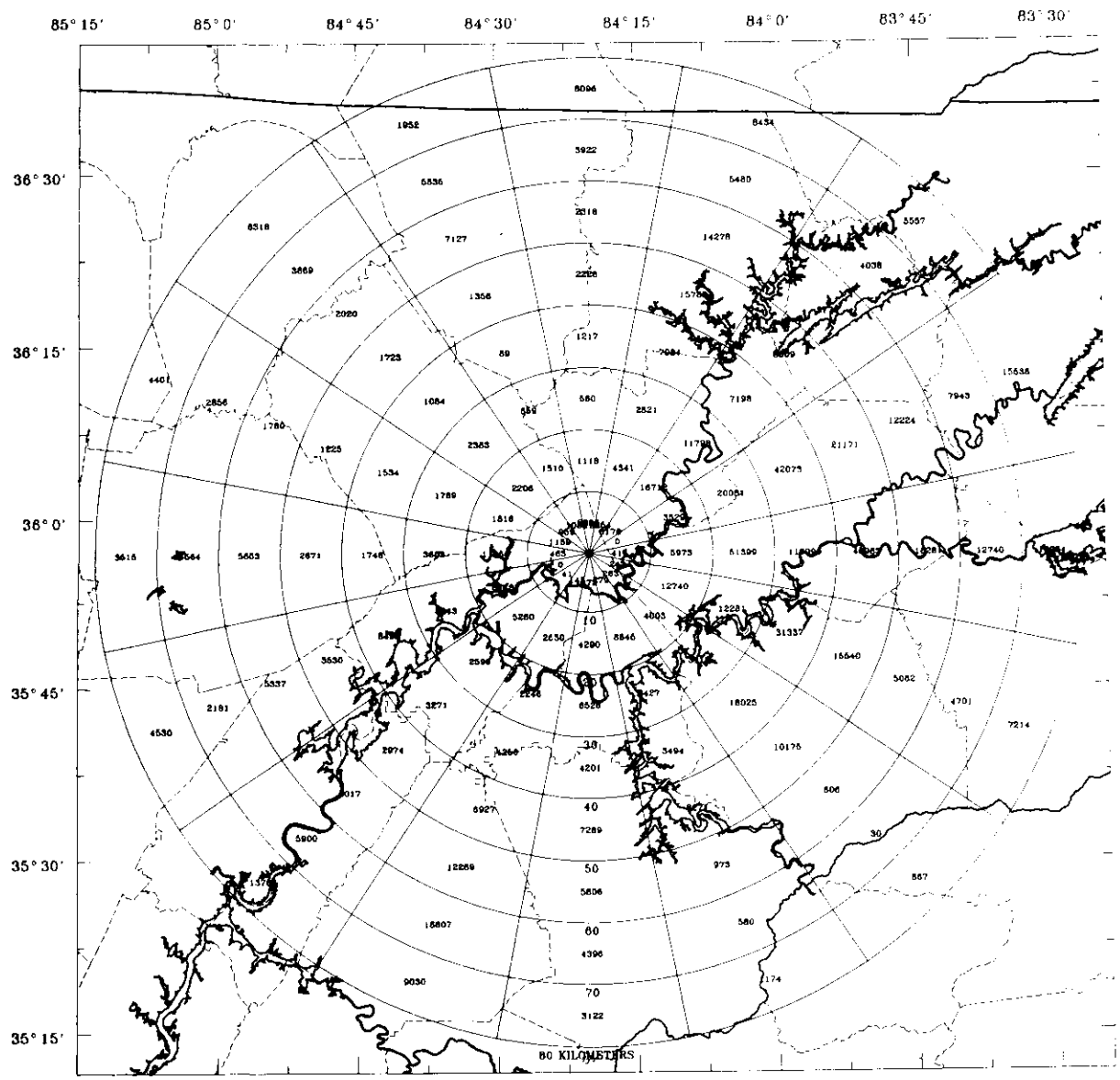

Fig. 1.2.2. Projected 1988 population by sector from the center of the Oak Ridge Reservation, based on 1980 census data.

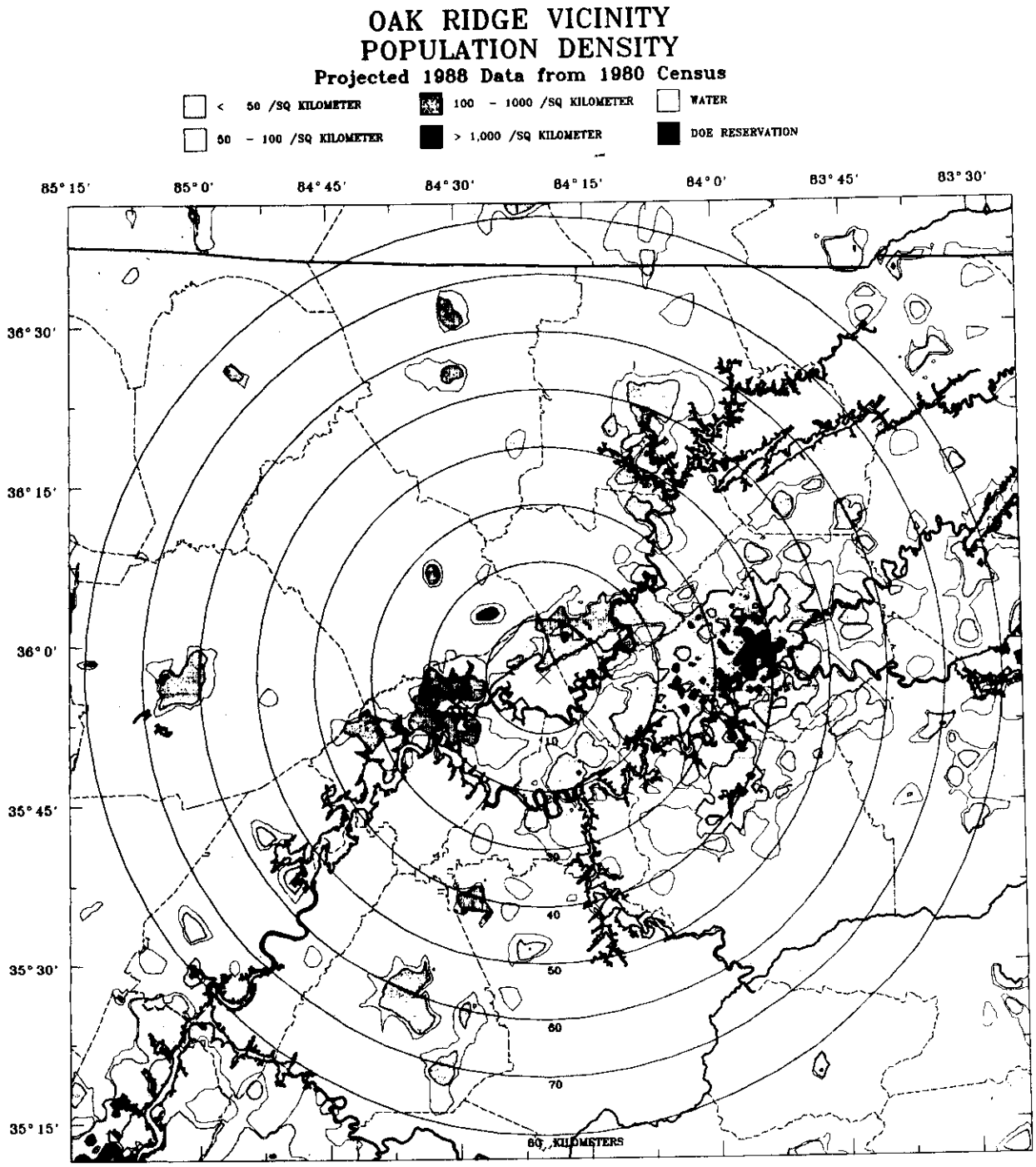

Fig. 1.2.3. Projected 1988 population densities by 10-km (6.2-miles) section of East Tennessee area, based on 1980 census data.

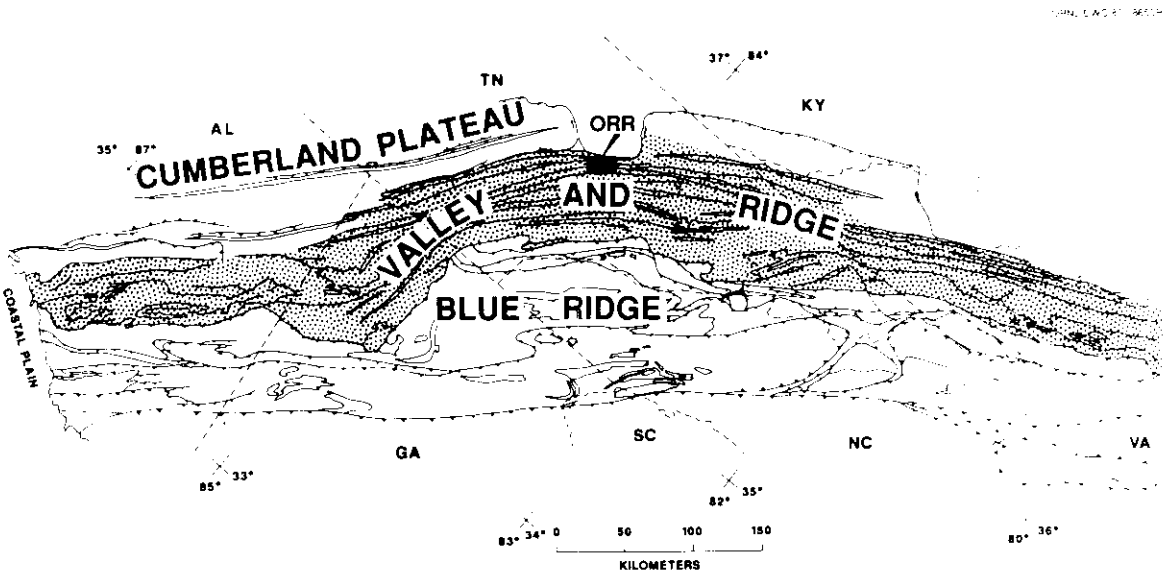

Fig. 1.3.1. Geology of the Southern Appalachians.

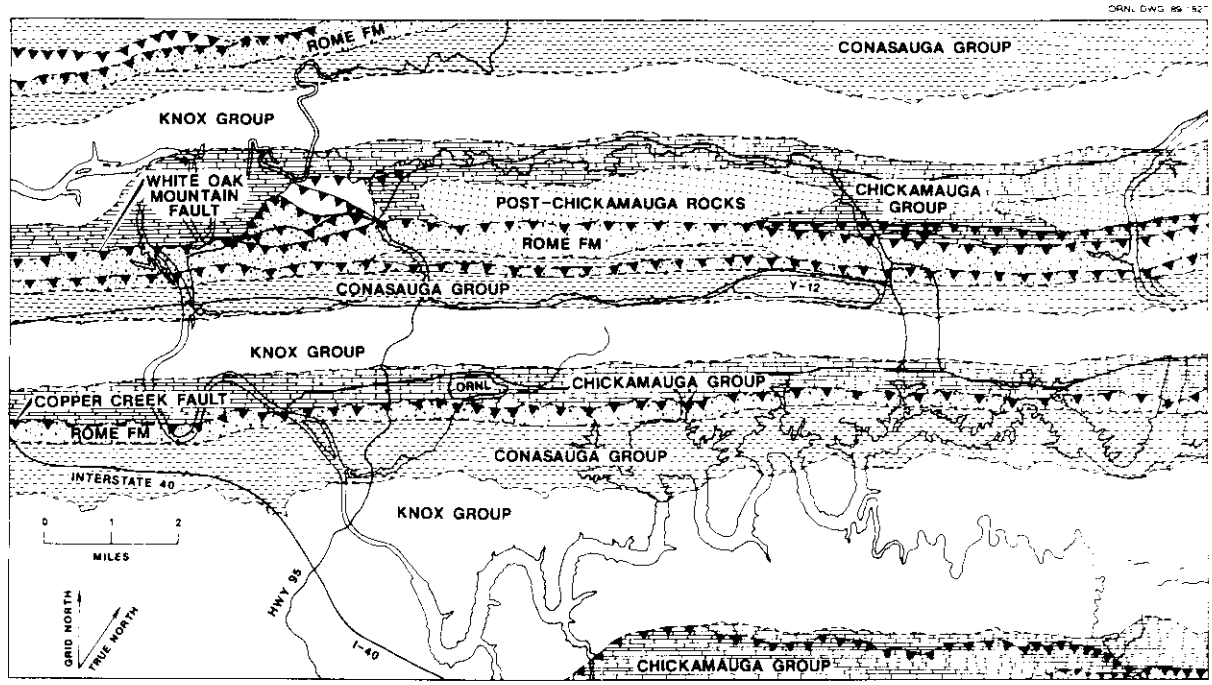

Fig. 1.3.2. Geologic map of the Oak Ridge Reservation.

ORNL- DWG 85-10908

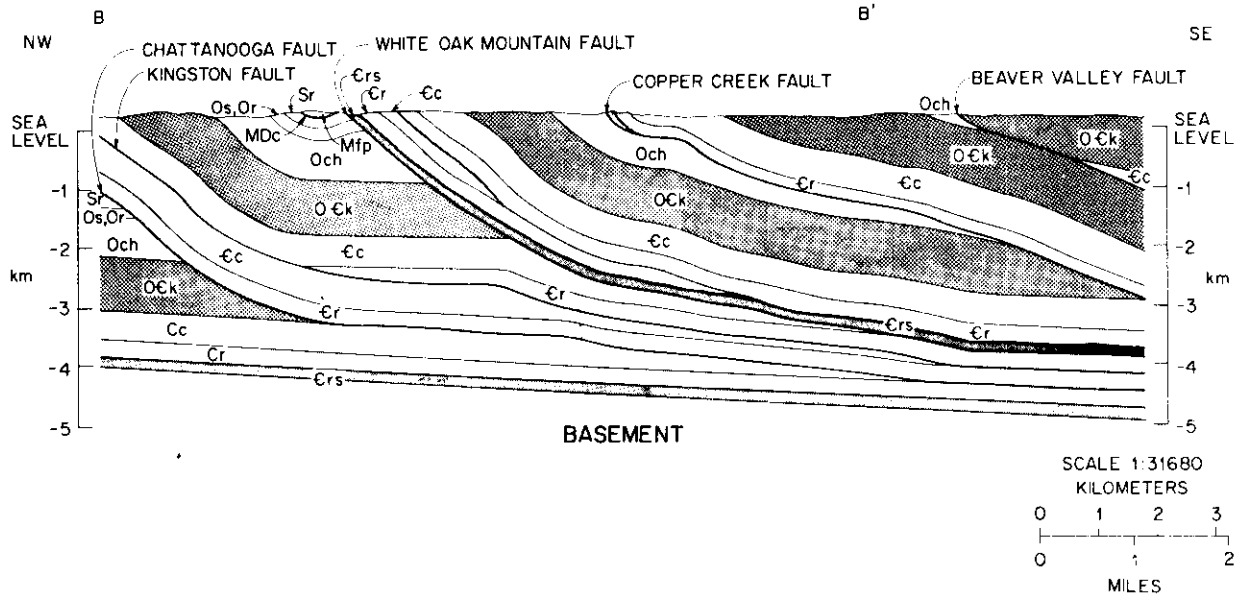

Fig. 1.3.3. Geologic cross-section of the Oak Ridge Reservation.

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).

1.3.1.1 Rome Formation

The Cambrian Rome Formation crops out on 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. (Refer to Appendix A for further description.)

1.3.1.2 Conasauga Group

The Cambrian Conasauga Group crops out in 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. 1.3.4). 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, the Conasauga Group weathers to a thick fractured saprolite of approximately 12 m (40 ft) that is covered by a veneer of the upper soil horizons.

1.3.1.3 Knox Group

The Cambrian-Ordovician Knox Group crops out on Copper Ridge, Chestnut Ridge, McKinney Ridge, and Blackoak Ridge. In eastern Tennessee,

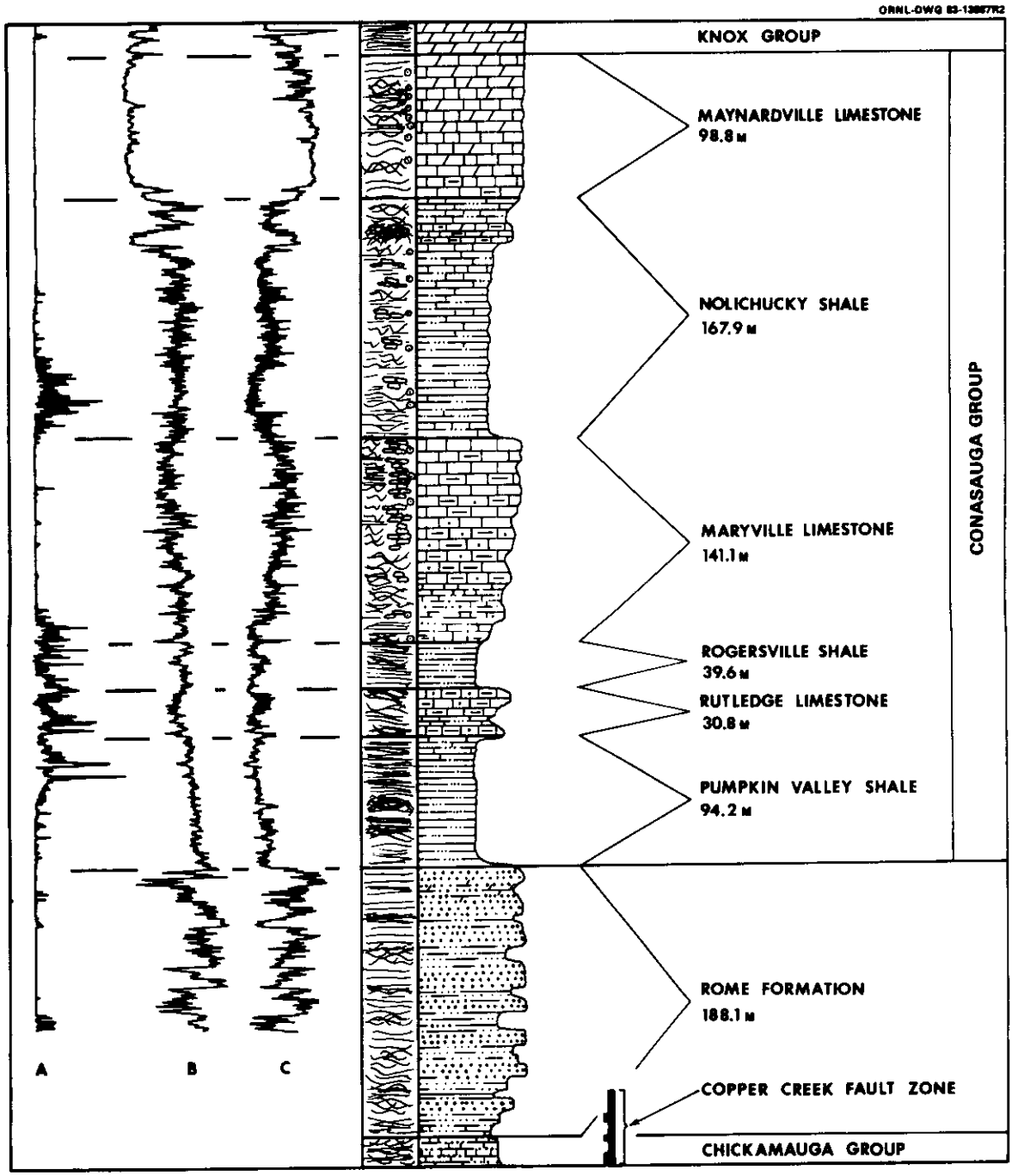

Fig. 1.3.4. Conasauga Group stratigraphy.

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 include: 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)], dark, orange-red clay residuum that commonly contains abundant chert. No primary structural fabrics are preserved in the residuum. Significant portions of the Knox Group are characterized by karst features, as is to be expected of carbonate rocks in a humid climate.

1.3.1.4 Chickamauga Group

The Ordovician age Chickamauga Group crops out in East Fork Valley, in the ORGDP area, and in 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. 1.3.5) 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 (Appendix A). In ascending order, the Chickamauga Group consists of the following formations: Blackford, Lincolnshire, Benbolt, Wardell, Bowen, Witten, and Moccasin.

1.3.1.5 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 (McMaster 1962).

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. Fracture formation may have developed at any time from the Ordovician (as a result of burial processes) to the present (as a result of erosion and unroofing processes). However, the Alleghanian Orogeny was probably the strongest influence on fracture formation.

1.3.2.1 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 (14,000 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, at the ORR, the CC Fault shows a shallow dip (0–25°) and displays a relatively simple outcrop pattern although portions of the Chickamauga Group in the footwall of the

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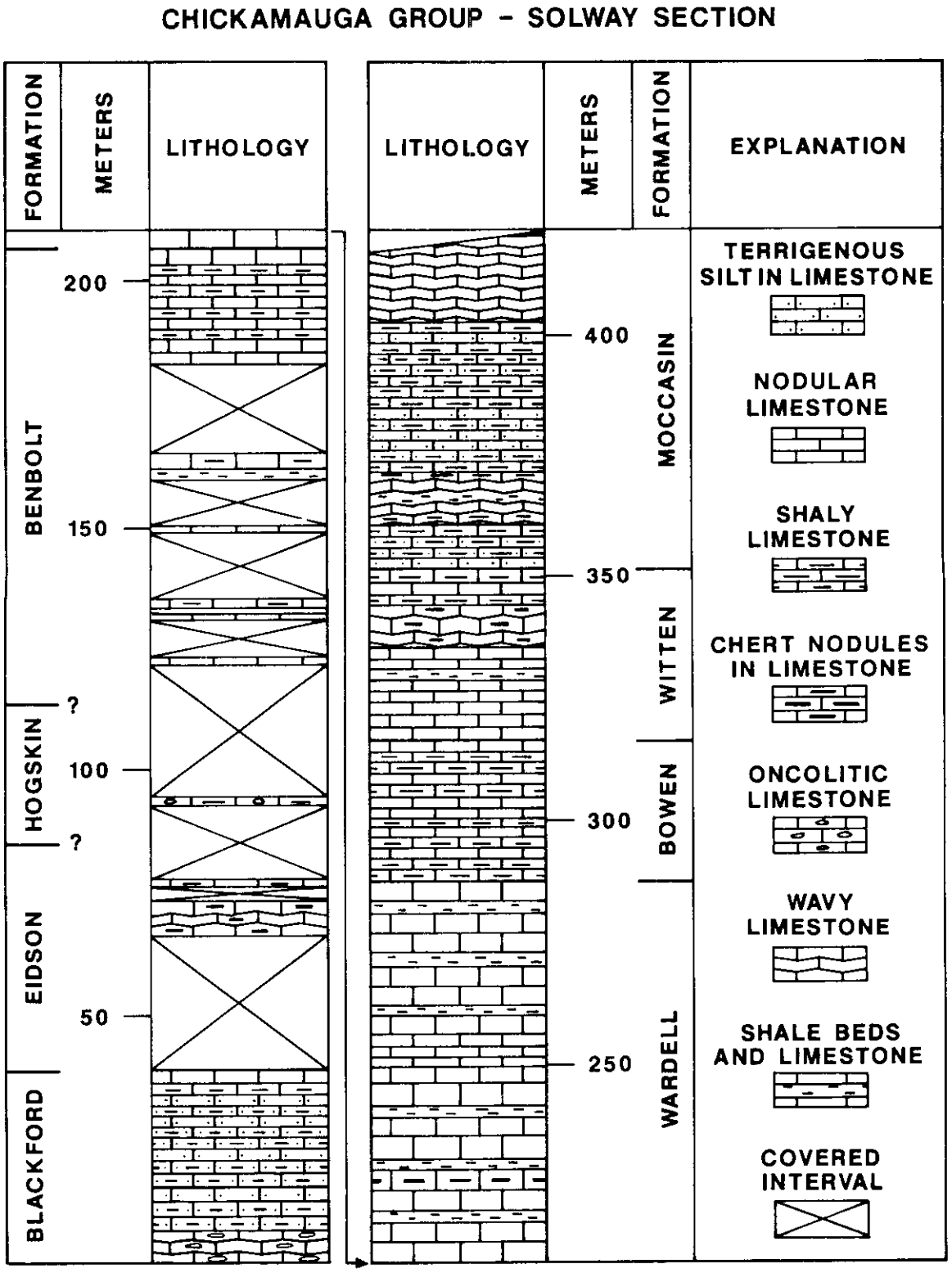

Fig. 1.3.5. Chickamauga Group—Solway section.

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 tear faults have been identified by local offset of topographic ridges, prominent topographic depressions, stream patterns, and discrepancies in lithologic contacts as determined from borehole data (Dreier and Leat, in press). 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 an associated fracture zone.

The 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, in press). 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, in press). Tight, locally overturned folds with wavelengths that range from centimeters to several meters per second are commonly associated with these minor faults.

1.3.2.2 Fractures

All geologic units in the ORR are highly fractured. The fracturing is pervasive throughout all rock units and also occurs in zones that are associated with faults. Because total permeability and porosity of these rocks are strongly influenced by a secondary-fracture permeability and porosity, studies have recently been initiated to investigate fracture characteristics in sections of the ORR. Recent detailed investigations of Conasauga Group core from Bear Creek Valley (Lutz, in prep.) 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. Recent studies elsewhere in the Appalachians suggest that release joints can form at depths up to 1 km (0.6 mile) (Engelder 1985). 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 have been healed by mineral (predominantly calcite) precipitates and do not contribute to a secondary permeability. Open fractures appear to be most common in the upper 45.8 m (150 ft) below land surface and in deformed massive shale units (Dreier et al. 1988), although exceptions to this generalization do exist. In addition, if stylolites are considered to be fractures in the hydrologic sense (e.g., a surface that is conductive to fluids) then stylolites in massive limestones appear to behave as open fractures. In general, open fractures form 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 has been reported from 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 have been noted (Rothschild 1984). The cavities commonly parallel bedding planes.

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 of Vol. 2 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 of Vol. 2. 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 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 located on the Tennessee River and affects the flow of the lower reaches of the Clinch.

1.4.4 Water Use

There are nine public water supply systems serving about 91,500 people that withdraw surface water within a 32-km (20-mile) radius of the ORR. Of these nine supply systems, only one (city of Kingston) is 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.

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 formations, residual soil accumulations near the bedrock surface, and in a few alluvial aquifers along the largest rivers. Groundwater flow in the shales and carbonate rocks that dominate the region's bedrock is attributed to 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

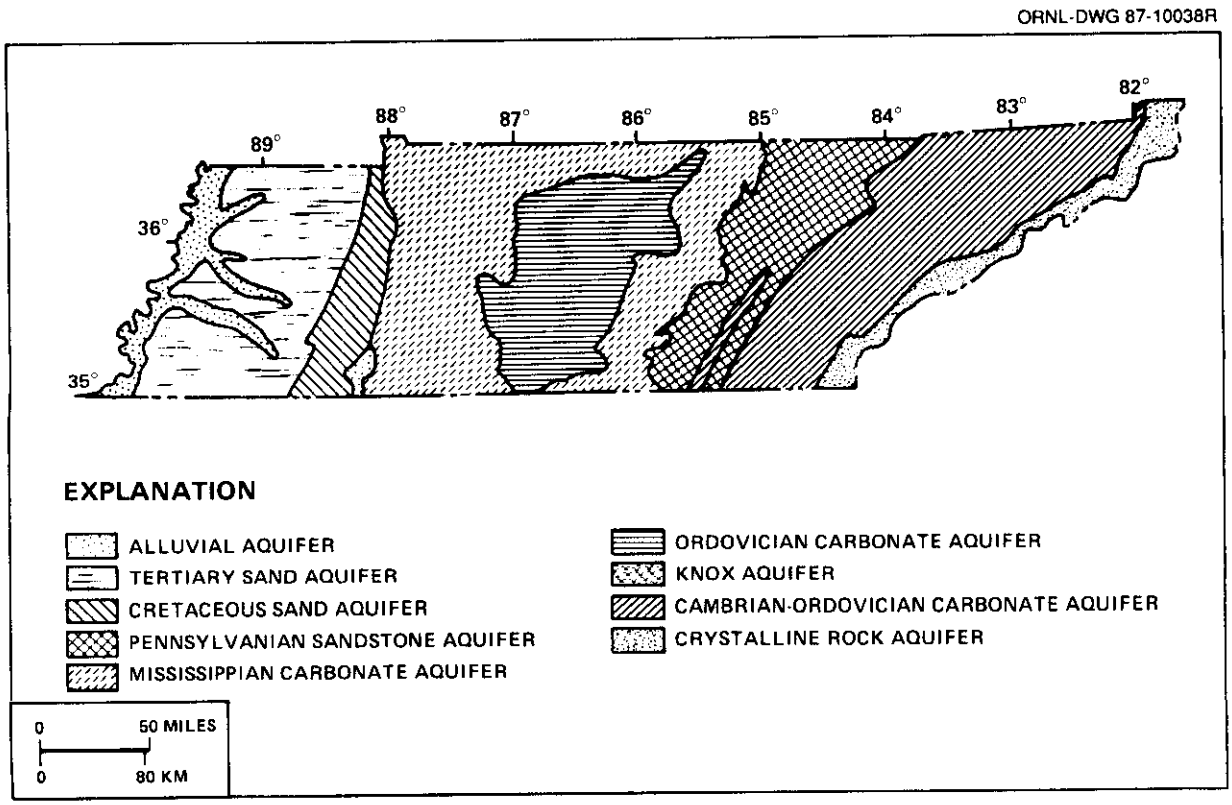

Fig. 1.5.1. Principal aquifers in Tennessee.

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, groundwater on the ORR and in areas adjacent to the ORR occurs primarily in solution cavities 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.

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 38-year annual average precipitation (water equivalent) is 1.36 m

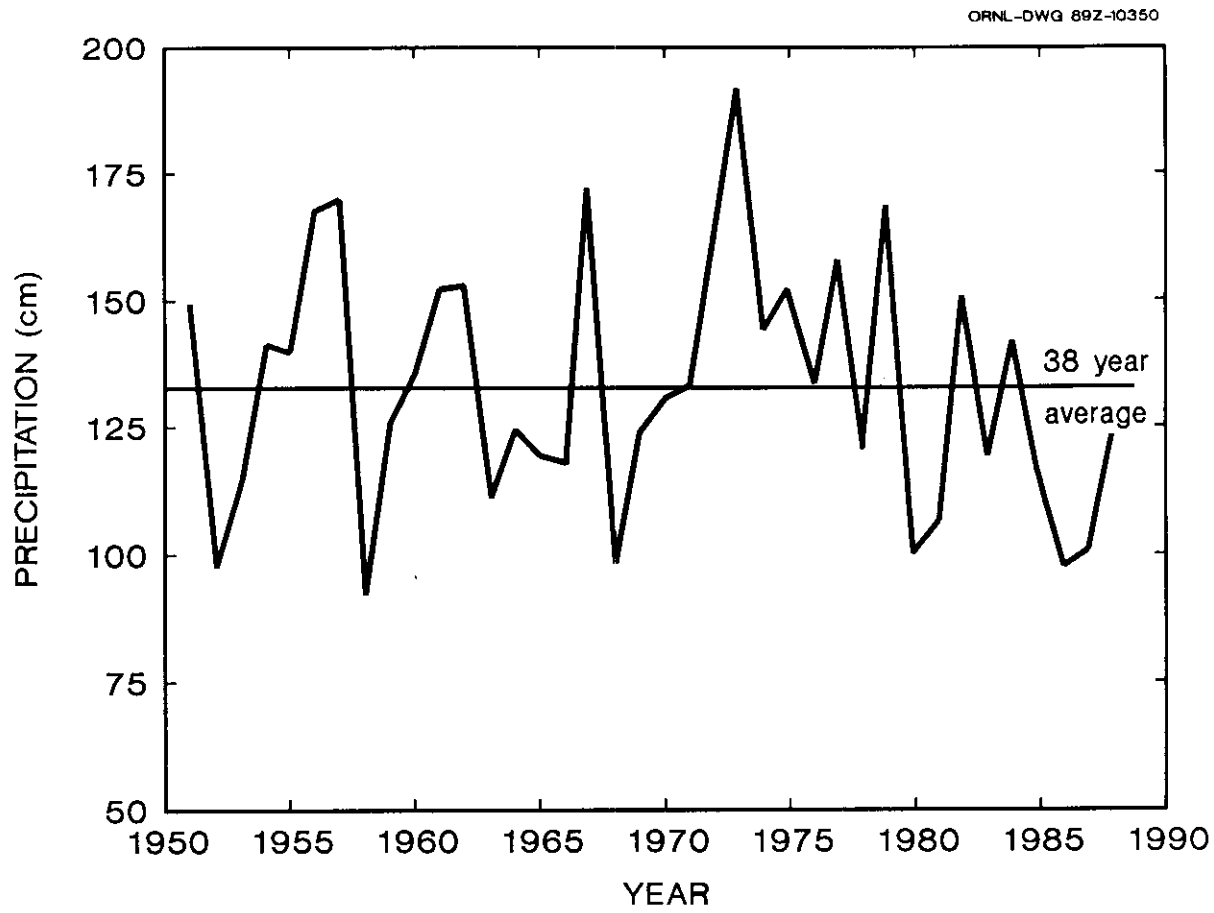

Fig. 1.7.1. Annual precipitation history of the Oak Ridge area.

(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 1988 was 124.4 cm (48.5 in.), about 12 cm (4.7 in.) short of the annual average.

Since 1986, 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.

2. ENVIRONMENTAL MONITORING SUMMARY

Published environmental summary reports for the DOE Oak Ridge Reservation have been issued for each year since 1971. The current environmental program is designed primarily to meet regulatory requirements and the DOE directives and to provide a continuity of data on environmental media at unregulated locations.

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, providing a means to control effluents at or near the point of discharge, demonstrating compliance with applicable standards and permit requirements, and for the purpose of determining compliance with applicable standards 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 Draft DOE Order 5400.xx. These concentration guides were established for drinking water and inhaled air and are guidelines for the protection of the public. Draft DOE Order 5400.xx 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 man" would receive the most restrictive of (1) an effective dose equivalent of 100 mrem or (2) a dose equivalent of 5 rem to any tissue, including skin and lens of the eye. A "reference man" 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 0.01, 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 method for reporting radioactivity measurements near background concentrations changed during the year. The changes are intended to increase the information content of analytical results at or near the detection limit and to be consistent with the data reporting conventions in Draft DOE Order 5400.xx. In the past, if a value was below a statistically determined detection limit, the result was reported as "less than the detection limit" or "<" along with the detection limit number. New software was installed on the analytical equipment that provided reports of gross activity; background activity; and, through subtraction, net activity. 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 statistical summaries of the data are equally representative of all the component values. In the case where "less than detection limit" values are included, the statistics are biased high because the detection limit is used to represent the sample result even though the radioactivity of the sample was less than that amount.

The change in data reporting for radioactivity measurements has been accommodated in this document by taking all results at face value. This means that data sets including "less than detection limit" results were summarized using the detection limit value. Negative values were also used. In some cases where the two reporting conventions are combined in an annual data set, the SE was not provided. This is because differences in the underlying statistical assumptions between the two reporting methods may have precluded calculating a credible measure of variance.

Radiation measurements are reported in units of curies (Ci). The curie is defined as 3.7×10^{10} Bq. A becquerel (Bq) is an Système Internationale (SI) unit equivalent to 1 disintegration per second.

Nonradionuclide results that are below the analytical detection limit are expressed as "less than" (<). In computing average values, "less than" results are assigned the detection limit. The average value is expressed as less than the computed value when at least one of the results used for the average is less than the detection limit.

Quantities of nonradiological chemical emissions are not included in this report this year. An addendum that will include the information will be published after the Superfund Amendments Reauthorization Act (SARA) Title III report is issued on July 1, 1989. When the addendum is published, probably in late July, a summary of the SARA Title III 313 Report will be included. The SARA report provides the community with the opportunity to learn about estimated quantities of certain toxic chemicals used at a facility that are routinely or accidentally released into the environment. The addendum that will be published after the SARA report will summarize the SARA report and is expected to include 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. The addendum will not be all inclusive but will provide emissions information on the major chemical emissions to the air, water, or land from processes at the facilities.

2.1 AIRBORNE DISCHARGES, AMBIENT AIR MONITORING, AND METEOROLOGICAL MONITORING

Airborne emissions from each DOE Oak Ridge facility are regulated under provisions of the Clean Air Act (CAA) of 1977 and the Tennessee Air Quality Control Act. The Tennessee Department of Health and Environment (TDHE), Division of Air Pollution Control, has the responsibility for enforcing the provisions of the CAA and the Tennessee Air Quality Control Act. In addition, the U.S. Environmental Protection Agency (EPA) provides oversight reports to ensure that airborne emissions are maintained within CAA standards and that appropriate emissions monitoring and reporting criteria are being met.

The CAA provides the authority from which most regulations promulgated by the EPA for the control of air pollution are mandated. The

regulations include limits for maximum allowable air emission rates and define ambient air quality standards for the protection of the public health and welfare. The regulations separate potential air pollutants into two specific classes: (1) criteria pollutants and (2) noncriteria pollutants. Pollutant categories addressed by the regulations are listed in Table 2.1.1. The criteria pollutants are those for which national ambient air quality standards (NAAQS) have been established. Although no national ambient air quality standards have been set for noncriteria pollutants, the Tennessee Air Pollution Control Act does contain ambient air quality standards for fluoride (expressed as hydrogen fluoride). Other noncriteria air pollutants include those contaminants that have been designated as hazardous to public health by the EPA. Hazardous air pollutants are regulated under the National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations. The TDHE has assumed regulatory responsibility for all NESHAP-regulated pollutants except radionuclides. The EPA retains regulatory and enforcement responsibility for radionuclides.

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 sophisticated exhaust gas scrubbers, baghouses, and exhaust filtration systems designed to remove airborne pollution from the exhaust gas before it is released into the atmosphere. In addition, administrative controls play a critical role in regulating emissions. Each installation has developed an extensive 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 ensure that operations within the three Oak Ridge facilities do not adversely affect the ambient air quality of the region.

The following three sections describe radioactive airborne pollutants emitted from the

Table 2.1.1. Air pollutant categories

Criteria pollutants	Noncriteria pollutants
Total suspended particulates[a]	Hazardous air contaminants
Sulfur dioxide	Asbestos
Nitrogen oxides	Beryllium
Carbon monoxide	Mercury
Ozone	Vinyl chloride
Hydrocarbons (nonmethane)	Radionuclides
Lead	Benzene
	Inorganic arsenic
	Coke oven emissions
	Other air contaminants
	Fluorides
	Sulfuric acid mists
	Hydrogen sulfide
	Total reduced sulfur

[a]Under regulations promulgated July 1, 1987, particulate matter smaller than 10 μm in diameter will replace total suspended particulates as the primary air quality standard.

Oak Ridge facilities during 1988. 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 1988 at each facility. The discussion of atmospheric dispersion modeling and atmospheric radiological dose modeling is included in Sect. 3 and is therefore not presented here.

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 operations. There are several hundred point sources of building ventilation exhaust within the facility. Many of these building exhausts provide ventilation to plant fabrication operations. Additionally, the Y-12 Plant has over 700 TDHE-permitted air pollution sources that are tied into the exhaust ventilation systems (Table 2.1.21, Vol. 2). Approximately 85 of these exhausts serve areas where depleted or enriched uranium is processed, and these are monitored continuously for radioactive emissions.

As illustrated in Fig. 2.1.1, 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, numerous improvements are being 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 uranium emission estimates are further broken down in Table 2.1.2. Y-12 Plant uranium stack emission totals were made using stack sampling data obtained from new 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 2.1.2.

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 new estimate of 34.9 kg is still considered to be conservative.

Although emission estimates have been made for a number of major pollutant categories, 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). Estimates of these emissions will be reported in the chemical emissions addendum in July 1989. Special sampling to characterize potential fugitive emissions from the S-3 Ponds was terminated in

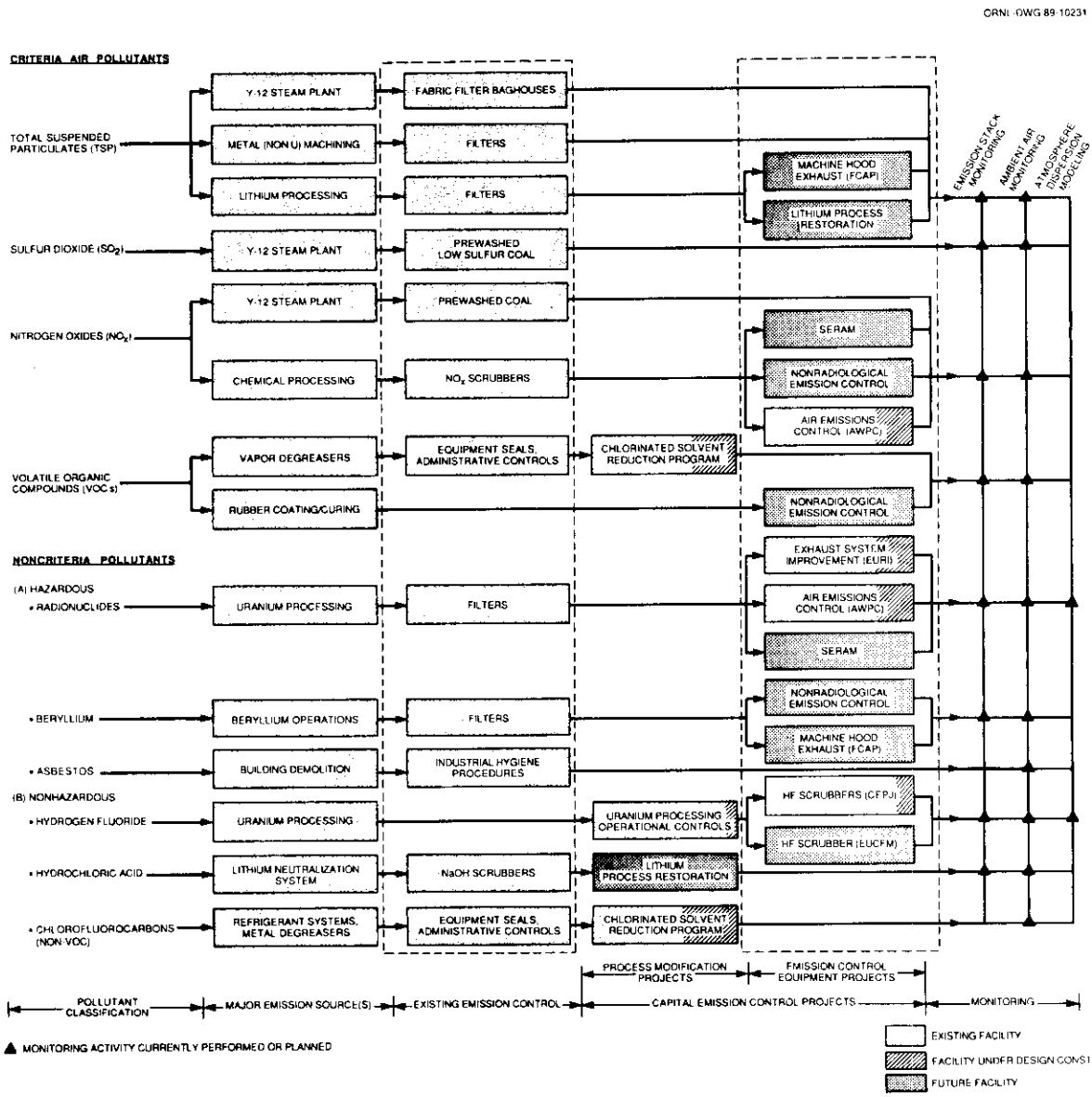

Fig. 2.1.1. Air pollution control program at the Y-12 Plant.

Table 2.1.2. 1988 Y-12 Plant airborne uranium emissions estimates[a]

Source of emissions	Quantity emitted	
	(kg)	(Ci)
Enriched uranium process exhaust	1.6	0.103
Depleted uranium process exhaust	10.9	0.004
Enriched uranium room exhaust	0.0	0.000
Depleted uranium room exhaust[b]	34.9	0.013
Total	47.4	0.120

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

[b]New estimate based on 1988 study; see text.

June 1988 when the clean cover was put in place under closure activities. As closure activities began at New Hope Pond in 1988, special air sampling at that site was initiated. Emissions from each of these facilities are well below the NESHAP guideline for mercury in ambient air of 1 $\mu g/m^3$, but continued monitoring is required to ensure that ongoing remedial action activities do not adversely affect long-term ambient air quality. Additional information is provided in Sect. 6.1.7.

Discussion

It is estimated that a total of 0.12 Ci (47.4 kg) of uranium was released into the atmosphere in 1988 as a result of Y-12 Plant fabrication operations (Figs. 2.1.2 and 2.1.3). Because of the significantly higher specific activity of enriched uranium over that of depleted uranium, approximately 86% of the curie release was from emissions of enriched uranium particulates, while only 3% of the total mass of uranium released was from enriched uranium losses.

As illustrated in Fig. 2.1.3, 1988 Y-12 Plant uranium emissions estimates were considerably lower than in recent years, including 1987 when an 18-week strike by the Atomic Trades and Labor Council (ATLC) caused a significant reduction in plant production and emissions. 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. 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.

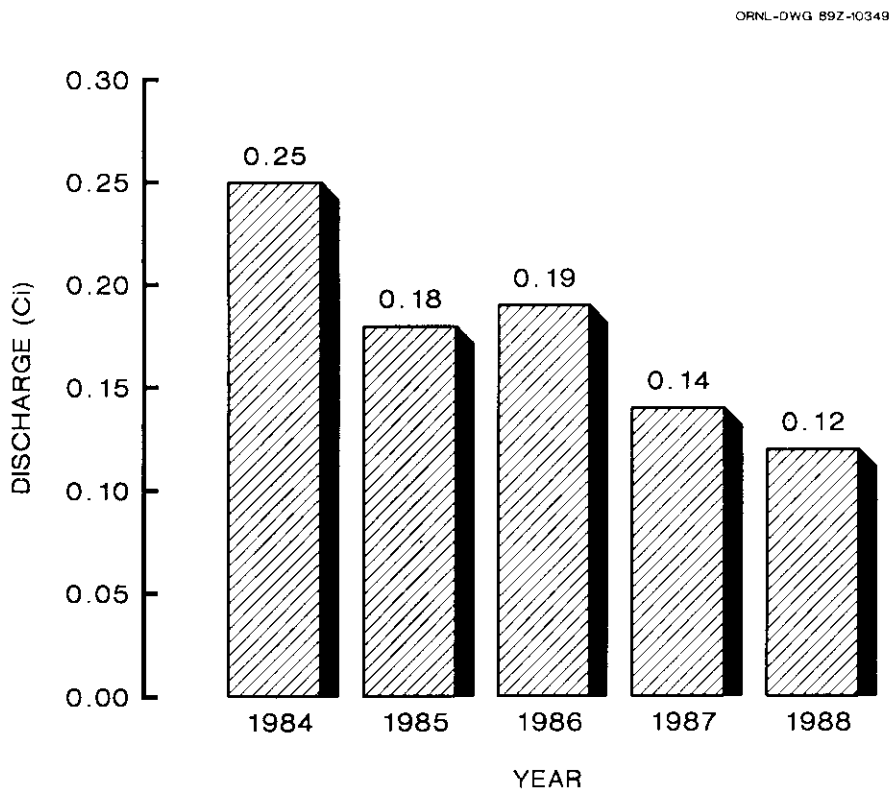

Fig. 2.1.2. Total curie discharges of uranium from the Y-12 Plant to the atmosphere.

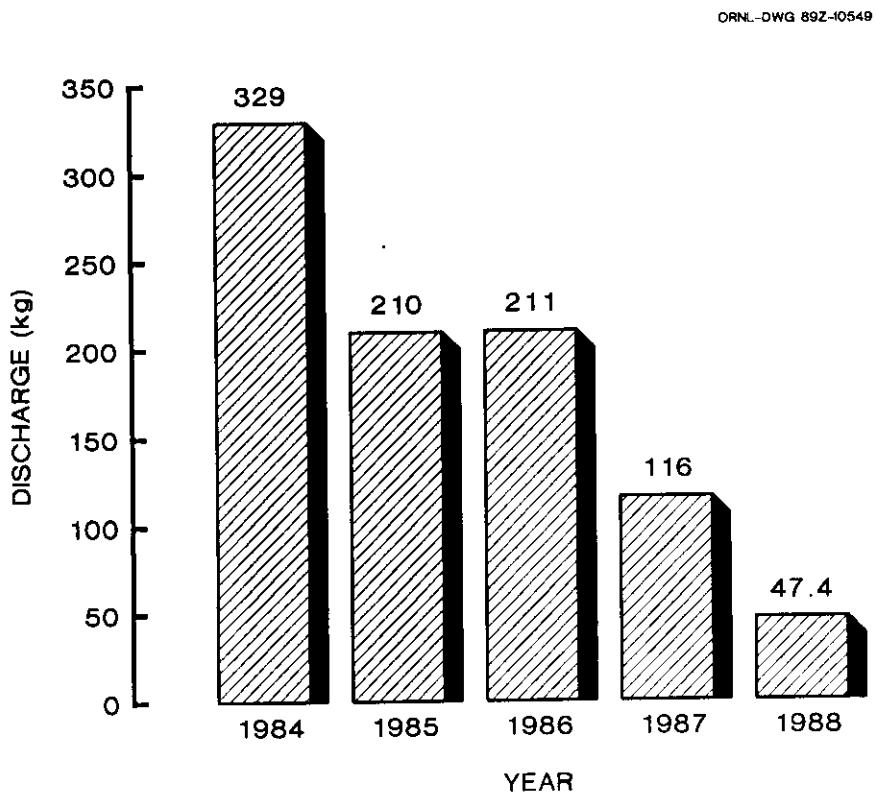

Fig. 2.1.3. Total kilograms of uranium discharged from the Y-12 Plant to the atmosphere.

2.1.1.2 Oak Ridge National Laboratory

Description

The gaseous emission point sources for ORNL consist of nine stacks located in Bethel and Melton valleys (Fig. 2.1.4):

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, Thorium-Uranium Recycle Facility, Transuranium Processing Plant)
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, or 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 2.1.22 of Vol. 2. All gaseous emissions are treated and filtered before discharge to the atmosphere. Typically, contaminated and potentially contaminated gaseous wastes are

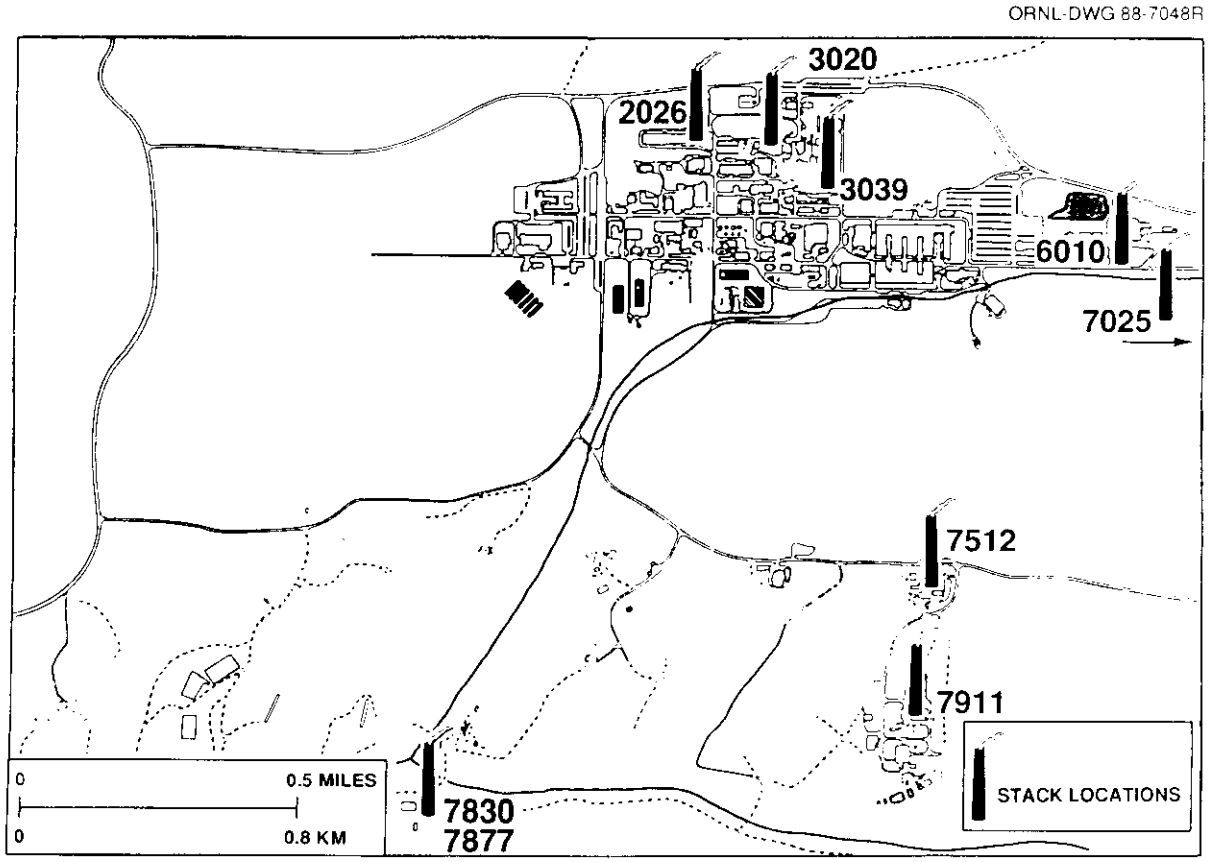

Fig. 2.1.4. Locations of major stacks (emission points) at ORNL.

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 the 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 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. A stack-monitoring improvement project that will provide continuous samplers at this stack is scheduled for 1989.

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 1988 airborne emission source term are shown in Table 2.1.3 and are further discussed in

Table 2.1.3. ORNL radioactive airborne emissions data sources

Isotope	Charcoal filter	Weekly particulate filter	Monthly particulate composite	Monitoring or inventory	Silica gel
^{7}Be			X		
^{82}Br	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				
^{132}I	X				
^{133}I	X				
^{134}I	X				
^{135}I	X				
^{191}Os	X		X		
^{212}Pb	X				
^{239}Pu			X		
^{125}Sb	X				
^{75}Se	X		X		
^{228}Th			X		
Total Sr			X		
^{234}U			X		
^{235}U			X		
^{238}U			X		
^{3}H				X	X
Noble gas				X	

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.

Summary

The 1988 radioactive airborne emissions data included 25 isotopes and three gross parameters captured from five data sources. Table 2.1.3 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 typically collected weekly. The 3039 area was 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 were summed.

Charcoal filters are a standard method for capturing and quantifying radioactive iodines in airborne emissions. Gamma spectroscopic analysis of the charcoal traps identified seven additional non-iodine isotopes, as shown in Table 2.1.3.

Particulate filters were held for 8 d prior to analysis in order to minimize the contribution from

short-lived, naturally occurring isotopes. These samples were analyzed for gross alpha and gross beta because radioactive particulates are typically alpha and beta emitters.

A new program was initiated in May to composite particulate air filters from these stacks. Each composite was dissolved and analyzed for long-lived radionuclides. 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. Composites were prepared for the 3039, 7830, and 7911 stacks for 7 months of the year (May–November). The filter compositing program was initiated in May 1988, and data for December were not ready for inclusion in this report.

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-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 1988 noble gas emissions are based upon the median counts-per-minute value for December 1988 and January 1989. This time period follows improvement of the software that validated the data as they are captured. The median counts per minute was then converted to an annual noble gas emission as ^{85}Kr 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 2.1.4. Results for four of the stacks, 2026, 3020, 7830, and 7512, are based upon samples collected for the full year. The upgraded sampling system at the 3039 stack area was operational for the last eight months of the year. At stack 7911, particulate samples and silica gel samples were collected for the last nine months of the year and charcoal filters were collected for the last ten months of the year. The stack 7025 tritium sampling system was upgraded for the last five months of the year. In each case where the data represented less than a full year, the data were converted into annual emissions by dividing the emission values by the number of days for which data were available and multiplying by 365 days in a year. This approach assumes that the data captured are representative of the time period when samples were not taken.

The 7877 stack emissions were associated with a short-duration program to solidify radioactive liquid wastes. This program was in operation for the last four months of the year.

No samples were collected from stack 6010 because the emissions from this facility exhibit extremely low concentrations of very short-lived radioisotopes. Consequently, this stack has virtually no impact upon the radiation dose associated with the operation of ORNL.

Trends in historically analyzed emission parameters are presented in Figs. 2.1.5 through 2.1.8. The noble gas source term was assumed to be 83% ^{133}Xe and 17% ^{85m}Kr based upon data collected at the High Flux Isotope Reactor (HFIR) (Craddick and Cook, in press). Many of the isotopes reported this year have not been analyzed for in the past. This increase in the emission source term reflects changes in the sampling systems and changes in the regulatory environment.

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

Table 2.1.4. 1988 ORNL annual airborne radionuclide emissions[a]

Isotope	Stack number								Total (μCi)
	2026	3020	3039	7025	7830	7877	7911	7512	
Based upon analytical results									
^{7}Be			69				31		2.1
^{82}Br			100						540
^{60}Co	7.1		89		4.2		0.10		170
^{137}Cs	25		74		0.27		0.49	0.36	160
^{152}Eu							100		0.11
^{154}Eu							100		0.15
^{155}Eu							100		0.099
Gross alpha	80	1.8	18		0.012	<0.001	0.51	0.044	1,900
Gross beta	5.0	0.17	95		0.008	<0.001	0.062	0.004	34,000
^{125}I	0.84	7.7	84		0.084		4.7	2.8	270
^{129}I	2.9	21	54		0.23		14	6.8	510
^{131}I	0.012	0.016	37		<0.001	<0.001	62	0.003	56,000
^{132}I							100		75
^{133}I	0.033	0.073	0.27		0.002	<0.001	100	0.009	30,000
^{134}I							100		55
^{135}I	0.017	0.015	0.094		<0.001	<0.001	100	0.002	16,000
^{191}Os	<0.001	<0.001	100		<0.001			<0.001	5,100,000
^{212}Pb	57	3.4	26		0.014	0.001	14	0.24	51,000
^{239}Pu			100						0.0031
^{125}Sb			100						2.3
^{75}Se			100		0.001				490
^{228}Th			87		0.41		12		0.20
Total rad. Sr			100				0.030		330
^{234}U			100						0.063
^{235}U			100						0.0010
^{238}U			100						0.0013
Based upon inventory or monitoring									
Tritium			98	1.6			<0.001		21,000[b]
Noble gas			99				0.84		37,000[b]

[a]Percent contribution to emissions, by stack.
[b]Units are curies, not microcuries.

emission points except the steam plant. Estimates of major chemical emissions from ORNL will be reported in an addendum to be issued in July 1989.

2.1.1.3 Oak Ridge Gaseous Diffusion Plant

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 2.1.23 in

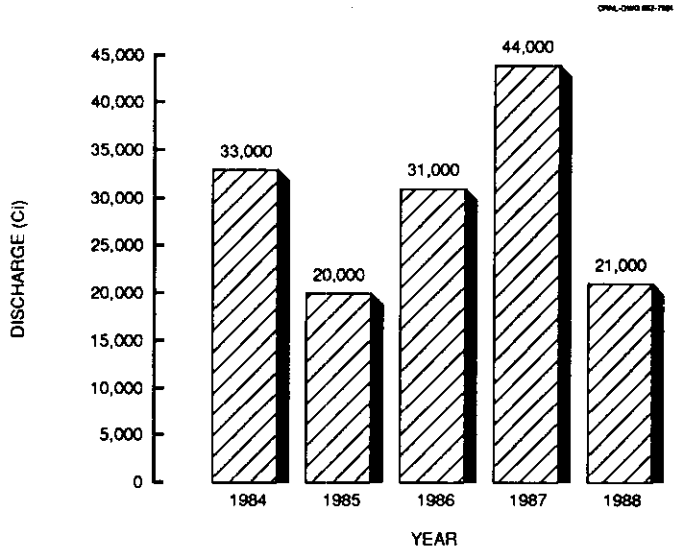

Fig. 2.1.5. Total curie discharges of tritium from ORNL to the atmosphere.

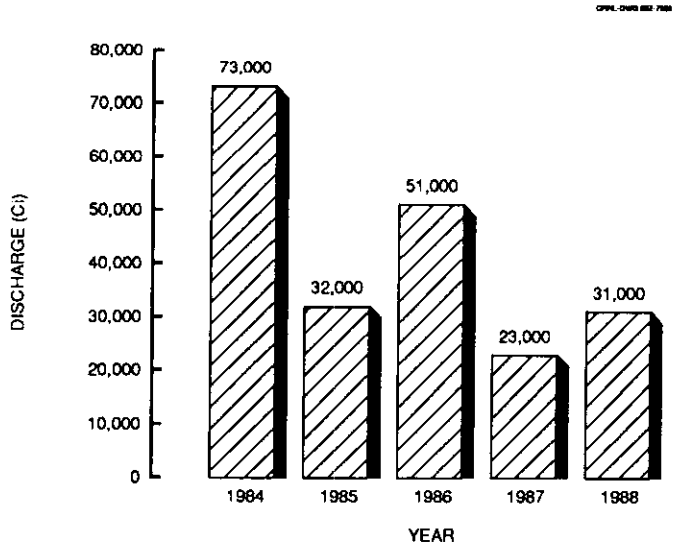

Fig. 2.1.6. Total discharges of xenon-133 from ORNL to the atmosphere.

Vol. 2 lists air permits issued by TDHE for ORGDP.

The locations of airborne radioactive effluent release points at ORGDP are shown in Fig. 2.1.9, except for a test, the Y-12 sludge detoxification demonstration. The test produced insignificant emissions of uranium (336 μg). All radionuclide emissions were included in all dose modeling. Figure 2.1.10 describes the general types of air emission sources at ORGDP, and Fig. 2.1.11 depicts the air pollution control program strategy in detail.

Currently, the only major emission sources operating are the K-1501 steam plant and the

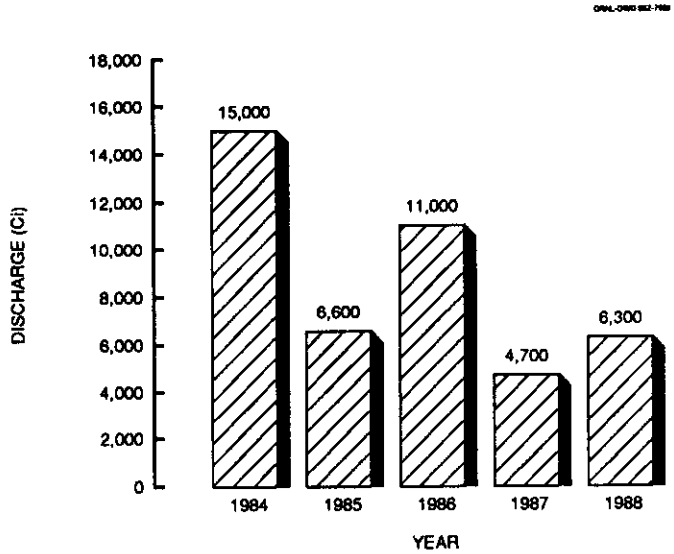

Fig. 2.1.7. Total discharges of krypton-85 from ORNL to the atmosphere.

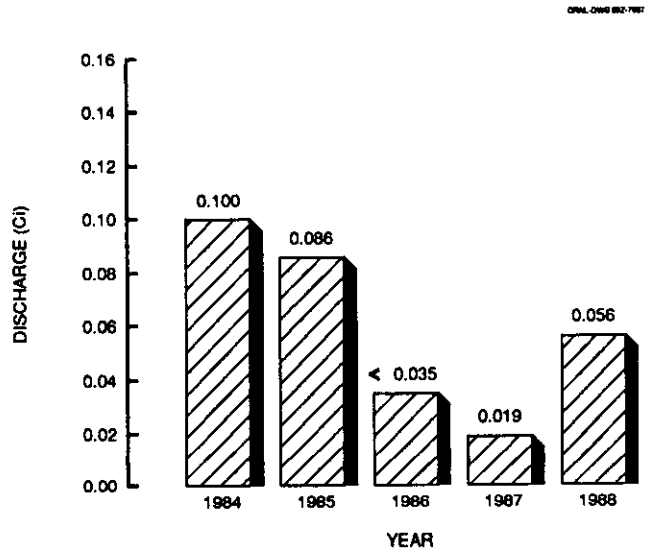

Fig. 2.1.8. Total discharges of iodine-131 from ORNL to the atmosphere.

K-1435 Toxic Substances Control Act (TSCA) incinerator.

The K-1501 steam plant is still operational, and this system has a continuous opacity monitor. To reduce opacity excursions, a decision was made in 1985 to use natural gas as much as possible. Because sufficient natural gas capacity is not available during very cold winter conditions, some coal must be burned during peak periods of use.

Preoperational testing of NESHAP sampling equipment at the K-1435 TSCA incinerator was conducted in August and September 1988. Normal operations were conducted October through December 1988. Off-gas samples were pulled continuously any time radionuclides were burned in the incinerator. The incinerator was operated intermittently during this period and was used primarily to test and verify equipment performance

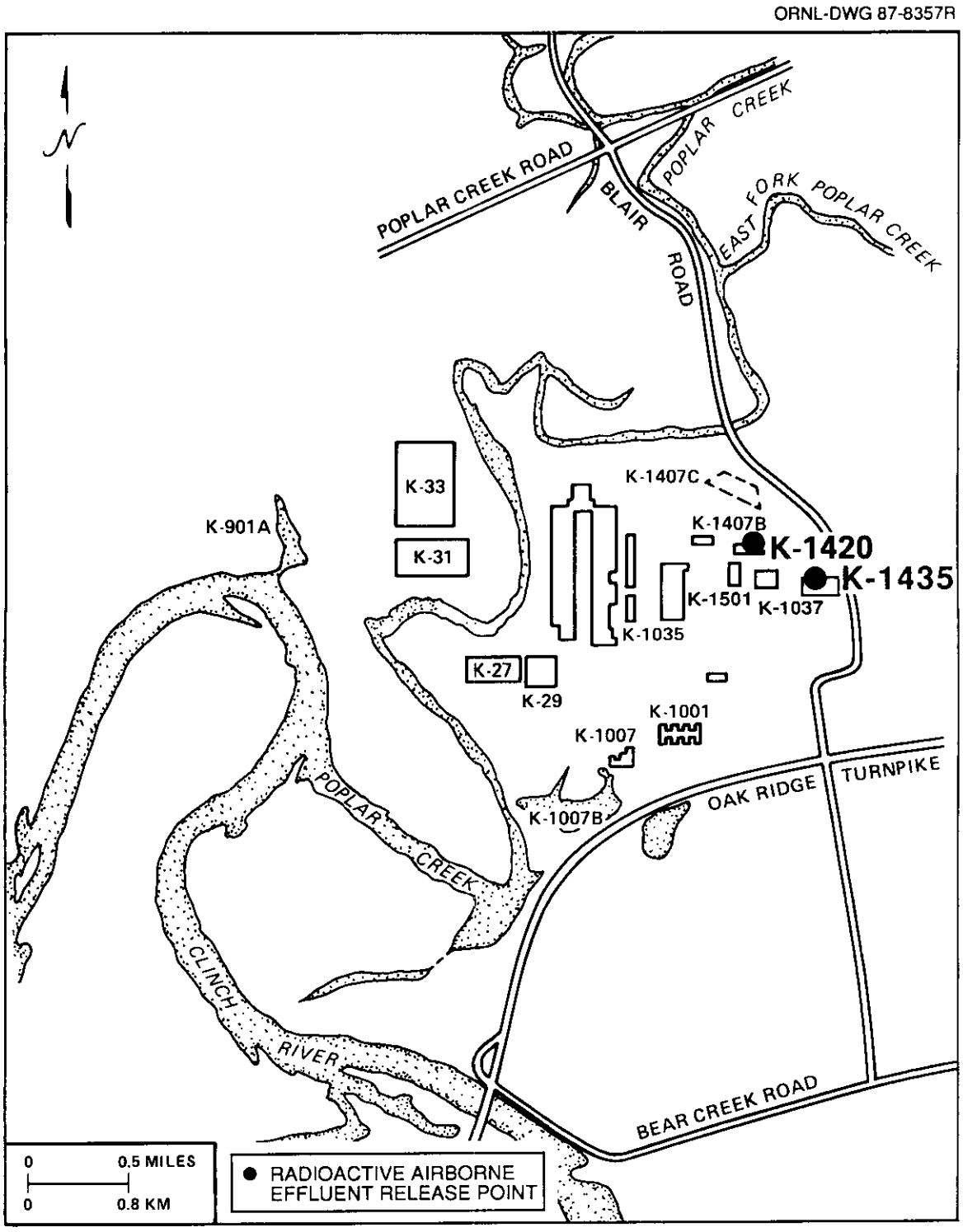

Fig. 2.1.9. Locations of airborne effluent release points at ORGDP.

ORNL-DWG 87-7346

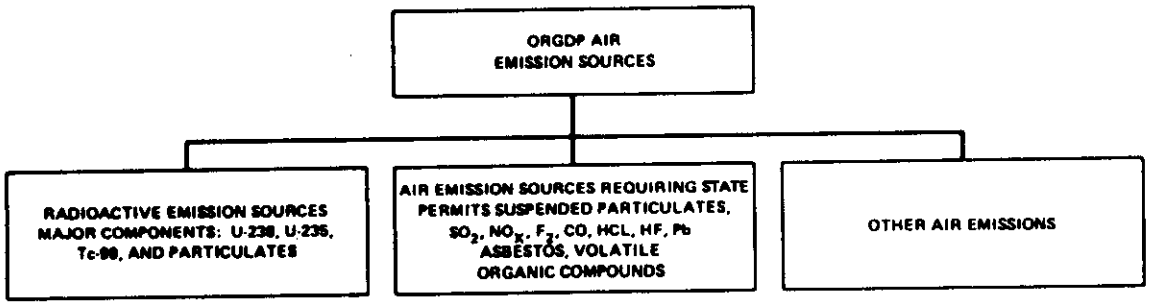

Fig. 2.1.10. Air emission sources at ORGDP.

ORNL-DWG 87-7345R

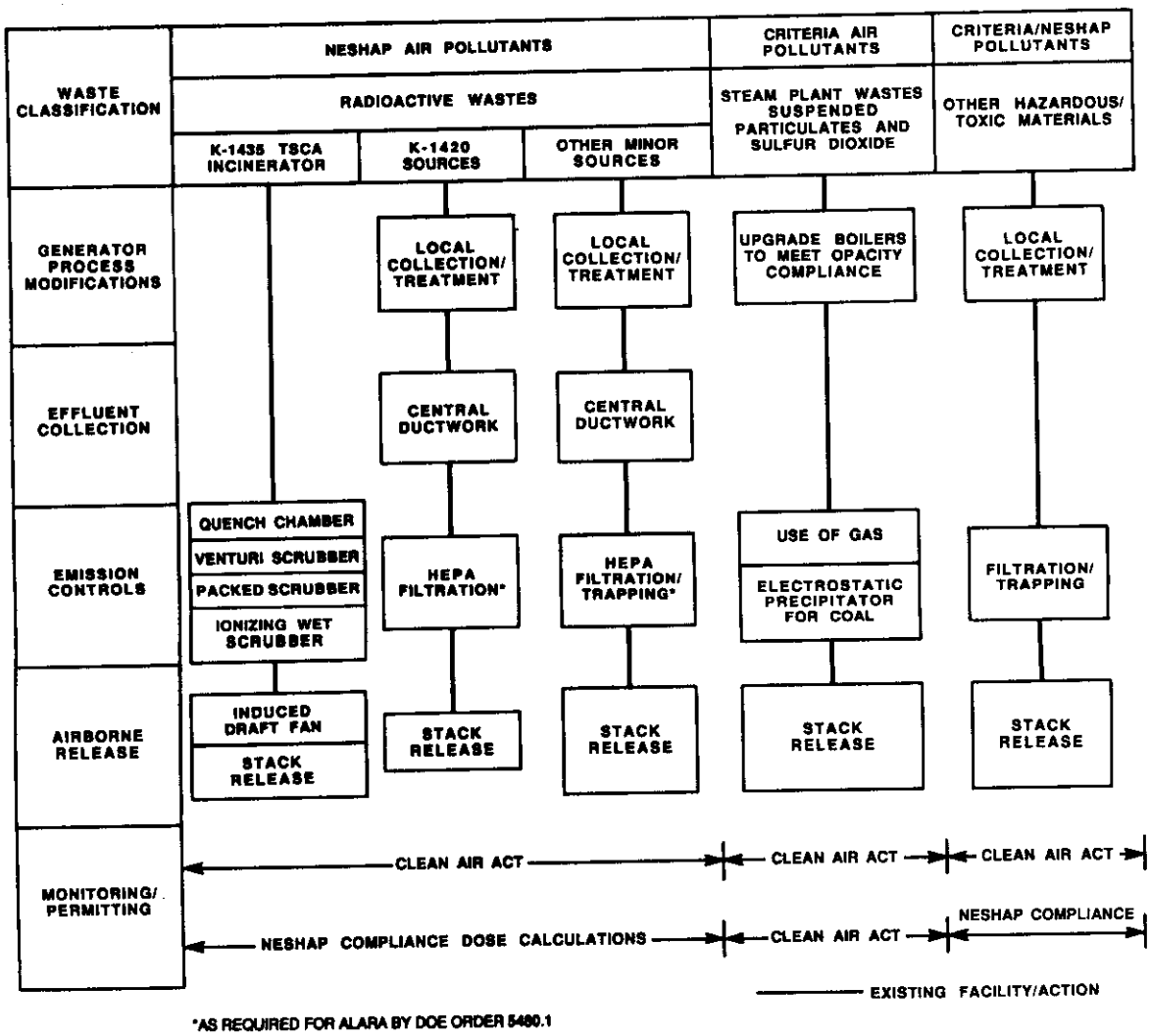

Fig. 2.1.11. Air pollution control program at ORGDP.

and operating conditions. Monitoring was conducted in accordance with the protocol submitted to the EPA on August 26, 1987; however, there were periods when deviations occurred. Most of the deviations occurred because the NESHAP equipment was newly installed and operational testing to work out system compatibility had not been completed.

The only radioactive isotopes incinerated in the K-1435 TSCA incinerator during this quarter 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.

A majority of the emissions occurred from either the K-1501 steam plant, the K-1420 decontamination facility, or the K-1435 TSCA incinerator. In these cases, the estimates of the amount of pollutants emitted are based on actual operating activity. Emissions from the steam plant were due to 29 d of coal operation in 1988. The estimates for radionuclide emissions from the various stacks at K-1420 are based on both actual operating time in 1988 and stack sampling data obtained in 1984, 1985, and 1988.

Figures 2.1.12 and 2.1.13 compare ORGDP's discharges of uranium for 1988 with those of previous years. Uranium emissions increases for 1988 resulted almost entirely from operation and testing of the K-1435 TSCA incinerator. Samples collected in 1988 detected ^{99}Tc in emissions from K-1420 and K-1435. Figures 2.1.14 and 2.1.15 compare ORGDP's discharges of ^{99}Tc for 1988 with those of previous years.

The K-1435 Toxic Substances Control Act (TSCA) incinerator underwent a series of tests in 1988 to achieve compliance with permit conditions in order to receive final operating permits. In May and June, the Environmental Protection Agency (EPA) and the Tennessee Department of Health and Environment (TDHE) were on site to observe trial burns as required by RCRA and TSCA. In November, the TDHE was back on site to observe the compliance air test as required by the state air regulations.

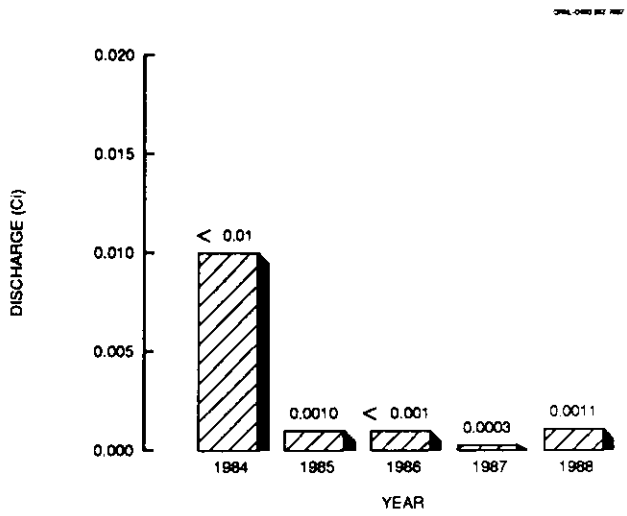

Fig. 2.1.12. Total curie discharges of uranium from ORGDP to the atmosphere.

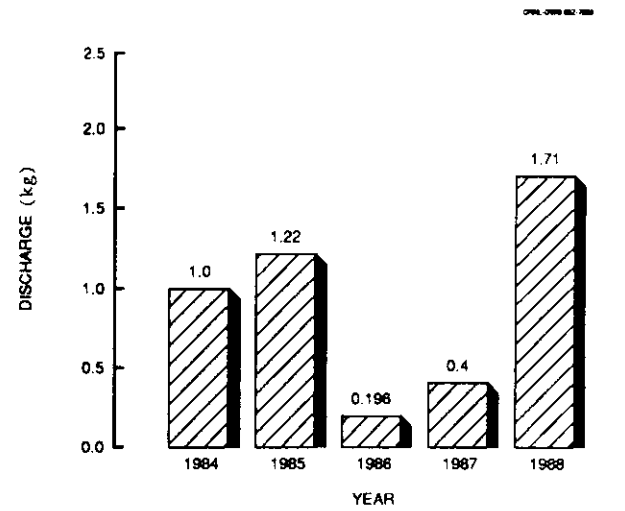

Fig. 2.1.13. Total kilograms of uranium discharged from ORGDP to the atmosphere.

The RCRA trial burn was structured to achieve compliance with the performance requirements of RCRA under maximum designed operating conditions. Under RCRA, the incinerator is required to demonstrate (1) a destruction and removal efficiency of 99.99% for hazardous organic

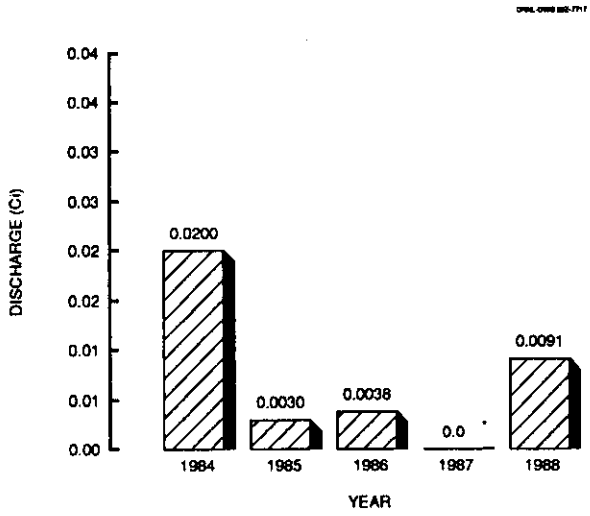

Fig. 2.1.14. Total curie discharges of ^{99}Tc from ORGDP to the atmosphere. (There was no ^{99}Tc detected in 1987.)

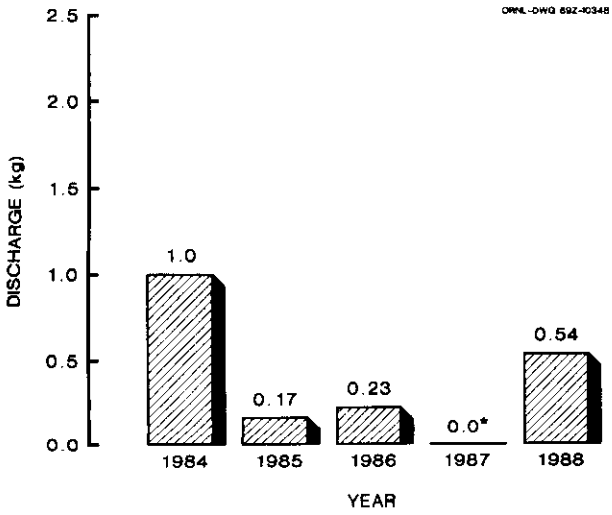

Fig. 2.1.15. Total kilograms of technetium discharged from ORGDP to the atmosphere. (There was no technetium detected in 1987.)

materials, (2) a stack particulate removal of less than 0.08 grains/dry standard cubic feet, and (3) a stack hydrochloric acid removal to less than 4 lb/h. The test was conducted using surrogate materials (trichlorofluoromethane and carbon tetrachloride) which, if successfully destroyed, would allow any waste materials to be incinerated by the incinerator. The test report was sent to the EPA and the TDHE for approval in September.

In February 1989, it was learned from the TDHE that the data submitted for the RCRA test was inconclusive and that a retest would be required. The reasons that the test report was ruled inconclusive was (1) because two of three HCl samples were broken in transit to the laboratory, (2) some stack samples were contaminated with methylene chloride and were not analyzed properly, and (3) some samples were held past the required preservation period before being analyzed. All samples that were analyzed correctly were within the required performance standard limits. A retest is planned in June 1989.

The TSCA trial burn was structured to achieve compliance with the performance requirements of TSCA in order to be allowed to incinerate polychlorinated biphenyls (PCBs). The test was conducted under maximum design conditions.

Under TSCA, the incinerator was required to demonstrate (1) a destruction and removal efficiency of 99.9999% for PCBs, (2) a stack particulate removal of less than 0.08 grains per dry standard cubic foot, and (3) a stack hydrochloric acid removal to less than 4 lb/h. The test report was sent to the EPA for approval in September. In March 1989, the EPA issued an approval to DOE to allow the incinerator to burn PCBs.

The TDHE air compliance test was conducted to achieve compliance with the state air regulations. The test was structured to demonstrate that the incinerator could meet the stack emission limits for (1) nitrogen oxides, (2) particulates, (3) hydrogen fluoride, (4) lead, and (5) beryllium. The test was conducted using triplicate runs maximizing the feed rates in order to receive the most flexible operating permit. Analytical results from the test revealed that the emission limits for lead and beryllium had been exceeded during all three runs. All other emissions were within required limits. A study done to determine what caused the exceedances showed that stratification of the lead and beryllium in the feed tank was the primary reason for

miscalculation of the feed input to the incinerator. Thus, more lead and beryllium was emitted during the test than had been structured in the test plan.

There are no permit requirements to sample or monitor all chemical emissions from ORGDP; however, estimatesof the major gaseous chemicals emitted to the atmosphere in 1988 are being prepared and will be included in a chemical emissions addendum to be issued in July 1989.

2.1.2 Ambient Air Monitoring

In addition to stack monitoring and sampling conducted at the DOE Oak Ridge installations, an extensive 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 radiological concentrations in the environment surrounding the facilities, allows plant operators to determine the relative level of radioactivity at various points during an emergency condition, and ensures compliance with regulations and safety standards for the public. This ensures that plant workers and the general public are adequately protected from potential hazards that could result during an emergency 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, all ambient air monitors were operated by ORNL during 1988. The following discussions include data summary tables in which 1988 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 2.1.20.

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 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 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. 2.1.16.

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 ambient air quality. If a sample is found to exceed the state standard, Y-12 Plant personnel have the filter scrutinized under a microscope to determine the cause. In all such cases, the majority of the filter is covered with road dust, pollen, insects, and other particles arising from the natural environment.

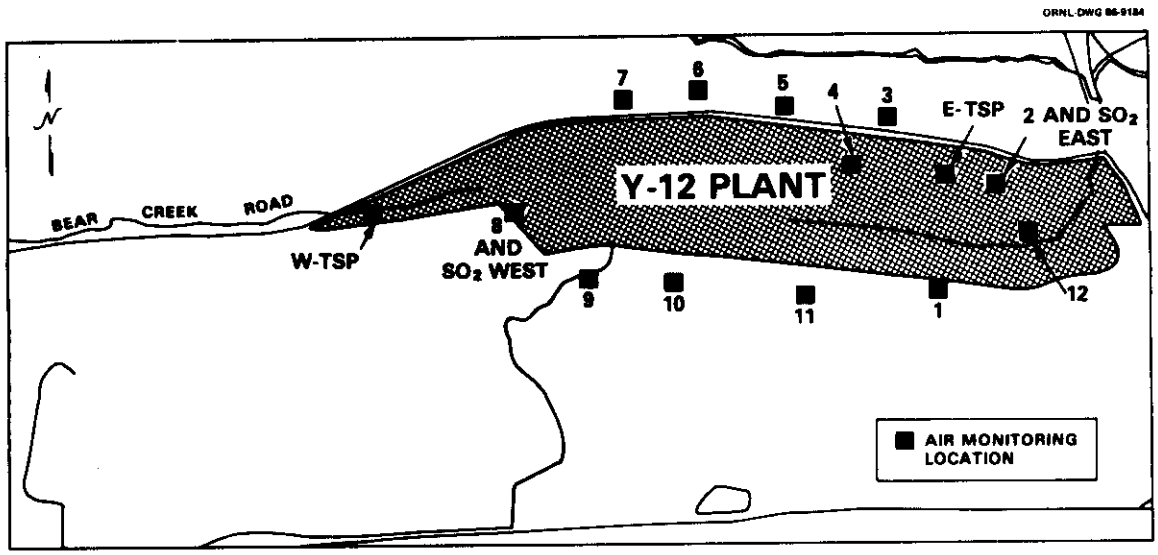

Fig. 2.1.16. Ambient air monitoring stations operated by the Y-12 Plant.

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 2.1.5 through 2.1.9. Table 2.1.5 shows the maximum, minimum, and average gross alpha and gross beta concentrations measured at each of the 12 stations during 1988. Similarly, the ^{234}U, ^{235}U, ^{236}U, and ^{238}U average uranium concentrations are shown in Table 2.1.6. Table 2.1.7 shows similar data for ambient fluoride concentration during 1988 as well as a comparison with the state standard for fluorides.

Table 2.1.8 summarizes the measured SO_2 concentrations at each of the two Y-12 Plant SO_2 monitoring stations during 1988. Table 2.1.9 shows TSP data for the two Y-12 Plant TSP ambient air monitoring stations during 1988. 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 1988 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 draft DOE Order 5400.xx.

Measured SO_2 concentrations at the two Y-12 Plant air monitoring stations were well below state standards throughout 1988 (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 1988.

Table 2.1.5. 1988 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	3.50	1.72	2.71
2	4	5.01	2.97	3.71
3	4	6.60	5.54	6.15
4	4	7.06	4.55	5.69
5	4	18.71	8.18	10.56
6	4	6.14	3.50	4.80
7	4	6.47	5.54	5.92
8	4	6.71	4.22	4.99
9	4	7.92	4.29	5.44
10	4	3.23	2.70	2.95
11	4	4.05	3.43	3.67
12	4	5.38	3.36	4.06
		Gross beta		
1	4	23.5	20.5	21.68
2	4	22.7	19.0	20.92
3	4	25.9	23.6	24.75
4	4	24.9	20.8	22.48
5	4	28.0	20.7	25.78
6	4	21.4	23.1	22.32
7	4	28.9	23.4	26.18
8	4	27.4	22.7	24.55
9	4	25.2	21.2	22.82
10	4	22.6	18.1	20.70
11	4	19.7	19.5	19.58
12	4	26.6	19.9	23.05

[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 Vol. 2, Sect. 2.

2.1.2.2 Oak Ridge National Laboratory

Description

Atmospheric concentrations of materials occurring in the general environment around ORNL, the ORR, and the vicinity are sampled continuously by an air monitoring network of 27 stations. The approximate locations of these stations are shown in Figs. 2.1.17 and 2.1.18. These air monitoring stations are categorized into three groups according to their geographical locations.

1. The ORNL perimeter air monitoring network consists of stations 3, 4, 7, 9, 20, 21, and 22. These stations are located at or near the ORNL boundary (Fig. 2.1.17).

Table 2.1.6. 1988 uranium concentrations in air at the Y-12 Plant[a]

Station ID	No. of analyses[b]	Concentration (10^{-15} μCi/cm³)			DCG (%)
		Max	Min	Av	
		^{234}U			
1	4	1.21	0.38	0.841	1.49
2	4	2.31	0.91	1.55	2.85
3	4	4.22	2.77	3.74	5.21
4	4	5.99	3.19	4.39	7.40
5	4	7.63	4.88	6.08	9.42
6	4	2.56	1.24	1.96	3.16
7	4	2.78	1.30	2.16	3.43
8	4	3.50	1.09	2.21	2.84
9	4	2.59	0.91	1.76	3.20
10	4	1.37	0.63	0.86	1.69
11	4	1.80	0.34	1.08	2.22
12	4	1.59	0.47	1.01	1.96
		^{235}U			
1	2	0.031	0.018	0.025	0.038
2	3	0.041	0.090	0.069	0.051
3	4	0.217	0.017	0.100	0.268
4	4	0.148	0.072	0.100	0.183
5	4	0.370	0.041	0.197	0.457
6	3	0.047	0.007	0.032	0.058
7	4	0.092	0.062	0.076	0.114
8	4	0.310	0.014	0.137	0.383
9	4	0.139	0.033	0.065	0.172
10	4	0.088	0.008	0.031	0.109
11	3	0.091	0.010	0.044	0.112
12	3	0.143	0.021	0.074	0.177
		^{236}U			
1	3	0.101	0.027	0.067	0.125
2	3	0.133	0.007	0.089	0.164
3	4	0.114	0.007	0.066	0.141
4	4	0.157	0.047	0.115	0.194
5	4	0.451	0.056	0.200	0.551
6	3	0.092	0.062	0.075	0.114
7	4	0.099	0.042	0.083	0.122
8	4	0.279	0.039	0.168	0.344
9	4	0.306	0.028	0.126	0.378
10	4	0.086	0.046	0.066	0.106
11	3	0.098	0.041	0.077	0.121
12	3	0.134	0.037	0.072	0.165

Table 2.1.6 (continued)

Station ID	No. of analyses[b]	Concentration (10^{-15} μCi/cm^3)			DCG (%)
		Max	Min	Av	
		^{238}U			
1	4	0.393	0.032	0.156	0.485
2	4	0.286	0.060	0.181	0.353
3	4	0.419	0.179	0.273	0.517
4	4	0.435	0.191	0.331	0.537
5	4	0.379	0.097	0.265	0.468
6	4	0.423	0.134	0.212	0.522
7	4	0.418	0.244	0.306	0.516
8	4	0.520	0.200	0.387	0.642
9	4	2.55	0.222	0.899	3.148
10	4	0.316	0.043	0.145	0.390
11	4	0.325	0.030	0.172	0.401
12	4	0.223	0.029	0.127	0.275

[a]See Fig. 2.1.14.

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

Table 2.1.7. 1988 fluorides in air at the Y-12 Plant

Station ID	No. of 7-d samples	Concentration (10^{-15} μg/m^3)				Percentage of standard[b]
		Max	Min	Av	Tenn. std.[a]	
1	54	0.0614	<0.007	<0.0133	1.6	0.83
2	54	0.0860	<0.007	<0.0179	1.6	1.12
3	54	0.1404	<0.007	<0.03	1.6	1.88
4	54	0.1649	<0.007	<0.0428	1.6	2.68
5	54	0.1860	<0.007	<0.0352	1.6	2.20
6	54	0.1158	<0.007	<0.0207	1.6	1.29
7	53	0.0807	<0.007	<0.0251	1.6	1.57
8	53	0.1579	<0.007	<0.0236	1.6	1.48
9	54	0.3509	<0.007	<0.0286	1.6	1.79
10	53	0.0614	<0.007	<0.0144	1.6	0.90
11	52	0.0298	<0.007	<0.0117	1.6	0.73

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

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

Table 2.1.8. 1988 sulfur dioxide in air—Y-12 Plant sulfur dioxide monitoring stations

Station ID	Concentration (ppm SO_2)				
	Monthly av	Max 3-h av	Tenn. std. 3-h av	Max 24-h av	Tenn. std. 24-h av
East (004)	0.014	0.076	0.50	0.029	0.140
West (005)	0.010	0.061	0.50	0.023	0.140

Table 2.1.9. 1988 total suspended particulates in air—Y-12 Plant TSP monitoring stations

Station ID	No. of samples	Concentration ($\mu g/m^3$)					
		Max	Min	Av	Tennessee standard[a]	Percent of standard[b]	Number of exceedances
East	48	99	0.5	50	260	19.2	0
West	45	110	3	54	260	20.8	0

[a]Tennessee primary air quality 24-h standard = 260 $\mu g/m^3$.
[b]Percent of standard calculated using average TSP concentration.

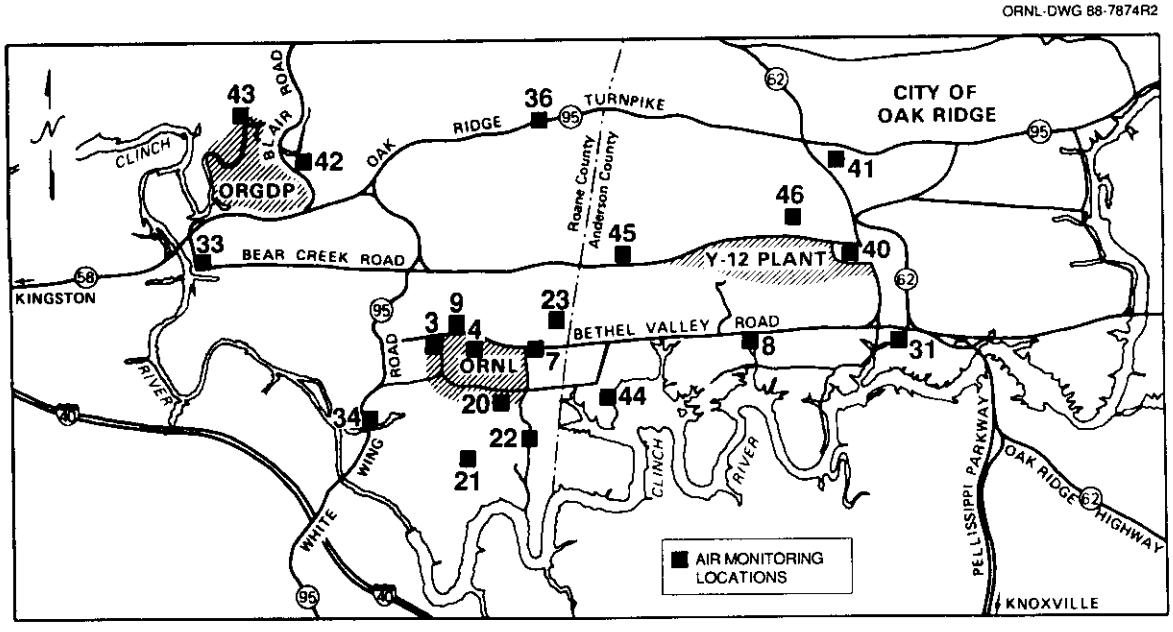

Fig. 2.1.17. ORR and ORNL perimeter monitoring locations.

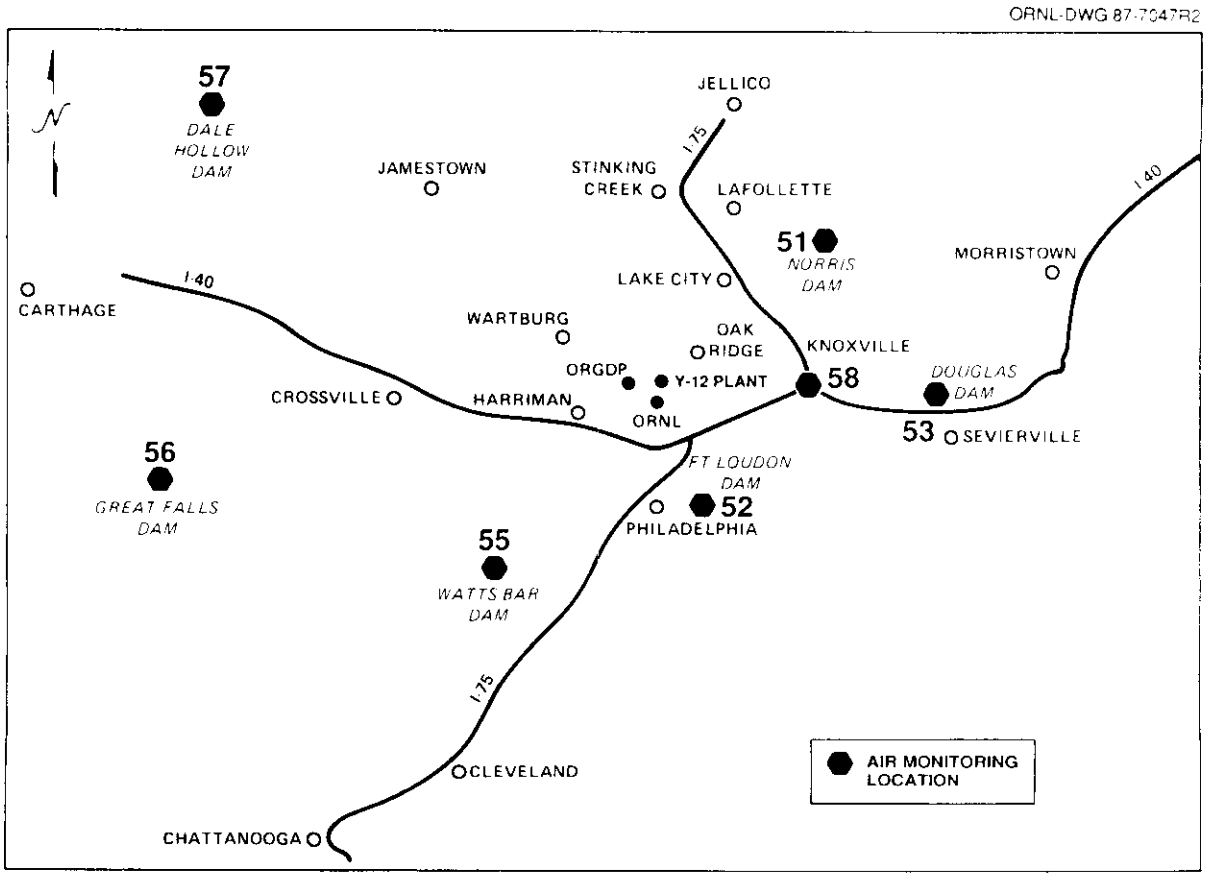

Fig. 2.1.18. Remote air monitoring locations.

2. The DOE ORR perimeter air monitoring network consists of stations 8, 23, 31, 33, 34, 36, and 40–46 (Fig. 2.1.17). All of these stations except station 23 have the capability to perform both sampling and continuous monitoring.

3. The remote air monitoring network consists of stations 51–53 and 55–58. These stations are located within a 120-km (74.4-mile) radius of ORNL outside the ORR (Fig. 2.1.18).

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 2.1.10. The real-time monitoring system is the only measure of radioactive noble gases in the area.

Airborne radioactive particulates are sampled weekly by pumping a continuous flow of air through a 47-mm (1.88-in.) diam paper filter and then through a 47-mm diam × 25-mm thick (1.88-in. diam × 1-in. thick) charcoal cartridge. The square paper filters previously used at the ORNL perimeter stations and at the remote stations have been replaced with round paper filters consistent with the stack monitoring equipment. The new filters are easier to handle and give a higher counting efficiency. The filter papers are collected and analyzed weekly for gross alpha and gross beta activities. To minimize artifacts from short-lived radionuclides, the filter paper is analyzed 3 to 4 d after collection. The airborne ^{131}I is collected weekly 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

Table 2.1.10. Summary of collection and analysis frequencies of ORNL air monitoring stations

Station[a]	Parameter	Collection frequency	Type	Analysis frequency
3, 4, 7, 8, 9, 20, 21, 22, 23, 31, 33, 34, 36, 40–46	^{131}I, gross alpha, gross beta	Weekly	Continuous	Weekly
3, 8	Tritium	Monthly	Continuous	Monthly
Local,[b] perimeter,[c] remote,[d] 34, 36, 40, 41, 45, 46	^{7}Be, ^{60}Co, ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{228}Th, ^{230}Th, ^{232}Th, total Sr,[e] ^{234}U, ^{235}U, ^{238}U	Weekly	Continuous	Quarterly

[a]See Figs. 2.1.17 and 2.1.18.
[b]Composite of 3, 4, 7, 9, 20, 21, and 22.
[c]Composite of 8, 23, 31, 33, 42, 43, and 44.
[d]Composite of 51–53 and 55–58.
[e]Total radioactive Sr (^{89}Sr + ^{90}Sr).

off, and flow rates are recorded when a sampler 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 1988, 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 concentration of tritium in the air is calculated by dividing total activity accumulated per month by total volume of air sampled.

Air filters are composited quarterly from ORNL perimeter stations (3, 4, 7, 9, 20, 21, and 22), Reservation perimeter stations (excluding 34, 36, 40, 41, 45, and 46), remote stations (51–53 and 55–58), and individual stations (34, 36, 40, 41, 45, and 46) and 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.

Summary

Annual data summaries are presented in Table 2.1.11 for 3 gross parameters and 10 to 12 radionuclides. As discussed previously, the data are divided into three groups. The ORNL perimeter air monitors are designed to evaluate the specific impact of ORNL upon 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 insight into the relative contribution of ORNL as compared to other facilities on the Reservation. The remote air monitors 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 data and ORR data to the remote air monitor data, the net impact of the

Table 2.1.11. 1988 radionuclide concentrations in air

Area[a]	Determination	Number of samples	Concentration (10^{-15} μCi/mL)				
			Max	Min	Av	Standard error	DCG (%)
ORNL PAMS	Gross alpha	289	1.8	−2.3	−0.22	0.056	
	Gross beta	289	81	4.2	27	0.49	
	^{131}I	289	6.7	−4.8	0.54	0.092	<0.01
	^{3}H	12	0.07	−0.32	−0.0098	0.028	<0.01
	^{60}Co	4	<0.071	0.035	<0.054	0.0083	<0.01
	^{137}Cs	4	0.15	0.064	0.10	0.019	<0.01
	^{238}Pu	4	0.0019	−0.000044	0.00087	0.00047	<0.01
	^{239}Pu	4	0.0010	−0.00064	0.00021	0.00034	<0.01
	^{228}Th	4	0.10	0.024	0.053	0.017	0.13
	^{230}Th	4	0.049	0.0070	0.022	0.0097	0.055
	^{232}Th	4	0.021	0.0062	0.013	0.0038	0.19
	Total Rad. Sr	4	0.12	0	0.069	0.027	<0.01
	^{234}U	4	0.10	0.062	0.081	0.0085	0.090
	^{235}U	4	0.042	0.0036	0.014	0.0094	0.014
	^{238}U	4	0.049	0.015	0.028	0.0075	0.028
Reservation PAMS	Gross alpha	646	17	−3.3	−0.043	0.051	
	Gross beta	646	94	6.7	27	0.32	
	^{131}I	646	12	−4.7	0.50	0.058	<0.01
	^{3}H	12	0.054	−0.35	−0.017	0.030	<0.01
	^{60}Co	28	<0.36	−0.098	<0.18	0.030	<0.01
	^{137}Cs	28	<0.36	−0.084	<0.13	0.022	<0.01
	^{238}Pu	28	0.017	−0.12	−0.0037	0.0046	<0.01
	^{239}Pu	28	0.0019	−0.039	−0.0050	0.0015	<0.01
	^{228}Th	28	0.85	0.0098	0.22	0.041	0.55
	^{230}Th	28	0.38	0.0054	0.095	0.021	0.24
	^{232}Th	28	0.073	0.0050	0.022	0.0031	0.31
	Total Rad. Sr	28	0.66	−0.11	0.11	0.032	<0.01
	^{234}U	28	1.0	0.041	0.37	0.050	0.41
	^{235}U	28	0.30	0.0014	0.042	0.013	0.042
	^{238}U	28	1.6	0.015	0.14	0.056	0.14
RAMS	Gross alpha	308	4.0	−3.3	0.11	0.072	
	Gross beta	308	61	1.9	29	0.53	
	^{60}Co	4	<0.055	−0.011	<0.025	0.015	<0.01
	^{137}Cs	4	0.072	−0.021	0.027	0.025	<0.01
	^{238}Pu	4	0.0022	−0.00017	0.00054	0.00055	<0.01
	^{239}Pu	4	0.00017	−0.00083	−0.00034	0.00021	<0.01
	^{228}Th	4	0.073	0.021	0.046	0.011	0.12
	^{230}Th	4	0.031	0.0065	0.019	0.0062	0.048
	^{232}Th	4	0.028	0.0087	0.018	0.0048	0.26
	Total Rad. Sr	4	0.068	−0.00042	0.030	0.015	<0.01
	^{234}U	4	0.13	0.019	0.063	0.025	0.070
	^{235}U	4	0.0088	0.0015	0.0034	0.0018	<0.01
	^{238}U	4	0.033	0.013	0.021	0.0044	0.021

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. For each isotope, the annual average concentration is divided by the derived concentration guide (DCG) for inhalation of that isotope 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 is provided in the introduction to this chapter. The definition of DCG is given in the introduction to this chapter. Data summaries for individual monitoring stations are provided in Tables 2.1.6–2.1.20 of Vol. 2.

There appears to have been little or no airborne gross alpha activity at any of the sampling stations during 1988. The average values for the ORNL perimeter and the ORR are not statistically different from the reference values obtained from the remote stations.

The gross beta averages for 1988 are higher than the averages for 1987. This is a result of changing the counting time from 1 min to 30 min for these samples. The change was made to lower the minimum detectable activity. No gross beta activity in excess of the reference average was associated with the ORR or ORNL.

Iodine-131 and tritium concentrations for ORNL and ORR were less than 0.01% of the DCG. There were no statistically different concentrations of either isotope between the ORNL and ORR stations. 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 to the remote station data. They are ^{60}Co, ^{228}Th, ^{230}Th, ^{234}U, and ^{235}U. Thorium-228 made the largest contribution to inhaled dose with an annual average of 0.55% of the DCG. All the elevated values are associated with ORR perimeter stations 34, 40, 41, 45, and 46.

The most likely sources of these increased concentrations are fugitive dusts associated with remedial action activities at the ORR. Station 34 is located near ORNL SWSA 6, which is part of a remedial program, as described in Sect. 4. The other stations are located around the Y-12 Plant, where construction activities were conducted to close New Hope Pond. 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 shows that ORNL does not have a statistically significant impact upon 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. The impact upon inhaled dose from these isotopes ranges from <0.01 to 0.55% of the DCGs. No significant changes in the concentrations of these radionuclides were detected between 1987 data and the 1988 data for the remote stations. Therefore, based upon these data, ORR operations are making a slight impact upon the local air quality and not significantly impacting 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. 2.1.19. 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

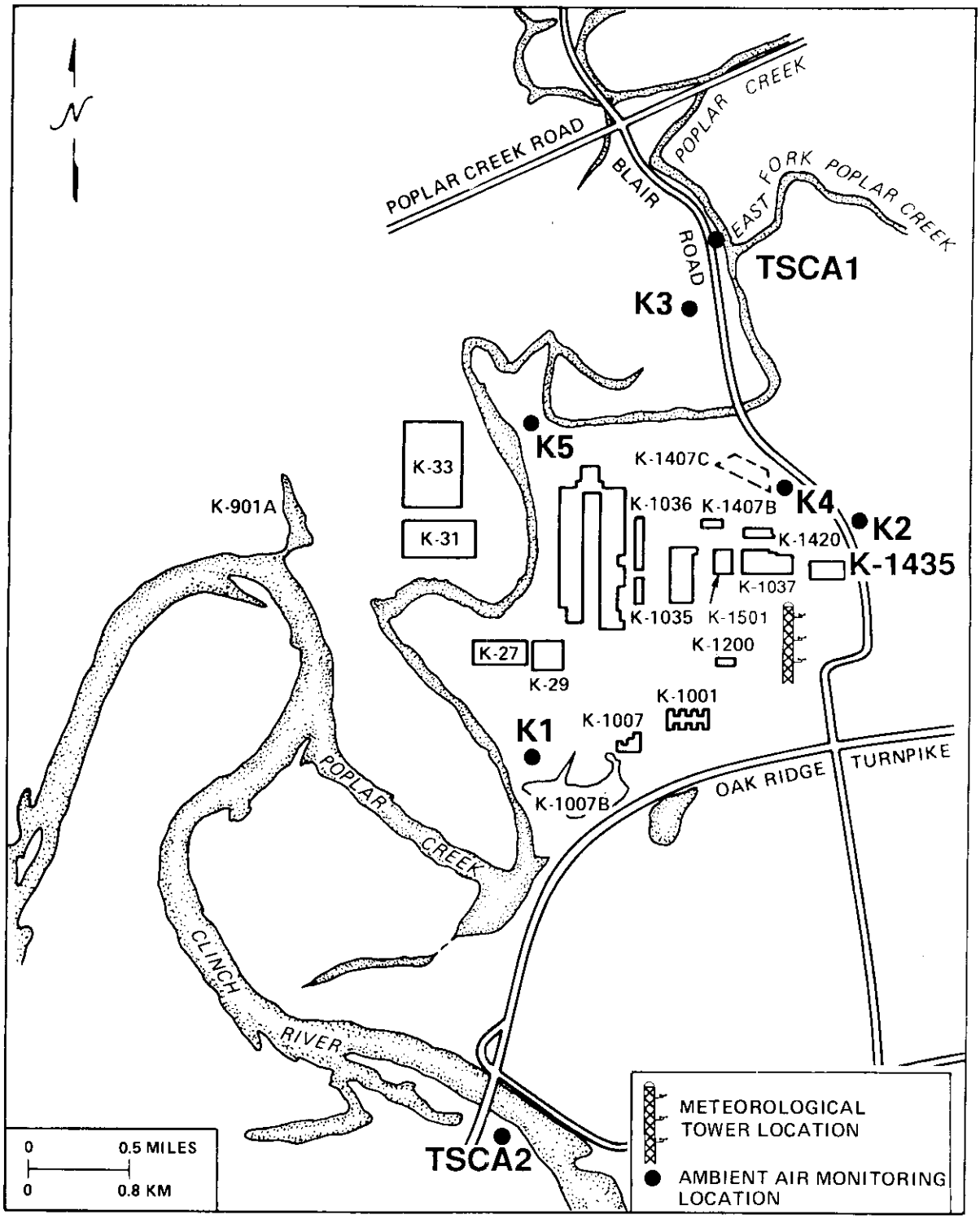

Fig. 2.1.19. Location of ORGDP ambient air monitors and meteorological tower.

ambient air monitoring station K4. The state of Tennessee is required by the CAA to have operational PM10 particulate systems by July 1, 1989. This monitor was added to provide one 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. 2.1.19 as TSCA1 and TSCA2. Initial systems checks were made on these monitor stations in November 1988. No data were collected during 1988.

Fluoride sampling was not conducted at ORGDP in 1988 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.

Summary

Table 2.1.12 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 61 to 62. 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 42% of the secondary standard. For lead, the percentage of standard never exceeded 3%.

The PM10 maximum for TSP was approximately 68% of the TSP maximum for the colocated station, K4. In addition, the average 1988 TSP data for the PM10 monitor was significantly less than that for station K4.

As only one data point was available on PM10 for the metals, no useful statements can be made for 1988.

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. 2.1.20, 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. The other towers (MT7 and MT8) shown in Fig. 2.1.20 are not commonly used for routine modeling or emergency response activities.

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

Table 2.1.12. 1988 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	62	62.51	5.28	19.53	24	42
K2	62	57.17	2.48	18.11	22	38
K3	62	58.72	5.88	19.34	23	39
K4	62	57.93	2.11	20.58	22	39
K5	62	50.24	4.51	17.83	19	33
PM10	30	39.21	5.88	17.89	26	26
			Lead[c]			
K1	62	0.0278	<0.0035	<0.0103	2	*d*
K2	62	0.0294	<0.0046	<0.0099	2	*d*
K3	62	0.0475	<0.0048	<0.0115	3	*d*
K4	62	0.0291	<0.0050	<0.0126	2	*d*
K5	62	0.0237	<0.0044	<0.0105	2	*d*
PM10	1	0.0157	0.0157		1	
			Chromium[e]			
K1	62	0.0181	<0.0018	<0.0027	*d*	*d*
K2	62	0.0052	<0.0020	<0.0026	*d*	*d*
K3	62	0.0059	<0.0009	<0.0026	*d*	*d*
K4	62	0.0057	<0.0020	<0.0026	*d*	*d*
K5	62	0.0061	<0.0022	<0.0026	*d*	*d*
PM10	1	0.0099	0.0099			
			Nickel[f]			
K1	62	0.0281	<0.0018	<0.0038	*d*	*d*
K2	62	0.0161	0.0020	0.0037	*d*	*d*
K3	62	0.0128	<0.0009	<0.0037	*d*	*d*
K4	62	0.0150	<0.0021	<0.0045	*d*	*d*
K5	62	0.0153	<0.0022	<0.0037	*d*	*d*
PM10	1	0.0120	0.0120			
			Uranium[g]			
K1	61	0.0017	<0.0001	<0.0002	1	*d*
K2	62	0.0019	<0.0001	<0.0002	1.3	*d*
K3	62	0.0016	<0.0001	<0.0002	1.1	*d*
K4	62	0.0037	<0.0001	<0.0003	2.5	*d*
K5	62	0.0022	<0.0001	<0.0002	1.5	*d*
PM10	1	0.0005	0.0005		0.3	

[a]See Fig. 2.1.17.

[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.

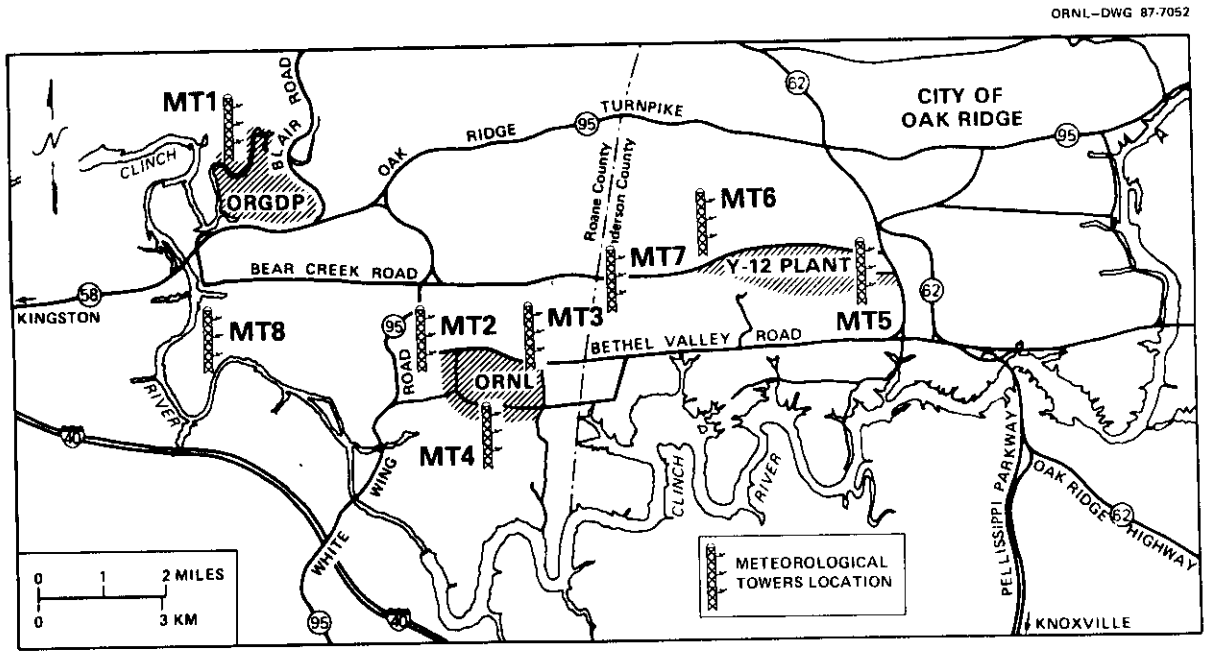

Fig. 2.1.20. ORR meteorological monitoring network.

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. 2.1.21. 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 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. 2.1.21 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. 2.1.21 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.

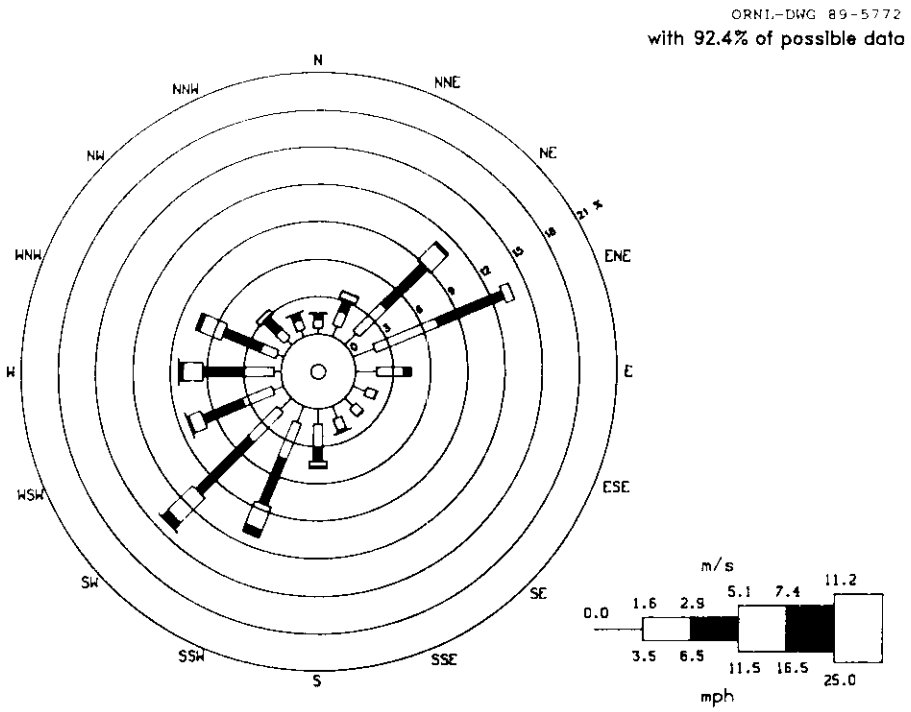

Fig. 2.1.21. 1988 wind rose for ORNL tower MT2 [100-m (328-ft) level].

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 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 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 ORGDP meteorological tower was operational for only 60% of 1988 because of several system upgrades. These included the addition of an electrical grounding modification and the replacement of the dedicated control computers. During these downtimes, meteorological data from the ORNL and Y-12 Plant towers were used for dispersion modeling.

2.2 SURFACE WATER

The surface waters on the Oak Ridge Reservation (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 anthropogenic 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.

Quality of water in the Clinch River is affected by contamination introduced upstream from the ORR, by ORR activities, and by flow regulation at Tennessee Valley Authority (TVA) dams. Stream impoundment generally results in increased water temperatures, retention of sediments, and adsorbed contaminants in impoundments. Intermittent release of water from dams causes scouring of the river channel (e.g., downstream from Melton Hill Dam) where bedrock is exposed on the river bed (Loar 1981). In the vicinity of the ORR, temperature increases are ameliorated by the practice of releasing cold bottom water from Norris Dam and thus maintaining cool water temperatures in Melton Hill Reservoir (Loar 1981).

Several institutions routinely monitor water quality in the Clinch River. Both the TVA and the U.S. Geological Survey (USGS) monitor water quality just below Melton Hill Dam. The Tennessee Department of Health and Environment (TDHE) maintains a monitoring station at Clinch River kilometer (CRK) 16.3 (river mile 10.1), 3.2 km (2 miles) below the mouth of Poplar Creek and the Oak Ridge Gaseous Diffusion Plant (ORGDP).

Water quality, radioactivity, and flow measurements are made at a number of stations operated by Energy Systems for the Department of Energy (DOE). 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 National Pollutant Discharge Elimination System (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).

Fission product radionuclide concentrations are determined by specific radionuclide analysis and gamma spectrometry. Uranium is analyzed by fluorometry method or mass spectrometry. Transuranic alpha emitters are determined by radiochemical separation and alpha spectrometry.

Concentrations of chemicals 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–Oak Ridge Operations (ORO). In many cases, the allowable concentrations are dictated by the plants' discharge permits, which are issued by the TDHE, or by the city of Oak Ridge. 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 the Environmental Protection Agency (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 effects of the seepage of the S-3 Ponds. Analytical data are reported to the TDHE as an attachment to the Discharge Monitoring Report (DMR) required by NPDES. The S-3 Ponds were emptied of wastewater in 1986. The ponds were filled in 1988, and a multilayered cap is being constructed. This site was monitored once per week for the radiological parameters shown in Table 2.2.1. As shown in Fig. 2.2.2, these data continue to show improvements in water quality since 1987. Monitoring at this site was temporarily halted in

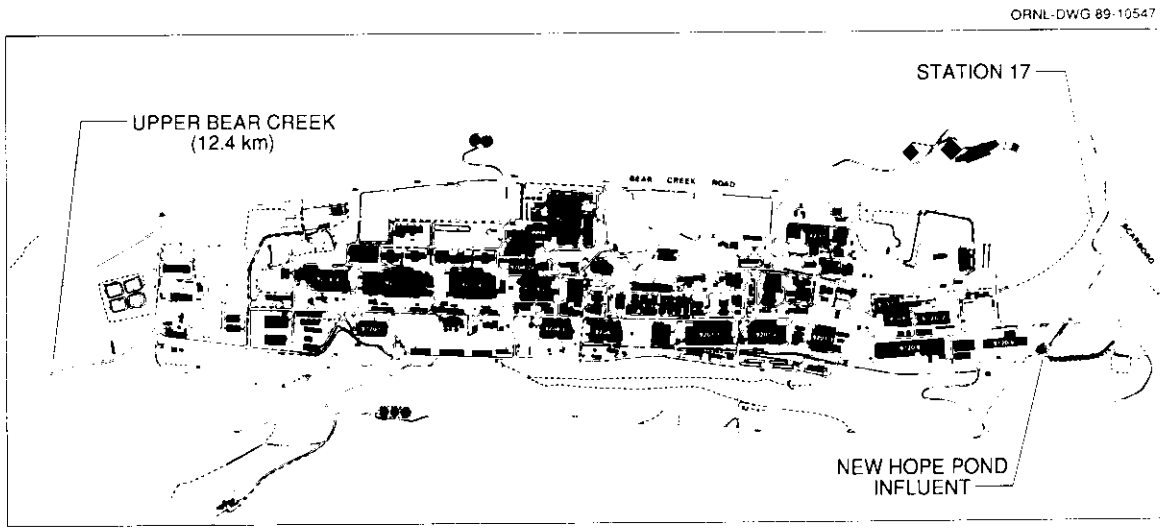

Fig. 2.2.1. Y-12 Plant non-NPDES routine surface water monitoring sites.

Table 2.2.1. 1988 annual summary for Upper Bear Creek Radiological data (km 12.4)

Parameter	No. Samples	Concentration[a]			Std. Error	% DCG
		Max	Min	Av		
Alpha (pCi/L)	11	470	74	391	42	NA[b]
^{241}Am (pCi/L)	11	0.14	0	0.02	0.02	0.08
Beta (pCi/L)	11	600	87	298	46	NA
^{237}Np (pCi/L)	11	1.1	0	0.51	0.13	1.7
^{238}Pu (pCi/L)	11	0.18	0	0.034	0.013	0.05
$^{239/240}$Pu (pCi/L)	11	0.11	0	0.023	0.013	0.057
^{99}Tc (pCi/L)	11	0.71	0.09	0.29	0.06	0.0003
^{235}U (pCi/L)	11	15	2.7	6.4	1.5	1.1
^{235}U (%)	11	0.58	0.29	0.36	0.03	NA
Uranium	11	0.88	0.371	0.71	0.07	NA

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

early 1988 because of construction activities at this site and the S-3 Ponds, but special monitoring was conducted downstream temporarily (see Sect. 6, Special Studies). Because of decreased flow at this site since the closure of the S-3 Ponds, a new site downstream of kilometer 12.4 is being proposed as a replacement site in 1989.

The influent to New Hope Pond was monitored almost daily for radiological parameters to determine the effectiveness of New Hope Pond (see Table 2.2.2). In early November, this inlet was closed to divert the water into the new Lake Reality and initiate Resource Conservation and Recovery Act (RCRA) closure of New Hope Pond. The pumping mechanism, located at the pond inlet, 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.

After the inlet to New Hope Pond was closed, it was determined that a new sampling point was needed to monitor East Fork Poplar Creek

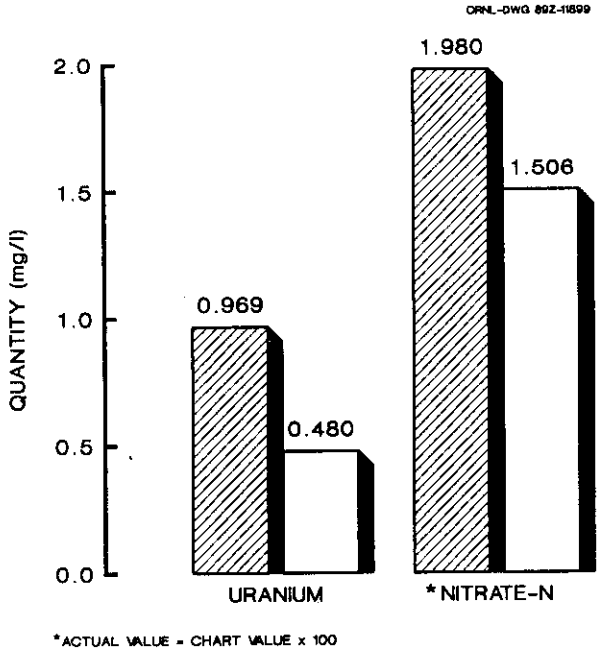

Fig. 2.2.2. Upper Bear Creek trend chart, 1987–1988.

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 2.2.4.

The Y-12 Plant holds Industrial User's Permit Number 001 with the city of Oak Ridge. This 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 2.2.5 and 2.2.6.

Oak Ridge National Laboratory

ORNL collects samples for radiological analyses at off-site and on-site drinking water locations, at background or reference locations, in streams at the ORNL site, and from all process discharge point sources. Table 2.2.7 provides a summary of the locations, parameters analyzed, and frequencies of sample collection and analysis for all radiological samples. This section will summarize results from the first three types of locations. Concentrations of radionuclides from process points will be discussed in Sect. 2.2.2, NPDES Monitoring Program. Three stream monitoring locations that are required to be monitored under the NPDES permit are also covered in Sect. 2.2.2.

Treated water samples are collected weekly at the Kingston and ORGDP (Gallaher) potable water treatment plants and are analyzed quarterly (Fig. 2.2.3). For comparison, samples were collected daily from the ORNL potable water system (tap water) in Building 4500-S and analyzed quarterly. ORNL tap water is the same as that for the city of Oak Ridge—both are derived from Melton Hill Lake. In addition, flow-proportional samples are collected weekly from Melton Hill Dam and analyzed quarterly. This sampling location, which is on the Clinch River, is above ORNL's discharge point to the Clinch River and serves as a local background or reference station.

Draft DOE Order 5400.xx, Chapter II, 2.a. requires comparison of annual average discharge concentrations to the derived concentration guide (DCG) values. These concentrations apply at the point of discharge to a receiving stream prior to dilution in the stream. Although the EPA drinking water standards apply at the outlet of a public water distribution system, the EPA standards are more applicable for the Clinch River sampling locations than the DOE DCGs, which are the equivalent of 100 mrem/year based on 2 L/d water consumption.

The annual radionuclide summaries for the off-site stream monitoring locations and tap water are given in Table 2.2.8. Average concentrations are given as a percentage of the DCG and as a percentage of the EPA drinking water standard. None of the percentages as compared with the DCG was above 0.2%. Average concentrations were all less than 24% of the drinking water standard. There were no significant differences in the total plutonium or ^{235}U measured at any of the four locations. ORNL tap water concentrations of uranium isotopes were at least as low as in the

Table 2.2.2. 1988 annual summary for NHP influent radiological data
Monthly composites (Jan–Oct)

Parameter (pCi/L)	No. samples	Concentration[a]			Std. error	% DCG
		Max	Min	Av		
^{241}Am	10	0.37	0	0.09	0.04	0.31
^{137}Cs	10	0.21	0	0.021	0.021	0.0007
^{60}Co	10	1	0	0.1	0.1	0.002
^{237}Np	10	1.4	0	0.2	0.14	0.670
^{95}Nb	10	2.8	0	0.3	0.3	0.0004
^{238}Pu	10	0.17	−0.03	0.03	0.02	0.075
$^{239/240}Pu$	10	0	0	0	0	0
^{226}Ra	10	9.7	−0.77	1.2	1.0	1.2
^{106}Ru	10	20	0	2	2	0.03
^{90}Sr	10	70	−0.82	9	6.8	0.9
^{99}Tc (pCi/mL)	10	0.05	−0.06	0.003	0.011	0.000002
^{238}Th	10	14	0	1.5	1.26	0.38
^{230}Th	10	0.24	0	0.06	0.024	0.02
^{232}Th	10	0.98	−0.05	0.1	0.1	2
Thorium, total (mg/L)	10	0.027	<0.004	<0.003	0.002	NA[b]
Tritium	10	890	−280	225	110	0.01
^{234}U	10	150	0.01	21	14	0.42
^{235}U activity	10	5.2	0	1	0.6	0.02
^{235}U (%)	10	8.39	0.14	1.4	0.8	NA
^{238}U	10	15	1.5	5	1.2	0.08
Uranium, total (mg/L)	10	4.8	0.011	0.5	0.48	NA
^{95}Zr	10	1.4	0	0.14	0.14	0.0004
^{235}U (%)[c]	199	22.4	0.131	1.285	0.165	NA
Uranium, total (mg/L)[c]	199	0.324	0.007	0.022	0.002	NA

[a]All units are in pico curies per liter (pCi/L) unless otherwise noted.
[b]NA = not applicable.
[c]24-h composites samples (Jan–Oct).

Table 2.2.3 1988 annual radiological summary for diversion ditch (Nov.–Dec.)

Parameter	No. samples	Concentration[a]			Std. error	% DCG
		Max	Min	Av		
Uranium, total	8	0.059	0.022	0.03	0.004	NA[b]
^{235}U (%)	8	0.64	0.38	0.50	0.034	NA
Thorium, total	8	0.005	<0.003	<0.003	0.0002	NA

[a]Units are in milligrams per liter (mg/L) unless otherwise noted.
[b]NA = not applicable.

Table 2.2.4. 1988 annual summary for station 17 influent radiological data[a]

Parameter	No. samples	Concentration (mg/L)			Std. error	% DCG
		Max	Min	Av		
Uranium	4	0.036	0.02	0.03	0.004	NA[b]
Thorium	2	0.65	0.005	0.33	0.32	NA

[a]Sampling period is Nov.–Dec. 1988.
[b]NA = not applicable.

Table 2.2.5. 1988 annual radiological summary for West End Sanitary Sewer

Parameter	No. samples	Concentration[a]			Std. error	% DCG
		Max	Min	Av		
Alpha (pCi/L)	9	190	4.6	80	23.4	NA[a]
Beta (pCi/L)	9	240	12	90	30.0	NA
^{238}Pu (pCi/L)	8	0.61	0	0.11	0.07	0.28
^{235}U (pCi/L)	9	2.5	<0	<0.4	0.27	0.07
^{235}U (%)	9	5.43	0.72	1.71	0.48	NA
Uranium	9	0.023	0.002	0.011	0.003	NA

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

Table 2.2.6. 1988 annual radiological summary for East End Sanitary Sewer

Parameter	No. samples	Concentration[a]			Std. error	% DCG
		Max	Min	Av		
Alpha (pCi/L)	22	1000	0	96	10.1	NA[b]
Beta (pCi/L)	22	160	0	52	8.3	NA
^{238}Pu (pCi/L)	22	0.3	0	0.06	0.02	0.18
^{235}U (pCi/L)	22	2.5	0	0.13	0.11	0.03
^{235}U (%)	22	2.72	0.07	1.0	0.095	NA
Uranium	22	0.01	0.001	0.003	0.0005	NA

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

Table 2.2.7. Summary of collection and analysis frequencies of surface, pond, and tap water samples

Station	Parameter	Collection frequency	Type	Analysis frequency
190 ponds	Gamma scan, gross alpha, gross beta	Weekly	Flow proportional	Monthly
1500 area, 3518	Gross alpha, gross beta	Weekly	Flow proportional	Monthly
2000 area, 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
Kingston	^{3}H, gamma scan, gross alpha, gross beta, total Pu, total Sr[a], U isotopes	Weekly	Grab	Quarterly
Gallaher	^{3}H, gamma scan, gross alpha, gross beta, total Pu, total Sr[a], U isotopes	Weekly	Time proportional	Quarterly
HFIR ponds	Gamma scan, gross alpha, gross beta	After discharge	Flow proportional	Monthly
Melton Hill Dam	^{241}Am, ^{244}Cm, gamma scan, gross alpha, total Pu, total Sr[a], ^{3}H, U isotopes	Weekly	Flow proportional	Monthly and quarterly
NWT	Gamma scan, total Sr[a]	Weekly	Flow proportional	Monthly
ORNL tap	Gamma scan, gross alpha, gross beta, total Pu, total Sr[a], U isotopes	Daily	Grab	Quarterly
WOC headwaters	^{241}Am, ^{244}Cm, gamma scan, gross alpha, total Sr[a], ^{3}H, ^{238}Pu, ^{239}Pu	Weekly	Flow proportional	Monthly
WOD	^{241}Am, ^{244}Cm, gamma scan, gross beta, ^{238}Pu, ^{239}Pu, total Sr[a], ^{3}H	Weekly	Flow proportional	Weekly
TPP ponds	Gross beta	After discharge	Flow proportional	Monthly

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

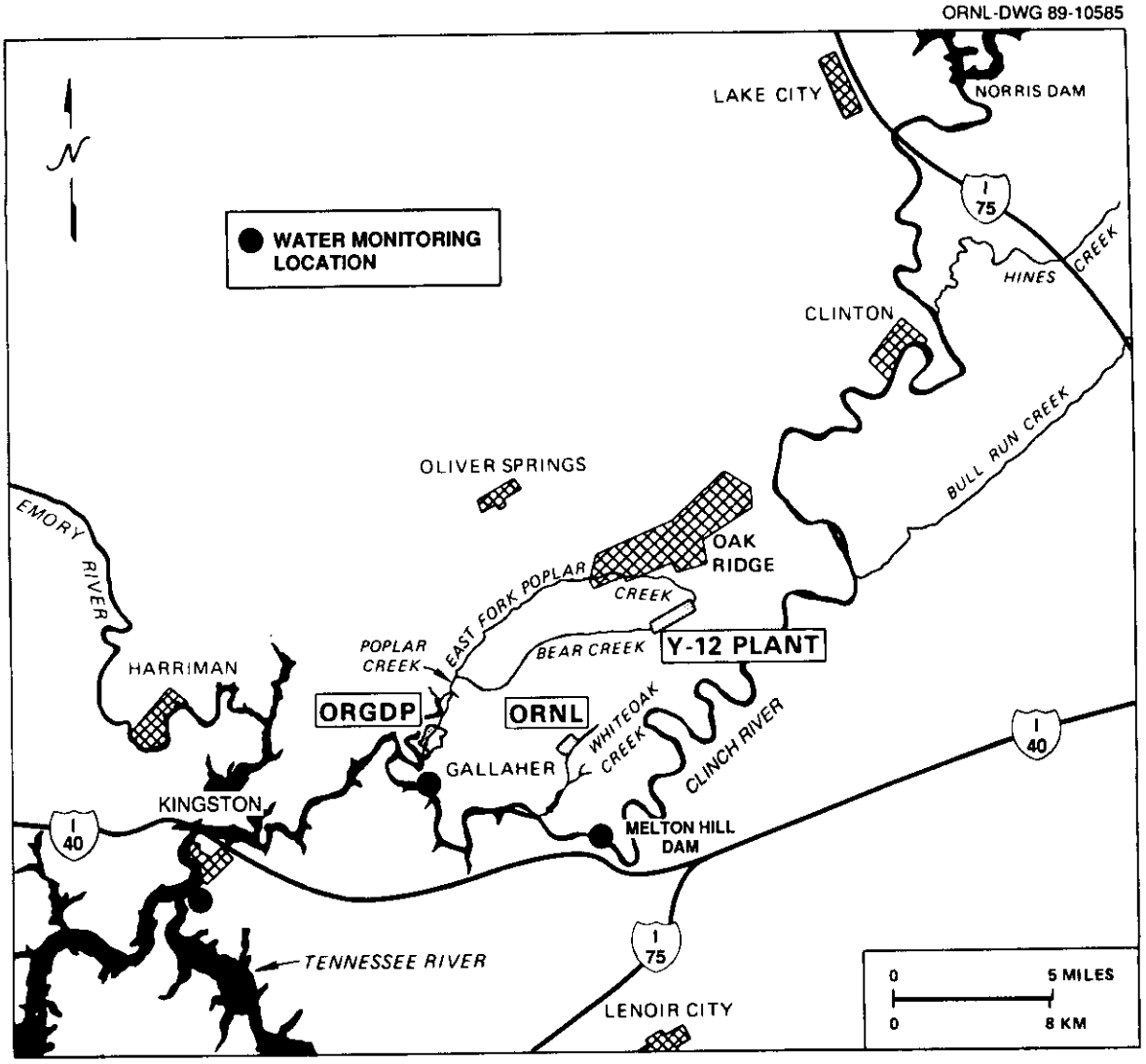

Fig. 2.2.3. TVA drainage basin near ORR.

off-site streams. Differences in the stream concentrations of uranium isotopes may be the result of natural background levels.

Surface water samples are collected from six streams near ORNL: White Oak Creek, Melton Branch, 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 Table 2.2.1 in Vol. 2. The last column in that table shows the average value for each radionuclide as a percent of the DCG for water. Data-reporting conventions are discussed in the introduction to this section, as are DCGs. Average annual concentrations of most radionuclides in surface streams were less than 1% of the DCG. Total radioactive strontium was the exception. Concentrations of this parameter ranged from less than 1% at the reference locations (Melton Hill Dam and White Oak Creek Headwaters) to 52% in First Creek. One other notable exception was ^{238}Pu at Melton Hill Dam. An unusually high value was measured, but is believed to be in error.

Concentrations of radioactive contaminants in the on-site creeks and the Clinch River are affected by rainfall, surface runoff, subsurface

Table 2.2.8. 1988 ORNL radionuclide concentrations in water from off-site locations and tap water

Radionuclide	Number of samples	Concentration (pCi/L)				Percent of DCG[b]	Percent of DWL[c]
		Max	Min	Av	Stardard error[a]		
			Gallaher				
^{60}Co	4	0.81	−0.24	<0.55	0.26	0.011	*d*
^{137}Cs	4	1.1	<0.27	<0.68	0.17	0.023	*d*
Gross alpha	4	0.92	0.0081	0.38	0.19	*d*	2.5
Gross beta	4	12	4.6	7.2	1.6	*d*	14
Total Pu[e]	4	<0.0030	<0.0030	<0.0030	0.0	0.010	*d*
Total Sr[f]	4	4.6	0.11	1.9	0.97	0.19	24
^{3}H	3	1800	770	1400	330	0.071	7
^{234}U	4	0.15	0.12	0.14	0.0074	0.028	*d*
^{235}U	4	0.0048	0.0037	0.0043	0.00024	<0.001	*d*
^{236}U	4	0.051	<0.00015	<0.013	0.013	0.0026	*d*
^{238}U	4	0.10	0.077	0.090	0.0051	0.015	*d*
			Kingston				
^{60}Co	4	0.30	<0.14	<0.24	0.036	0.0049	*d*
^{137}Cs	4	0.43	−0.035	<0.23	0.097	0.0076	*d*
Gross alpha	4	0.76	0.081	0.36	0.14	*d*	2.4
Gross beta	4	4.3	1.1	2.5	0.67	*d*	5.0
Total Pu[e]	4	<0.0030	<0.0030	<0.0030	0.0	0.010	*d*
Total Sr[f]	4	0.65	0.19	0.38	0.10	0.038	4.8
^{3}H	3	250	170	220	24	0.011	1.1
^{234}U	4	0.20	0.073	0.12	0.028	0.023	*d*
^{235}U	4	0.0064	0.0022	0.0038	0.00091	<0.001	*d*
^{236}U	4	0.0032	0.00046	0.0013	0.00066	<0.001	*d*
^{238}U	4	0.12	0.042	0.072	0.017	0.012	*d*
			Melton Hill Dam				
^{60}Co	4	1.8	<0.27	<0.74	0.37	0.015	*d*
^{137}Cs	4	1.8	<0.20	<0.69	0.36	0.023	*d*
Gross alpha	4	1.6	0.027	0.76	0.35	*d*	5.1
Gross beta	4	4.3	1.6	2.6	0.63	*d*	5.2
Total Pu[e]	4	<0.0030	<0.0030	<0.0030	0.0	0.010	*d*
Total Sr[f]	4	0.35	0.081	0.18	0.061	0.018	2.3
^{234}U	4	0.18	0.034	0.12	0.032	0.025	*d*
^{235}U	4	0.0050	0.0011	0.0036	0.00087	<0.001	*d*
^{236}U	4	0.00017	<0.000026	<0.000098	0.000030	<0.001	*d*
^{238}U	4	0.10	0.023	0.074	0.018	0.012	*d*
			ORNL tap water				
^{60}Co	4	0.27	<0.14	<0.21	0.036	0.0042	*d*
^{137}Cs	4	0.27	<0.14	<0.24	0.034	0.0079	*d*
Gross alpha	4	1.2	0.43	0.64	0.18	*d*	4.3
Gross beta	4	4.3	1.7	2.8	0.56	*d*	5.6
Total Pu[e]	4	<0.0030	<0.0030	<0.0030	0.0	0.010	*d*
Total Sr[f]	4	0.081	0.027	0.047	0.013	0.0047	0.59
^{234}U	4	0.13	0.042	0.096	0.019	0.019	*d*
^{235}U	4	0.0038	0.0012	0.0029	0.00059	<0.001	*d*
^{236}U	4	<0.00015	<0.000069	<0.000030	0.011	<0.001	*d*
^{238}U	4	0.077	0.026	0.060	0.012	0.0099	*d*

[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.
[d]Not applicable.
[e]Total Pu (^{239}Pu + ^{240}Pu).
[f]Total radioactive Sr (^{89}Sr + ^{90}Sr).

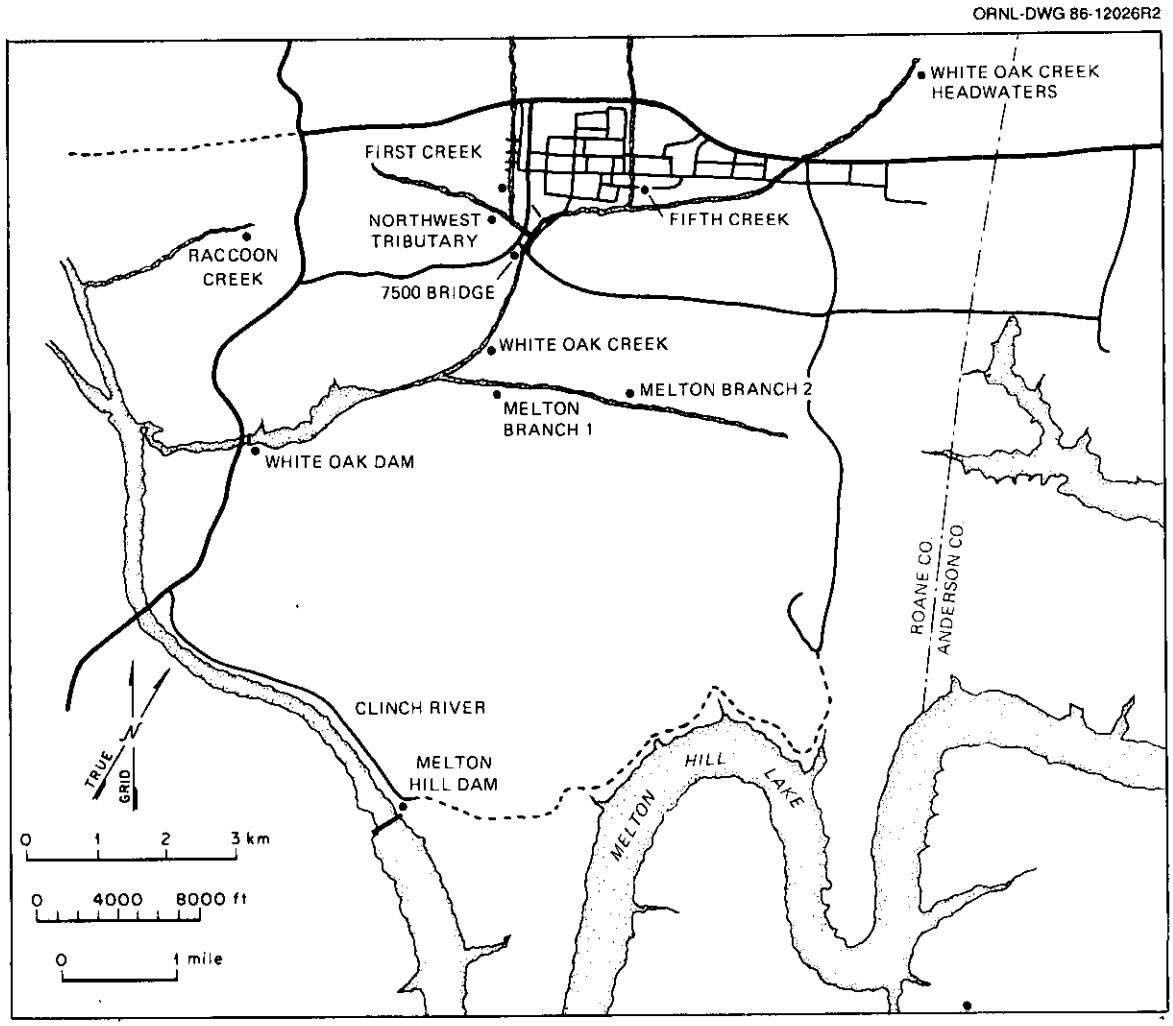

Fig. 2.2.4. ORNL surface water and reference sampling locations

inflow to streams, and stream flows. Modeling efforts are under way by staff members of the Environmental Sciences Division (ESD), in conjunction with the Tennessee Valley Authority Norris Engineering Laboratory with assistance from the Environmental and Health Protection Division at ORNL, to predict the fate (travel times and dispersion of large-scale releases into the Clinch River under various streamflow and climatic conditions.

Flows in the Clinch River (as measured at Melton Hill Dam) and in WOC (as measured at WOD) are summarized in Table 2.2.9. Water over Melton Hill Dam is closely controlled by TVA. The flow in the Clinch River ranged from 52 $\times$ 10^9 L (13.5 $\times$ 10^9 gal) (April) to 320 $\times$ 10^9 L (83.2 $\times$ 10^9 gal) (June). Flow in WOC ranged from 0.43 $\times$ 10^9 L (0.11 $\times$ 10^9 gal) (June) to 1.0 $\times$ 10^9 L (0.26 $\times$ 10^9 gal) (January).

Discharges of radioactivity in WOC and Melton Branch 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. 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. Discharges are calculated for each period (month or week) and totaled for the year. Yearly

Table 2.2.9. 1988 flows for Clinch River and White Oak Creek

Month	Monthly flow (L × 10^9)		Average ratio[a]
	Clinch River	White Oak Creek	
January	270	1	370
February	210	0.81	290
March	100	0.98	120
April	52	0.7	76
May	63	0.51	130
June	320	0.43	730
July	160	0.65	280
August	170	0.52	340
September	130	0.62	260
October	140	0.46	310
November	100	0.72	170
December	140	0.66	230

[a]Ratio of Clinch River to White Oak Creek flow is calculated daily and averaged for the month.

Table 2.2.10. 1988 ORNL liquid releases and radionuclide concentrations

Radionuclide	Emission (Ci)	Concentration guide (DCG)[a] (pCi/L)	Concentration (pCi/L)	Percent of DCG[b]
		Melton Branch 1		
^{60}Co	<0.028	5,000	<20	<0.41
^{137}Cs	<0.074	3,000	<54	<1.8
Total Sr[c]	0.45	1,000	330	33
^{3}H	2,500	2,000,000	1,800,000	90
		White Oak Creek		
^{60}Co	<0.15	5,000	<20	<0.40
^{137}Cs	0.59	3,000	76	2.5
Total Sr[c]	0.85	1,000	110	11
^{3}H	270	2,000,000	35,000	1.8
		White Oak Dam		
^{241}Am	0.0017	30	0.22	0.72
^{244}Cm	0.0027	60	0.33	0.55
^{60}Co	<0.070	5,000	<8.7	<0.17
^{137}Cs	0.39	3,000	48	1.6
Gross beta	2.6	*d*	330	*d*
^{238}Pu	0.0024	40	0.29	0.74
^{239}Pu	0.00062	30	0.077	0.26
Total Sr[c]	1.1	1,000	140	14
^{3}H	1,700	2,000,000	210,000	10

[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.

flow-weighted concentrations for each radionuclide are calculated by dividing the total radionuclide discharge by the total annual flow. The ratio of the flow-weighted concentrations to the DCG for each radionuclide is also given in Table 2.2.10. None of the ratios exceeded 100% of the DCG. The major problem area appears to be tritium activity in Melton Branch, which is being addressed by the RI/FS.

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. During 1988, CH2M Hill, Inc., conducted an assessment of the Oak Ridge Reservation's ambient monitoring program. In the 1989–1990 time frame, the sampling program will be revised to address the content of the assessment conducted by CH2M Hill, Inc. The assessment is discussed in Sect. 6.

During 1988, grab samples were collected once a month at the following locations: the Clinch River, K-901 at 892, 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. 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 2.2.4 gives the sampling locations.

With the exception of plutonium at K-1513, only uranium was above the detection limit in Poplar Creek and the Clinch River. The plutonium percentage is high (25% of DCG) because of one unexplainable high value. The quarterly ORNL data immediately downstream at Gallaher do not reflect this anomaly. The uranium determination was conducted by wet chemistry methods and reduced for presentation as pCi/L. Results indicate that uranium values were elevated in Poplar Creek both above and below ORGDP. Uranium values at West Fork Poplar Creek were not elevated. There was no relative increase in uranium values below ORGDP in Poplar Creek. There was indication of elevated uranium values in the Clinch River samples above ORGDP after the confluence of Poplar Creek. ORGDP does not appear to contribute to any elevated uranium concentrations in Clinch River and Poplar Creek.

Data indicate that both gross alpha and gross beta are sometimes elevated in Mitchell Branch; this is attributed to past practices at the plant site. Remedial investigations are planned to characterize the site conditions and determine appropriate cleanup actions.

2.2.1.2 Nonradiological summary

Y-12 Plant

Nonradiological parameters were also monitored at the non-NPDES Y-12 sites listed in 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. This monitoring was also halted temporarily in early 1988, but the special monitoring that was performed downstream, and discussed in Sect. 6, encompassed the nonradiological parameters as well.

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

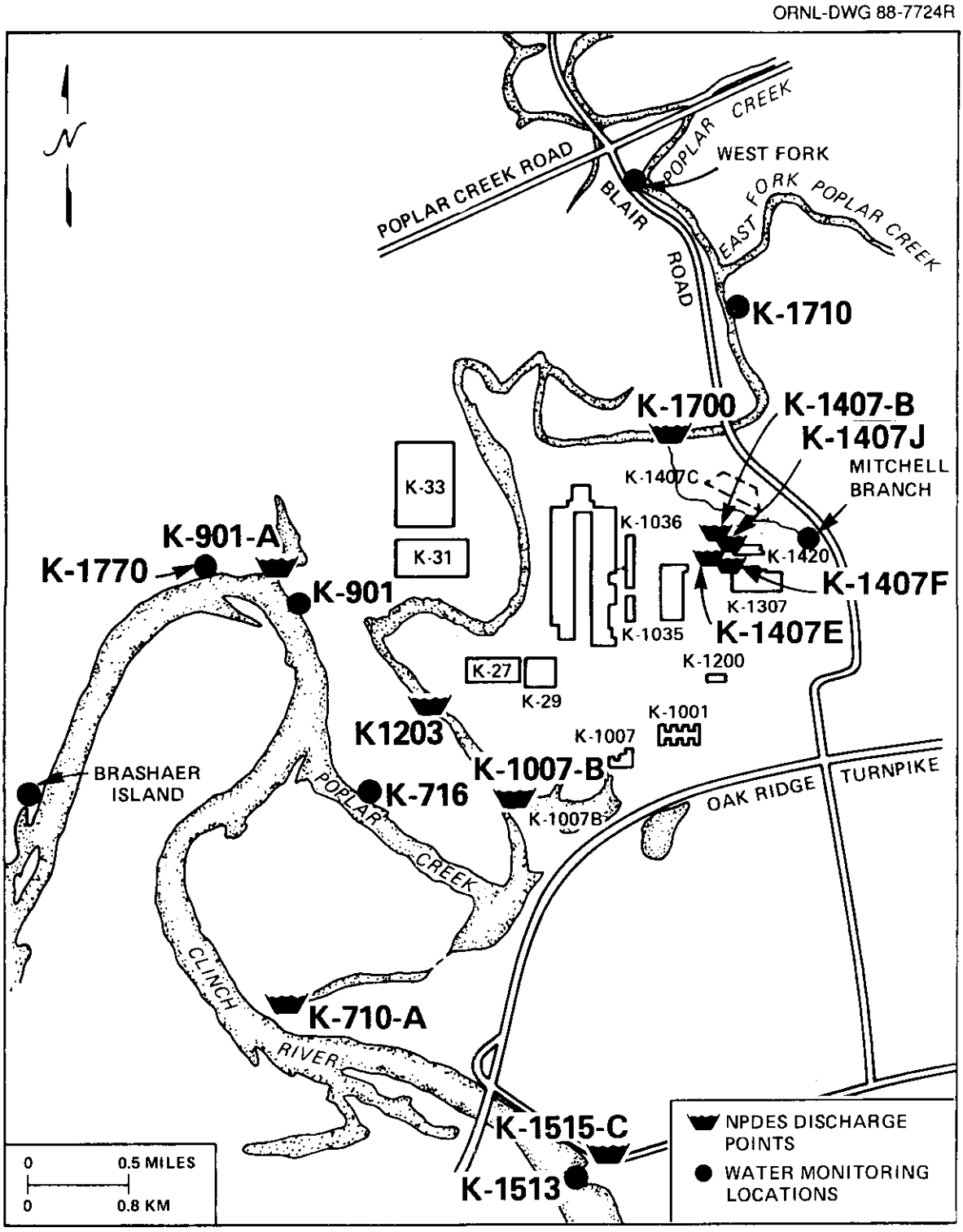

Fig. 2.2.5. ORGDP NPDES and perimeter monitoring locations.

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-B	TDHE	NPDES	003
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.

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.

Oak Ridge National Laboratory

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. Analytical data are reported quarterly to the TDHE as an attachment to the Discharge Monitoring Report (DMR). (A summary of 1988 data is presented in Table 2.2.1.) Comparison of these data with data collected in 1987 shows a continuation of the improvements in water quality noted since the S-3 ponds were emptied of wastewater in 1986. Some parameters, however, remain substantially elevated above background levels (e.g., NO_3-N, TDS). The S-3 Ponds were backfilled in during 1988, and a multilayered cap is being constructed to continue water quality improvements in this area. Because of construction activities in the S-3 area, sampling on upper Bear Creek was temporarily halted in late 1988; however, sampling has resumed.

Monitoring was conducted at the influent to New Hope Pond through October 1988. Most of the samples collected at this location are time-proportional, 24-h composites. Both radiological and nonradiological parameters are analyzed at this location. See Tables 2.2.2 and 2.2.3 for a summary of 1988 data.

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 time-proportional, 24-h composites. Both radiological and nonradiological parameters are analyzed at this location, and data collected are used for a variety

Table 2.2.12. 1988 annual summary for Upper Bear Creek Nonradiological data (km 12.4)

Parameter	No. Samples	Concentration[a]			Std. Error
		Max	Min	Av	
Mercury	11	0.0049	<0.0002	<0.0008	0.0005
Cyanide	11	0.014	0.004	<0.008	0.001
Fluoride	11	1.7	0.7	0.14	0.08
Nitrate-N	11	120	12	57	13
Dissolved oxygen	11	10.9	4	7.8	0.65
pH (units)	11	7.3	6.8	NA[b]	0.06
Phenols	11	0.007	<0.001	<0.002	0.0008
Total dissolved solids	11	1700	650	1361	119
Total suspended solids	11	6	<5	<5	0.12
Chloroform (μg/L)	11	170	<10	<25	14
Methylene chloride (μg/L)	11	10	<10	<10	0
Perchloroethylene (μg/L)	11	10	<10	<10	0
PCB	11	<0.0005	<0.0005	<0.0005	0
Aluminum	11	6.46	0.04	0.91	0.70
Arsenic	11	<0.04	<0.04	<0.04	0
Barium	11	0.0968	0.0334	0.0639	0.0061
Beryllium	11	0.0004	<0.0001	<0.0001	0.00003
Boron	11	0.104	0.039	0.075	0.007
Cadmium	11	0.006	<0.003	<0.003	0.0003
Calcium	11	419	32	207	37
Cerium	11	<0.02	<0.02	<0.02	0
Chromium	11	<0.006	<0.006	<0.006	0
Cobalt	11	0.004	<0.002	<0.002	0.0002
Copper	11	0.013	<0.002	<0.004	0.0001
Gallium	11	<0.01	<0.01	<0.01	0
Iron	11	5.08	0.04	0.68	0.55
Lanthanum	11	<0.003	<0.003	<0.003	0
Lead	11	<0.02	<0.02	<0.02	0
Lithium	11	0.026	0.009	0.015	0.002
Magnesium	11	58.9	4.8	32.7	4.9
Manganese	11	2.79	0.143	0.804	0.26
Molybdenum	11	<0.006	<0.006	<0.006	0
Nickel	11	0.014	<0.007	<0.008	0.0008
Niobium	11	<0.01	<0.01	<0.01	0
Phosphorus	11	0.2	<0.06	<0.07	0.02
Potassium	11	9	3.8	5.8	0.56
Scandium	11	0.0012	<0.0004	<0.0005	0.00009
Silver	11	0.019	<0.004	<0.005	0.002
Sodium	11	379	71.7	109.2	33.0
Strontium	11	0.795	0.243	0.543	0.06
Thorium	11	<0.01	<0.01	<0.01	0
Titanium	11	0.035	<0.002	<0.010	0.003
Vanadium	11	0.006	<0.004	<0.004	0.0002
Zinc	11	0.044	0.003	0.014	0.004
Zirconium	11	0.003	<0.002	<0.002	0.0001

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

Table 2.2.13. 1988 annual summary for New Hope Pond influent Nonradiological data

Parameter	Count	Concentration[a] (mg/L)			Std. error
		Max	Min	Av	
Mercury	198	0.023	0.0001	0.0023	0.0002
Selenium	198	0.003	−0.02	−0.002	0.0001
Ammonia	198	4.6	−0.2	0.5	0.04
BOD	199	71	−5	−2.8	0.67
COD	199	170	−5	13	0.96
Chloride	199	210	2.2	24.0	1.3
Cyanide	199	0.039	−0.002	0.009	0.0005
Fluoride	199	1.6	0.44	1.1	0.012
Nitrate	199	10	1.7	3.3	0.06
TOC	199	82	−2	5	0.5
TDS	199	530	24	287	4.6
TSS	198	400	−5	6	3
Sulfate	198	230	29	72	2.6
Aluminum	199	14.8	−0.01	0.61	0.13
Arsenic	199	−0.04	−4	−0.06	0.02
Barium	199	0.194	0.0125	0.053	0.001
Beryllium	199	0.001	−0.0005	−0.0001	0.00001
Boron	199	1.72	−0.007	0.063	0.009
Cadmium	199	49.3	−0.03	0.24	0.25
Calcium	199	218	−0.02	52.8	1.5
Cerium	199	0.08	−0.08	−0.02	0.0007
Chromium	199	0.021	−0.030	−0.005	0.0004
Cobalt	199	0.063	−0.010	−0.001	0.0003
Copper	199	0.181	−0.002	0.011	0.001
Gallium	115	0.01	−0.01	−0.01	0.0002
Iron	199	12.4	−0.02	0.52	0.10
Lanthanum	199	0.003	−0.010	−0.003	0.00005
Lead	199	0.03	−0.10	−0.02	0.0005
Lithium	199	0.496	−0.018	0.026	0.003
Magnesium	199	64.6	4.62	11.8	0.28
Manganese	199	0.333	0.005	0.059	0.0030
Molybdenum	199	1.45	−0.006	0.16	0.008
Nickel	199	0.32	−0.05	−0.001	0.002
Niobium	198	0.01	−0.05	−0.01	0.0002
Phosphorus	199	1.9	−0.06	0.37	0.01
Potassium	199	13.1	1.4	2.4	0.08
Scandium	199	0.0026	−0.002	−0.0003	0.00003
Silver	199	0.006	−0.02	−0.004	0.0001
Sodium	199	120	6.1	20	1.2
Strontium	199	0.706	0.105	0.148	0.003
Thorium	199	0.03	−0.05	−0.01	0.0003
Titanium	198	0.04	−0.02	0.006	0.0005
Vanadium	199	0.018	−0.02	−0.002	0.0003
Zinc	199	2.66	0.034	0.094	0.013
Zirconium	199	0.04	−0.01	−0.002	0.0002

[a]Negative numbers (−) are indicative of less than (<) numbers.

Table 2.2.14. 1988 annual summary for Station 17 influent nonradiological data[a,b]

Parameter	Concentration (mg/L)			Count	Std. error
	Max	Min	Av		
Mercury	0.0037	<0.0002	<0.0019	71	0.0001
Nitrate-N	10.0	3.4	4.3	11	0.6
Total Phosphorus	0.40	0.23	0.34	11	0.016
Copper	0.047	0.005	0.012	11	0.004
Zinc	0.139	0.048	0.080	11	0.007
Chromium	0.013	<0.006	<0.007	11	0.0007
Molybdenum	0.173	0.053	0.128	11	0.011
Lithium	0.451	0.014	0.067	11	0.04
Selenium	0.002	<0.002	<0.002	8	0
Cadmium	0.006	<0.00005	<0.004	11	0.0008
Lead	0.02	<0.001	<0.01	11	0.003
Nickel	0.020	<0.007	<0.011	11	0.001
Calcium	66.9	36.0	56.9	11	3
Magnesium	15.0	7.3	11.3	11	0.6
Sodium	55.3	0.0	23.6	11	5.6
Potassium	3.9	1.8	2.9	11	0.2
Sulfate	1900	74	334	8	223
Chloride	28	20	25	8	0.9
Fluoride	2.00	0.73	1.23	10	0.16
Total suspended solids	90	5	21	11	7.7
Total dissolved solids	440	160	317	11	24.3
Alkanlinity	130	100	116	8	3.2
Total organic carbons	110	7	26	8	12.3
Residual chlorine, total	0.2	<0.1	<0.13	11	0.011
Temperature (°F)	69	15.9	61.7	24	2.07
Ph (units)	8.3	7.3	NA	25	0.05
Dissolved oxygen	9.4	6.2	8.1	7	0.45

[a]Sampling period is Nov–Dec 1988.
[b]Flow during operations and/or discharging.
[c]NA = not applicable.

Table 2.2.15. 1988 annual nonradiological summary for West End Sanitary Sewer

Parameter	No. samples	Concentration[a]			Std. error	% DCG
		Max	Min	Av		
Mercury	9	0.0069	0.0002	0.0014	0.0007	NA[b]
Cyanide	9	0.028	<0.002	<0.005	0.003	NA
Nitrate-N	9	4.4	<0.01	<1.09	0.46	NA
pH (units)	9	7.8	6.9	NA	0.1	NA
Kjeldahl nitrogen	9	26	0.3	13.7	3.4	NA
Total suspended solids	9	150	<5.0	<43.2	17	NA
PCB	9	0.005	<0.0005	<0.001	0.0005	NA
Biological oxygen demand	9	130	<5.0	<28.6	13.1	NA
Aluminum	9	0.66	0.01	0.26	0.48	NA
Arsenic	9	<0.04	<0.04	<0.04	0	NA
Barium	9	0.127	0.0395	0.073	0.001	NA
Beryllium	9	0.0002	<0.0001	<0.0001	0.0001	NA
Boron	9	0.138	<0.012	<0.061	0.018	NA
Cadmium	9	0.006	<0.003	<0.004	0.0005	NA
Calcium	9	49.6	37.9	42.7	1.33	NA
Cerium	9	<0.02	<0.02	<0.02	0	NA
Chromium	9	<0.006	<0.006	<0.006	0	NA
Cobalt	9	0.003	<0.002	<0.002	0.0001	NA
Copper	9	0.06	<0.002	<0.021	0.0065	NA
Gallium	9	<0.01	<0.01	<0.01	0	NA
Iron	9	2.27	0.03	0.7	0.242	NA
Lanthanum	9	<0.003	<0.003	<0.003	0	NA
Lead	9	<0.02	<0.02	<0.02	0	NA
Lithium	9	0.032	0.002	0.012	0.0034	NA
Magnesium	9	13	7.35	9.7	0.60	NA
Manganese	9	0.277	0.029	0.106	0.026	NA
Molybdenum	9	0.011	<0.006	<0.007	0.0006	NA
Nickel	9	0.014	<0.007	<0.009	0.0007	NA
Niobium	9	<0.01	<0.01	<0.01	0	NA
Phosphorus	9	5.67	0.21	2.4	0.56	NA
Potassium	9	10.5	2.4	6.4	0.88	NA
Scandium	9	<0.0004	<0.0004	<0.0004	0	NA
Silver	9	<0.004	<0.004	<0.004	0	NA
Sodium	9	91.2	13.1	26.4	8.2	NA
Strontium	9	0.138	0.099	0.117	0.004	NA
Thorium	9	<0.01	<0.01	<0.01	0	NA
Titanium	9	0.03	<0.002	<0.007	0.003	NA
Vanadium	9	<0.004	<0.004	<0.004	0	NA
Zinc	9	0.334	0.014	0.13	0.036	NA
Zirconium	9	<0.002	<0.002	<0.002	0	NA

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

Table 2.2.16. 1988 annual nonradiological summary for East End sanitary sewer

Parameter	No. samples	Concentration[a]			Std. error	% DCG
		Max	Min	Av		
Mercury	23	0.009	0.0003	0.003	0.0006	NA[b]
Cyanide	23	0.064	<0.002	<0.006	0.003	NA
Nitrate-N	23	2.21	0.1	0.40	0.093	NA
pH (units)	23	7.9	7.2	NA	0.038	NA
Kjeldahl nitrogen	23	26	1.6	11	1.3	NA
Total suspended solids	23	240	<5.0	<46	12.0	NA
PCB	23	<0.0005	<0.0005	<0.0005	0	NA
Biological oxygen demand	23	68.1	<5.0	<28.7	3.6	NA
Aluminum	23	0.49	0.1	0.26	0.027	NA
Arsenic	23	<0.04	<0.04	<0.04	0	NA
Barium	23	0.079	0.0317	0.05	0.003	NA
Beryllium	23	0.0002	<0.0001	<0.0001	0.00001	NA
Boron	23	0.188	0.026	0.07	0.010	NA
Cadmium	23	<0.006	<0.003	<0.005	0.0003	NA
Calcium	23	57.1	37.7	42.0	1.09	NA
Cerium	23	<0.02	<0.02	<0.02	0	NA
Chromium	23	0.045	<0.006	<0.008	0.002	NA
Cobalt	23	<0.002	<0.002	<0.002	0	NA
Copper	23	0.29	0.003	0.028	0.015	NA
Gallium	08	<0.01	<0.01	<0.01	0	NA
Iron	23	0.92	0.18	0.4	0.05	NA
Lanthanum	23	<0.003	<0.003	<0.003	0	NA
Lead	23	0.22	<0.02	<0.03	0.011	NA
Lithium	23	0.06	0.005	0.010	0.003	NA
Magnesium	23	11.9	9	10.7	0.17	NA
Manganese	23	0.103	0.046	0.064	0.003	NA
Molybdenum	23	0.207	0.009	0.028	0.011	NA
Nickel	23	0.09	<0.007	<0.014	0.004	NA
Niobium	23	<0.01	<0.01	<0.01	0	NA
Phosphorus	23	4.3	0.37	2.2	0.23	NA
Potassium	23	9.4	2.2	5.1	0.44	NA
Scandium	23	0.0004	<0.0004	<0.0004	0	NA
Silver	23	0.098	<0.004	<0.013	0.005	NA
Sodium	23	19.6	8.7	13.8	0.76	NA
Strontium	23	0.159	0.112	0.13	0.003	NA
Thorium	23	<0.01	<0.01	<0.01	0	NA
Titanium	23	0.033	<0.002	<0.007	0.002	NA
Vanadium	23	<0.004	<0.004	<0.004	0	NA
Zinc	23	0.312	0.004	0.144	0.014	NA
Zirconium	23	<0.002	<0.002	<0.002	0	NA

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

of purposes. See Table 2.2.4 for a summary of 1988 data.

During November 1988, EFPC was diverted through a new channel around New Hope Pond and through a synthetic-lined, 2.5-acre (1 ha) lake, Lake Reality. This change began the closure of New Hope Pond under the Resource Conservation and Recovery Act (RCRA), and as a result station 17 became the Y-12 Plant's end monitoring point. From January through October 1988, outfall 303 at New Hope Pond was the Y-12 Plant's end monitoring point for EFPC. Summaries of these data are presented in Table 2.2.39 of Vol. 2.

The Y-12 Plant sanitary sewage system discharges to the city of Oak Ridge west end sewage treatment facility through two sewer lines. 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.

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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 above ORNL's discharge point into the Clinch River and WOC headwaters, above the point where ORNL discharges to WOC (see Fig. 2.2.4). The samples were analyzed for organic and inorganic compounds. The results of these analyses will help determine which compounds ORNL may be discharging and will help in the minimization of potentially hazardous discharges.

Samples from the WOC headwaters were all taken by the manual grab method. A new weir and sampling station was used part of the year at that location. The organics and PCBs at Melton Hill Dam were collected by the manual grab method; the inorganics, oil and grease, and dissolved solids were collected weekly from a flow-proportional sampler. All grab samples were taken monthly with the following exceptions. No sample was taken for the month of May at any background surface water sampling site during a re-evaluation of the sampling plan. The parameters with seven samples (see Tables 2.2.17 and 2.2.18) were new analyses begun in June after the plan was evaluated. The parameters with three samples are primarily pesticides, which were analyzed only from June through August to determine baseline conditions.

Tables 2.2.17 and 2.2.18 contain a summary of the analytical results. Table 2.2.17 displays an inorganic compound list, and Table 2.2.18 displays an organic compound list. The percent DWL column shows the average annual concentration as a percentage of the National Primary or Secondary Drinking Water Regulation level, where available. (See Tables 2.3.1–2.3.3 in Vol. 2 for levels.) No abnormally high levels of organic compounds were found at either location. Inorganic compounds were also below the national primary and secondary drinking water regulation levels. The average concentration of manganese at Melton Hill Dam was found to be 173% of the National Secondary Drinking Water limit, which is 0.05 mg/L. Because the standard error of this average is high, the drinking water limit falls within a 95% confidence interval about the average. More samples would be required to determine if the drinking water standard has actually been exceeded. Analytical results for selenium were all below the method detection limit. The percent DWL of 550 for Melton Hill Dam and 542 for White Oak Creek demonstrate that the water standard is about one-fifth of the minimum detectable amount for the analytical method.

Oak Ridge Gaseous Diffusion Plant

Tables 2.2.3 through 2.2.10 in Vol. 2 give the water quality parameter data for the ambient surface water surrounding ORGDP. Figure 2.2.5 depicts the sampling locations. ORGDP does not appear to affect any parameters when data from Poplar Creek and Clinch River, both upstream and downstream from the site, are reviewed.

Mitchell Branch has been designated by the TDHE as a biologically impacted stream. Sources of these impacts have been identified as (1) chlorine residual and temperature from once-through cooling with sanitary water, (2) process discharges with high levels of total dissolved solids,

Table 2.2.17. 1988 inorganic surface water analysis at reference locations

Parameter	Number of samples	Concentration (mg/L)				Percentage of DWL[b]
		Max	Min	Av	Standard error[a]	
Clinch River at Melton Hill Dam[c]						
Aluminum (total)	11	0.70	0.082	0.35	0.057	
Ammonia (as N)	11	0.080	0.024	0.056	0.0054	
Antimony (total)	7	<0.050	<0.030	<0.044	0.0036	
Arsenic (total)	11	<0.060	<0.018	<0.048	0.0053	<96
Barium (total)	7	0.046	0.024	0.038	0.0028	3.7
Beryllium (total)	7	0.0045	0.0011	0.002	0.00043	
BOD	11	6.0	<5.0	<5.1	0.090	
Cadmium (total)	11	<0.0020	<0.0010	<0.0017	0.00014	<16
Calcium (total)	7	41	32	37	1.2	
Chromium (total)	11	0.0070	<0.0036	<0.0050	0.00033	<10
Cobalt (total)	7	<0.0030	<0.0020	<0.0024	0.00020	
Copper (total)	11	0.011	<0.0060	<0.0086	0.00063	<0.86
TDS	11	220	89	160	11	
Iron (total)	11	0.66	0.055	0.30	0.063	100
Lead (total)	11	<0.050	<0.0040	<0.026	0.0058	<52
Magnesium (total)	7	12	8.4	10	0.46	
Manganese (total)	11	0.24	0.017	0.092	0.023	184
Mercury (total)	1	<0.0000	<0.0000	<0.0000		
Nickel (total)	11	<0.0060	<0.0036	<0.0049	0.00034	
Oil and grease	11	11	2.0	3.1	0.81	
TOC	11	3.5	1.8	2.4	0.14	
Phosphorus (total)	11	0.20	<0.10	<0.11	0.0090	
Recoverable phenolics (total)	11	<0.0020	<0.0010	<0.0011	0.00009	
Selenium (total)	7	<0.060	<0.050	<0.054	0.0020	<550
Silicon (total)	7	2.3	0.80	1.6	0.18	
Silver (total)	11	<0.0060	<0.0050	<0.0055	0.00015	<10
Sodium (total)	7	6.8	5.1	5.8	0.22	
Strontium (total)	7	0.14	0.094	0.11	0.0058	
Sulfate (as SO_4)	11	48	24	29	2.0	11
TSS	11	23	<5.0	<8.0	1.6	
Vanadium (total)	7	0.012	0.0068	0.0085	0.00063	
Zinc (total)	11	0.039	<0.0018	<0.010	0.0031	<0.20
White Oak Creek headwaters[c]						
Aluminum (total)	11	0.61	<0.036	<0.24	0.041	
Ammonia (as N)	11	0.069	0.020	0.047	0.0043	
Antimony (total)	7	<0.050	<0.030	<0.044	0.0036	
Arsenic (total)	11	<0.060	<0.018	<0.048	0.0053	<96
Barium (total)	7	0.12	0.055	0.10	0.0083	10
Beryllium (total)	7	0.0021	<0.0003	<0.0014	0.00027	
Cadmium (total)	11	<0.0020	<0.0010	<0.0016	0.00015	<16
Calcium (total)	7	35	15	30	2.5	
Chromium (total)	11	0.052	<0.0036	<0.0090	0.0043	<18
Cobalt (total)	7	<0.0030	<0.0020	<0.0024	0.00020	
Copper (total)	11	<0.010	<0.0060	<0.0085	0.00060	<0.85
TDS	11	180	68	130	11	
Iron (total)	11	0.56	0.048	0.20	0.049	65
Lead (total)	11	<0.050	<0.0040	<0.026	0.0058	<52
Magnesium (total)	7	19	7.0	16	1.5	
Manganese (total)	11	0.11	0.0093	0.037	0.0096	74
Nickel (total)	11	<0.0060	<0.0036	<0.0049	0.00034	

Table 2.2.17 (continued)

Parameter	Number of samples	Concentration (mg/L)				Percentage of DWL[b]
		Max	Min	Av	Standard error[a]	
White Oak Creek headwaters[c] (continued)						
TOC	11	2.0	0.90	1.3	0.10	
Phosphorus (total)	11	0.20	0.10	0.11	0.0090	
Recoverable phenolics (total)	11	<0.0020	<0.0010	<0.0011	0.00009	
Selenium (total)	7	<0.060	<0.050	<0.054	0.0020	<542
Silicon (total)	7	3.7	2.9	3.5	0.12	
Silver (total)	11	<0.0060	<0.0050	<0.0055	0.00015	10
Sodium (total)	7	0.59	<0.17	<0.38	0.058	
Strontium (total)	7	0.041	0.020	0.035	0.0028	
TSS	11	21	<5.0	<7.4	1.4	
Vanadium (total)	7	0.013	0.0053	0.010	0.0010	
Zinc (total)	11	0.032	<0.0018	<0.010	0.0026	<0.20

[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.

and (3) organic contaminants from groundwater. Ambient data from Mitchell Branch source (Table 2.2.10 in Vol. 2) has to be compared with K-1700 NPDES monitoring (Table 2.2.78 in Vol. 2) to review the impact of plant streams on Mitchell Branch Water quality.

2.2.2 NPDES Monitoring Program

Under the requirements of the CWA, an NPDES permit has been issued to each of the three Oak Ridge facilities. There are as many as six components to the NPDES permit at the Oak Ridge Plants. Each plant is required to develop a radiological sampling plan specific to its problems. The NPDES permit for each plant outlines specific outfalls and sampling locations, parameters, and frequencies for analysis for all nonradiological parameters. It may also list permit compliance limits to ensure environmental protection. Table 2.2.11 in Vol. 2 lists the outfall number or designation for each of the Oak Ridge facilities and gives a brief description of the location. Other components of the permit includes the toxicity control and monitoring program (TCMP), the biological monitoring and abatement program (BMAP), a mercury assessment plan, and a PCB sampling plan for aquatic pathways. Tables 2.2.19, 2.2.20, and 2.2.21 detail the permit requirements and compliance records at each outfall during 1988. Within the last few years, the NPDES permit requirements have shifted. Consequently, biological monitoring has become a major component of environmental compliance programs at the Y-12 Plant, ORNL, and ORGDP. The recent emphasis on biological monitoring by regulatory agencies reflects a shift from a strictly water-quality-based approach to wastewater treatment to a biological-monitoring-based policy that emphasizes impacts on the receiving waters in addition to best available technology (BAT). Biological monitoring at the three Oak Ridge facilities also provides the framework for the establishment of interim, less restrictive effluent limits until new wastewater treatment facilities and other remedial actions are completed and water quality standards can be met.

NPDES permits issued in 1984–1986 under Sect. 402 of the CWA required implementation of a Biological Monitoring and Abatement Program

Table 2.2.18. 1988 organic surface water analysis at reference locations

Parameter	Number of samples	Concentration (μg/L)				Percentage of DWL[b]
		Max	Min	Av	Standard[a] error	
Clinch River at Melton Hill Dam[c]						
4,4'-DDD	3	<0.11	<0.10	<0.11	0.0033	
4,4'-DDE	3	<0.11	<0.10	<0.11	0.0033	
4,4'-DDT	3	<0.11	<0.10	<0.11	0.0033	
Acetone	11	15	~2.0	~9.6	0.89	
Aldrin	3	<0.060	<0.050	<0.057	0.0033	
Chlordane	3	<0.60	<0.50	<0.55	0.028	
Dieldrin	3	<0.11	<0.10	<0.11	0.0033	
Endosulfan I	3	<0.060	<0.050	<0.057	0.0033	
Endosulfan II	3	<0.11	<0.10	<0.11	0.0033	
Endosulfan sulfate	3	<0.11	<0.10	<0.11	0.0033	
Endrin	3	<0.11	<0.10	<0.11	0.0033	<53
Endrin ketone	3	<0.11	<0.10	<0.11	0.0033	
Heptachlor	3	<0.060	<0.050	<0.057	0.0033	
Heptachlor epoxide	3	<0.060	<0.050	<0.057	0.0033	
Methoxychlor	3	<0.60	<0.50	<0.55	0.028	<0.55
Methylene chloride	11	10	~1.0[d]	~3.7	0.89	
PCB-1016	10	<0.60	<0.50	<0.54	0.015	
PCB-1221	10	<0.60	<0.50	<0.54	0.015	
PCB-1232	10	<0.60	<0.50	<0.54	0.015	
PCB-1242	10	<0.60	<0.50	<0.54	0.015	
PCB-1248	10	<0.60	<0.50	<0.54	0.015	
PCB-1254	10	<1.1	<0.50	<0.99	0.056	
PCB-1260	10	<1.1	<0.50	<0.99	0.056	
Toluene	11	<5.0	~1.0	~4.6	0.36	
Toxaphene	3	<1.1	<1.0	<1.1	0.033	<21
alpha-BHC	3	<0.060	<0.050	<0.057	0.0033	
beta-BHC	3	<0.060	<0.050	<0.057	0.0033	
delta-BHC	3	<0.060	<0.050	<0.057	0.0033	
gamma-BHC (Lindane)	3	<0.060	<0.050	<0.057	0.0033	
White Oak Creek headwaters[c]						
4,4'-DDD	3	<0.11	<0.10	<0.11	0.0033	
4,4'-DDE	3	<0.11	<0.10	<0.11	0.0033	
4,4'-DDT	3	<0.11	<0.10	<0.11	0.0033	
Acetone	11	<10	~1.0	~8.5	0.98	
Aldrin	3	<0.060	<0.050	<0.057	0.0033	
Chlordane	3	<0.60	<0.50	<0.55	0.028	
Chlordane	3	<0.60	<0.50	<0.55	0.028	
Dieldrin	3	<0.11	<0.10	<0.11	0.0033	
Endosulfan I	3	<0.060	<0.050	<0.057	0.0033	
Endosulfan II	3	<0.11	<0.10	<0.11	0.0033	
Endosulfan sulfate	3	<0.11	<0.10	<0.11	0.0033	
Endrin	3	<0.11	<0.10	<0.11	0.0033	<53
Endrin ketone	3	<0.11	<0.10	<0.11	0.0033	
Heptachlor	3	<0.060	<0.050	<0.057	0.0033	
Heptachlor epoxide	3	<0.060	<0.050	<0.057	0.0033	

Table 2.2.18 (continued)

Parameter	Number of samples	Concentration (μg/L)				Percentage of DWL[b]
		Max	Min	Av	Standard[a] error	
White Oak Creek headwaters[c] (continued)						
Methoxychlor	3	<0.60	<0.50	<0.55	0.028	<0.55
Methylene chloride	11	<5.0	~0.90	~2.9	0.61	
PCB-1016	10	<0.60	<0.50	<0.54	0.015	
PCB-1221	10	<0.60	<0.50	<0.54	0.015	
PCB-1232	10	<0.60	<0.50	<0.54	0.015	
PCB-1242	10	<0.60	<0.50	<0.54	0.015	
PCB-1248	10	<0.60	<0.50	<0.54	0.015	
PCB-1254	10	<1.1	<0.50	<0.99	0.056	
PCB-1260	10	<1.1	<0.50	<0.99	0.056	
Tetrachloroethene	11	<5.0	~2.0	~4.7	0.27	
Toluene	11	<5.0	~1.0	~4.6	0.36	
Toxaphene	3	<1.1	<1.0	<1.1	0.033	<21
alpha-BHC	3	<0.060	<0.050	<0.057	0.0033	
beta-BHC	3	<0.060	<0.050	<0.057	0.0033	
delta-BHC	3	<0.060	<0.050	<0.057	0.0033	
gamma-BHC (Lindane)	3	<0.060	<0.050	<0.057	0.0033	

[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.

[d]Estimated value based on a linear extrapolation of the calibration data.

(BMAP) at each of the three facilities. The BMAPs were developed by ORNL's ESD staff and 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. Further details of the selected studies carried out under the BMAPs at the three Oak Ridge facilities are discussed in more detail in Sect. 6.4.

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 document the effects on stream biota resulting from construction and operation of major new pollution abatement facilities and other remedial actions.

Results of toxicity testing and instream community surveys indicate that reaches varying in length from approximately 200 m (218 yd) to 1.7 km (1.05 miles) of six receiving streams [a total of 4 km (2.5 miles) in length] are toxic to biota. In approximately 3.4 km (83%) of these streams, the toxicity patterns are dominated by episodic discharges of chlorine. Many of these streams also show evidence of ecological recovery over both spatial (i.e., downstream of the toxic reaches) and temporal scales. For example, a significant recovery of the fish communities has occurred between 1980 and 1985 in lower WOC below ORNL and between 1974 and 1984 in upper

Table 2.2.19. 1988 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	7
	pH (units)			>6.5	<8.5	100	8
	Total suspended solids			30.0	50.0	100	7
	Temperature (°C)				30.5	100	7
	Zirconium				3.0	100	7
302 (Rogers Quarry)	Oil and grease			10.0	15.0	100	48
	pH (units)			>6.5	<8.5	85	48
	Settleable solids (mL/L)				0.5	100	48
	Total suspended solids			30.0	50.0[a]	100	48
	Temperature (°C)				30.5	100	48
303 (New Hope Pond)	Ammonia (as N)				1.6	94	199
	Cadmium, total			0.0025	0.0035	100	201
	Chromium, total			0.05	0.08	100	201
	Copper, total			0.015	0.022	98	201
	Dissolved oxygen			5.0[b]		100	239
	Dissolved solids				2000	100	199
	Fluoride			1.5	2.0	100	199
	Lead, total			0.012	0.17	100	201
	Lithium, total				5.0	100	201
	Mercury, total			0.0035	0.0080	99	604
	Nitrogen, total (as N)				20.0	99	95
	Oil and grease			10.0	15.0	100	82
	pH (units)			>6.5	<10.0	100	229
	Settleable solids (mL/L)				0.50	93	30
	Surfactants (as MBAS)			5.0	8.0	99	98
	Total suspended solids				20.0[c]	93	199
	Temperature (°C)				30.5	100	147
	Zinc, total			0.20	0.30	99	201
304 (Bear Creek)	Oil and grease			10.0	15.0	100	52
	pH (units)			>6.5	<8.5	100	52
305 (leaking burial grounds and wet weather springs—Oil Pond 1)	Oil and grease			10.0	15.0	100	102
	pH (units)			>6.5	<8.5	90	102
	Total suspended solids			30.0	50.0	96	102
306 (seepage from burial pit and surface water runoff—Oil Pond 2)	Oil and grease			10.0	15.0	100	26
	pH (units)			>6.5	<8.5	69	26
	Total suspended solids			30.0	50.0	100	26
307 (West Borrow Area)	Temperature (°C)					100	2
	pH (units)					100	2
	Oil and grease					100	2
	Total suspended solids					100	2
308 (East Borrow Area)	Temperature (°C)					100	1
	pH (units)					100	1
	Oil and grease					100	1
	Total suspended solids					100	2

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	38
	Chromium, total	0.5	0.75	1.71	2.77	100	38
	Copper, total	0.6	0.9	2.07	3.38	100	38
	Cyanide, total	0.2	0.33	0.65	1.20	100	38
	Lead, total	0.12	0.19	0.43	0.69	100	38
	Nickel, total	0.65	1.1	2.38	3.98	100	38
	Oil and grease	7.1	14.2	26.0	52.0	100	38
	pH (units)			>6.0	<9.0	100	38
	Silver, total	0.07	0.12	0.24	0.43	100	38
	Temperature (°C)				30.5	100	38
	Total suspended solids	8.5	16.4	31.0	60.0	100	38
	Total toxic organics		0.6		2.13	97	38
	Zinc, total	0.4	0.7	1.48	2.61	100	38
502 West End Treatment Facility (WETF)	Cadmium, total	0.07	0.019	0.26	0.69	100	91
	Chromium, total	0.50	0.75	1.71	2.77	100	91
	Copper, total	0.60	0.92	2.07	3.38	100	91
	Cyanide, total	0.2	0.33	0.65	1.20	98	84
	Lead, total	0.12	0.19	0.43	0.69	100	91
	Nickel, total	0.65	1.10	2.38	3.98	92	91
	Oil and grease	7.1	14.2	26.0	52.0	100	84
	pH (units)			>0.6	<9.0	100	84
	Silver, total	0.07	0.12	0.24	0.43	100	91
	Temperature (°C)				30.5	100	84
	Total suspended solids	8.5	16.4	31.0	60.0	100	91
	Total toxic organics		0.6		2.13	100	16
	Zinc, total	0.4	0.7	1.48	2.61	100	91
503 (Steam Plant Wastewater Treatment Facility)	Chromium, total	0.38	0.38	0.20	0.20	100	155
	Copper, total	1.89	1.89	1.0	1.0	100	155
	Iron, total	1.89	1.89	1.0	1.0	98	155
	Zinc, total	1.89	1.89	1.0	1.0	100	155
	Oil and grease	28.4	37.9	15.0	20.0	100	155
	Total suspended solids	57.0	189.0	30.0	100.0	100	155
	Temperature (°C)				30.5	99	155
	pH (units)			>6.0	<9.0	100	155
Category I outfalls (precipitation runoff and small amounts of groundwater)	pH (units)			>6.5	<8.5	100	19
Category II outfalls (cooling waters, condensate, precipitation runoff, and building, roof, and foundation drains)	pH (units)			>6.5	<8.5	100	84
	Temperature[d] (°C)					100	84
Category III outfalls (process wastewaters)	pH (units)			>6.5	<8.5	100	44
Category IV outfalls (untreated process wastewaters)	pH (units)			>6.5	<8.5	95	608

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	28
	Chromium, total	0.50	0.75	1.71	2.77	100	28
	Copper, total	0.60	0.92	2.07	3.38	100	28
	Cyanide, total	0.2	0.33	0.65	1.20	100	28
	Lead, total	0.12	0.19	0.43	0.69	100	28
	Nickel, total	0.65	1.10	2.38	3.98	100	28
	Oil and grease	7.1	14.2	26.0	52.0	100	28
	pH (units)			>0.6	<9.0	100	28
	Silver, total	0.07	0.12	0.24	0.43	100	28
	Temperature (°C)				30.5	100	28
	Total suspended solids	8.5	16.4	31.0	60.0	96	28
	Total toxic organics		0.6		2.13	100	28
	Zinc, total	0.4	0.7	1.48	2.61	100	28
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	29
	Chromium, total	0.50	0.75	1.71	2.77	100	29
	Copper, total	0.60	0.92	2.07	3.38	100	29
	Cyanide, total	0.2	0.33	0.65	1.20	100	29
	Lead, total	0.12	0.19	0.43	0.69	100	29
	Nickel, total	0.65	1.10	2.38	3.98	100	29
	Oil and grease	7.1	14.2	26.0	52.0	100	29
	pH (units)			>0.6	<9.0	100	29
	Silver, total	0.07	0.12	0.24	0.43	100	29
	Temperature (°C)				30.5	100	29
	Total suspended solids	8.5	16.4	31.0	60.0	100	29
	Total toxic organics		0.6		2.13	100	29
	Zinc, total	0.4	0.7	1.48	2.61	100	29
623 (Steam Plant fly ash sluice water)	pH (units)			>6.5	<8.5	100	49
506 (9204-3 sump pump oil)	Temperature (°C)				30.5	85	27
	Oil and grease			10.0	15.0	100	27
	pH (units)			>6.5	<8.5	100	27
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	*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	65
	Copper, total			0.5	1.0	100	65
	Free available chlorine			0.2	0.5	72	65
	pH (units)			6.5	8.5	37	65
	Temperature (°C)			35	38	100	65
	Zinc, total			0.5	1.0	100	65
Miscellaneous discharges (demineralizers)	pH units			6.5	8.5	*e*	
	Total suspended solids			30	50	*e*	

[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.

Table 2.2.20. 1988 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)	Biological oxygen demand (summer)	8.7	13.1	10	15	1	98.9
	Biological oxygen demand (winter)	17.4	26.2	20	30	1	98.4
	Total suspended solids	26.2	39.2	30	45	3	95.3
	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	2	96.9
	Dissolved oxygen						
	pH (units)[a]					0	100
	Residual chlorine				0.5	4	97.5
	Fecal coliform, geometric mean			200[b]	400[b]	3	98
X02 (Coal yard runoff treatment facility)	Temperature (°C)				30.5	4	96.9
	Total suspended solids				50	1	97.9
	Oil and grease			15.0	20.0	0	100
	Chromium, total			0.2	0.2	0	100
	Copper, total			1.0	1.0	0	100
	Iron, total			1.0	1.0	5	90.2
	pH (units)[a]					4	98.4
	Zinc			1.0	1.0	0	100
X03 (1500 area)	pH (units)[a]					0	100
X04 (2000 area)	pH (units)[a]					0	100
X06 (3539 and 3540 ponds)	pH (units)[a]					0	100
X07 (Process Waste Treatment Plant–3544)	pH (units)[a]					1	98.1
X08 (TRU)	pH (units)[a]					0	100
X09 (HFIR)	pH (units)[a]					0	100
X11 (Acid neutralization facility)	pH (units)[a]					3	94.2
Category I	Oil and grease			10	15	3	82.4
	pH (units)[a]					0	100
	Temperature (°C)				30.5	0	100
	Total suspended solids			30	50	8	82.4

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)		
Category II	Oil and grease			10	15	2	98.6
	pH (units)[a]					1	99.3
	Total suspended solids			30	50	24	83.4
Category III	pH (units)[a]					0	100
Steam plant (SP2519)	pH (units)[a]					2	50
	Temperature (°C)			35	38	1	75
Vehicle cleaning (VC7002)	Biological oxygen demand			30	45	0	100
	Fecal coliform			200[c]		3	75
	Oil and grease			10		1	91.7
	pH (units)[a]					0	100
	Phenols			1.0	2.0	0	100
	Total suspended solids			25	40	1	91.7
Equipment maintenance facility (EF7007)	Oil and grease				15	0	100
Paint facility (PF7007)	Oil and grease			10	15	0	100
	pH (units)[a]					0	100
	Phenols			1.0	2.0	0	100
	Total suspended solids			25	40	0	100
Cooling systems	Chlorine				0.2	7	86.3
	Chromium				1.0	0	100
	Copper		0.5	1.0		1	98.6
	Temperature (°C)			35	38	1	98.6
	Zinc			0.5	1.0	11	84.3
	pH (units)[a]					0	100

[a]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, X06, X07 and X11; (2) a per discharge grab sample taken at the effluent for discharge points X08, X09; (3) a monthly grab sample taken at the effluent for discharge points X13, X14, X15; (4) once per year by a grab sample taken at the effluent for pH 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 month at PF7007; and (10) 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, PF7007, 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.

[b]Colonies per 100 mL.

[c]Minimum.

Table 2.2.21. 1988 NPDES compliance at ORGDP

Discharge point	Effluent parameters	Effluent limits				Number of noncompliances	Percent of 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	10	90
	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
	Perchloroethylene	0.12	0.21	1.9	3.3		100
	Trichloroethane	0.11		1.7			100
	Methylene chloride	0.035		0.54			100
	Trichloroethylene	0.41	0.61	6.4	9.5		100
	Lead	0.0080	0.93	0.12	14		100
	Zinc	0.12	1.5	1.86	246		100
	Total halomethanes	1.2	2.1	19	32		100
	Beryllium	0.0010	0.0020	0.016	0.032		100
	Cadmium	0.0040	0.010	0.060	0.16		100
	Mercury	0.0013	0.011	0.021	0.17		100
	Selenium	0.12	0.31	1.9	4.8		100
	Silver	0.014	0.027	0.22	0.42		100
003							
(K1407-B)[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				100
	PCB, μg/L		0.014			1	98

Table 2.2.21 (continued)

Discharge point	Effluent parameters	Effluent limits				Number of noncompliances	Percent of compliance
		Monthly av (mg/L)	Daily max (mg/L)	Monthly av (kg/d)	Daily max (kg/d)		
005							
(K-1203 sanitary treatment facility)[d]	Ammonia nitrogen	5.0	7.0	12	17.3		100
	BOD	15	20	37	49.5		100
	Chlorine residual		0.24				100
	Dissolved oxygen	5.0[b]					100
	Fecal coliform, No./100 mL	200	400				100
	pH, units		6.0–9.0			2	99
	Suspended solids	30	45	74	110		100
	Settleable solids, mL/L		0.50			1	99
	Beryllium	0.0010	0.0020	0.0020	0.0050		100
	Cadmium	0.0040	0.010	0.010	0.025		100
	Mercury	0.0013	0.011	0.0030	0.027		100
	Selenium	0.12	0.31	0.30	0.77		100
	Silver	0.014	0.027	0.035	0.067		100
	Lead	0.008	0.93	0.02	2.30		100
	Zinc	0.12	1.52	0.30	3.76		100
	Perchloroethylene	0.12	0.21	0.30	0.52		100
	Trichloroethane	0.11		0.27			100
	Methylene chloride	0.035		0.087			100
	Trichloroethylene	0.41	0.61	1.01	1.51		100
	Total halomethanes	1.23	2.05	3.04	5.07		100
(K-1007-B holding pond)	COD	20	25	120	150	16	85
	Chromium (total)		0.050		0.30		100
	Dissolved oxygen	5.0[b]				3	99
	Fluoride	1.0	1.5	6.1	9.1		100
	Oil and greas	10	15	61	91		100
	pH, units		6.0–9.0				100
	Suspended solids[a]	30	50	182	304		100

Table 2.2.21 (continued)

Discharge point	Effluent parameters	Effluent limits				Number of noncompliances	Percent of compliance
		Monthly av (mg/L)	Daily max (mg/L)	Monthly av (kg/d)	Daily max (kg/d)		
007							
(K-901-A holding	Chromium (total)		0.05		0.68	1	98
pond)	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]				3	99
009							
(K-1515-C sanitary	Suspended solids[a]	30	50	34	51	1	98
water plant)	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*			4	*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				100
	PCB, μg/L		0.014				100

Table 2.2.21 (continued)

Discharge point	Effluent parameters	Effluent limits				Number of noncompliances	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				100
	Oil and grease	15	20				100
	Chromium	0.2	0.2				100
	Copper	1.0	1.0				100
	Iron	1.0	1.0			1	96
	Zinc	1.0	1.0				100
	PCB (μg/L)		0.014				100
	pH, units		6.0–9.0			1	99

[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.

Bear Creek. Additional improvement in the fish population of upper Bear Creek was observed in 1985 in association with neutralization of the S-3 Ponds. Almost a tenfold increase in fish abundance occurred between May and October 1986 in EFPC just below New Hope Pond, and this high density has been sustained through 1988. Unlike the fish community, the rate of recovery of the benthic invertebrate (bottom-dwelling organisms) community has been much slower, especially in Bear Creek and EFPC just below New Hope Pond, due in part to the loss of an upstream source area for recolonization (the Y-12 Plant is situated on the headwaters of the two streams).

In addition to determining environmental compliance by evaluation of the ecological status of receiving streams, the BMAP can also be used to investigate cause-effect relationships associated with adverse impacts. Identification of chlorine as the variable controlling toxicity in several different streams will guide efforts toward development of appropriate remedial action plans to address a generic problem. Biomonitoring can also be used to assess the effectiveness of these and other remedial actions through documentation of the process of ecological recovery.

Additional 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 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 Central Pollution Control Facility (CPCF), West End Treatment Facility (WETF), Steam Plant Wastewater Treatment Facility (SPWTF), and the Plating Rinsewater Treatment Facility (PRTF). Point and area discharges 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 pond number 2. The in-stream locations for 1988 included outfall 303, New Hope Pond (until closure activities began in November), and outfall 304, Bear Creek. These data are summarized in Table 2.2.22.

DOE Order 5480.1A 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 the same locations as required for nonradiological monitoring in the permit. Parameters analyzed and frequencies of analysis are given in Table 2.2.7. Table 2.2.12 in Vol. 2 gives a summary of radiological parameter concentrations from each of these locations.

At 2 of the 8 water monitoring locations where ^{60}Co was measured, the average concentration was greater than 1% of the DCG. These releases are primarily attributable to process discharges. The highest percentage (95%) of the DCG for ^{60}Co was measured at the discharge from the HFIR ponds. Below this discharge point at MB1 (See Fig. 2.2.4), the average ^{60}Co concentration was 0.85% of the DCG. The other location where the maximum ^{60}Co exceeded 1% of the DCG was the discharge from the 3544 PWTP (1.4%).

The average ^{137}Cs concentrations exceeded 1% of the DCG at 3 of 8 locations. Cesium-137 releases to the creeks appear to be primarily the

Table 2.2.22. 1988 annual radiological summary in water around Y-12 Plant

Parameter (pCi/L)	Count	Concentration (pCi/L)			Std. error	% DCG
		Max	Min	Av		
East Fork Poplar Creek Outfall 303						
Alpha activity	47	4200	0	190.4	88	NA[a]
Beta activity	47	6730	−12	182.0	142	NA
^{237}Np	14	0.240	0	0.03	0.02	0.10
^{226}Ra	14	1.9	−1.9	0.16	0.23	0.16
^{228}Ra	13	7.1	−1.3	0.85	0.62	0.85
^{90}Sr	14	8.0	−4.9	2.5	1.007	0.26
Bear Creek Outfall 304						
Alpha activity	38	260	0	70	11.4	NA
Beta activity	38	7.3	0	53.2	8.63	NA
^{237}Np	14	7.6	0	0.57	0.15	1.89
^{226}Ra	14	5.2	−1.5	0.89	0.24	0.89
^{228}Ra	14	7.3	−1.5	0.67	0.18	0.67
^{90}Sr	14	0.1	−2.9	1.55	0.41	0.16

[a]NA = not applicable.

result of process discharges. The highest percentage of the DCG for ^{137}Cs was in the discharge from the PWTP 3544 (120%). Other stations where the percentage of the DCG for ^{137}Cs exceeded 1% include WOD (1.3%) and WOC (2.5%). Concentrations of ^{137}Cs at WOC and WOD appear to be augmented by contributions from SWSAs 4 and 5 and the pits and trenches area of the burial grounds.

For comparison purposes, the DCG for ^{90}Sr was used to evaluate total radioactive strontium discharges. This is a conservative approach. At 5 of 6 locations where total radioactive strontium was measured, the average concentration, as a percentage of the DCG, was greater than 1%. The highest percentages occurred in First Creek (52%) and MB1 (32%), followed by WOD (13%), WOC (10%), and the sewage treatment plant (7.8%). Most of the total radioactive strontium appears to be coming from the main ORNL plant area (4500 complexes) and the 2000 area, with a smaller portion from the 7500 and 3000 areas. Unlike the ^{60}Co and ^{137}Cs discharges, which are primarily process related, the total radioactive strontium releases are more diffuse and are probably the result of past activities and subsurface input rather than discharges from process facilities.

The highest percentages of tritium relative to the DCG were measured at MB1 station (91%), followed by the WOD station (10%) and WOC station (1.6%). Most of the tritium is believed to come from SWSA 5.

Characterization of SWSA 5, particularly the tritium releases, is one of the highest priorities of the remedial investigation/feasibility study (RI/FS) subcontract. This characterization, which began in August 1987, is needed to comply with the RCRA requirements and to determine the measures that will most effectively reduce the flow of ^{3}H and other contaminants from SWSA 5.

Oak Ridge Gaseous Diffusion Plant

NPDES effluent monitoring is specified in ORGDP NPDES permit TN0002950. Conditions are determined by negotiations involving DOE, TDHE, EPA, and Energy Systems. The EPA is the issuing agency for the existing NPDES permit; however, beginning in October 1986, the TDHE assumed primacy over the NPDES program. The

radionuclide analyses for both ambient surface water and NPDES programs are restricted to the types common to past and current plant operations. Deviation from the specified frequencies and limits results in permit noncompliances and resultant actions from the regulatory agencies.

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.

The NPDES sampling station upgrading project was initiated during 1987 and was completed in 1988. During 1987, the sample station platforms were replaced and flow monitoring systems were installed. During 1988, refrigerated composite samplers were installed and linked to the flow monitoring systems to allow flow-proportional sampling.

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 NPDES point (Fig. 2.2.5) has the greatest potential for radioactive emissions because of the facilities operating nearby. Because K-1407-B is upstream from K-1700, the same rationale is used for parameter analysis as at K-1700. 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.

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 2.2.16 in Vol. 2). Uranium, determined by wet chemistry analysis, is reduced and presented by isotope in the Vol. 2 tables. All values are <6% of the DCG. These low values are supported by the fact that ambient surface water radiological samples do not indicate contamination from ORGDP.

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,

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-1407-B	Continuous	Daily		pH
K-1407-B	Continuous	Daily		Flow
K-1407-B	Grab	Daily		Temperature
K-1407-B	24 h/comp.	2/week		Cadmium
K-1407-B	24 h/comp.	2/week		Chromium
K-1407-B	24 h/comp.	2/week		Copper
K-1407-B	24 h/comp.	2/week		Lead
K-1407-B	24 h/comp.	2/week		Nickel
K-1407-B	24 h/comp.	2/week		Silver
K-1407-B	24 h/comp.	2/week		Zinc
K-1407-B	Grab	1/week		Cyanide
K-1407-B	Grab	1/week		Total toxic organics
K-1407-B	Grab	2/week		Oil and grease
K-1407-B	24 h/comp.	4/week		Total suspended solids

Table 2.2.23 (continued)

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

Table 2.2.23 (continued)

Location	Sampling type	Sample frequency	Analysis[a] frequency	Parameter analyzed
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
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

Table 2.2.23 (continued)

Location	Sampling type	Sample frequency	Analysis[a] frequency	Parameter analyzed
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
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

Table 2.2.23 (continued)

Location	Sampling type	Sample frequency	Analysis[a] frequency	Parameter analyzed
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
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.

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 the Toxicity Control and Monitoring Program (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 and shown in Fig. 2.2.1. 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 1988 are summarized in Tables 2.2.17 through 2.2.37 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. Regulators have directed the Y-12 Plant to provide treatment for a variety of wastewaters discharged to East Fork Poplar Creek. Discharge allowed under the permit include storm drainage, cooling water, cooling tower blowdown,

Table 2.2.24. Y-12 Plant NPDES-permitted outfalls

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
S-3 Ponds Liquid Treatment Facility—outfall 507
Miscellaneous discharges (cooling towers, regeneration wastes, vapor blasters)

and process wastewaters including effluents from pollution control facilities. Sumps that collect groundwater inflow in building basements are also discharged to the creek.

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 over 160 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 liters (359 million gallons) per year of water are required as makeup for the 18 major cooling tower systems. About 550 million liters (143 million gallons) per year are discharged as blowdown into East Fork Poplar Creek, and 830 million liters (216 million gallons) are lost as evaporation. The blowdown consists of water containing nontoxic chemical treatment (a corrosion inhibitor and microbiocide). During 1988, the NPDES compliance for the cooling tower blowdown showed 100% compliance for temperature and a decrease from 81% compliance in 1987 to 37% in 1988 for pH. This decrease in compliance is attributed to a change in the use of corrosion inhibitors that caused fluctuations in pH. The cooling tower system is currently being upgraded by replacement of old towers and modifying chemical treatment to better satisfy NPDES requirements.

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.
- The SPWTF began collecting and treating coal-pile runoff and boiler blowdown during 1988. After treatment, the water is discharged to East Fork Poplar Creek.
- In 1988 wastewaters from the ORNL Biology Complex at the Y-12 Plant began being 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.

Two new NPDES discharge points were added in 1988. These two points are sedimentation ponds located in the two clay borrow areas where soil is being obtained to construct RCRA caps for the Bear Creek Burial Grounds and New Hope Pond. These sedimentation ponds, called the east and west borrow areas, were routinely monitored for suspended solids.

During 1988, the Y-12 Plant was 97% in compliance with NPDES standards as compared with 99% compliance in 1987. These trends can be seen in Figs. 2.2.6 and 2.2.7. The main reason for this drop in compliance level was the initiation of two water management plans affecting three NPDES outfalls late in the year. When closure

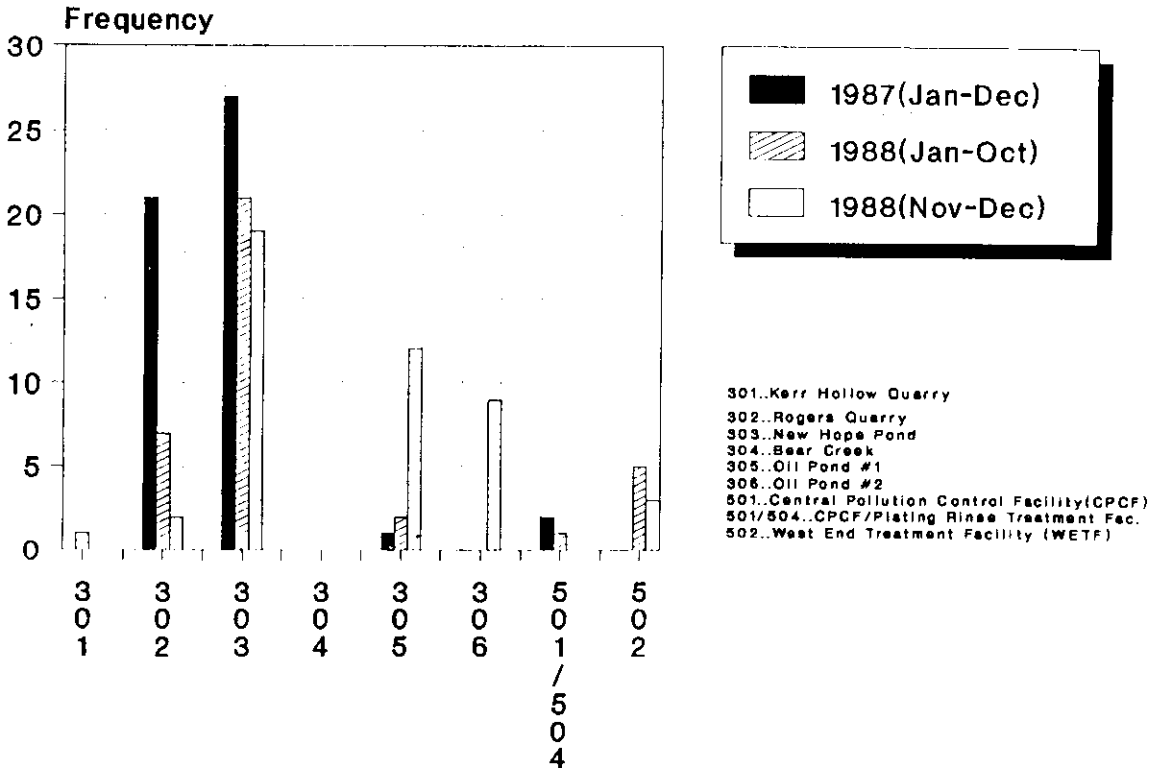

Fig. 2.2.6. Y-12 Plant excursion trend.

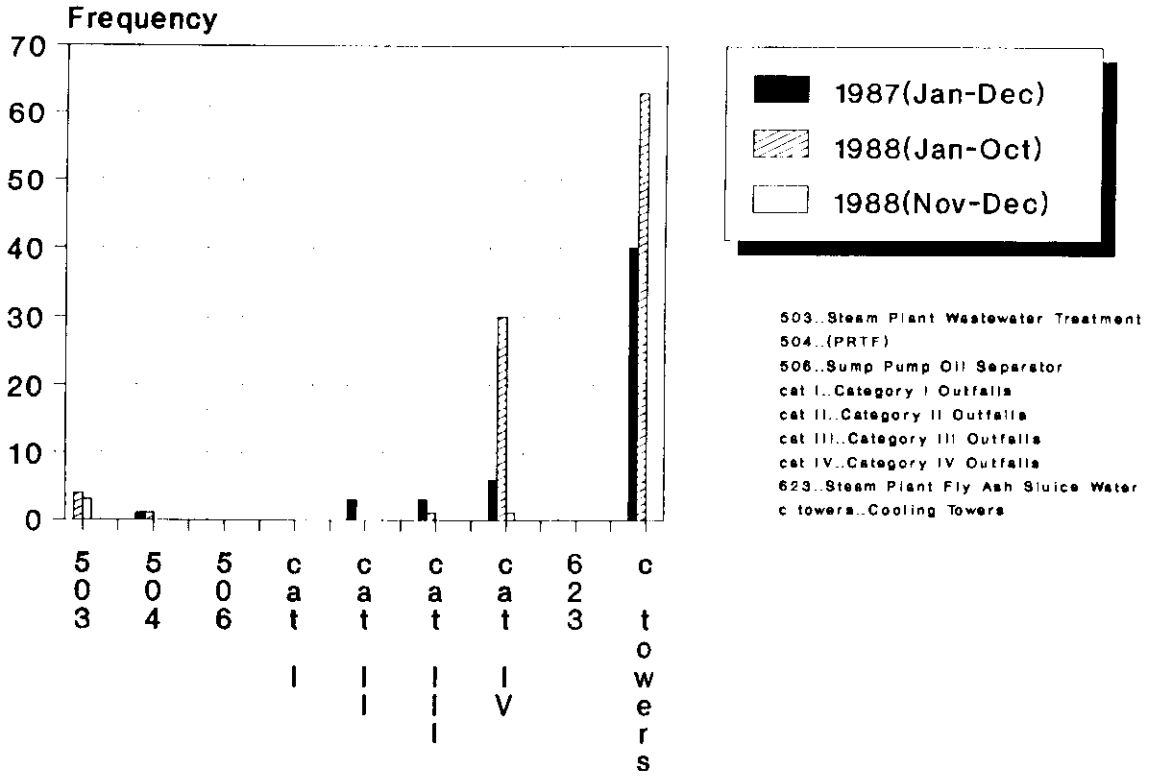

Fig. 2.2.7. Y-12 Plant excursion trend.

began on New Hope Pond in November 1988, this outfall (303) became the monitoring point for the New Hope Pond Closure Project Water Management Plan. This water management plan contained the same requirements as the NPDES permit for this outfall. Exceptions to the permit criteria included more frequent monitoring and the addition of extra grab samples to be analyzed for certain indicator parameters such as metals, PCBs, total volatile organics, and solids. Because of this closure, compliance levels dropped on ammonia (99% in 1987 to 94%) and total suspended solids (99% in 1987 to 93%). However, mercury compliance was up to 99% from 94% last year.

The two oil retention ponds were also under closure activities. 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 being pumped into tanker trucks and discharged through a filter system or a carbon filter system located at Oil Retention Pond Number 1. The parameters required by this water management plan for these two outfalls (305 and 306) were the same as the NPDES permit except for the addition of PCBs, volatile organics, and a more frequent monitoring schedule. These closure activities caused a drop in compliance level for pH at outfall 305 (100% in 1987 to 90%) and outfall 306 (100% in 1987 to 69%).

The compliance level for pH was up to 85% at Rogers Quarry (outfall 302) from 62% in 1987. At Kerr Hollow Quarry the compliance dropped to 88% for pH because of a single excursion. A 100% compliance was maintained for other permitted parameters at Kerr Hollow Quarry.

Progress was also made during 1988 on several projects to minimize the release of pollutants to surface waters at the Y-12 Plant. These include improvements to CPCF, WETF, PRWTF, and the startup of 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 being treated on-site and no longer transported to ORGDP for partial treatment and back to the Y-12 Plant for final treatment. CY 1988 was the first full year of operation for PRTWF, and it treated over 3.8 million liters (1 million gallons) of planting rinsewaters. SPWTF was completed and began operation in 1988. As a result, approximately 180 million liters (47 million gallons) per year of acidic and caustic discharges from the Y-12 Plant coal yard and steam plant operations receive treatment before release to East Fork Poplar Creek.

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.

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The point source and ambient stations are shown in Fig. 2.2.8. Table 2.2.38 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 2.2.39 through 2.2.57 in Vol. 2. Effluent limits have been placed on the Sewage Treatment Plant and the Coal Yard Runoff Treatment Facility; category I, II, and III outfalls; and the miscellaneous source discharges. Discharge limits are also placed on pH for most of the outfalls.

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 in compliance for 1988. 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 95% for all parameters measured. Fecal coliform and chlorine concentrations resulting from the low chlorine limit of the permit were occasionally problematic; however, ORNL, DOE, and TDHE have worked together and have identified possible solutions. It is expected that the situation will be resolved sometime in 1989.

Category I and II outfalls include storm drains and parking lot and roof drains and are not

Table 2.2.25. Surface water analytical results of the polychlorinated biphenyls monitoring plan for Oak Ridge Y-12 Plant 1988 Annual Report

Site number	Location	Date sampled	PCB concentration (mg/L)
PCB-1	Outfall 301, Kerr Hollow Quarry	03/08/88	<0.0005
		06/20/88	<0.0005
		12/27/88	<0.0005
PCB-2	Outfall 302, Rogers Quarry	03/08/88	<0.0005
		06/20/88	<0.0005
		12/13/88	<0.0005
PCB-3	Outfall 303, New Hope Pond	03/08/88	<0.0005
		06/11/88	<0.0005
		06/12/88	<0.0005
		06/20/88	<0.0005
		07/20/88	<0.0005
PCB-5	New Hope Pond Inlet	03/08/88	<0.0005
		06/20/88	<0.0005
		a	
PCB-6	Upstream of Outfall 135 (EFPC headwaters)	03/08/88	<0.0005
		06/20/88	<0.0005
		12/27/88	<0.0005
PCB-7	Outfall 304, Bear Creek	03/08/88	<0.0005
		06/20/88	<0.0005
		12/27/88	<0.0005

[a]Undergoing closure activities.

contaminated by any known activity, nor do they discharge through any oil/water separator or other treatment facility or equipment. During rain events, water from the parking lots and surrounding areas wash into these outfalls, carrying with it oil, grease, and other residue. This situation frequently results in noncompliances for oil and grease and total suspended solids (TSS) at a number of these outfalls.

Iron limit exceedences that were measured at the Coal Yard Runoff Treatment Facility were attributed to a malfunction of sampling equipment. This malfunction resulted in collection of both bottom sediments and water from the facility, instead of just effluent water. The sediments have a high iron content, which contributed to the permit violations. The equipment was repaired and functioned properly thereafter.

The fecal coliform bacteria limit exceedances at the vehicle cleaning facility were not attributable to activities at that facility. ORNL personnel have initiated dye studies of sanitary pipelines near the vehicle cleaning facility to determine whether inleakage from sanitary sewers is causing the fecal coliform exceedances.

In March 1988 an error was discovered in the temperature measurement procedure being used for the ORNL NPDES sampling program; the error resulted in the invalidation of 33 previously taken temperature readings. No temperature limit exceedences are known to have occurred in any of these instances. The error was corrected immediately upon discovery.

The pH limit exceedance situation at the ORNL steam plant (SP 2519) improved in 1988; however, the effluent remains problematic and

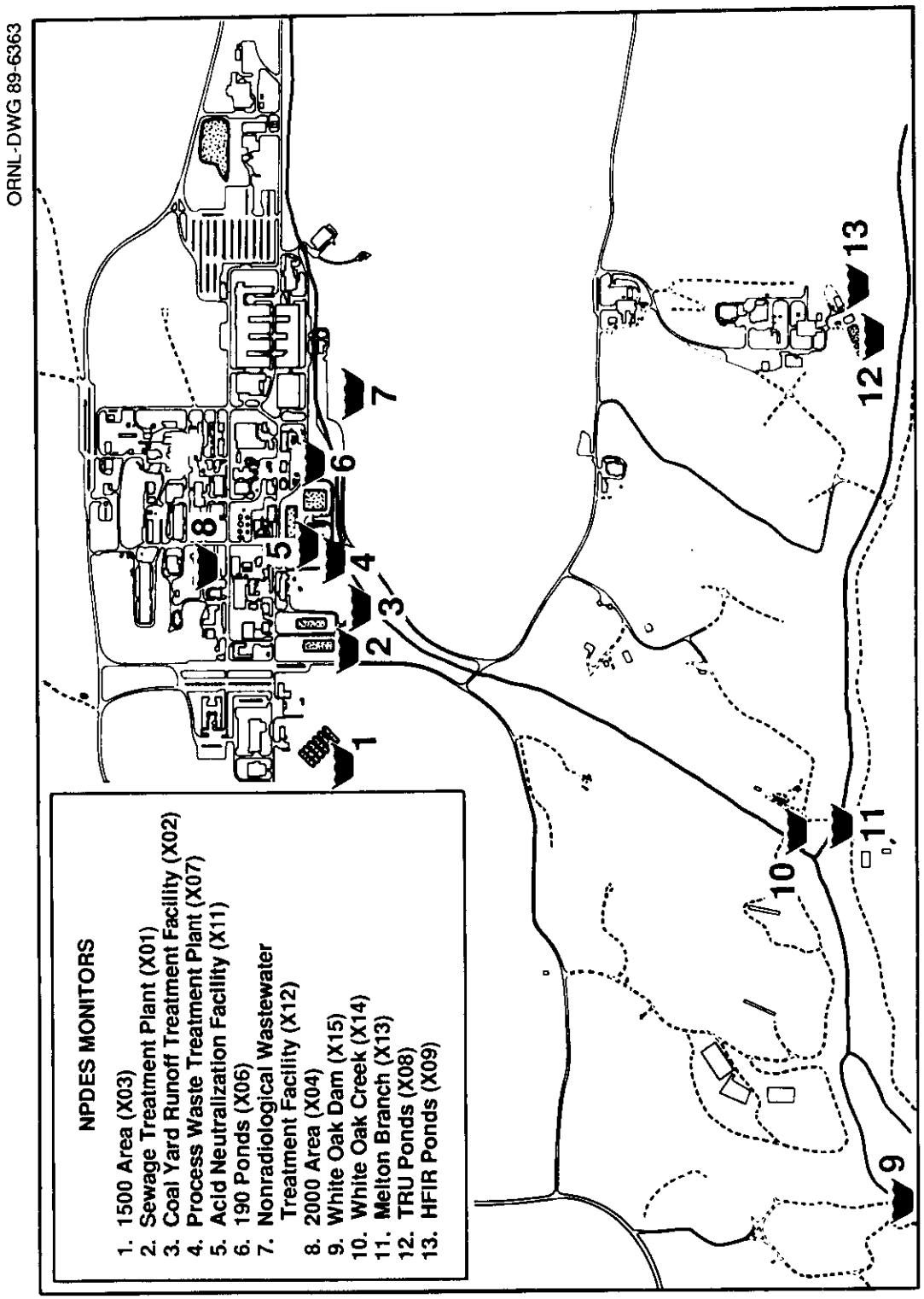

Fig. 2.2.8. ORNL NPDES and radioactivity sampling locations.

ORNL personnel are in the process of identifying an appropriate treatment mechanism for the effluent.

In conjunction with an ORNL cooling tower upgrade effort, expanded monitoring of cooling tower effluents was conducted in 1988. A steady decrease in the number of limit exceedances at cooling tower blowdown locations in 1988 attests to the success of the upgrade program.

In 1988, 12 noncompliances were recorded at ORNL because administrative failures occurred in collecting required samples. No exceedences of permit limits are believed to have occurred in any of these instances. Quality assurance is a continuing priority of the ORNL environmental monitoring staff.

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 Discharge Monitoring Reports (DMRs). Monthly summaries of sampling for the NPDES permit are found in Tables 2.2.58 through 2.2.77 of Vol. 2.

Table 2.2.26 provides summary data for all parameters monitored in White Oak Creek (WOC) at WOD (NPDES station number X15). The 1988 maximum concentrations for copper, fluoride, iron, manganese, lead, and zinc equaled or exceeded Tennessee Water Quality Standards for protection of drinking water, fish and aquatic life, and recreation classifications; however, 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 2.2.68 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. Sample preservation during 1987 was conducted after samples were taken to the laboratory. Since February 1988, sample preservation was conducted in the field. 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 to moderate stream flows by enhancing percolation to groundwater systems and reducing runoff quantity and rate. A storm sewer survey to characterize water quality has been completed. Results of this survey were used in the NPDES permit renewal application submitted in August 1988.

Only two cooling towers, K-1037 and K-1101, are currently operated. They require 800,000 L/d

Table 2.2.26. 1988 ORNL annual effluent summary for White Oak Creek at White Oak Dam (outfall X15)

Parameter	Number of samples	Concentration (mg/L)			Standard error
		Max	Min	Av	
Silver (total)	12	<0.0050	<0.0050	<0.0050	0
Aluminum (total)	12	1.9	0.32	0.87	0.14
Arsenic (total)	12	<0.060	<0.018	<0.045	0.0049
Biochemical oxygen demand	12	<5.0	<5.0	<5.0	0
Cadmium (total)	12	<0.0020	<0.0020	<0.0020	
Chloroform	12	<0.0050	0.0010[a]	0.0038[a]	0.00051
Chlorine (total residual)	52	0.10	<0.010	<0.012	0.0017
Conductivity (ms/cm)	12	0.80	0.30	0.43	0.044
Chromium (total)	12	0.033	<0.0036	<0.015	0.0020
Copper (total)	12	0.020	<0.0060	<0.010	0.0013
Oxygen (dissolved)	52	16	4.0	9.7	0.35
Fluoride (total)	12	1.1	<1.0	<1.0	0.011
Iron (total)	12	1.9	0.29	0.77	0.15
Flow (millions of gal/d)	249	84	2.6	6.4	0.42
Mercury (total)	12	<0.00010	<0.000050	0.000059	0
Manganese (total)	12	0.19	0.038	0.074	0.013
NH_4-N	12	0.18	0.020	0.073	0.013
Nickel (total)	12	0.0095	<0.0036	<0.0052	0.00049
NO_3-N	12	<5.0	<5.0	<5.0	0
Oil and grease	52	38	<2.0	<4.9	1.0
Phosphorus (total)	12	1.1	0.20	0.31	0.073
Lead (total)	12	0.0040	<0.0040	<0.0040	0
PCB (total)	12	<0.0005	<0.00050	<0.0005	0
pH (standard units)	12	9.2	6.5	*b*	*c*
Sulfate (as SO_4)	12	69	35	53	2.7
Dissolved solids (total)	12	280	140	220	12
Temperature (°C)	35	88	1.6	19	2.5
Organic carbon (total)	12	4.2	2.2	3.2	0.21
Trichloroethene	12	<0.0050	<0.0050	<0.0050	0
Total suspended solids	12	61	<5.0	<18	5.0
Turbidity	12	78	8.0	30	5.2
Zinc (total)	12	0.058	0.012	0.028	0.0036
^{241}Am (pCi/L)	52	3.5	−1.4	0.26	0.093
^{244}Cm (pCi/L)	44	4.1	−0.84	0.33	0.099
^{60}Co (pCi/L)	52	15	−1.4	<8.3	0.46
^{137}Cs (pCi/L)	52	170	6.2	40	4.7
Gross beta (pCi/L)	45	1,100	110	320	22
^{238}Pu (pCi/L)	52	5.4	−3.8	−0.0052	0.14
^{239}Pu (pCi/L)	52	0.43	−0.81	0.055	0.025
Total rad Sr (pCi/L)	52	300	65	130	5.8
Tritium (pCi/L)	52	410,000	43,000	200,000	17,000

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

Table 2.2.27. 1988 ORNL annual effluent summary for Melton Branch (outfall X13)

Parameter	Number of samples	Concentration (mg/L)			Standard error
		Max	Min	Av	
Silver (total)	12	<0.0050	<0.0050	<0.0050	0
Aluminum (total)	12	1.3	0.15	0.50	0.093
Arsenic (total)	12	<0.060	<0.018	<0.045	0.0049
Biochemical oxygen demand	12	<5.0	<5.0	<5.0	0
Cadmium (total)	12	<0.0020	<0.0020	<0.0020	0
Chloroform	12	<0.0050	<0.0050	<0.0050	0
Chlorine (total residual)	52	<0.010	<0.010	<0.010	0
Conductivity (ms/cm)	12	0.80	0.25	0.40	0.049
Chromium (total)	12	0.0086	<0.0036	<0.0056	0.00049
Copper (total)	12	<0.010	<0.0060	<0.0081	0.00058
Oxygen (dissolved)	52	19	3.8	9.5	0.36
Fluoride (total)	12	1.0	<1.0	<1.0	0
Iron (total)	12	1.1	0.14	0.37	0.078
Flow (millions gallons per day)	249	41	0.090	0.80	0.17
Mercury (total)	12	<0.000050	<0.000050	0.000050	0
Manganese (total)	12	0.19	0.068	0.11	0.011
NH_4-N	12	7.2	0.026	0.71	0.59
Nickel (total)	12	0.0081	<0.0036	<0.0050	0.00041
NO_3-N	12	<5.0	<5.0	<5.0	0
Oil and grease	52	9.0	<2.0	<2.8	0.21
Phosphorus (total)	12	1.0	<0.10	<0.33	0.076
Lead (total)	12	<0.0040	<0.0040	<0.0040	0
PCB (total)	12	<0.00050	<0.00050	<0.00050	0
pH (standard units)	12	8.9	6.7	*a*	*a*
Phenols (total)	12	<0.0020	<0.0010	<0.0011	0.000083
Sulfate (as SO_4)	12	34	25	30	0.88
Dissolved solids (total)	12	290	140	200	11
Temperature (°C)	34	30	1.6	15	1.4
Organic carbon (total)	12	6.4	1.9	3.0	0.38
Trichloroethene	12	<0.0050	<0.0050	<0.0050[a]	0
Total suspended solids	12	62	<5.0	<14	4.8
Turbidity (NTU)	12	240	0	48	22
Zinc (total)	12	0.039	<0.0018	<0.015	0.0029
^{60}Co (pCi/L)	12	180	<2.7	<43	15
^{137}Cs (pCi/L)	12	140	−0.27	<18	12
Total rad Sr (pCi/L)	12	410	210	320	15
Tritium (pCi/L)	12	2,700,000	970,000	1,800,000	180,000

[a]Not applicable.

(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 has 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 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 CNF discharges through K-1407-J (Fig. 2.2.5).

Table 2.2.28. ORGDP NPDES permit discharges[a]

Serial discharges	Effluent discharges	Average Flow ($L \times 10^6/d$)	Receiving stream
K-1700	K-1407-B effluent surface runoff once-through cooling	0.83	Poplar Creek
K-1407-B	Steam plant and coal yard Metals cleaning facility Uranium recovery Chemical Process Development Facility Surface runoff TSCA incinerator	0.54	Mitchell Branch
K-901-A	Lime-softening sludges from fire water makeup treatment Surface runoff	0.33	Clinch River
K-1203	Sanitary wastewaters Organic industrial wastewaters	1.5	Poplar Creek
K-1007-B	Potable water from once-through cooling systems Fire water from once-through systems Surface runoff	4.3	Poplar Creek
K-1515-C	Water from sludge and backwash systems associated with the potable water plant Surface runoff	0.45	Clinch River

[a]*Source:* J. L. Kasten, *Resource Management Plan for the Oak Ridge Reservation, Volume 21: Water Conservation Plan for the Oak Ridge Reservation,* ORNL/ESH-1/V21, November 1986.

Table 2.2.21 lists the TN0002950 NPDES permit limits, number of noncompliances, and percentage of compliance for all ORGDP locations. Overall, a 99.8% compliance rate was maintained with the NPDES permit during 1988. Individual parameters are listed by annual values for all ORGDP NPDES locations in Tables 2.2.78 through 2.2.88 in Vol. 2. The wide variety of parameters measured at K-1407-B 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 in there being only three noncompliances during 1988. The noncompliances occurred when the plant was overloaded because of heavy rains.

At the K-901-A discharge point, chromium had one noncompliance. This condition was repeatedly experienced during 1986; however, it is now believed to be under control. Dissolved oxygen was out of compliance three times during the summer months. Since the cascade was shut down, this pond experiences very low flows. The result is stagnated water, which causes dissolved oxygen problems periodically.

It is believed that noncompliances for aluminum at K-1700 and 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 1989.

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

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 toxicity control and monitoring program (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 toxicity control and monitoring program (TCMP). Under the TCMP, treated wastewaters [Central Pollution Control Facility (CPCF), Plating Rinse Water Treatment Facility (PRWTF), and West End Treatment Facility (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. The results of the toxicity tests of wastewaters from three treatment facilities (CPCF, PRWTF, and WETF), five category IV nontreated wastewaters, and one cooling tower are given in Table 2.2.29. This table provides, for each wastewater, the month the test was conducted, the wastewater's NOEC for fathead minnows and *Ceriodaphnia,* and the wastewater's IWC.

The CPCF and PRWTF discharges were each tested once during the year. The wastewater from the CPCF had NOECs for fathead minnows and *Ceriodaphnia* of 25% and 10%, respectively. The wastewater from the PRWTF had a NOEC of ≥25% for both species. For these two wastewaters, the NOECs obtained from the toxicity tests were greater than the respective IWCs (CPCF = 0.27% and PRWTF = 0.85%), indicating that these wastewaters would be unlikely to adversely impact aquatic biota in EFPC. Wastewater from the WETF was tested five times during 1988. This wastewater's NOEC for fathead minnows ranged from ≥15% to ≥30%. The *Ceriodaphnia* were more sensitive to the wastewater than were the fathead minnows, with NOECs ranging from 0.3% to 5%. However, the wastewater's NOEC for *Ceriodaphnia* was lower than the IWC (0.51%) in only one of five tests. Toxicity identification tests with the WETF wastewater showed that salt remaining in the wastewater after treatment, particularly sodium sulfate, would account for nearly all of the toxicity.

The category IV discharges tested included the circuit board rinsewaters, catch basin, overhead still, photographic rinsewaters, and plasma torch rinsewaters. Each of these wastewaters was tested at least once during the year. The circuit board rinsewaters, catch basin wastewater, overhead still

Table 2.2.29. 1988 toxicity test results of Y-12 Plant wastewaters

Discharge facility	Test date (1988)	Fathead minnow NOEC[a] (%)	*Ceriodaphnia* NOEC[a] (%)	Instream waste concentration (%)
Central Pollution Control Facility (outfall 501)	Feb.	25	10	0.27
Plating Rinsewater Treatment Facility (outfall 504)	Feb.	≥25	≥25	0.85
West End Treatment Facility (outfall 502)	Jan.	*b*	2.0	0.51
	March	≥15	0.3	
	April	≥15	3.0	
	April	≥30	3.0	
	Nov.	≥15	5.0	
Circuit board rinsewaters (category IV)	Jan.	≥10	≥10	0.0022
	Nov.	20	*c*	
	Dec.	25	25	
Catch basin (category IV)	Sept.	10	*c*	0.19
	Oct.	*b*	25	
Overhead still (category IV)	Aug.	20	10	0.52
Photographic rinsewaters (category IV)	May	1	1	0.28
	July	0.01	0.03	
	July	<0.3	0.03	
Plasma torch rinsewaters (category IV)	March	*b*	≥30	0.00047
	Oct.	*b*	≥30	
Cooling tower 9409-13	Aug.	100	20	5.4

[a]NOEC = no-observed-effect concentration; a ≥ indicates that there was no adverse effect on the animal at the highest concentration tested.

[b]Not tested.

[c]Unacceptable test due to low fecundity of animals in the control.

wastewater, and plasma torch rinsewaters had NOECs for fathead minnows and *Ceriodaphnia* ranging from 10% to ≥30%. The IWCs for each of these wastewaters is considerably lower than the NOECs obtained from the toxicity tests, indicating that these wastewaters would not adversely impact the aquatic biota of EFPC. The photographic rinsewater's NOEC for fathead minnows and *Ceriodaphnia* ranged from ≤0.3 to 1%, and 0.03 to 1%, respectively. The low NOEC (compared to the IWC of 0.28%) suggests that this wastewater could affect the aquatic biota in EFPC. Toxicity identification tests showed that when the silver was removed from the wastewater by ion exchange, toxicity declined. In two toxicity tests with photographic rinsewaters treated using ion exchange, the NOECs for fathead minnows and *Ceriodaphnia* ranged from 10% to 40%.

Cooling tower 9409-13 wastewater was tested once during the year. The wastewater's NOECs for

fathead minnows and *Ceriodaphnia* were 100% and 20%, respectively. These values are much higher than the average annual IWC (5.4%) for all Y-12 Plant cooling towers. In addition, some of the toxicity to *Ceriodaphnia* may have been caused by elevated concentrations of total residual chlorine, which degrades rapidly in the presence of sunlight, oxygen, and oxidizable organic material. Chlorine is used in cooling tower operation to prevent the growth of microbiota that can damage the interior surfaces of heat exchangers.

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 sewage treatment plant (STP), the process waste treatment plant (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

Table 2.2.30. 1988 toxicity test results of ORNL wastewaters and ambient waters

ORNL outfall	Test date (1988)	Fathead minnow NOEC[a] (%)	*Ceriodaphnia* NOEC[a] (%)	Instream waste concentration (%)
Coal Yard	Jan.	80	25	3.6
Runoff	March	100	≥60	
Treatment	July	60	15	
Facility (X02)	Sept.	100	*b*	
Process Waste	Jan.	80	80	21.9
Treatment	March	80	80	
Plant (X07)	June	80	80[c]	
	Oct.	80	*b*	
Sewage	Feb.	<75	<75	25.7
Treatment	June	100	100	
Plant (X01)	Dec.	<80	<80	
Melton Branch	Jan.	100	100	*d*
(X13)	Feb.	100	100	
	April	100	100	
	June	100	100	
	Aug.	100	100	
White Oak	Jan.	100	100	*d*
Creek (X14)	Feb.	100	100	
	April	100	100	
	June	100	100	
	Aug.	100	100	

[a]NOEC = no-observed-effect concentration.

[b]Unacceptable test due to low fecundity of animals in the control.

[c]Based on survival only. Fecundity comparisons could not be made because of the high proportion of males in the test.

[d]Not applicable.

Ceriodaphnia. Average water quality measurements obtained during each toxicity test are shown in Table 2.2.31.

The PWTF and CYRTF effluents were each tested four times during the year, while the STP was tested three times. After March, with authorization from the TDHE, testing of these wastewaters was reduced to a frequency of twice per year. The PWTP wastewater's NOEC for fathead minnows and *Ceriodaphnia* was consistently 80%. Because the NOEC is nearly four 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 NOECs for fathead minnows and *Ceriodaphnia* ranging from 60 to 100% and 15 to ≥60%, respectively. Although this wastewater is more toxic than 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 at full strength during one test. Although the remaining tests during the year did not provide a definitive NOEC, it is highly unlikely that the wastewater would be toxic to fathead minnows or *Ceriodaphnia* at a concentration equal to the IWC (25%). During 1987, for example, the average NOECs of the STP wastewater for fathead minnows and *Ceriodaphnia* were 100% and 63%, respectively.

The two ambient waters were not toxic to fathead minnows or *Ceriodaphnia*. These two sites were tested five times in 1988 to evaluate area-source contributions to ambient toxicity. A complete summary of survival and reproduction of *Ceriodaphnia* and of survival and growth of

Table 2.2.31. 1988 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 (1988)	pH (units)	Conductivity (μS/cm)	Alkalinity (mg/L)	Hardness (mg/L)
Coal Yard Runoff Treatment Facility (X02)	Jan.	6.8	1700	5.9	1006
	March	7.2	1800	9.3	960
	July	7.6	2500	21	2010
	Sept.	7.3	2600	13	1500
Process Waste Treatment Plant (X07)	Jan.	7.4	670	40	3.7
	March	7.8	660	59	4.2
	June	7.6	840	54	0.6
	Oct.	7.9	680	61	0.1
Sewage Treatment Plant (X01)	Feb.	7.7	480	88	170
	June	7.8	450	82	160
	Oct.	7.8	460	104	180
Melton Branch (X13)	Jan.	8.0	320	98	150
	Feb.	8.0	320	110	150
	April	8.0	320	130	160
	June	8.0	360	140	170
	Aug.	8.0	340	130	160
White Oak Creek (X14)	Jan.	8.1	409	110	140
	Feb.	8.08	410	109	170
	April	8.06	340	120	150
	June	8.08	401	110	160
	Aug.	8.09	390	110	170

fathead minnows in the ambient waters of WOC and its tributaries is published in the *Third Annual Report on the ORNL Biological Monitoring and Abatement Program* (Loar 1989).

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-B pond is evaluated for toxicity. Because the closure of the K-1407-B pond was scheduled for 1988, wastewater discharged from the K-1407-E and K-1407-F ponds and K-1407-J were also 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-B and K-1407-E/F 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-B pond was tested five times during the year. After October, closing procedures curtailed the toxicity testing. The wastewater from K-1407-B had a NOEC for fathead minnows and *Ceriodaphnia* of <100% once during the year (October). During all other tests, the NOEC for both species was 100%. The wastewater from the K-1407-E/F pond was tested six times during the year. The lowest NOEC was measured in January when the pH was atypically low. During the remainder of the year the NOEC for the two species ranged from <50 to 100% but was usually 100%. Because these wastewaters would have an IWC of 100% only during the driest times of the year, under normal-to-high flow conditions they would be unlikely to adversely affect aquatic biota in Mitchell Branch.

2.2.2.4 Mercury assessment of ORNL streams

An assessment plan was implemented during 1988 to comply with the CWA and the mandates of the NPDES permit. The key objectives of the plan were to identify, locate, and minimize all sources of mercury contamination in ORNL discharges to the aquatic environment.

The initial goal was to locate sources of mercury from past operations and spills through a review of file records and interviews with personnel familiar with those data. Routine water monitoring data were also scrutinized for evidence of elevated

Table 2.2.32. 1988 toxicity test results of the ORGDP wastewaters

ORGDP outfall	Test date (1988)	Fathead minnow NOEC[a] (%)	*Ceriodaphnia* NOEC[a] (%)
K-1407-B	Feb.	100	100
	April	100	100
	June	100	100
	Aug.	100	100
	Oct.	100	50
K-1407-E/F	Jan.	40	50
	April	100	100
	June	100	100
	Aug.	100	100
	Oct.	100	<50
	Dec.	100	50

[a]NOEC = no-observed-effect concentration.

Table 2.2.33. 1988 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 (1988)	pH (units)	Conductivity (μS/cm)	Alkalinity (mg/L)	Hardness (mg/L)
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

mercury concentrations. This provided the basis to design a monitoring network, focusing on the discharge pipes and NPDES monitoring stations most likely to reveal sources of mercury. A total of 90 locations were considered to have potential for mercury releases. The locations of these sites are depicted in Figs. 2.2.9 and 2.2.10. Water samples were collected during periods of soil moisture recharge (February) and soil moisture deficit (October).

The major uses of mercury at ORNL involved pilot plant operations during 1954 and 1955 in support of the thermonuclear weapons program at the Y-12 Plant. The activities involved separation processes in Buildings 4501 and 4505. One major use of mercury at ORNL was in the OREX operation, which was designed to separate lithium isotopes and was located in the basement of Building 4501 in 1954. The lithium was amalgamated, pressed into billets, sintered, and the mercury was then removed by vacuum distillation, leaving the lithium. The basement floor was of concrete construction with tar seams, and it was flooded with 10 cm (~4 in.) of water. The water layer was intended to reduce mercury fumes in the work environment. A steel grate above the water supported personnel and equipment. The condensed mercury was pumped to a tank truck and transferred to Building 3592 for cleaning and recycle. Past soil analyses around Building 4501 confirm that mercury has escaped the building area. It has been estimated that an excess of 23,000 kg (50,000 lb) of mercury may have been lost during the process.

The second major use of mercury at ORNL involved the METALLEX process. METALLEX was designed in 1955 to demonstrate the production of uranium and thorium metals by reducing UCl_4 and $ThCl_4$ using a sodium amalgam. This activity occurred in Building 4505. The amalgam was pressed to form a billet that was sintered to remove the mercury by vacuum distillation, leaving the uranium and thorium metals. An early report indicated that as much as 130,000 kg (300,000 lb) of mercury were required for the process. It has been estimated that in excess of 2000 kg (4400 lb) may have been lost in spills. Soil analyses around Building 4505 confirm the presence of mercury contamination.

In a planning study in 1987, 220 samples were analyzed from 71 locations. A summary of the mercury concentrations at these locations is given in Table 2.2.84 in Vol. 2. Three areas were identified through water chemistry data as areas of mercury contamination. These included outfall 309 (Fig. 2.2.9), which discharged wastes from the

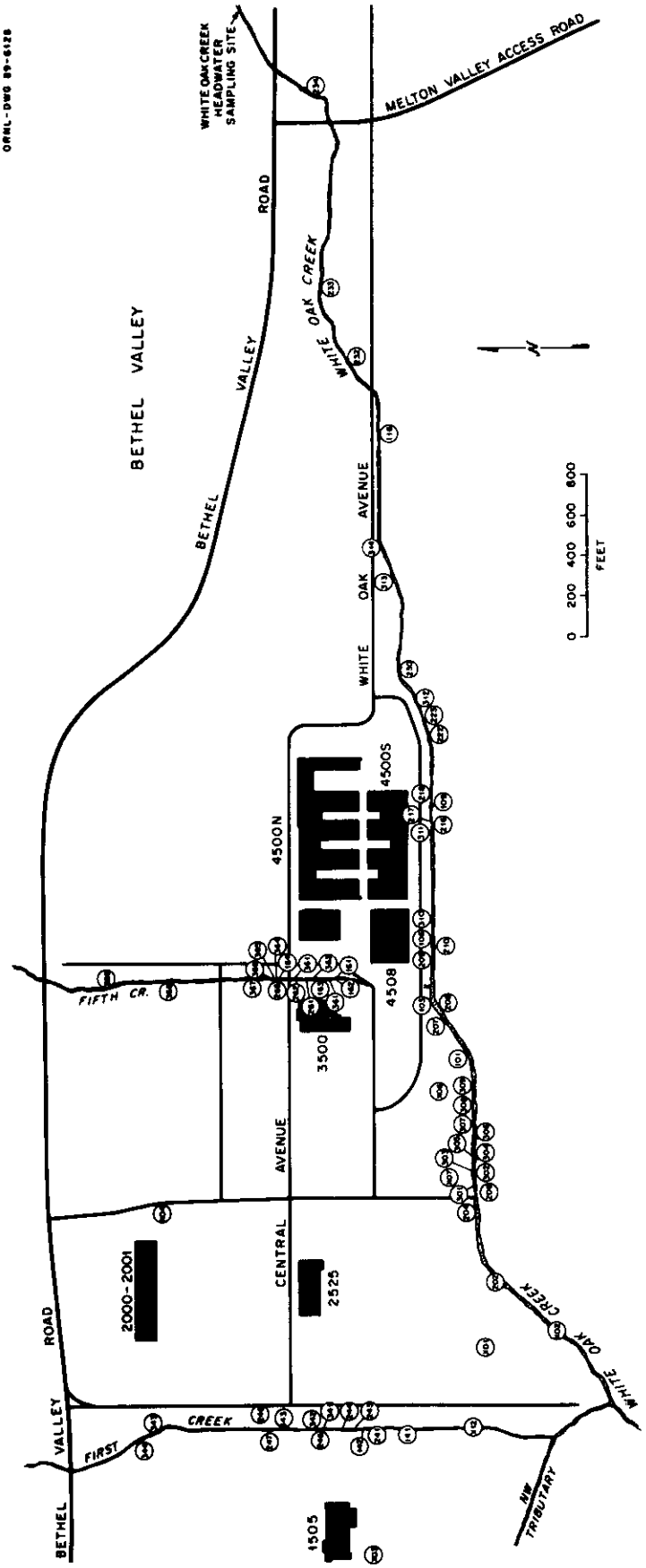

Fig. 2.2.9. Map of sampling locations in the ORNL area. The circled numbers show the sample locations.

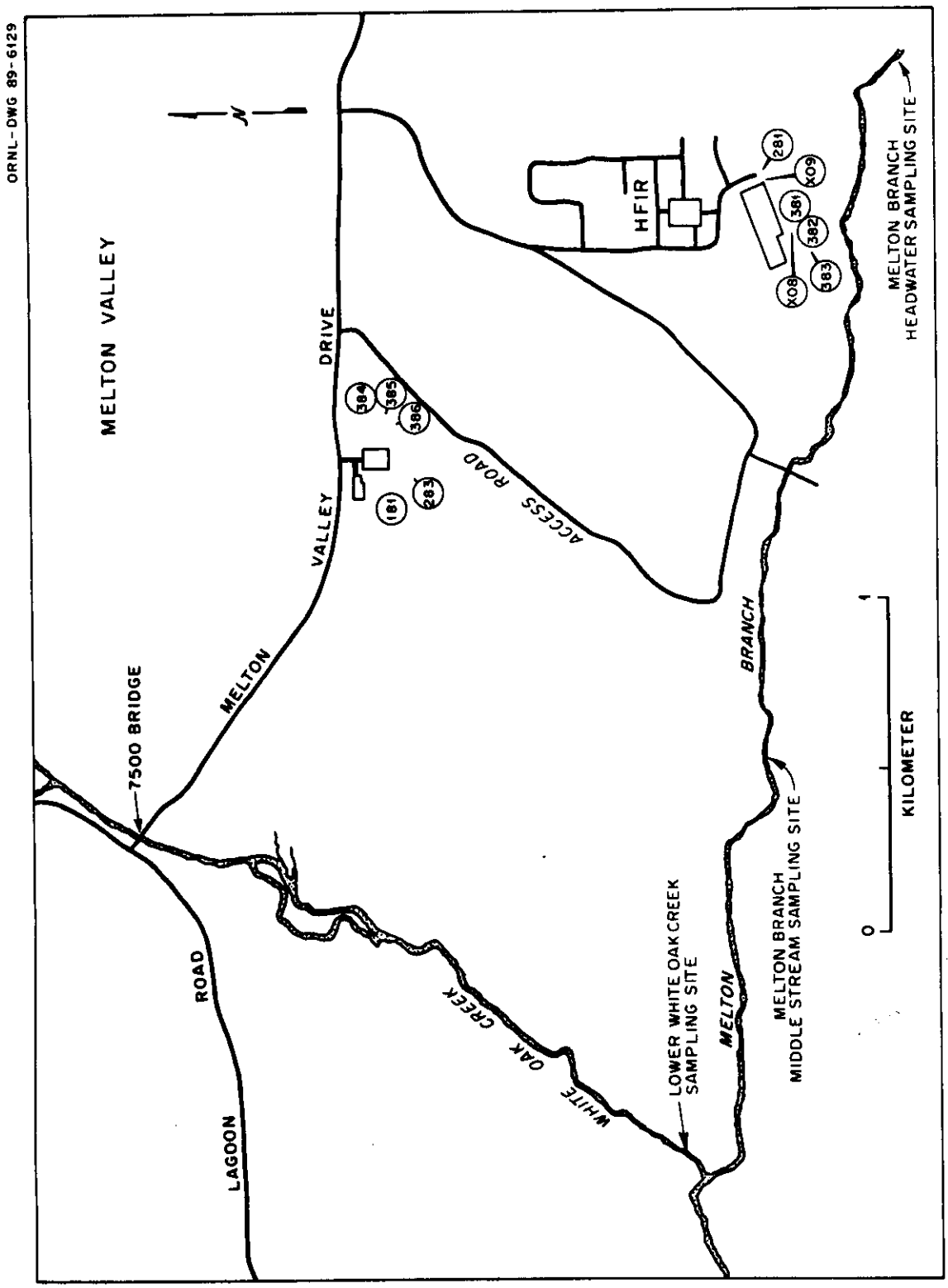

Fig. 2.2.10. Map of sampling stations in the ORNL Melton Valley complex. The circled numbers show the sample locations.

4500-S Research Complex through holding basins 3539 and 3540, and outfall 261 and NPDES monitoring station X06. Outfall 309 discharges directly into WOC and had a mean concentration of 2.3 ± 0.38 ppb, while outfall 261 along Fifth Creek had an average concentration of 4.8 ± 0.18 ppb. The X06 NPDES station (Fig. 2.2.8) had a mean concentration of 0.73 ± 0.03 ppb. Station X06 is the NPDES dedicated monitoring station before discharge through outfall 309.

In February 1988, 61 stations representing 183 samples were analyzed for mercury contamination. The highest concentration was 2.1 ± 0.06 ppb from outfall 309. In October 1988, 88 locations representing 264 samples were analyzed for mercury. During this period, outfall 367 (isotopes area storage and service building 3036) had the maximum concentration of 1.87 ± 0.17 ppb.

The maximum, minimum, and average values and standard errors of the mean for the period of January through December 1988 are shown on Table 2.2.105 of Vol. 2. The EPA primary drinking water regulatory limit for mercury is 2.0 μg/L (ppb). The average value's percentage of this limit is also shown on the Vol. 2 table. As previously indicated, the table shows that outfalls 309 and 367 contained the highest concentrations of mercury during 1988.

Based on the water chemistry data, 12 sites were selected for mercury analyses in sediments. The locations and concentration data for ORNL streams are illustrated in Fig. 2.2.11. The sediment concentrations for mercury ranged from background (0.13 ± 0.02 μg/g) in the WOC headwaters to a maximum of 4900 ± 2600 μg/g below outfall 261 along Fifth Creek. While some concentrations appear to be excessive, note that the potential source plume is small. For example, the

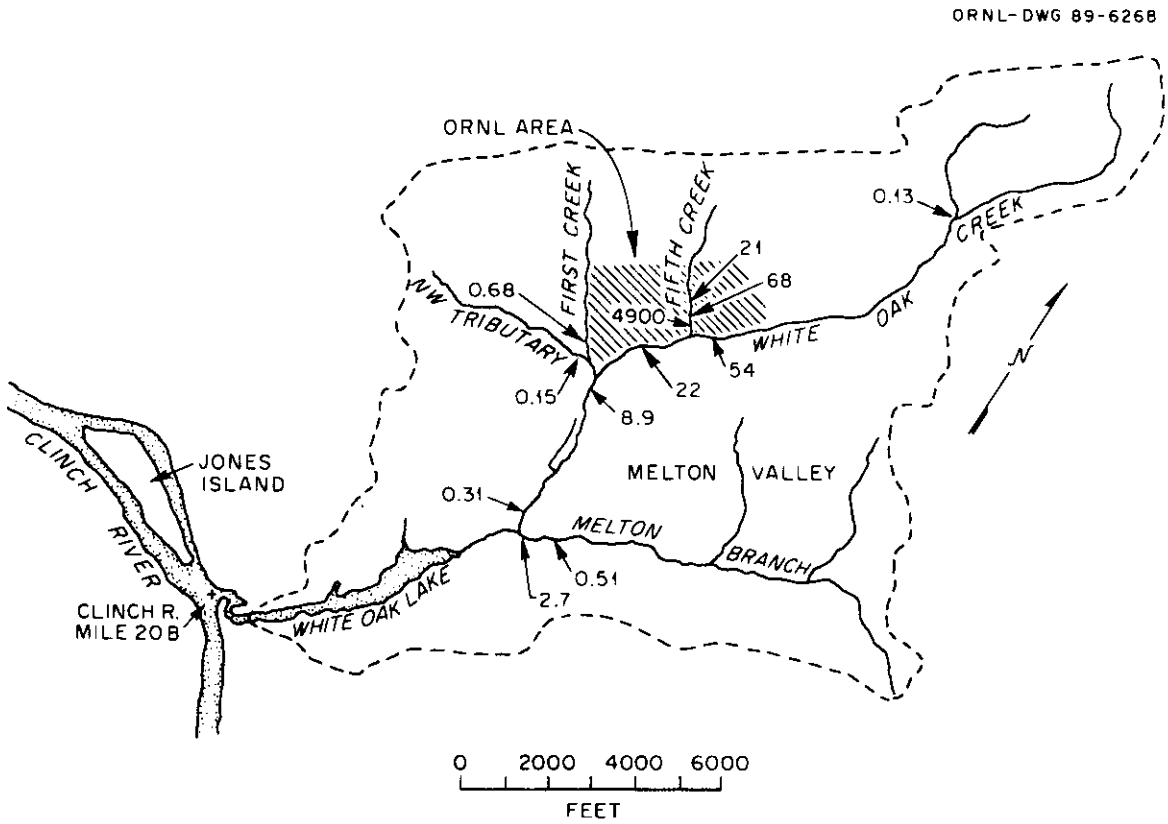

Fig. 2.2.11. Map depicting excess mercury concentrations (μg/g) in sediments in ORNL streams.

sediment plume at outfall 261 into Fifth Creek is restricted to an area 0.2 m (8 in.) wide for a length of 1 m (39.6 in.) and a depth of 0.05 m (2 in.). If a sediment bulk density of 1.4 is assumed, the maximum estimated total mercury present is 68 gm.

The water chemistry data are supported by the sediment data in identifying sources of mercury in ORNL streams. The sediment analyses thus far indicate surface [0 to 5 cm (0 to 2 in.)] contamination only.

2.2.2.5 Polychlorinated biphenyls in the aquatic environment

Water and sediment samples were collected during May and October 1988 from various locations along WOC, Melton Branch (MB), and the Clinch River (CR) to determine PCB concentrations in these areas (see Fig. 2.2.12). A total of nine sites was sampled; four on WOC (including one at White Oak Dam), one on Melton Branch, and four on the Clinch River. Two

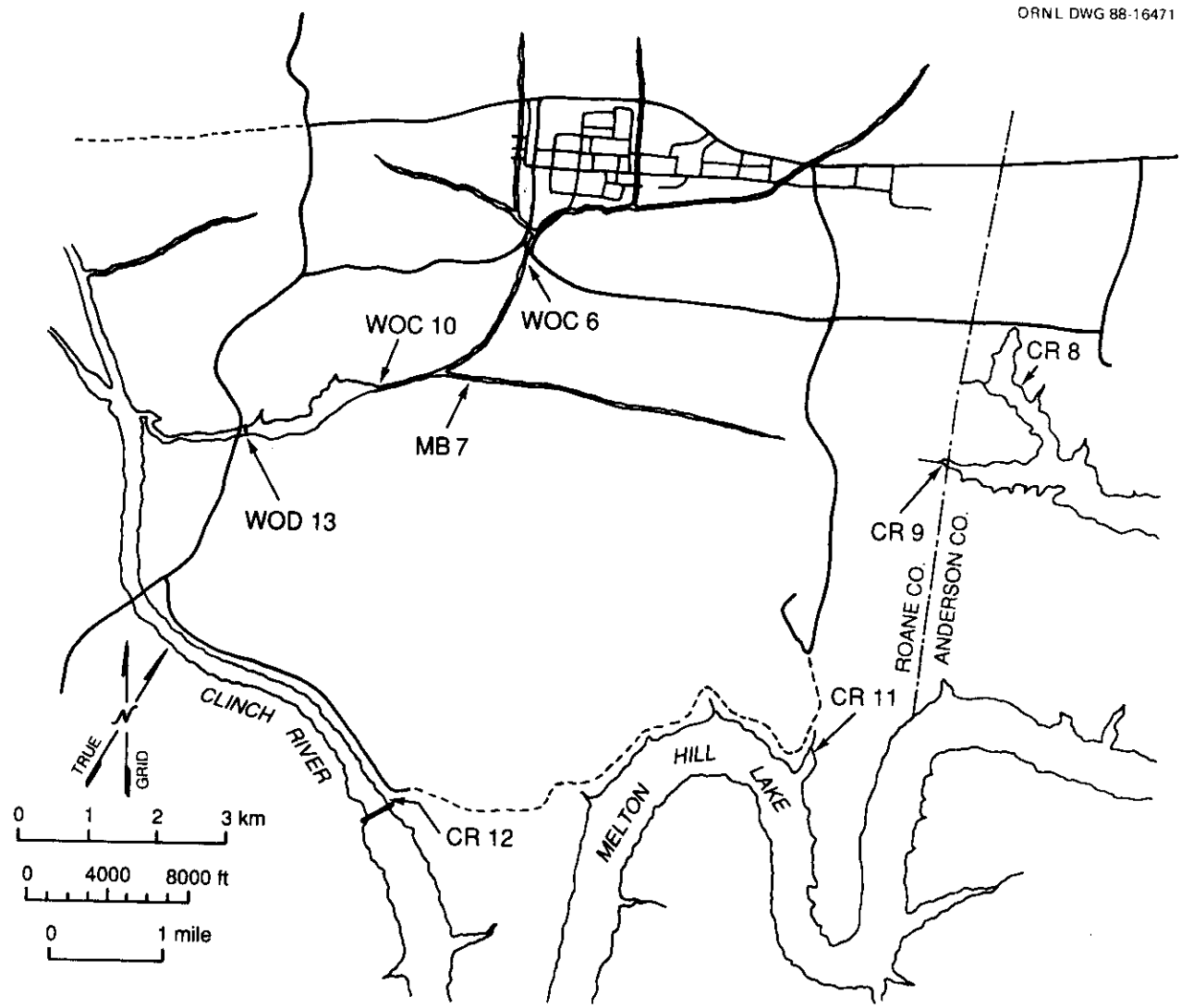

Fig. 2.2.12. Map depicting PCB sampling locations.

samples per site were taken in May 1988, and two more samples per site were taken in October. This was done to comply with the Clean Water Act (CWA) and is an integral part of ORNL's NPDES activities. Sediment samples were collected and analyzed in addition to water because PCBs are relatively insoluble in water and tend to accumulate in stream sediments. Water sampling is being performed quarterly, and sediment sampling is being performed semiannually.

Water from building areas containing either equipment or storage drums with PCB concentrations >500 ppm was sampled at five locations along the Northwest Tributary (NWT) and WOC. In addition, water samples were taken on MB, White Oak Lake (WOL) near WOD, and the CR. Sediment samples were taken from WOC, MB, WOD, and the CR.

There are currently no regulatory guidelines for PCB concentrations in water or stream sediment. The results from these samples will be used to help detect sources of PCB contamination and provide an overview of PCB concentrations in the ORNL area.

The concentrations of PCBs (by aroclor) in water during 1988 were below the analytical detection limit at all sampling sites. The 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.

Table 2.2.34 contains a summary over all stations of the sediment sample results for each aroclor. The concentrations of each aroclor at each sediment-sampling location are presented in Table 2.5.11 of Vol. 2. All samples except those taken at WOC 6, WOC 10, and WOD 13 had results below their detection limits. PCB aroclor 1254 is the only aroclor that is detected at these locations. The data suggest that the source of PCB contamination is primarily from locations originating at ORNL buildings. WOC 6, which is the closest to ORNL buildings, shows the highest average concentration of PCB aroclor 1254 (approximately 3300 μg/kg). This value decreases as the sampling location gets farther from ORNL. WOC 10, which is farther downstream, shows an average concentration of PCB aroclor 1254 of approximately 910 μg/kg. WOD 13, which is the farthest downstream of the three locations, shows an approximate average concentration of 190 μg/kg. Each of these concentrations are estimated concentrations. Some of the sample results contained in the average values were below the quantitative detection limit for PCB aroclor 1254, but are reported because the presence of this compound was detected.

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

Table 2.2.34. Summary of PCB concentrations in sediment, May through October 1988[a]

Analysis	Number of samples	Concentration (μg/kg)			
		Max	Min	Av	Standard error
PCB-1016	36	<910	<80	<190	29
PCB-1221	36	<910	<80	<190	29
PCB-1232	36	<910	<80	<190	29
PCB-1242	36	<910	<80	<210	33
PCB-1248	36	3000	<80	<330	110
PCB-1254	36	7800	~19	~690	250
PCB-1260	36	2500	<160	<480	89

[a]See Fig. 2.2.9.

Congress mandating that actions be taken to preserve water resources from contamination. These statutes have been codified into regulations by the Environmental Protection Agency (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 Resource Conservation and Recovery Act (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 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 or postclosure permit application to the regulatory authority. Final disposition of Part B permit applications for all land disposal facilities was required by November 8, 1988. 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. Sites on the ORR previously administered under CERCLA are now considered 3004(u) facilities. There are no specific requirements in the regulations which define the groundwater monitoring requirements for 3004(u) facilities; instead, the 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 potential for contamination, groundwater monitoring would be necessary to evaluate that

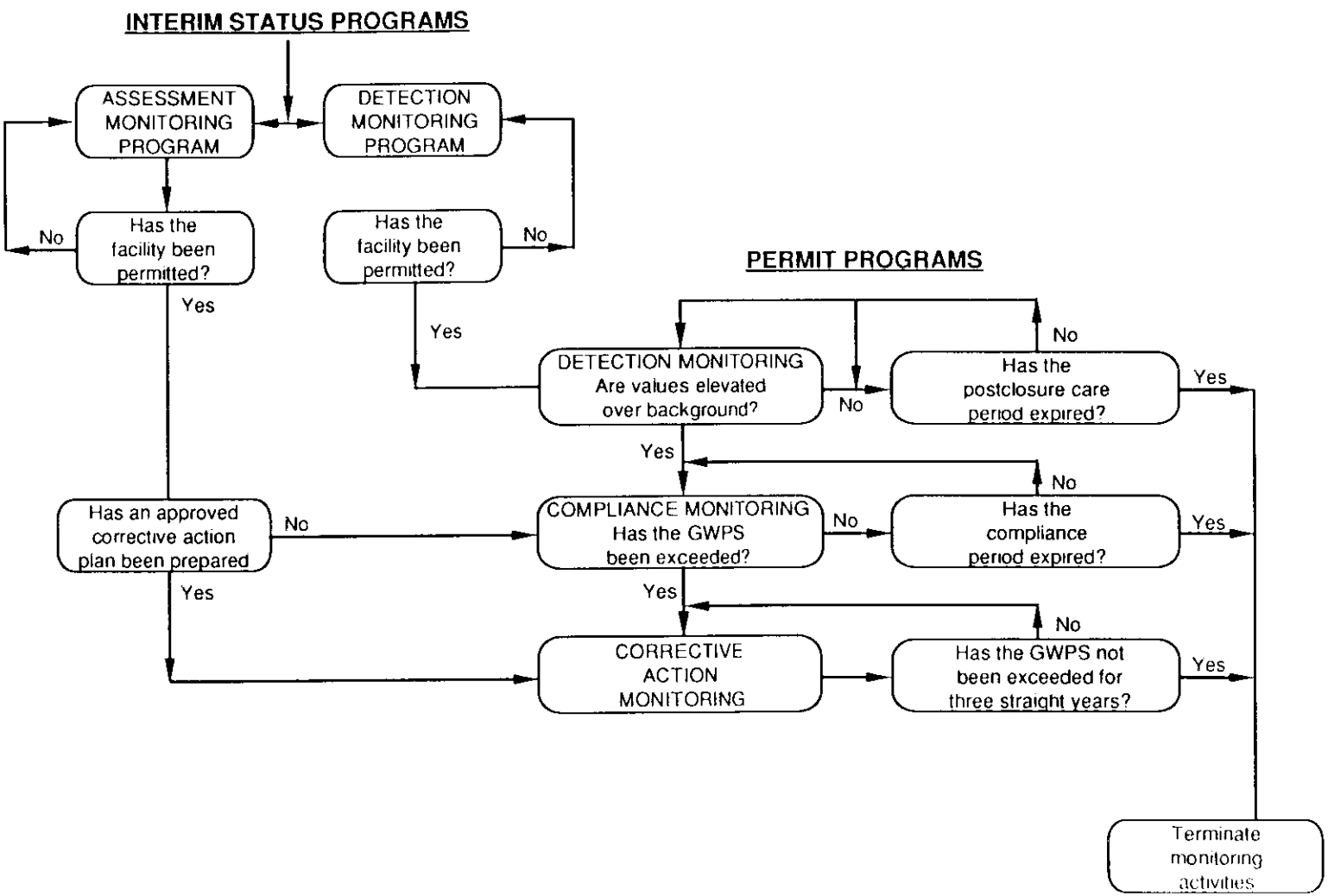

Fig. 2.3.1. Relationship between interim status monitoring and permit monitoring programs.

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 determine 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 potential 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 almost 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. 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, 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 and 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 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. However, the dominant openings for lateral groundwater flow and vertical drainage are

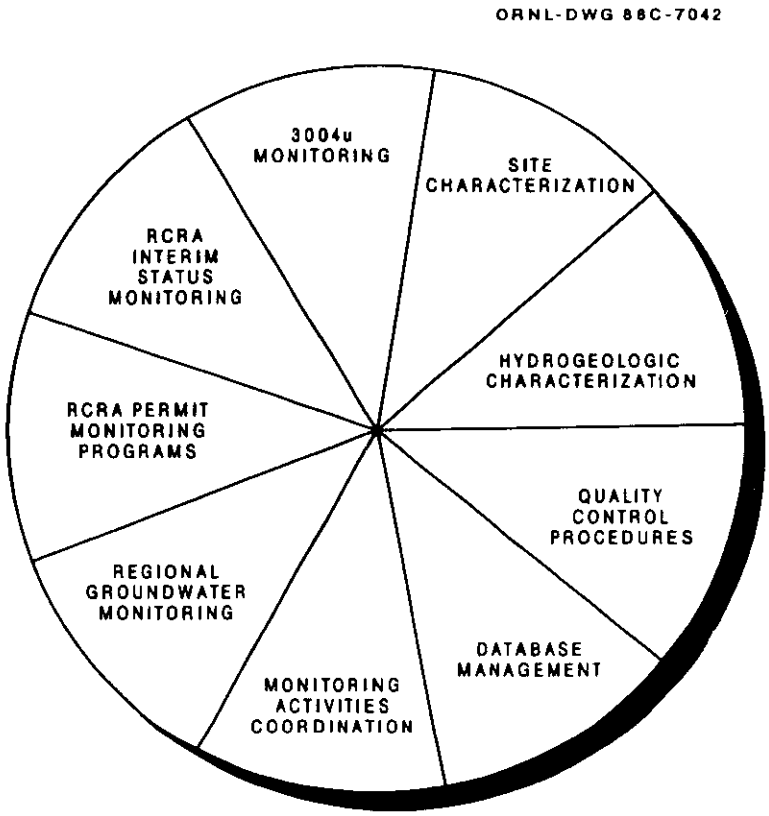

Fig. 2.3.2. Components of Oak Ridge Reservation groundwater surveillance program.

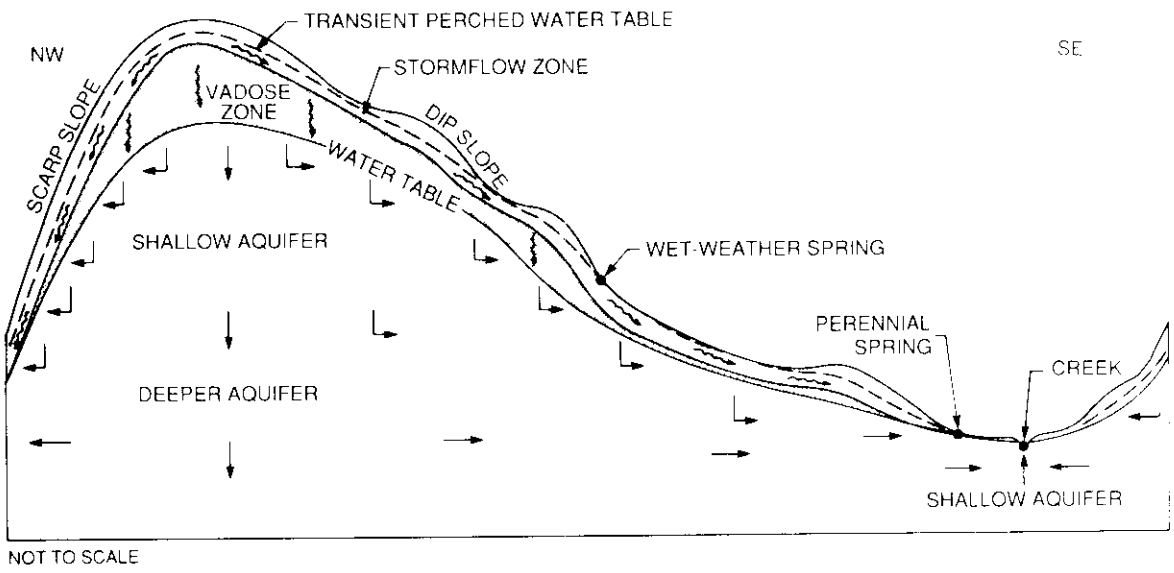

Fig. 2.3.3. Occurrence and flow of groundwater on the Oak Ridge Reservation.

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 (1.6 in./d) for the water-producing intervals but is only 0.00044 m/d (0.01732 in./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 relative 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 (0.4 in./d to 39.4 in./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 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 4 times larger in the Knox Group than in the Rome Formation, the Conasauga Group, and the Chickamauga Group. Based on a relatively few data, cavities below the water table have a geometric mean of 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 easily be determined, 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 locations at 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 of 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 above applicable standards are shown in this report. Tables in Sect. 2.3 of Vol. 2 outline the applicable standards and depict levels of parameters found in groundwater that are above 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 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 1988 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 2.3.1 in Vol. 2 of this report. During 1988, 151 wells were routinely sampled. Figure 2.3.4 shows 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 1988: 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 1988. 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 site-specific groundwater quality assessment reports (GWQAR). The assessment monitoring will continue on a quarterly basis until a post closure permit is obtained for the respective facility.

S-3 Ponds. The S-3 Ponds, constructed in 1951 adjacent to the west end of the Y-12 Plant, consist of four unlined impoundments covering an area of roughly 122 m by 122 m (400 ft by 400 ft). The original pond excavations penetrated residual soil and fill materials but did not extend down to bedrock. The ponds are approximately 5 m (17 ft) deep and contain 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

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

Unit name	Regulatory status	Current groundwater monitoring program							Parameters monitored[a]	Monitor wells	Sampling frequency	Comments
		Interim status		Permit								
		Detection	Assessment	Detection	Compliance	Corrective action	Operating	3004(u)				
Bear Creek Burial Grounds	RCRA	1985	1986	*b*				*b*	1, 2, 3, 4, 5, 6, 7, 8, 10,11	37	Quarterly	
LLWDDD lysimeter demonstration site									2, 3, 4, 5, 6, 8, 10,11	2	Quarterly	
LLWDDD packaging site									2, 3, 4, 5, 6, 8, 10,11	4	Quarterly	
Beta-4 Security Pits	3004(u)	*b*		*b*				1985	2, 3, 4, 10, 11	6	Semiannually	*c*
Chestnut Ridge Security Pits	RCRA	1985	1988	*b*				*b*	3, 4, 5, 6, 7, 10,11	11	Quarterly	
Chestnut Ridge Sediment Disposal Basin	RCRA	1985		*b*				*b*	2, 3, 4, 5, 6, 7, 10,11	8	Quarterly	
East Chestnut Ridge Waste Pile	RCRA	*b*					1988	*b*	2, 3, 4, 5, 6, 8, 10,11	5	Quarterly	
Filled Coal Ash Pond	3004(u)	*b*		*b*					12, 3, 4, 5, 6, 8, 10,11	3	Quarterly	
Industrial Landfill III	3004(u)	*b*		*b*				1988	2, 3, 4, 5, 6, 8, 10,11	7	Quarterly	
Industrial Landfill IV	3004(u)	*b*		*b*				1988	2, 3, 4, 5, 6, 8, 10,11	5	Quarterly	
Kerr Hollow Quarry	RCRA	1985		*b*				*b*	NA 2, 3, 4, 10 11	7	Quarterly	
New Hope Pond site	RCRA[d]	1985	1988	*b*				*b*	3, 4, 5, 6, 7, 10,11	17	Quarterly	
Oil Landfarm Area	RCRA	1985	1986	*b*				*b*	3, 4, 5, 6, 7, 10,11	26	Quarterly	
Ravine Disposal Site	3004(u)	*b*		*b*				1985	2, 3, 4, 10, 11	5	Semiannually	*c*
Rogers Quarry	3004(u)	*b*		*b*				1985	2, 3, 4, 5, 6, 8, 10,11	6	Semiannually	*c*

Table 2.3.1 (continued)

Unit name	Regulatory status	Current groundwater monitoring program							Parameters monitored[a]	Monitor wells	Sampling frequency	Comments
		Interim status		Permit								
		Detection	Assessment	Detection	Compliance	Corrective action	Operating	3004(u)				
Rust Spoil Area	3004(u)	*b*		*b*				1987	2, 3, 4, 5, 6, 8, 10,11	7	Quarterly	
S-3 Site Waste Management Area												
S-3 Ponds	RCRA	1985	1986	*b*				*b*	1, 2, 3, 4, 5, 6, 7, 8, 9, 10,11	33	Quarterly	
Salvage Yard	RCRA			*b*				*b*	2, 3, 4, 5, 6, 7, 9, 10, 11	6		
Salvage Yard/OSDS	3004(u)	*b*		*b*				1985	2, 3, 4, 5,	10	Quarterly	*c*
S-2 Site	3004(u)	*b*		*b*				1986	2, 3, 4, 5, 6, 7, 9, 10, 11	2	Semiannually	
Spoil Area I	3004(u)	*b*		*b*				1987	2, 3, 4, 5, 6, 8, 10,11	6	Quarterly	
United Nuclear Corporation Landfill	3004(u)	*b*		*b*				1985	2, 3, 4, 6,	5	Quarterly	

[a]See the following tables for parameters monitored.

1. Primary drinking water parameters (Table 2.3.2 in Vol. 2).
2. Parameters establishing groundwater quality (Table 2.3.3 in Vol. 2).
3. Indicator parameters (Table 2.3.4 in Vol. 2).
4. Metals analyzed by inductively coupled argon plasma (Table 2.3.5 in Vol. 2).
5. Metals analyzed by atomic absorption spectroscopy (Table 2.3.6 in Vol. 2).
6. Anions (Table 2.3.7 in Vol. 2).
7. Volatile organics (Table 2.3.8 in Vol. 2).
8. Pesticides and PCBs (Table 2.3.9 in Vol. 2).
9. Acid-base/neutral extractable organics (Table 2.3.10 in Vol. 2).
10. Radionuclides and radioactive metals (Table 2.3.11 in Vol. 2).
11. Other parameters (Table 2.3.12 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 groundwater analyses during 1988

Analytical procedure	Number of samples run	Number of items reported
Elemental analyses		
ICAP	1,431	33,583
AAS	1,333	7,419
Hg	972	972
U	1,432	1,432
Inorganic analyses	744	6,002
Phenols	312	312
Organics		
Volatile	504	17,513
Acid/base-neutral	30	1,950
Herbicides, pesticides, and PCBs	194	5,640
Field measurements	743	3,643
Lab replicates		
Conductivity and pH	760	6,017
TOC and TOX	366	2,859
Radiochemical Analyses		
Gross alpha and beta	665	1,330
Radium	499	499
Alpha emitters	46	304
Beta emitters	109	1,295
Total	9,828	90,458

Table 2.3.3. Y-12 Plant sites submitted for RFI plans for 1988

Solid waste management units	Site designation	Groundwater monitoring
Beta-4 Tanks	S217/S-218	*a*
Plating Shop Container Areas	S-334/S-351	*a*
Sanitary Landfill II	D-102	yes
Tank 2101-U	S-210	*a*
Filled Coal Ash Pond	D-112	yes
Building 81-10 area	S-117	yes
Coal Pile Trench	D-104	yes
Tank 2104-U	S-212	*a*
Tank 2116-U	S-214	*a*
Bear Creek	*b*	no

[a]In these plans, preliminary soil sampling will be performed. The final judgment on whether groundwater will be monitored at these sites will be based on the results of the analyses of the soil samples taken at the site.

[b]Not applicable.

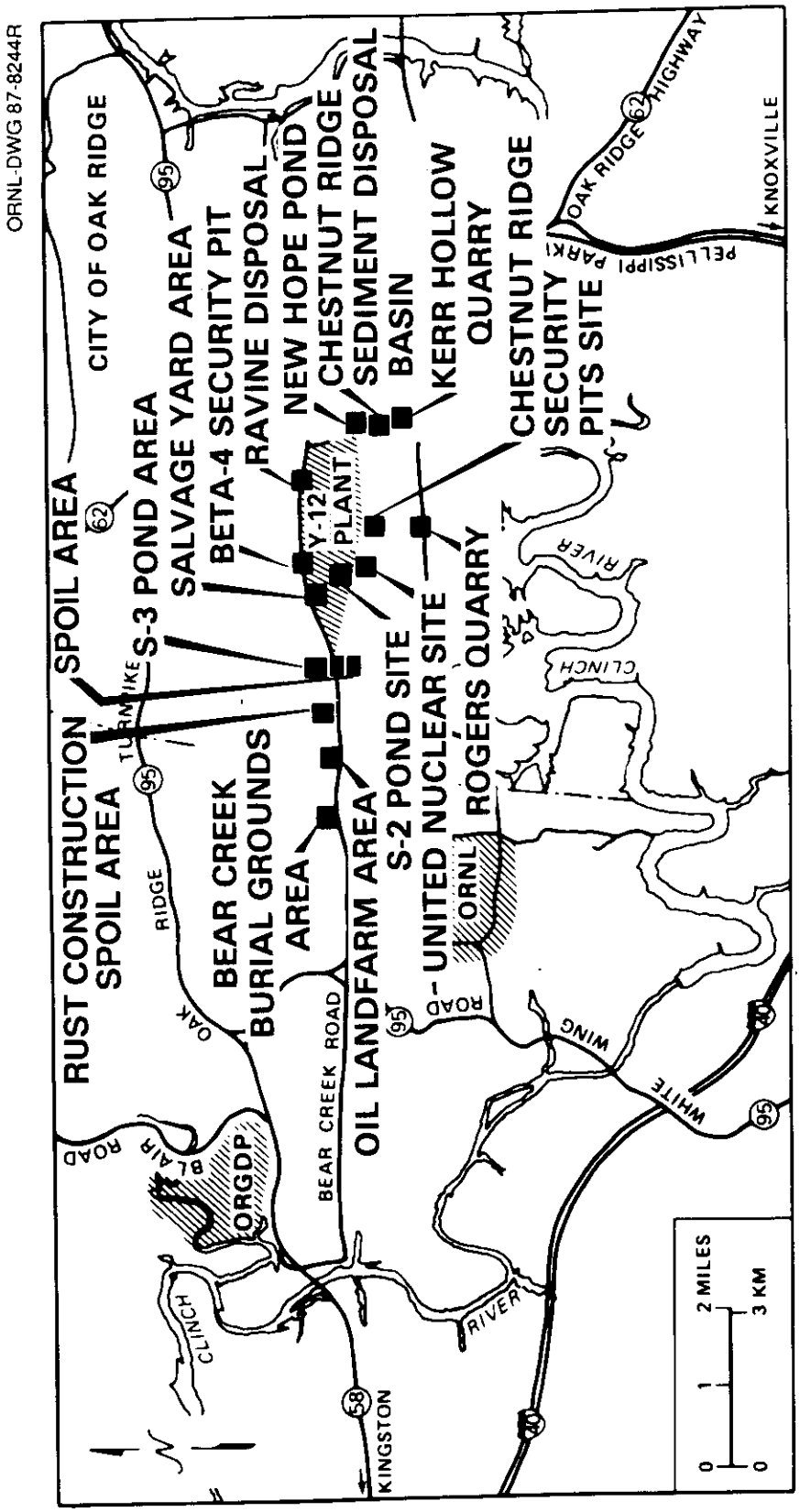

Fig. 2.3.4. Index map of Y-12 Plant comprehensive groundwater characterization program by sites.

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.

Results of water-quality analyses for water samples collected from the S-3 WMA assessment wells during the four quarters of 1988 confirm the presence of nitrate, trace metals, VOCs, uranium, and radioactivity in groundwater. The highest concentrations of these contaminants generally were detected in samples from wells within 500 ft to the northeast, south, and southwest of the site. Elevated levels of each category of contaminant were detected in wells screened in the unconsolidated zone and in the bedrock zone at depths of 150 ft in the Nolichucky and the Maynardville.

Nitrate is the most widespread groundwater contaminant at the S-3 WMA. Concentrations exceeding 1000 mg/L (as N) were detected in water samples from wells located within 500 ft of the site. Nitrate concentrations above the EPA drinking-water standard of 10 mg/L (as N) were measured in samples collected from wells as far as 3000 ft southwest of the site. The vertical extent of the plume lies between 150 ft and 500 ft and may be determined more accurately by the installation of proposed wells.

Barium and cadmium were the principal metals in groundwater at the S-3 WMA. The distribution of metals generally is related to the pH of the groundwater; the pH of samples with high metals concentrations typically ranged between 3.4 and 6.0. Samples with low pH values and elevated metals concentrations were collected from wells screened in the unconsolidated zone and up to 150 ft deep in the Nolichucky. The pH of samples from wells screened below 500 ft in the Nolichucky were found to range from 9.3 to 10.0. Correspondingly, trace metal concentrations in these wells did not exceed background concentrations.

Concentrations of uranium above 0.01 mg/L were detected in groundwater at the S-3 WMA. The distribution of uranium, like that of the trace metals, is related to the pH of the groundwater. High concentrations of uranium generally were detected in low-pH water sampled from wells screened in the upper 150 ft of the Nolichucky.

Review of the VOC results indicates that at least two sources of VOC constituents are present at the S-3 WMA. The S-3 Site is most likely a source of tetrachloroethene, as indicated by the high concentrations in water samples from wells adjacent to the site. However, high concentrations of carbon tetrachloride and low concentrations of tetrachloroethene in wells just west of the interim drum yard suggest the presence of another source. The Rust Spoil Area may be a third source of contamination, affecting the water quality of assessment well GW-64.

Efforts to identify the primary alpha- and beta-emitting radionuclides in the groundwater and to determine compliance with dose-equivalent regulations were not completed for reasons discussed in Section 2.3. A revised radiochemical program (Sect. 5) will be implemented in 1989 to achieve these goals.

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 1988 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. Other VOCs of concern at the site include 1,1-dichloroethane, carbon tetrachloride, trans-1,2-dichloroethene, and trichloroethene. The presence of fluorotrichloromethane at the CRSP is currently unconfirmed and requires additional sampling and analysis. Only isolated occurrences of other potential contaminants (i.e., beryllium, lead, cadmium, chromium, gross alpha, and gross beta)

were reported. These values are not corroborated by concurrent (1988) or historical data and are not thought to be representative of the groundwater chemistry at the CRSP.

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 of 1988, under a plan approved by TDHE. During 1988, CRSDB was in detection monitoring and will continue in that program during 1989.

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, 1988. During CY 1988, this site was in detection monitoring. No evidence of releases has been found in the groundwater.

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.

Water-quality analyses of samples collected from Oil Landfarm assessment wells during the four sampling quarters of 1988 support the earlier assessments of the extent of VOC contamination. New monitor wells have helped considerably in defining the extent and sources of VOC contamination. The highest concentrations of VOCs are generally found at greater depths. The distribution of individual VOCs indicate two plumes at the Oil Landfarm. One plume, which consists primarily of trichloroethene, is located south of Bear Creek and originates upstream from the Oil Landfarm. A second plume, containing more even proportions of several compounds, originates at the Oil Landfarm Disposal Units and extends southward to merge with the trichloroethene plume.

Trace metals contamination is restricted to a few isolated occurrences at the Oil Landfarm. Chromium and lead were occasionally detected above their respective EPA standards in total metals analyses. The standard of 0.01 mg/L for cadmium was exceeded only at GW-7 (0.02 mg/L) and only on one date. The concentration of barium was consistently close to the standard at one well (GW-229), exceeding the standard in one analysis. One other analysis for total barium at GW-364 exceeded the standard but appears to be related to a high turbidity.

Except for a persistent isolated occurrence in the vicinity of GW-85, contamination by nitrate is confined to a narrow band along Bear Creek. The pattern of contamination suggests that nitrate, originating at the S-3 Site upstream, is being transported through the cavernous zone underlying Bear Creek. Contamination by radiochemical parameters is largely confined to three wells (GW-64, GW-227, and GW-229) open to the

Maynardville and to two wells (GW-3 and GW-87) open to the unconsolidated zone.

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. 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 1988 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. The VOCs are generally confined to the upper 250 ft of the low-permeability shales of the Conasauga Group. Organic compounds trans,1,2-dichloroethene, tetrachloroethene, trichloroethene, and 1,1-dichloroethane constitute at least 30% of the total summed organics. With the exception of GW-45, from which the VOC results are unconfirmed, analyses of wells of less than 250 ft depth indicate that VOCs have not migrated more than several hundred feet from the waste sources.

Tetrachloroethene was reported in samples from GW-117, which monitors the Nolichucky at depths of about 500 ft, and samples from wells GW-118 and GW-119 indicated the presence of benzene at similar depths. It is possible that these constituents have been artificially introduced during or subsequent to well installation. Contaminant migration to these depths is suspect for the following reasons: (1) the wells each display upward vertical hydraulic gradients that would inhibit migration of dissolved contaminants, (2) the low permeability of the monitored formation and highly mineralized nature of the groundwater samples suggest long residence time of groundwater at that depth, and (3) the occurrence of single constituents, in particular benzene, is not typical of VOC-contaminated groundwater. Because of the extremely low yields, these wells (GW-117, GW-118, and GW-119) have not been purged prior to sampling. Sampling protocols are currently being reviewed as part of the confirmation process for results obtained from samples of these deep wells.

Occurrences of trace metals have been noted in five wells at the Burial Grounds. In these wells, the concentrations of total dissolved barium (GW-14 and GW-27) and cadmium (GW-39 and GW-42) were reported above the drinking-water standard. Uranium concentrations were elevated in wells GW-27 and GW-58. Because GW-58 monitors the cavernous Maynardville Limestone, it is possible that the S-3 Site may be the source of elevated uranium in this well.

Results for gross alpha analyses indicate that alpha radioactivity is not elevated in groundwater at the Burial Grounds. No wells were identified with annual average concentrations in excess of 15 pCi/L.

Gross beta concentrations exceeded 50 pCi/L in wells GW-39 and GW-58. Because these wells are not hydrologically connected, the beta sources may be isolated. It is possible, however, that because GW-58 monitors the cavernous Maynardville Limestone, the beta source in samples from this well may originate in the upper reaches of the Bear Creek watershed.

Beryllium was not present in elevated concentrations and asbestos was not detected in groundwater samples from the Burial Grounds assessment wells.

In general, the contaminants present in the Burial Grounds waste trenches have not migrated in the groundwater system more than several hundred feet from the waste sources over the more than 30 years of waste disposal. The ongoing assessment program will continue to evaluate possible migration of organic constituents to depths of about 500 ft in the groundwater.

New Hope Pond. NHP is 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 away from 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.

In 1973, sediments from NHP were removed and placed in the Chestnut Ridge Sediment Disposal Basin (CRSDB). Since 1973, sediment from the inlet diversion ditch has been 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 do not exhibit the characteristics of a RCRA waste (Saunders 1983; Kimbrough and McMahon 1989a and 1989b).

Because the presence of polychlorinated biphenyls (PCBs), mercury, and uranium in NHP sediments make sediment removal a less viable option than leaving them in place, NHP is being closed with the wastes in place in a manner equivalent to a RCRA landfill. The volume of sediment at the site is estimated at 25,000 yd^3. These sediments will be stabilized by the addition of coarse aggregate. A multilayered cap will be constructed to cover the entire site (Martin Marietta Energy Systems, Inc. 1988).

Results of water-quality analyses of groundwater samples collected from NHP assessment wells during 1988 confirm the presence of VOCs, uranium, and lead in groundwater at the site. The highest concentrations of these constituents, except for uranium at monitor well GW-154, were detected at wells upgradient of NHP, suggesting that the pond is not the source. The lack of elevated uranium in the other downgradient monitor wells, the upward net vertical gradient between the bedrock wells GW-222 and GW-223 with GW-154, and the setting of GW-154 in a location where groundwater probably flows toward the well from the east, south, and west, suggests that the source of uranium in this well may not be NHP. Gross alpha was elevated at GW-154 because of the high levels of uranium.

Lead was detected in elevated concentrations only at monitor well GW-152, which is upgradient of NHP. The source of this lead may be the CRSDB or the Y-12 Security Pistol Range. However, lead has not been detected in monitor wells at the CRSDB.

Concentrations of VOCs increase upgradient of NHP toward the Y-12 Plant. The highest concentrations were detected in bedrock wells monitoring the Maynardville Limestone. Tetrachloroethene may be more prevalent at depth, especially at locations where the highest concentrations occur. The remaining VOCs (carbon tetrachloride, chloroform, trichloroethene, trans-1,2-dichloroethene, and vinyl chloride) appear to be nonpreferentially distributed within the bedrock portion of the aquifer.

Other site-specific groundwater monitoring

Groundwater monitoring has been ongoing in 1988 for several 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 Fig. 2.3.4): the Beta 4 Security Pit, Ravine Disposal Area, UNC Site, Rogers Quarry, S-2 Pond, the Salvage Yard Area (includes five SWMUs), Filled Coal Ash Pond, Rust Construction Spoil Area, and Spoil Area I. RCRA facility investigation (RFI) plans have been submitted for the S-2 Pond, Salvage Yard Area, Filled Coal Ash Pond, Rust Construction Spoil Area, and Spoil Area I. No RFI is planned for the other sites.

The following commentary summarizes the findings from the 1988 data.

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.

Ravine Disposal Area. The Ravine Disposal Area is located immediately north of the Y-12 Plant Garage (Building 9712), inside the Y-12 Plant perimeter fence that runs along the south side of Bear Creek Road. The history of material disposed of at this site is poorly documented; however, disposal appears to have consisted of a substantial amount of wood, construction debris, and dirt. Lesser amounts of metal scrap and possibly some uranium-contaminated material were also disposed of at the site. Five groundwater investigation wells were installed at the Ravine Disposal Area in late 1985. The site is hydrologically similar to the Beta-4 Security Pit. Review of 1988 data for all five wells at the Ravine Disposal Area suggests that it is free of groundwater contamination. The site disposal history is consistent with this analysis.

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 is 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 a general control as to 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 1988 were consistent with the conclusion that the UNC Site is not contributing contamination to the groundwater. Based on the 1986 through 1988 results, this 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, and has subsequently been used for the disposal of a variety of materials from the Y-12 Plant. 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.

Levels of arsenic, chloride, and total dissolved solids appear to be elevated above those usually found in natural waters.

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. Specific records of the identity and quantity of wastes disposed of at the site were not kept. 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.

A variety of undocumented liquid wastes were disposed of at the S-2 Site during its period of usage. The facility was used for the disposal of deteriorated chemical reagents and spent extraction raffinates. 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 is contaminated with 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 1988, groundwater studies for this area were proposed for inclusion 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 and for deheading and crushing used drums. 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. During 1988, groundwater showed contamination with volatile organics, heavy metals, and nitrate. The nitrate and elevated gross alpha and beta levels are probably associated with the S-3 Site plume.

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 1988, groundwater at this site exhibited elevated levels of coliform bacteria and gross beta radiation. The beta radiation is considered to be anomalous because of high solids rather than indicative of contamination. Anticipated construction of this landfill is pending based on availability of funding.

Industrial Landfill IV. Industrial Landfill IV will be 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 later replaced. Although

three parameters (gross beta, iron, and manganese) were above standards, these are background numbers because the site has not yet been opened to waste disposal activities.

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 1988 data show values above standards for gross beta, iron, manganese. and pH. 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 was collected at this site. Values above standards were found for cadmium, chromium, gross alpha, gross beta, iron, lead, manganese, and pH. Although these values may be indicative of groundwater contamination, the values are background for LLWDDD and the sources are upgradient in the Bear Creek Burial Grounds Waste Management Area. Construction of this facility has been halted. There will be no additional construction beyond the initial site preparation phase.

LLWDDD—uranium lysimeter demonstration project

This study is a joint effort by the LLWDDD and the Y-12 Plant's Waste Transportation, Storage, and Disposal Department (WTSD).

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, 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 the fourth quarter of 1988. Initial results indicate varying levels of iron, manganese, and lead, with some values exceeding water quality standards for drinking water. The values are representative of the natural groundwater and not of contamination.

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 1988 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., example, 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.

There is the possibility that 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 1988, data were collected from seven monitoring wells around this site. During the year, values exceeded water quality standards for coliform, dissolved solids, gross alpha and beta, iron, lead, manganese, nitrate-nitrogen, pH, and radium.

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 or Coal Ash Basin, is an 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.

Monitoring wells installed in FY 1988

In FY 1988, 46 groundwater wells and 5 piezometers were installed as a result of the drilling program at the Y-12 Plant. Table 2.3.4 lists the sites and the number of wells installed. The sites are divided into three categories. Category I sites are new facilities. No wells or environmental monitoring facilities exist at these sites. For the most part, they are new areas designed to meet the expanding needs of the Y-12 Plant. Category II sites are existing sites that require additional characterization to fill previously identified data gaps to meet regulatory requirements or to complement the comprehensive groundwater monitoring plan. Category III sites are those sites previously identified under RCRA 3004(u) provisions. These sites require wells and groundwater characterization to comply with DOE orders and the new provisions of the law.

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 Remedial Action Program (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 Solid Waste Management Unit (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

Table 2.3.4. Y-12 Plant 1988 well installation program

Site	Category	Wells installed
Bear Creek Burial Grounds	II	10
Oil Landfarm	II	9
LLWDDD lysimeter demonstration	I	5
S-3 Pond Site	II	7
Rust Garage	III	5
New Hope Pond site	II	6
Chestnut Ridge Sediment Disposal Basin	II	1
Filled Coal Ash Pond	II	3
Chestnut Ridge Security Pits	II	3
Industrial Landfill IV	II	2
Total		51

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 have been defined and boundaries identified. 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 (approximately 250) will be 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 that have been identified at ORNL and the number of potential remedial action sites within each WAG. Figure 2.3.5 shows the location of each of the 20 WAGs.

ORNL 1988 installation, development, and sampling activities

During 1988, 1 water quality well was installed. No more wells were installed during 1988

Table 2.3.5. Summary of ORNL waste area groupings

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.

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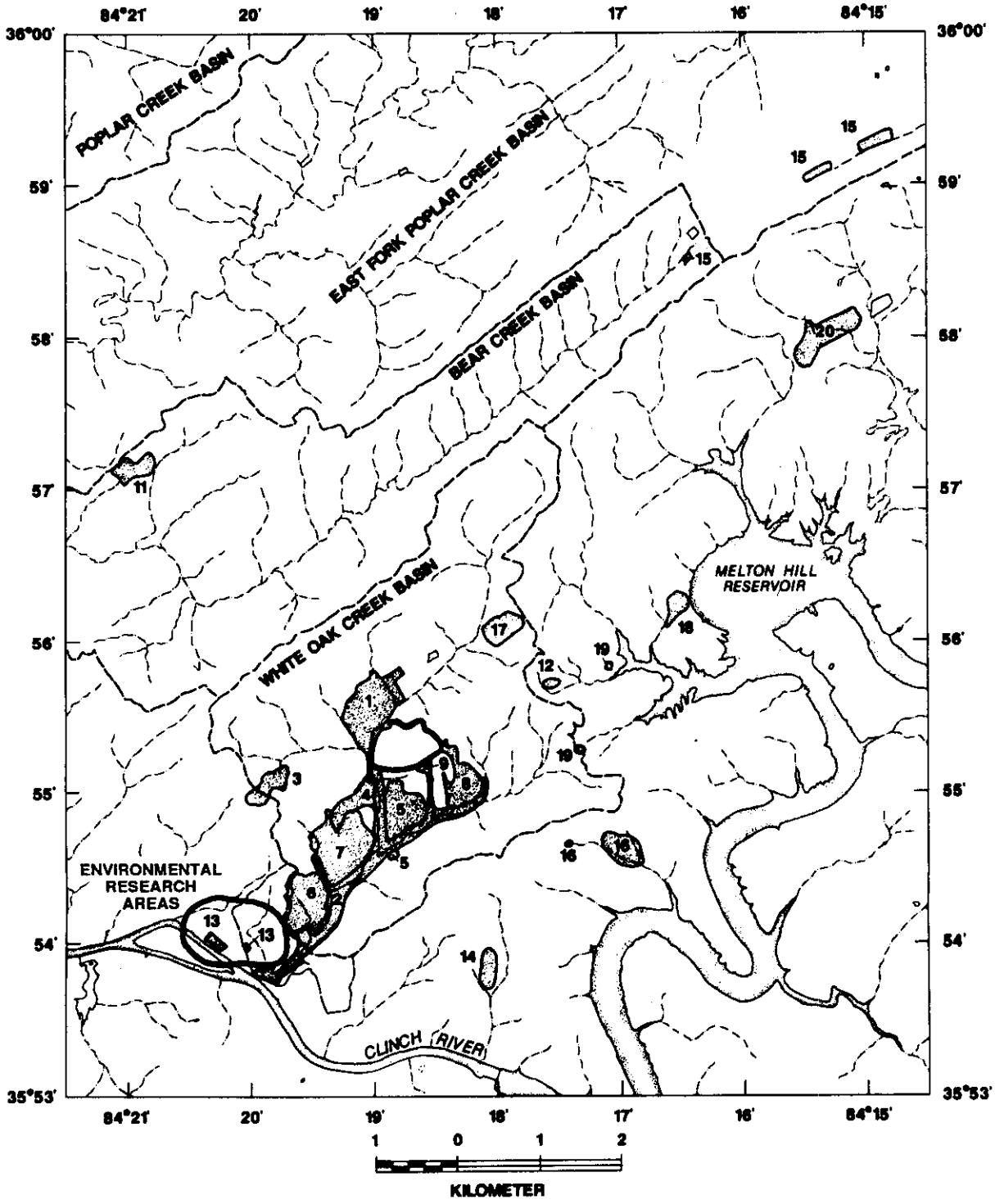

Fig. 2.3.5. ORNL WAGs.

because of insufficient funds and the need to complete the decontamination facility before continuing future efforts. Sampling of WAG 6 was begun in June of 1988, and two quarters of data from the 30 wells located in this WAG were collected. Additionally, development of the WAG 1 wells was completed in 1988, and sampling of WAG 1 was initiated in the fourth quarter (October) of 1988. WAG 6 is currently in the detection monitoring phase under the RCRA interim status regulations, and WAG 1 is being monitored under 3004(u) of RCRA. Table 2.3.6 provides a summary of the current groundwater surveillance program at ORNL and includes the regulatory status, parameters monitored, the number of monitoring wells, and the sampling frequency for each WAG.

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. 2.3.5. SWSA 6 is located in Melton Valley, northwest of WOL 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 Copper Creek 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. Wastes have been buried in trenches and auger holes, and presently SWSA 6 is being monitored under RCRA interim status regulations because hazardous wastes were buried after 1980 in some of the low-level waste trenches. Potential contaminants in SWSA 6 include ^{137}Cs, ^{60}Co, tritium, ^{90}Sr, heavy metals, and various organic liquids. The explosives detonation trench is an open trench approximately 4.6 m (15 ft) long by 1.5 m (5 ft) wide by 1.2 m (4 ft) deep located within SWSA 6. Explosive and shock-sensitive chemicals requiring disposal are taken to the trench, laid in the bottom, and detonated with a small explosive, plastic charge. Hazardous materials are consumed in the explosion and debris from the explosion is left in the trench. The emergency waste basin was constructed in 1961 through 1962 to provide storage of waste 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

Table 2.3.6. Summary of the groundwater surveillance program at ORNL

Unit Name	Regulatory status	Interim status			Parameters monitored[a]	Number of wells	Sampling frequency
		Detection	Assessment	3004(u)			
WAG 6	RCRA	1988			1, 2, 3, 4, 5, 6, 7, 8, 9, 10	30	Quarterly
WAG 1	3004(u)			1988	1, 2, 3, 4, 5, 10, 11	25	Quarterly

[a]Numbers refer to other tables as indicated:

1. Primary drinking water parameters (Table 2.3.2 in Vol. 2)
2. Parameters establishing groundwater quality (Table 2.3.3 in Vol. 2).
3. Indicator parameters (Table 2.3.4 in Vol. 2).
4. Metals analyzed by inductively coupled argon plasma (Table 2.3.5 in Vol. 2).
5. Metals analyzed by atomic absorption spectroscopy (Table 2.3.6 in Vol. 2).
6. Anions (Table 2.3.7 in Vol. 2).
7. Volatile organics (Table 2.3.8 in Vol. 2).
8. Pesticides and PCBs (Table 2.3.9 in Vol. 2).
9. Acid-base/neutral extractable organics (Table 2.3.10 in Vol. 2).
10. Radionuclides and radioactive metals (Table 2.3.11 in Vol. 2).
11. Other parameters (Table 2.3.12 in Vol. 2).

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 stops at 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. 2.3.5. The bedrock units beneath the main plant area consist of the limestone, siltstone, and calcareous shale facies of the Ordovician Chickamauga Group. Most of the WAG 1 SWMUs are sites used to collect and store LLW. The SWMUs also include spill 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 a source of future 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 2.3.7.

Table 2.3.7. Listing of WAG 1 sites by type

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 groundwater results

Groundwater wells in WAG 6 and WAG 1 are classified as upgradient (reference) or downgradient depending on their location relative to the general direction of groundwater flow. Upgradient wells are located to provide groundwater samples that would not be affected significantly 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.

Wells in WAG 6 were sampled for the third and fourth quarters of 1988, and wells in WAG 1 were sampled during the fourth quarter. Results for WAG 1 and WAG 6 sampling in 1988 are given in Tables 2.3.13 and 2.3.14 of Vol. 2, respectively. Levels of metals in WAG 6 were generally within the normal range for groundwater in the upgradient and perimeter wells and in all the site characterization wells except for well 852, where high barium concentrations were observed in both the total and dissolved metals samples for each quarter. Iron levels were also somewhat elevated in a few of the wells. Specific conductance, pH, temperature, alkalinity, and anion concentrations were also generally within expected ranges. High coliform levels were observed in a few of the wells during the first round of sampling; however, these levels appear to have been the result of materials or practices used during installation and development because subsequent sampling has not shown elevated levels. Higher than normal average concentrations of tritium were observed in several of the perimeter and site-characterization wells (see Fig. 2.3.6). The maximum concentration of tritium found in the perimeter wells was 920,000 pCi/L. Other radionuclides were present only at very low levels.

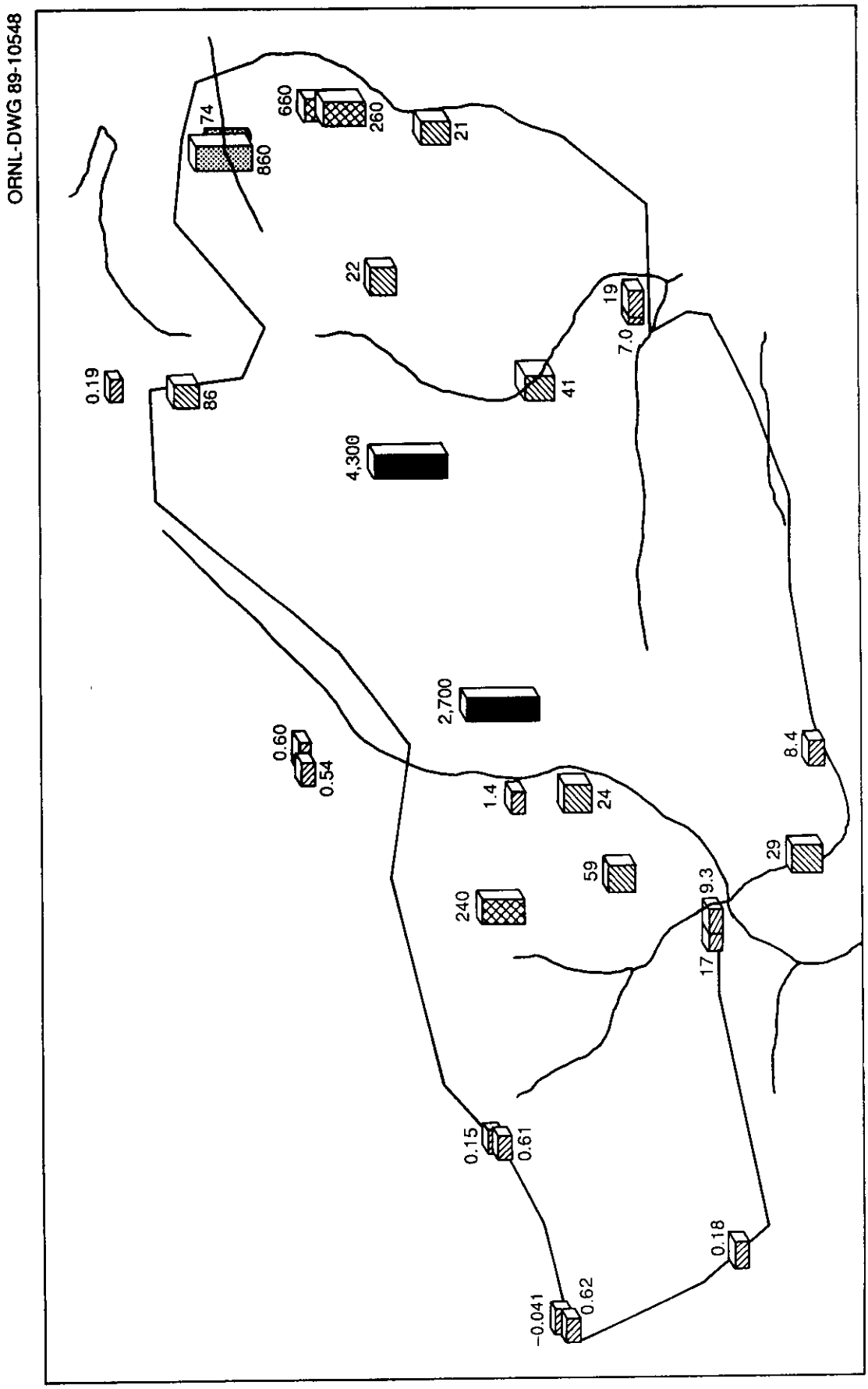

Fig. 2.3.6. Average tritium concentrations (nCi/L) in WAG 6 wells.

No pesticide values exceeded the drinking water standards and were either undetected or present only at extremely low levels. No semivolatile organics, except for naphthalene in well 850 and a few tentatively identified compounds, were found in the WAG 6 wells. The primary volatile organics found were trichloroethene, 1,2-dichloroethane, 1,2-dichloroethene, carbon tetrachloride, chloroform, and tetrachloroethene. Site-characterization wells also contained high levels of benzene, toluene, vinyl chloride, and xylene in one or more wells. No perimeter well contained more than 1 mg/L of any volatile organic, whereas toluene, trichloroethene, and xylene maximum concentrations of between 1.2 and 1.7 mg/L were found in the site-characterization wells. Acetone was found at high levels in two of the upgradient wells during the first sampling period but was not found in these wells during later sampling. It appears that, rather than a groundwater contamination problem, the acetone may be a contaminant that was somehow introduced into the well. Results from the first sampling of a well should always be considered somewhat suspect because of the potential for contamination during installation and development and from localized sources that may be present at the drilling site. Further sampling should confirm whether the acetone is present in these two wells.

Wells in WAG 1 were sampled for the first time during the fourth quarter of 1988. Levels of metals in WAG 1 were generally within the normal range for groundwater. Specific conductance, pH, temperature, anions, and coliform were also generally within expected ranges. Several wells were found to contain detectable levels of total organic carbon and/or total organic halides. Additional work will need to be done to determine what may be contributing to these elevated levels. Low levels of radionuclides were detected in several of the WAG 1 wells. These radionuclides included tritium, total radioactive strontium (^{89}Sr and ^{90}Sr), total radium (^{226}Ra and ^{228}Ra), and gross alpha and beta activity. One shallow well exhibited a high level, 7600 pCi/L, of total radioactive strontium. However, this well was only 15 ft deep, and the water level in the well at the time of sampling was only a few feet below the ground surface. Further efforts are needed to evaluate the cause and extent of radioactive strontium contamination in this well and the low levels of radioactivity seen in several of the other wells in the WAG 1 area.

Future ORNL plans and activities

During 1989, it is anticipated that the development of WAG 3 and 5 wells will be completed and sampling will be initiated. The 14 wells in WAG 3 and 15 wells in WAG 5 have been installed and will be monitored under RCRA 3004(u) requirements.

2.3.3.3 Oak Ridge Gaseous Diffusion Plant

The ORGDP groundwater protection program monitored groundwater quality at 13 sites during 1988, utilizing 80 RCRA-quality groundwater monitoring wells (Fig. 2.3.7). It is projected that the program will include monitoring at 42 sites by the end of 1989, including the use of 109 additional wells, 49 of which are scheduled for completion during 1989. Of the 13 sites considered in 1988, 2 were monitored in compliance with RCRA interim status regulations, while 11 (including 2 WAGs) were monitored for 3004(u) RFI characterization. Table 2.3.8 lists the sites monitored in 1988, their status in the program, and the samples being obtained. Groundwater monitoring at RFI sites varied during 1988 as one or two quarters of the extended list of parameters were sampled, completing the baseline year at the sites. This was followed by semiannual sampling for indicator parameters. Following compilation and evaluation of the four quarters of baseline data at each RFI site, site-specific parameter lists and monitoring frequencies will be established for 1989.

The following is a brief description of each unit and discussion of its 1988 monitoring results. A summary of the 1988 groundwater monitoring data for ORGDP by site is presented in Table 2.3.15 of Vol. 2.

K-1407-B pond (5 wells)

The K-1407-B pond is a RCRA interim status unit currently in assessment monitoring. This

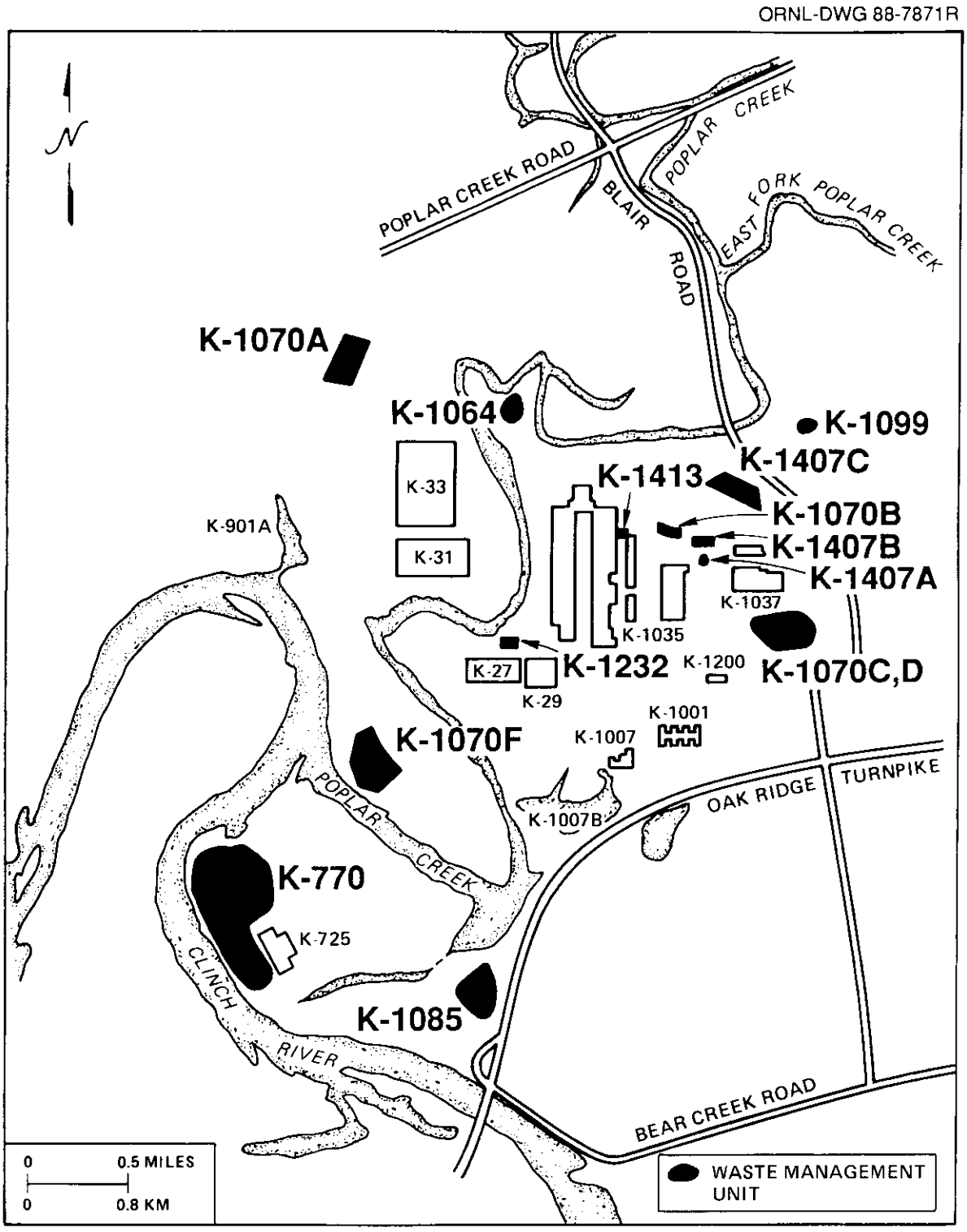

Fig. 2.3.7. Locations of monitoring wells in the ORGDP area.

Table 2.3.8. Oak Ridge Gaseous Diffusion Plant groundwater protection program site information

Unit name	Groundwater status	Current groundwater monitoring program						Date program was begun	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	*b*	Quarterly
K-1407-C holding pond	Interim	X							Nov. 1985	*a*	Semiannually
K-1407 WAG K-1070-B classified burial ground K-1407-A neutralization pit K-1700 stream	3004(u)						X		Apr. 1987	*b*	Quarterly
K-1407-C upgradient area	3004(u)						X		April 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		April 1987	*b*	Quarterly

[a]Parameters establishing groundwater quality (Table 2.3.3 in Vol. 2) and indicator parameters (Table 2.3.4 in Vol. 2).

[b]Primary drinking water parameters (Table 2.3.2 in Vol. 2); parameters establishing groundwater quality (Table 2.3.3 in Vol. 2); indicator parameters (Table 2.3.4 in Vol. 2); metals analyzed by inductively coupled argon plasma (Table 2.3.5 in Vol. 2); metals analyzed by atomic absorption spectroscopy (Table 2.3.6 in Vol. 2); anions (Table 2.3.7 in Vol 2); volatile organics (Table 2.3.8 in Vol. 2); pesticides and PCBs (Table 2.3.9 in Vol. 2); acid base/neutral extractable organics (Table 2.3.10 in Vol. 2); radionuclides and radioactive metals (Table 2.3.11 in Vol. 2); other parameters (Table 2.3.12 in Vol. 2).

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. The potential contaminants are heavy metals. The unit was removed from service during 1988 and is undergoing RCRA closure. A post-closure permit application has been submitted to TDHE.

A groundwater assessment was conducted at K-1407-B in late 1987, and a report was submitted to TDHE in May 1988. The statistical increase in specific conductivity was determined to have been caused by nonhazardous constituents. The statistical increase for TOX was thought to have been caused by some other source of organic contamination, but not enough evidence existed at the time to support this premise. Additional data subsequently gathered from nearby wells did provide evidence for a source other than B pond. TDHE has recently been presented with this additional evidence in support of a proposal to reinstate a modified detection program for the unit.

The K-1407-B pond wells were sampled twice in 1988, once for indicator and water quality parameters and once for assessment monitoring parameters. The data generated indicate that there is organic contamination at the site, but the groundwater assessment provides substantial evidence that its source is not B pond. The data also confirms that there are no hazardous metals exceeding drinking water standards at the site.

K-1407-C pond (6 wells)

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 post-closure groundwater monitoring will not be required, verification monitoring at the unit will be continued for at least 3 years.

A groundwater assessment was conducted at K-1407-C in late 1987, and a report was submitted to TDHE in May 1988. The statistical increase in specific conductivity was determined to have been caused by nonhazardous constituents; thus, a modified detection program was reinstated for the unit. The false-positive assessment did reveal elevated levels of lead, barium, and total chromium in the upgradient well. Sources for these contaminants are being investigated under a 3004(u) RFI.

The K-1407-C pond wells were sampled twice in 1988, once for indicators and water quality parameters and once for modified detection parameters. The data generated indicate no significant contamination at the site. The hazardous metals cadmium, chromium, and lead were detected above drinking water standards in one well during one sampling. This well resampled in accordance with TDHE regulations to determine if sampling or laboratory errors may have contributed to the high readings. Data received in April 1989 indicate these elevated levels were not correct.

K-1407 WAG (9 wells)

The K-1407 WAG is a 3004(u) RFI WAG. It 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 classified 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. K-1407-A 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 (CNF). The K-1700 stream receives discharge from K-1407-B pond and surface runoff from a number of waste management units. Sampling has shown the stream sediments contain elevated levels of heavy metals and uranium.

Eight of the K-1407 WAG wells were sampled twice in 1988, once for the extended list of baseline parameters and once for indicators. The ninth well

was sampled twice for baseline parameters. The data generated indicate that organics are the primary contaminants at the site. A number of these organics are present at levels considerably above drinking water standards. The only hazardous metals above standards were cadmium in 1 of 11 samples and chromium in 2. No elevated levels of uranium were detected.

K-1407-C upgradient area (3 wells)

The area upgradient of the K-1407-C pond is undergoing a 3004(u) RFI characterization. As discussed above, the upgradient well at C pond contains elevated levels of lead, barium, and total chromium. The area upgradient of C pond is being investigated to determine the source of these contaminants.

The K-1407-C upgradient area wells were sampled once for baseline parameters and once for indicators during 1988. The data generated indicate no substantial contamination at the site. Chromium was detected slightly above the drinking water standard once. Low levels of a few organics also were detected.

K-1413 WAG (4 wells)

The K-1413 WAG is a 3004(u) RFI WAG. It includes the K-1413-C neutralization pit, two smaller pits located to the north and east of the K-1413 building, the lines from the pits to the K-1401 acid line, the process lines within the K-1413 building, and the storm drains in the vicinity of the K-1413 building. Potential contaminants at the site include organic solvents and uranium from early uranium fluorination activities at the site.

The K-1413 WAG wells were sampled once for baseline parameters and once for indicators during 1988. The data generated indicates that trichloroethene is the primary contaminant at the site, but it was detected in only one well. Lead was also detected slightly above drinking water standards in one of five samples. No elevated levels of uranium were detected.

K-1070-C/D classified burial ground (13 wells)

The K-1070-C/D classified burial ground is a 3004(u) RFI site. It 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.

The K-1070-C/D classified burial ground wells were sampled twice for baseline parameters and once for indicators during 1988. The data generated indicate that the primary contaminants at the site are organics, some of which were detected at levels considerably above drinking water standards. The only hazardous metals to exceed standards were chromium in 6 of 27 samples and barium and lead in 1 sample each. Alpha activity was detected above drinking water levels in 2 of 27 samples, while beta activity was above the guidance level in 3.

K-770 scrap yard (7 wells)

The K-770 scrap yard is a 3004(u) RFI site. It has been used since the 1960s for storage of radioactively contaminated scrap metal. Potential contaminants include radioactivity and PCBs, mercury, and asbestos that might be incidental to scrap-metal operations.

The K-770 scrap yard wells were sampled once for baseline parameters and once for indicators during 1988. The data generated indicate that beta activity is the primary contaminant at the site, as it was detected in excess of guidance levels in four of eight samples. No hazardous metals exceeded drinking water standards, no PCBs were detected, nor was there significant organic contamination.

K-1064-G burn area/peninsula storage (7 wells)

The K-1064-G burn area/peninsula storage is a 3004(u) RFI site. The area was used in the 1950s and 1960s for open burning of solvents in open metal containers 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 closed in 1979.

The K-1064-G burn area/peninsula storage site wells were sampled once for baseline parameters and once for indicators during 1988.

The data generated indicate that alpha and beta activity are the primary contaminants at the site, both being detected above limits in four of eight samples. Low levels of organic contaminants were also detected. The only hazardous metals above drinking water limits were barium and lead, found in one of seven samples each. No PCBs were detected.

K-1085 firehouse burn area (5 wells)

The K-1085 firehouse burn area is a 3004(u) RFI site. In the mid-1940s it was used as a firehouse, garage, and fuel station (with underground storage tanks). 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.

The K-1085 firehouse burn area wells were sampled once for baseline parameters and once for indicators during 1988. The data generated indicate no substantial contamination, with no hazardous metals above standards and only low levels of a few organics being detected.

K-1070-A contaminated burial ground (9 wells)

The K-1070-A contaminated burial ground is a 3004(u) RFI site. It was used from the late 1940s to 1976 for disposal of unclassified low-level radioactive solid and mixed chemical waste, which was emptied into auger holes and trenches or buried in drums. Potential contaminants include chemicals, radioactivity, heavy metals, and some organics/oils.

The K-1070-A contaminated burial ground wells were sampled once for baseline parameters and once for indicators during 1988. The generated data indicates that organics, some considerably in excess of drinking water standards, and beta activity, which was above guidance levels in six of nine samples, are the primary contaminants at the site. The hazardous metals chromium and lead were found above drinking water standards in two of nine samples each.

K-1070-F old contractors' burial ground (5 wells)

The K-1070-F old contractors' burial ground is a 3004(u) RFI site. It 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. Materials disposed were supposed to be uncontaminated, but disposal records were not kept prior to 1977.

Four of the five wells at the K-1070-F old contractors' burial ground were sampled once for baseline parameters and once for indicators during 1988. The fifth well was sampled twice for baseline parameters. The data generated indicate no hazardous metal or radioactive contamination, with only low levels of a few organics being detected.

K-1232 treatment unit (6 wells)

The K-1232 treatment unit is a RCRA facility consisting of 12 tanks to provide 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) RFI characterization. Potential contaminants include nitrates, heavy metals, organics, and uranium.

The K-1232 treatment unit wells were sampled twice for baseline parameters and once for indicators during 1988. The data generated indicate that trichloroethene, above drinking water standards in 8 of 12 samples, and beta activity, above guidance levels in 6 of 12 samples, are the primary contaminants. In addition, fluoride was above drinking water levels in 4 of 12 samples, lead in 2, and chromium in 1. No elevated levels of nitrates or uranium were detected.

K-1099 Blair Road Quarry (1 well)

The K-1099 Blair Road Quarry is a 3004(u) RFI site. Material disposal and open burning was conducted within the quarry from 1945 to 1957. A policy existed that no contaminated materials be disposed at the quarry, according to personnel interviews. However, contaminated materials

(e.g., cleaning rags) may have been mixed with the trash.

The K-1099 Blair Road Quarry well was sampled once for baseline parameters and once for indicators during 1988. The data generated indicate no substantial contamination at the site. Sulfate levels did exceed the secondary drinking water limit in one sample, and low levels of two organics were detected.

2.3.4 Plugging and Abandonment

Any open borehole or well provides an unnatural opening in the subsurface environment. These openings provide a potential route for surface contamination to enter previously uncontaminated groundwater. Transfer or spread of contamination from one zone to another is known as crosscontamination. Crosscontamination can occur when an open borehole provides a pathway for a contaminated aquifer to enter or mix with an uncontaminated aquifer. Mixing in the subsurface can confuse monitoring results and spread contamination. To minimize the potential for groundwater 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.

Approximately 35 wells were successfully plugged and abandoned during 1988 under this program. Another 90 to 100 candidates have been identified for future action.

2.3.4.2 Oak Ridge National Laboratory

Three ORNL piezometer wells were plugged in 1988. Wells 795 and 796, both shallow wells, were completely removed when an underground gasoline tank was excavated. 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 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 1988.

2.3.5 Off-Site Monitoring

During 1988, Energy Systems developed and submitted a plan for monitoring the residential drinking water wells of homeowners living in close proximity to the ORO reservation. The purpose of the program is to assure local residents that their drinking water has not been adversely affected by DOE/ORO operations. As a forerunner to a larger program planned for 1989, three off-site wells were sampled in November 1988 for the primary drinking water parameters, volatile organics, metals, and radionuclides of concern on the DOE/ORO reservation. Results from this study are presented in Tables 2.3.9, 2.3.10, and 2.3.11. All results were within the normal expected range for uncontaminated groundwater except for one iron value, which exceeded the primary drinking water limit. The source of this elevated iron value is unknown, but the value may have been caused by materials and procedures used in installation and development of the well. Additionally, three parameters, selenium-GFAA, benzene, and carbon tetrachloride were 130%, 100%, and 100%, respectively, in excess of Drinking Water Regulation limits. Actually, the concentrations are reported as "less than" values. Because the limit of detection for these parameters was at or near the Drinking Water Regulation level, the resultant calculation indicated values at or greater than the standard. The values are within the normal expected range for uncontaminated groundwater and are not considered a problem.

Table 2.3.9. Off-site well water inorganic analyses, October 1988

Parameter	Number of samples	Concentration (mg/L)				Percentage DWL[a]
		Max	Min	Av	Standard error	
Alkalinity	6	240	170	200	11	
Arsenic-GFAA	6	<0.030	<0.0050	<0.018	0.0056	
Barium	6	0.15	0.027	0.079	0.022	7.9
Cadmium	6	<0.0050	<0.0030	<0.0040	0.0004	<40
Chloride IC	6	6.0	1.0	3.4	0.80	1.3
Chromium	6	<0.010	<0.010	<0.010	0	<20
Copper	6	0.040	<0.0040	<0.015	0.0056	<1.5
Dissolved solids	6	290	190	240	15	48
Fluoride IC	6	<1.0	0.10	<0.40	0.14	<20
Iron	6	0.59	0.035	0.17	0.089	57
Iron IC (reanalysis)	1	0.57	0.57	0.57		
Lead-GFAA	6	<0.030	<0.0040	<0.017	0.0058	<34
Lead IC (reanalysis)	1	0.0078	0.0078	0.0078		
Manganese	6	0.025	<0.0010	<0.0076	0.0037	<15
Mercury	6	<0.0010	<0.0002	<0.0006	0.0001	<30
Nitrate	6	2.6	<0.50	<1.1	0.38	<11
Selenium-GFAA	6	<0.030	<0.0050	<0.013	0.0042	<130
Silver	6	0.034	<0.0050	<0.013	0.0051	<27
Sulfate	6	14	1.0	7.0	2.2	2.8
Suspended solids	6	19	<1.0	<4.0	3.0	
Thallium-GFAA	3	<0.010	<0.010	<0.010	0	
Turbidity (NTU)	6	8.6	0.24	3.2	1.5	
Uranium fluorometric	6	<0.0010	<0.0010	<0.0010	0	
Zinc	6	0.15	0.016	0.069	0.023	1.4

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

Table 2.3.10. Off-site well water radiochemical analyses, October 1988

Parameter	Number of samples	Concentration (pCi/L)				Percentage DWL[a]
		Max	Min	Av	Standard error	
^{60}Co	6	<7.0	<2.7	<5.3	0.86	
^{137}Cs	6	<2.7	0	<1.4	0.60	
Gross alpha	6	4.9	<2.0	<3.1	0.45	<21
Gross beta	6	17	3.2	10	2.4	
^{99}Tc	6	<460	<14	<240	100	
Total radioactive strontium	6	<8.1	1.0	<5.7	1.5	<72
Total radium	6	<3.2	<2.7	<3.0	0.11	<59
Tritium	6	<3800	<1400	<2600	550	<13

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

Table 2.3.11. Off-site well water organic analyses, October 1988

Parameter	Number of samples	Concentration (mg/L)				Percentage DWL[a]
		Max	Min	Av	Standard error	
1,1,1-Trichloroethane	6	<5.0	<5.0	<5.0	0	<2.5
1,1,2,2-Tetrachloroethane	6	<5.0	<5.0	<5.0	0	
1,1,2-Trichloroethane	6	<5.0	<5.0	<5.0	0	
1,1-Dichloroethane	6	<5.0	<5.0	<5.0	0	
1,1-Dichloroethene	6	<5.0	<5.0	<5.0	0	
1,2-Dichloroethane	6	<5.0	<5.0	<5.0	0	<1.0
1,2-Dichloroethene (total)	6	<5.0	<5.0	<5.0	0	
1,2-Dichloropropane	6	<5.0	<5.0	<5.0	0	
2,4,5-T	8	<0.10	<0.10	<0.10	0	
2,4,5-TP (silvex)	8	<0.10	<0.10	<0.10	0	<1.0
2,4-D	8	<1.0	<1.0	<1.0	0	<1.0
2-Butanone	6	<10	<10	<10	0	
2-Hexanone	6	<10	<10	<10	0	
4-Methyl-2-pentanone	6	<10	<10	<10	0	
Acetone	6	<10	<10	<10	0	
Benzene	6	<5.0	<5.0	<5.0	0	<100
Bromodichloromethane	6	<5.0	<5.0	<5.0	0	
Bromoform	6	<5.0	<5.0	<5.0	0	
Bromomethane	6	<10	<10	<10	0	
Carbon disulfide	6	<5.0	<5.0	<5.0	0	
Carbon tetrachloride	6	<5.0	<5.0	<5.0	0	<100
Chlorobenzene	6	<5.0	<5.0	<5.0	0	
Chloroethane	6	<10	<10	<10	0	
Chloroform	5	<5.0	<5.0	<5.0	0	
Chloromethane	6	<10	<10	<10	0	
Dibromochloromethane	6	<5.0	<5.0	<5.0	0	
Endrin	8	<0.10	<0.10	<0.10	0	<50
Ethyl benzene	6	<5.0	<5.0	<5.0	0	
Methoxychlor	8	<0.50	<0.50	<0.50	0	<0.50
Methylene chloride	6	<5.0	<5.0	<5.0	0	
Styrene	6	<5.0	<5.0	<5.0	0	
Tetrachloroethene	6	<5.0	<5.0	<5.0	0	
Toluene	6	<5.0	<5.0	<5.0	0	
Toxaphene	8	<1.0	<1.0	<1.0	0	<20
Trichloroethene	6	<5.0	<5.0	<5.0	0	
Vinyl acetate	6	<10	<10	<10	0	
Vinyl chloride	6	<10	<10	<10	0	
Xylene (total)	6	<5.0	<5.0	<5.0	0	
cis-1,3-Dichloropropene	6	<5.0	<5.0	<5.0	0	
gamma-BHC(Lindane)	8	<0.050	<0.050	<0.050	0	<1.3
trans-1,3-Dichloropropene	6	<5.0	<5.0	<5.0	0	

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

2.4 BIOLOGICAL SAMPLING

Air and water are the principal dispersal media for the Oak Ridge Department of Energy (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 in 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.

Table 2.4.1. Summary of collection and analysis frequencies of biological samples in 1988

Station	Parameter	Collection frequency	Sample type	Analysis frequency
		Milk		
1,2,3,4,8	^{131}I, total Sr[b]	Biweekly	Grab	Biweekly
51,53,56[a]	^{131}I, total Sr[b]	Semiannually	Grab	Semiannually
		Fish		
CRK 8.0, CRK 33.0, CRK 40.0[c]	Gamma scan, total Sr[b], Hg, PCBs	Semiannually	Grab	Semiannually
		Grass		
3,4,7,8,9, 20,21,22,23 31,33,34,36, 40–46[d]	Gamma scan, total Sr[b], ^{238}Pu, ^{239}Pu, ^{234}U, ^{235}U, ^{238}U	Annually	Grab	Annually
51–53, 55–58[e]	Gamma scan, total Sr[b], ^{238}Pu, ^{239}Pu, ^{234}U, ^{235}U, ^{238}U	Annually	Grab	Annually
V1–V13[f]	Fluoride, uranium, technetium	Semiannually	Grab	Semiannually
		Pine needles		
PN1–PN6[f]	Fluoride, uranium, technetium	Semiannually	Grab	Semiannually

[a]See Fig. 2.4.1.
[b]Total radioactive strontium (^{89}Sr + ^{90}Sr).
[c]See Fig. 2.4.2.
[d]See Fig. 2.4.4.
[e]See Fig. 2.4.5.
[f]See Fig. 2.4.6.

2.4.1 Milk

One of the pathways of radiation 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

Raw milk from five sampling locations including one commercial dairy within a radius of 80 km (50 miles) of Oak Ridge is analyzed for ^{131}I and total radioactive strontium (^{89}Sr and ^{90}Sr) by Oak Ridge National Laboratory (ORNL). Samples are collected every 2 weeks from the stations located near the Oak Ridge area (Fig. 2.4.1). Three other stations are more remote with respect to the Oak Ridge facilities and are usually sampled semiannually (Fig. 2.4.1). Samples were analyzed for ^{131}I by gamma spectroscopy and for total radioactive strontium by chemical separation and low-level beta counting.

2.4.1.2 Results

Concentrations of ^{131}I and total radioactive strontium in milk are summarized for the two sampling areas—the immediate environs and the remote environs—in Table 2.4.2. Average values are compared with the Federal Radiation Council guidelines for adequate surveillance. Iodine-131 and total radioactive strontium concentrations were less than 30% of the guideline for both sampling networks. The differences in the ^{131}I concentrations between the immediate and the remote environs are caused by the method of reporting. Prior to August 1988, detection limits were reported. After that time, instrument background was subtracted from the sample value, which resulted in lower reported values. Because the remote stations were sampled only after August 1988, the values that were contributing to the summary statistics were lower than for the immediate environs. Sampling results for specific locations are given in Tables 2.4.1 and 2.4.2 of Vol. 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 polychlorinated biphenyls (PCBs), mercury, and radionuclide concentrations: bluegill, catfish, bass, carp, and crappie. The highest mercury and PCB concentrations were found in carp and then 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 1988 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 tissue analyses of radionuclides, mercury, and PCBs (Fig. 2.4.2; Table 2.4.3) by ORNL. Sampling locations include the following Clinch River kilometers (CRKs): (1) 40.0 (river mile 24.8), which is above Melton Hill Dam and serves as a background location for the DOE facilities as it is above all the Oak Ridge DOE facilities' outfalls with the exception of those from Oak Ridge National Laboratory's (ORNL's) 7600 area, 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 the Oak Ridge Gaseous Diffusion Plant (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

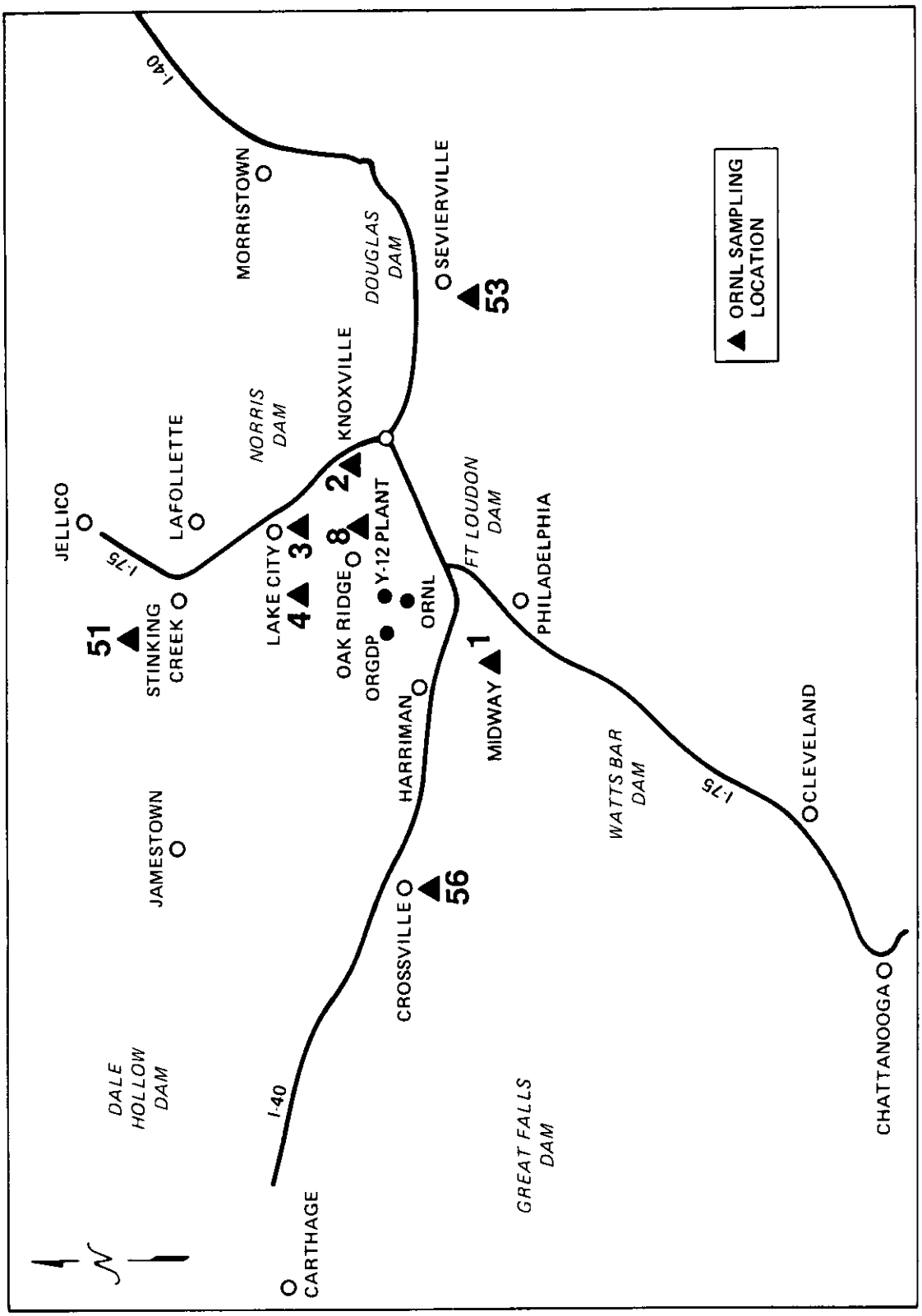

Fig. 2.4.1. Map showing milk sampling stations.

Table 2.4.2. 1988 radionuclide concentrations in milk[a]

Location[b]	Determination	Number of samples	Concentration (pCi/L)				Percent of guidelines[d]
			Max	Min	Av	Standard error[c]	
Immediate environs	^{131}I	109	<8.1	−9.5	−1.7	0.24	17
	Total Sr[e]	109	24	−0.81	4.4	0.30	22
Remote environs	^{131}I	5	0.54	−1.1	−0.26	0.31	−2.6
	Total Sr[e]	5	10	2.3	5.7	1.3	29

[a]Raw milk samples, except for one dairy.
[b]See Fig. 2.4.1.
[c]Standard deviation about the average.
[d]Percent of applicable FRC standard assuming 1 L/d intake: Range I for ^{131}I, 0–10 pCi/L, Range I for total Sr, 0–20 pCi/L; adequate surveillance required to confirm calculated intakes.
[e]Total radioactive strontium (^{89}Sr + ^{90}Sr).

sampling location during each period. Scales, head, and entrails were removed from each fish before samples were obtained. Composite samples were ashed and analyzed by gamma spectroscopy 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 U. S. Department of Energy's (DOE's) revised Order 5400.1 requires that concentrations be reported in pCi/g ash weight. Because the ash was 1%, the ash-to-wet ratio is 0.01 to 1. The 1988 concentration data can be converted to a wet weight basis and into kilograms by multiplying the numbers in Table 2.4.3 by 10. These data can then be compared to the previous years' data.

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 6.9% of the FDA guideline. For PCBs, the percentage of the guideline was 1.0% for PCB aroclor 1254 and 1.5% for PCB aroclor 1260 (or 2.5% 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. There were no statistically significant differences in the mercury concentrations in fish collected from CRK 8.0 and CRK 33.3 (river mile 5 and river mile 20.7) or between CRK 33.3 and CRK 40.0 (river mile 20.7 and river mile 25). However, mercury concentrations were significantly higher in fish from CRK 8.0 (river

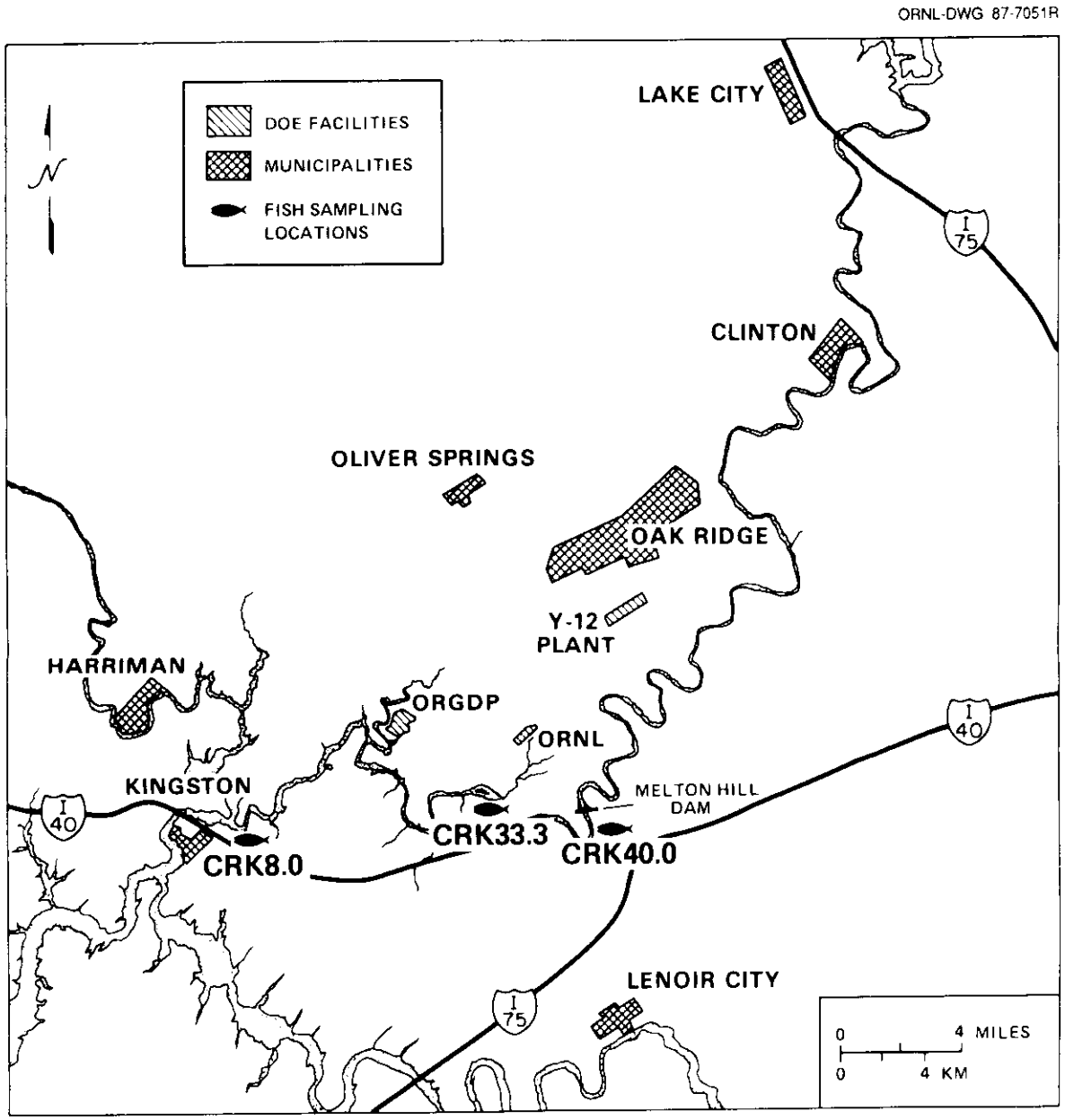

Fig. 2.4.2. Fish sampling locations along Clinch River.

mile 5) than CRK 40.0 (river mile 25). The highest concentration of mercury was measured at CRK 8.0 (0.2 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 6.9% 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 1988 are given in Table 2.4.4 of Vol. 2. There were no statistically significant differences in the concentrations of PCB aroclor 1254 in fish among the locations sampled. The highest concentration of PCB aroclor 1254 (0.05 μg/g) was measured in fish collected at CRK 8.0 (river mile 5), near Kingston. The maximum concentration of PCB aroclor 1260 (0.1 μg/g) was observed in fish

Table 2.4.3. 1988 tissue concentrations of Clinch River bluegill

Location[a]	Determination	Number of samples	Concentration[b]				Percent of guidelines[d]
			Max	Min	Av	Standard error[c]	
Clinch River	Hg	36	0.21	0.019	0.069	0.0073	6.9
	PCB aroclor 1254	36	0.05	<0.01	<0.02	0.0022	1.0
	PCB aroclor 1260	36	0.10	<0.01	<0.03	0.0038	1.5
	^{60}Co	18	0.46	−0.14	0.18	0.037	*e*
	^{137}Cs	18	18	0.24	4.7	1.2	*e*
	Total Sr[f]	18	1.2	−1.2	0.24	0.12	*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 deviation about the 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).

collected at CRK 40.0 (river mile 25). The average concentration of each type of PCB at each CRK was compared with the FDA's tolerance limit for PCBs in fish (2 μg/g wet weight). All average concentrations were less than 2% 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 of Vol. 2. It is suspected that the vials with fish tissue from CRK 8.0 and CRK 40.0 were inadvertently switched during preparation for radionuclide analyses for the sampling date of November 1988. The data tables presented in Vol. 2 reflect this. That is, results originally labeled CRK 8.0 were changed to CRK 40.0 and vice versa before summarization. No statistically significant differences in ^{60}Co were detected in fish collected at the three locations. Total radioactive strontium in fish was 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.

Average concentrations of radionuclides appear to be lower than during 1987. This is primarily the result of analytical reporting of data (see the introduction to Sect. 2). In addition, maximum values were lower in 1988 than in 1987.

2.4.3 Wildlife

Radiological surveys are conducted during the annual hunts that are held on the ORR for controlling the deer population and for reducing the number of deer-vehicle collisions. The hunt schedules were similar to those of 1987: four separate weekend hunts, with the first two restricted to archers (Oct. 15–16 and 22–23). Thirteen hundred permits were issued for each archery weekend. The first weekend archery hunt yielded a total harvest of 90 deer, and the second yielded an additional 39 deer. The other two hunts (shotguns or muzzle-loaders) were held on the weekends of November 12–13 and December 10–11. Nine hundred permits were issued for each of the two gun hunts. The first one produced a harvest of 209 deer, and the second yielded 169. The total 1988 harvest was 507 deer, of which 291 (57.4%) were bucks. The proportion of bucks in the 1988 harvest was very similar to that of 1987 (58%).

2.4.3.1 Sample collection and analytical procedures

Each successful hunter was required to bring his deer, along with its liver, to the DOE-Tennessee Wildlife Resources Agency (DOE-TWRA) checking station, where a quantitative determination of ^{137}Cs was made by counting a sample of the liver (muscle is sometimes used) in a large sodium iodide scintillation spectrometer. Strontium-90 contamination was determined by counting a 2-in. segment of foreleg bone taken from each deer at the station. Both the soft-tissue and bone analyses were performed while the hunter waited. Thyroid samples were taken from many of the harvested deer for special studies of radioiodine in the environment. Those studies are reported in Sect. 6.

The radiological survey of the 1988 DOE-TWRA–managed deer hunts was again performed by ORNL Analytical Chemistry Division personnel assisted by students from both Knoxville College and The University of Tennessee.

2.4.3.2 Radiological survey results

By use of the bone-screening procedures developed for the 1986 hunts, 13 deer were found to contain elevated levels of ^{90}Sr. Those animals were confiscated from the hunters; however, those hunters were issued permits to continue with that particular hunt or return for a subsequent one. One such hunter killed a second contaminated deer that was almost identical to the first (2.5-year-old, 8-point bucks, approximately 115 lb each). These deer were killed 1 month apart, but in the same location in the eastern part of the ORR. The percentage contamination in the deer harvest caused by ^{90}Sr (2.6%) was down significantly from the 5.7% recorded in 1987. No ready explanation for the decrease is available. Specific radiochemical analyses for ^{90}Sr were performed on bone samples from the confiscated animals. Results of the ^{90}Sr radiochemical analyses, along with ^{129}I concentrations determined on thyroid glands from the confiscated animals (previous studies showed elevated ^{129}I in most animals with elevated ^{90}Sr), are presented in Table 2.4.4 and Fig. 2.4.3.

Tissue concentrations of ^{137}Cs continued to be low and acceptable for the entire harvest. Eighty-six percent of all deer contained ^{137}Cs at concentrations of 0.5 pCi/g or less, and only 12 animals contained this nuclide at concentrations exceeding 1 pCi/g (the maximum value for any deer was 1.3 pCi/g).

Table 2.4.4. 1988 radionuclide concentrations in confiscated deer

Deer number	S-16 grid[a]	^{90}Sr in bone (pCi/g)	^{129}I in thyroid (pCi/g)[b]
26	03G	120	4.9
104	07G	*c*	0
154	05F	60	16
195	05F	190	4.1
215	10F	190	0
225	16E	90	0
240	06D	180	trace
343	16E	250	0.6
363	06G	20	15
372	09E	90	0
417	06F	10	1.4
452	06F	*c*	43
460	07E	22	40

[a]Administrative grid coordinates are shown in Fig. 2.4.3.
[b]A zero in this column indicates not detected.
[c]No analysis performed.

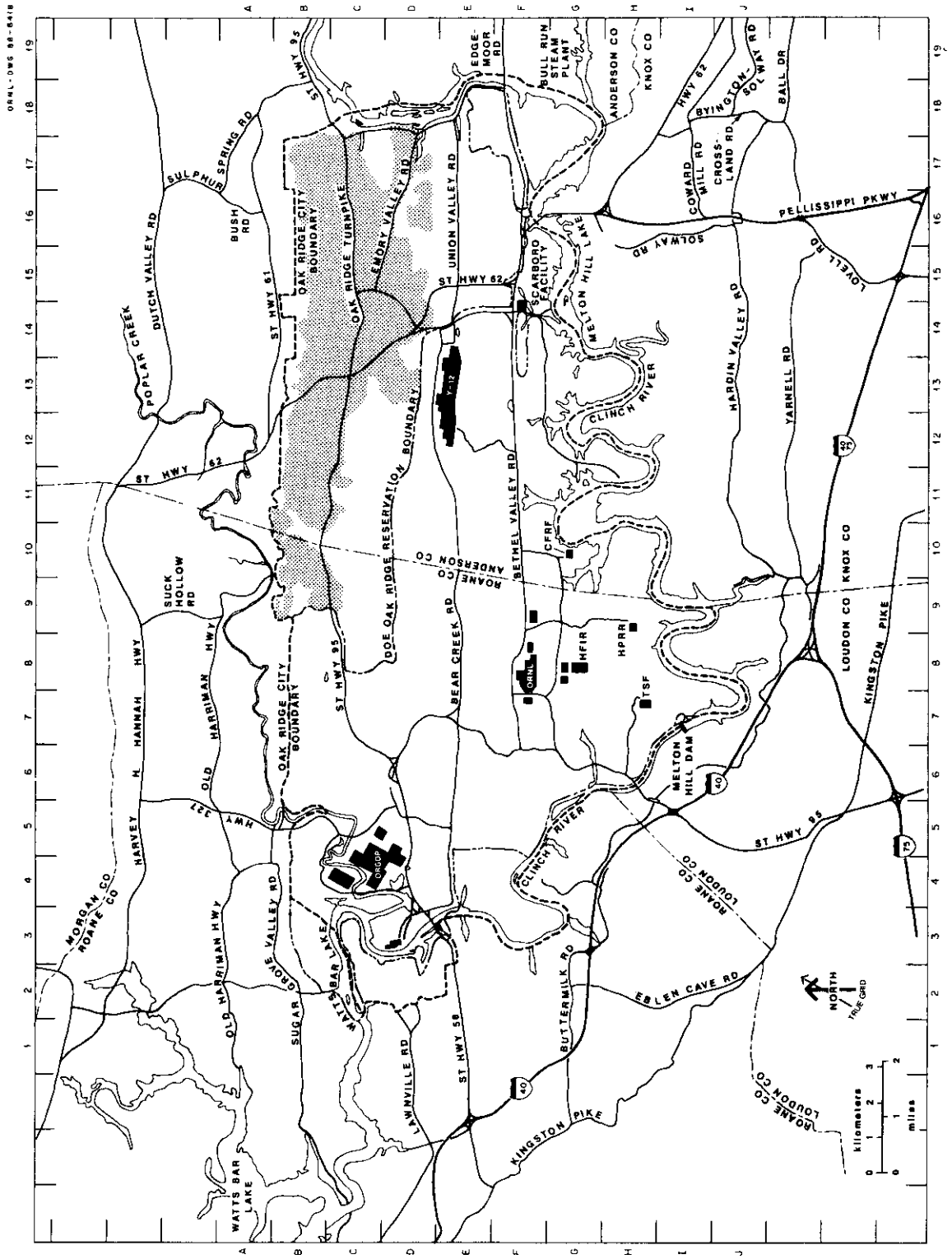

Fig. 2.4.3. Administrative grid coordinates of the ORR.

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 radioactivity by ORNL and 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.

2.4.4.1 Sample collection and analytical procedures

Grass samples were collected annually at ORNL perimeter locations, at the ORR locations (Fig. 2.4.4; Table 2.4.1), and at the remote locations (Fig. 2.4.5; Table 2.4.1). At all locations, samples were collected at 90° angles to the air monitoring station, for a total of four samples per location. Samples were ashed, except for those to be analyzed for gamma emitters. These were analyzed wet. After initial preparation, the samples were analyzed by gamma spectrometry and radiochemical techniques for a wide variety of radionuclides.

Grass and pine needles are collected semiannually at ORGDP from 13 and 6 locations, respectively. These locations are shown in Fig. 2.4.6. 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 2.4.5 gives a summary of the grass and pine needle sampling data. Table 2.4.6 in Vol. 2 provides data on individual sampling locations.

2.4.4.2 Results

Oak Ridge National Laboratory

Summaries of radionuclide concentrations in grass from each of the monitoring networks are given in Table 2.4.5. All data are reported on an ash weight basis. The ashed weight of grass samples ranged from 16 to 39%, with an average of 26%. Average concentrations of ^{60}Co and ^{137}Cs were near the analytical detection limits. Summaries of the grass concentrations of radionuclides and total radioactive strontium at each station are given in Tables 2.4.7 through 2.4.14 of Vol. 2.

Grass at station 4, which is very close to the Process Waste Treatment Plant and the treatment ponds, had concentrations of ^{137}Cs and total radioactive Sr that were about two orders of magnitude greater than typical values at the other stations. Concentrations of ^{239}Pu were also anomalously high in the grass around station 4. The observed concentrations in the samples around station 4 may be due to overflows from the pond. Because station 4 has not been sampled in the past, no trend information is available.

Concentrations of ^{234}U and ^{235}U were highest around stations 40 and 45, which are close to the Y-12 Plant site. The concentrations of ^{238}U at station 45 were high compared to the other stations.

Oak Ridge Gaseous Diffusion Plant

The results for the grass and pine needle samples are given in Table 2.4.6.

Fluoride levels in grass at all sampling points were below the 30-$\mu g/g$ level, which is considered to produce adverse effects when ingested by cattle with average grazing intakes (AIHA 1969). The uranium and technetium concentrations are always higher at V11, which is located at the contaminated scrap yard. The uranium concentrations ranged from below detection to 3.1 $\mu g/g$ (V11), with technetium concentration ranging from below detection to 70.0 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

Soil samples are routinely collected at the Oak Ridge National Laboratory (ORNL) perimeter

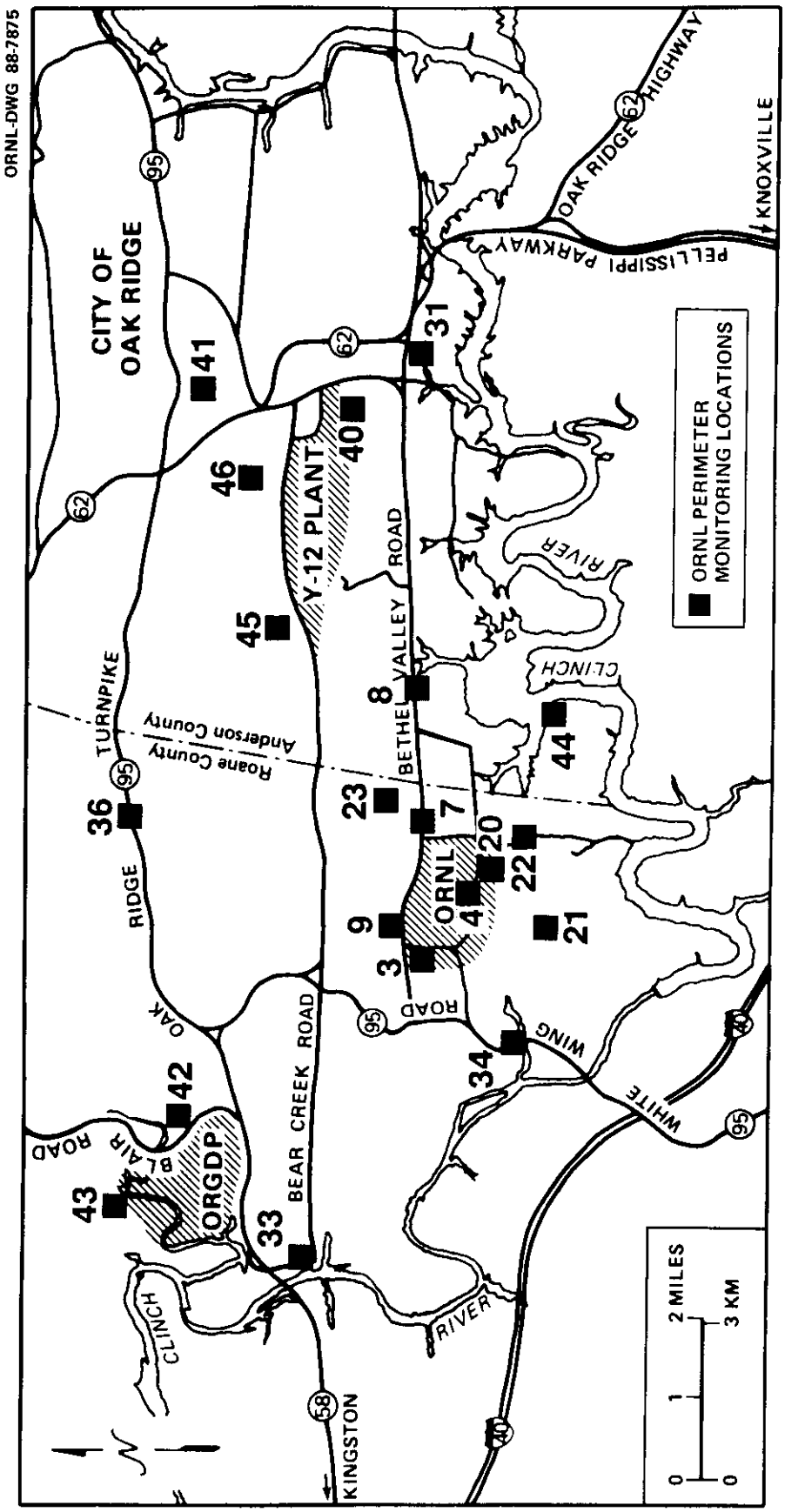

Fig. 2.4.4. ORNL perimeter and ORR grass and soil monitoring locations.

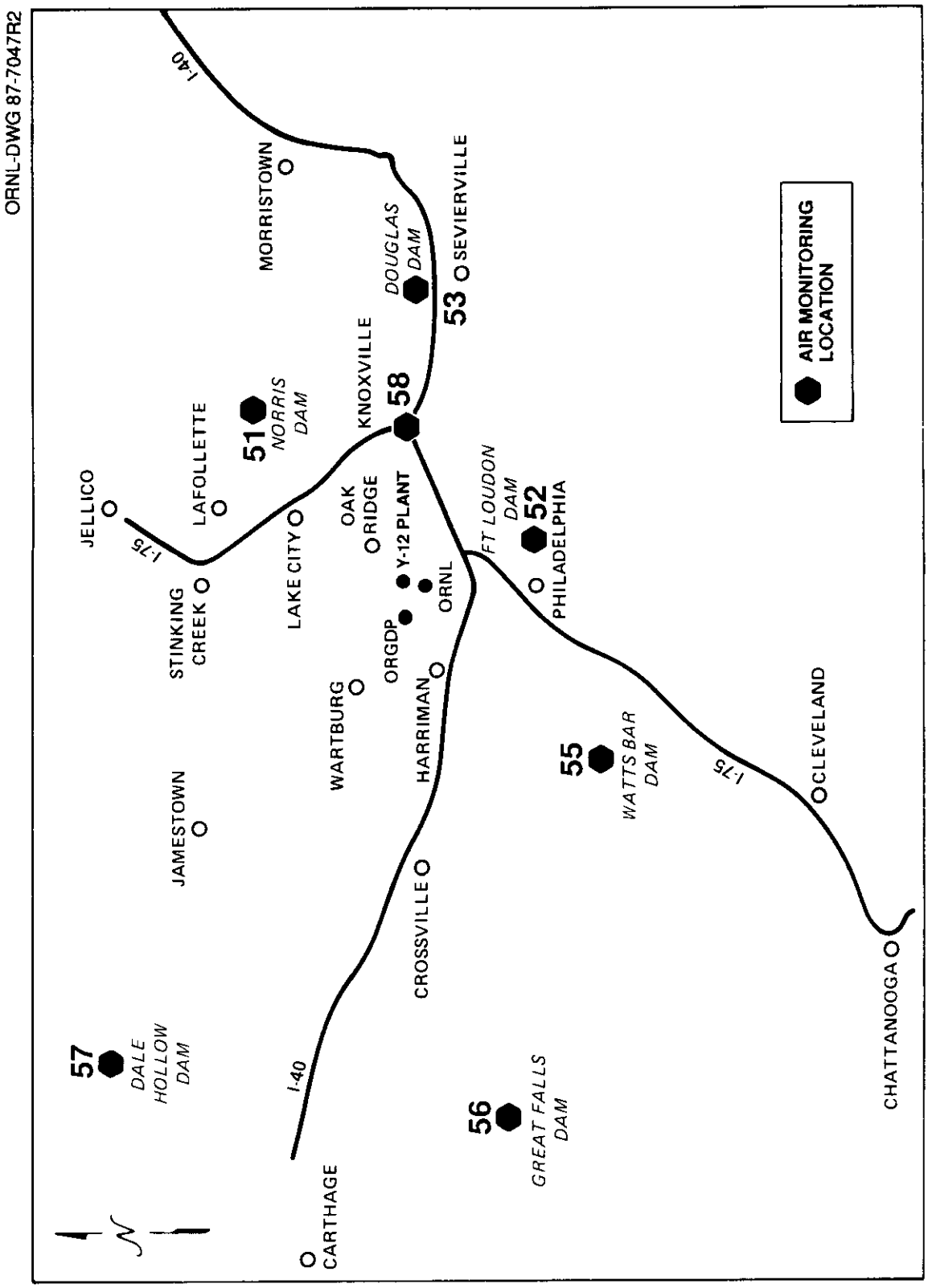

Fig. 2.4.5. ORNL remote grass and soil monitoring locations.

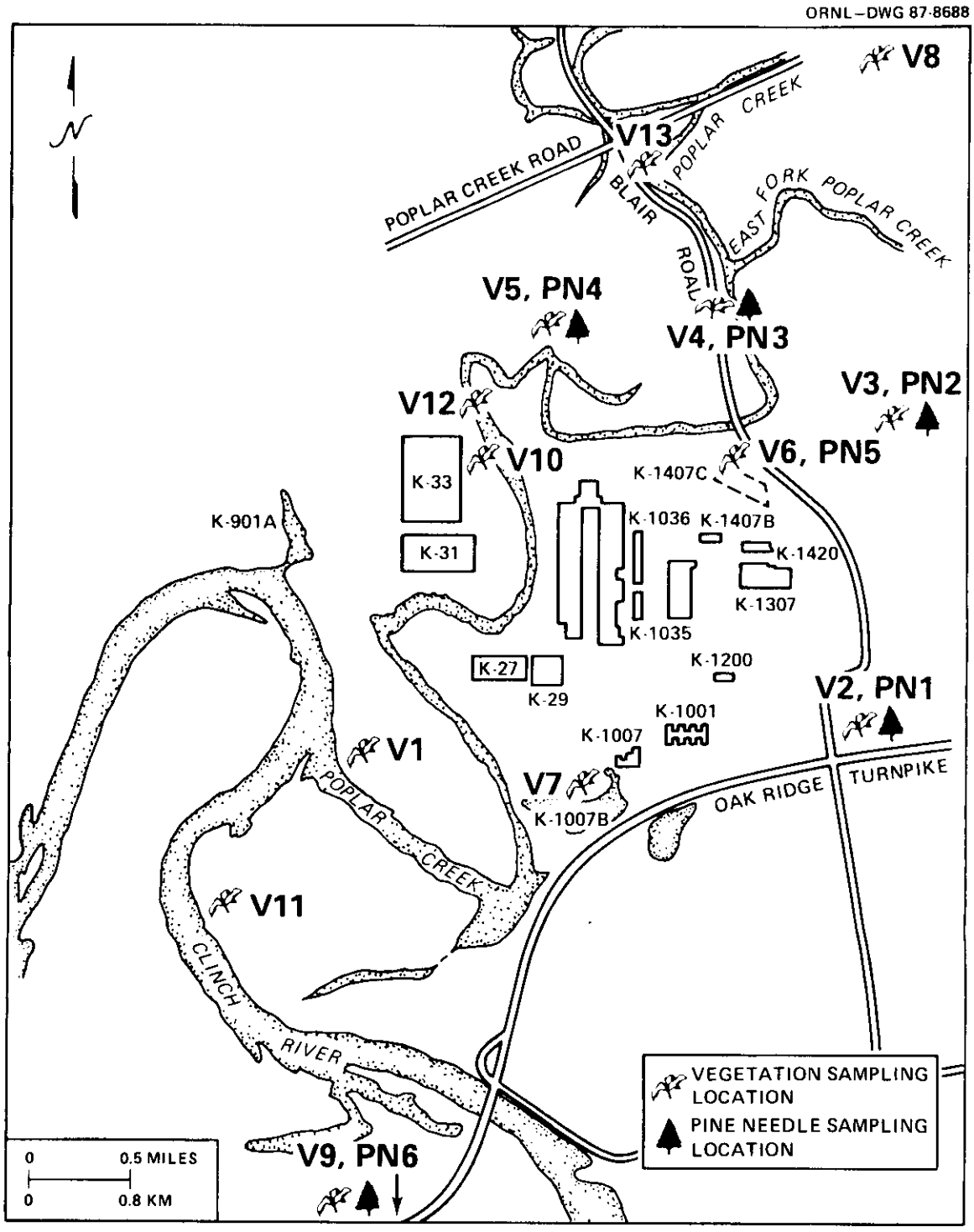

Fig. 2.4.6. Map of ORGDP pine needle and grass sampling locations.

Table 2.4.5. 1988 concentrations of radionuclides in grass

Location[a]	Radionuclides	Number of samples	Concentration (pCi/g ash wt)			
			Max	Min[b]	Av	Standard error[c]
ORNL perimeter stations	^{60}Co	28	0.11	−0.31	0.012	0.0057
	^{137}Cs	28	2.2	−0.090	0.28	0.13
	^{238}Pu	28	0.0030	−0.0030	−0.00010	0.00025
	^{239}Pu	28	0.022	−0.0043	0.0010	0.0010
	Total Sr[d]	28	22	0.019	2.2	1.0
	^{234}U	28	0.10	0.0073	0.030	0.0044
	^{235}U	28	0.011	−0.0015	0.0028	0.00056
	^{238}U	28	0.089	0.0027	0.019	0.0035
Oak Ridge Reservation stations	^{60}Co	52	0.087	−0.074	0.011	0.0041
	^{137}Cs	52	0.11	−0.040	0.015	0.0044
	^{238}Pu	52	0.0035	−0.0024	0.00024	0.00017
	^{239}Pu	52	0.0022	−0.010	−0.0018	0.00032
	Total Sr[d]	52	0.51	−0.11	0.16	0.019
	^{234}U	52	0.15	0.0068	0.033	0.0045
	^{235}U	52	0.013	−0.00054	0.0031	0.00043
	^{238}U	52	0.14	0.002	0.019	0.0043
Remote stations	^{60}Co	28	0.050	−0.10	0.012	0.0063
	^{137}Cs	28	0.044	−0.040	0.015	0.0040
	^{238}Pu	28	0.0024	−0.014	−0.00030	0.00054
	^{239}Pu	28	0.00051	−0.0046	−0.0015	0.00029
	Total Sr[d]	28	0.59	0.032	0.20	0.027
	^{234}U	28	0.059	0.0065	0.018	0.0027
	^{235}U	28	0.013	−0.00065	0.0020	0.00060
	^{238}U	28	0.030	0.0021	0.0070	0.0011

[a]See Figs. 2.4.4 and 2.4.5.

[b]Some radionuclides are reported without regard to lower limits of detection. This practice, approved by DOE and EPA, can result in values below zero (after correcting for background).

[c]Standard deviation about the average.

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

Table 2.4.6. 1988 grass and pine needle analyses at ORGDP

Radionuclide	Number of samples	Concentration (μg/g dry wt)			Standard error[a]
		Max	Min	Av	
		Grass			
F^-	26	17.8	<3	<5.1	3.5
U	26	3.1	<0.5	<2.7	3.0
^{99}Tc	26	70.0[b]	0.0	5.9[b]	17.8
		Pine needles			
F^-	12	4	<3	<3.3	0.45
U	12	1.8	<0.5	<0.6	0.4
^{99}Tc	12	0.9[b]	0.1[b]	0.7[b]	1.1

[a]Standard deviation about the average.

[b]Units are pCi/g instead of μg/g.

stations, the Oak Ridge Reservation (ORR) stations, and the remote stations. Table 2.5.1 provides a summary of the locations sampled and the frequencies of sampling and analysis. The remote stations are used as a reference or background for conditions that are not influenced by discharges from the Oak Ridge Department of Energy (DOE) facilities.

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 in 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, four samples are collected from each station annually.

Sample collection and analytical procedures

Soil samples were collected annually at the ORNL perimeter locations, the ORR locations (Fig. 2.4.4), and the remote locations (Fig. 2.4.5). At all locations, samples were collected at 90° angles to the air monitoring stations and designated as the north, south, east, and west areas. From each of these areas, two 1-m^2 (1.2-yd^2) plots were sampled. From each plot, five aliquots were taken with an 8-cm (3.7-in.) setter of the type used on golf courses. Aliquots from the two plots were composited for analysis for a total of four samples per location. Only the top 2 cm (0.8 in.) of soil were analyzed for radionuclides. All samples were dried before analysis.

Results

Summary concentrations of radioactive materials in soils at each of the monitoring networks are given in Table 2.5.2. All results are reported on a dry weight basis. The percentage of moisture in the soil samples ranged from 2 to 41%; the average was 18%.

Table 2.5.1. Summary of collection and analysis frequencies of soil and sediment sampling in 1988

Station	Parameter	Collection frequency	Type	Analysis frequency
	Soil			
3, 4, 7, 9, 8, 20, 21, 22, 23, 31, 33, 34, 36, 40-46[b]	Total Sr,[a] ^{239}Pu, gamma scan, ^{238}Pu, ^{234}U, ^{235}U, ^{238}U	Annually	Grab	Annually
51–53, 55–58[c]	Total Sr,[a] ^{239}Pu, gamma scan, ^{238}Pu, ^{234}U, ^{235}U, ^{238}U	Annually	Grab	Annually
S18–S30[d]	F, U	Semiannually	Grab	Semiannually
	Stream sediment			
SS1–SS8[e]	Hg, Pb, Ni, Cu, Zn, Cr, Mn, Al, Th, Cd, U	Semiannually	Grab	Semiannually

[a]Total radioactive strontium (^{89}Sr + ^{90}Sr).
[b]See Fig. 2.4.4.
[c]See Fig. 2.5.2.
[d]See Fig. 2.4.5.
[e]See Fig. 2.5.1.

Table 2.5.2. 1988 concentrations of radionuclides in soil

Location[a]	Radionuclides	No. of samples	Concentration (pCi/kg dry wt)			Standard error[c]
			Max	Min[b]	Av	
ORNL perimeter stations	^{60}Co	28	0.41	−0.035	0.044	0.015
	^{137}Cs	28	30	0.027	2.1	1.1
	^{238}Pu	28	0.012	−0.0019	0.0012	0.00065
	^{239}Pu	28	0.73	−0.0027	0.048	0.026
	Total Sr[d]	28	10	−0.024	1.0	0.42
	^{234}U	28	0.95	0.21	0.36	0.032
	^{235}U	28	0.035	0.010	0.018	0.0015
	^{238}U	28	0.57	0.14	0.25	0.017
Oak Ridge Reservation stations	^{60}Co	52	0.12	−0.041	0.019	0.0049
	^{137}Cs	52	2.1	0.038	0.64	0.065
	^{238}Pu	52	0.015	−0.0032	0.00068	0.00036
	^{239}Pu	52	0.042	−0.0065	0.013	0.0016
	Total Sr[d]	52	0.65	−0.019	0.10	0.014
	^{234}U	52	5.1	0.17	0.62	0.10
	^{235}U	52	0.49	0.0081	0.043	0.010
	^{238}U	52	8.6	0.12	0.57	0.17
Remote stations	^{60}Co	28	0.086	−0.043	0.028	0.0063
	^{137}Cs	28	2.3	0.032	0.86	0.12
	^{238}Pu	28	0.0046	−0.023	0.00021	0.00092
	^{239}Pu	28	0.054	−0.0054	0.018	0.0027
	Total Sr[d]	28	0.62	−0.019	0.20	0.026
	^{234}U	28	0.76	0.19	0.46	0.034
	^{235}U	28	0.070	0.0068	0.029	0.0033
	^{238}U	28	0.59	0.16	0.37	0.028

[a]See Figs. 2.4.4 and 2.4.5.

[b]Some radionuclides are reported without regard to lower limits of detection. This practice, approved by DOE and EPA, can result in values below zero (after correcting for background).

[c]Standard deviation about the average.

[d]Total radioactive strontium (^{89}Sr and ^{90}Sr).

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. Radionuclide concentrations at the ORNL perimeter stations and ORR stations were similar to those at the remote stations, with the following exceptions.

Concentrations of ^{60}Co, ^{137}Cs, ^{239}Pu, and total radioactive strontium (^{89}Sr + ^{90}Sr) at perimeter station 4 were about an order of magnitude greater than typical values for those respective isotopes at the other stations in the three sampling networks. Station 4 is very close to the Process Wastewater Treatment Plant and the treatment ponds, so elevated concentrations of certain radionuclides there would be expected. Inclusion of this station during 1988 has increased the ORNL perimeter average concentration over 1987 levels.

Strontium concentrations were above average (for the perimeter network) at station 22 and include an anomalously high maximum value. This was also the case in the 1987 samples.

Concentrations of uranium isotopes in the soil at the ORNL perimeter stations (including station 4) were generally about equal to or less than the average concentrations at the remote sites. Uranium isotopes were generally highest at stations near the Y-12 Plant, especially station 45, which is just west of the main plant. Uranium concentrations at station 40 were about an order of magnitude lower than the 1987 values. This is probably because of a difference in sampling location. The 1987 samples were taken near the corresponding meteorological station, but the 1988 samples were taken at a different location because of construction activity near the meteorological station. It is also noted, for future reference, that the construction activity included considerable earth movement and probably altered the concentrations of many substances in the soil in the immediate vicinity of station 40.

Anomalous values of ^{238}Pu in individual samples at stations 3, 4, and 31 resulted in elevated mean values for station 40 data and also led to elevated values of the standard errors.

2.5.1.2 Oak Ridge Gaseous Diffusion Plant

Sample collection and analytical procedures

Samples were collected from 13 locations in and around the Oak Ridge Gaseous Diffusion Plant (ORGDP) (Fig. 2.5.1) semiannually. Approximately 450 g of soil is collected using a stainless steel scoop to remove the top 1 cm (0.4 in.) of the sampling area. Fluorometric analysis is used to determine uranium levels, and a fluoride-selective-ion electrode is used to determine fluoride levels.

Results

The results of the semiannual sampling are given in Table 2.5.9, Vol. 2. The fluoride concentrations ranged from 227 $\mu g/g$ at station S23 to 875 $\mu g/g$ at station S21. The concentration of fluoride in the soil is almost 100 times higher than that in grass. Uranium concentrations have not changed significantly since 1985. In March 1988, two locations, sampling stations S25 and S29, had increased concentrations of uranium above those of 1987. The concentration of uranium in the soil is generally 10 times the amount in grass.

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 semiannually and analyzed for concentrations of mercury, lead, 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 on the ORGDP stream sediment samples. Since 1985, the concentrations of lead, nickel, copper, chromium, and aluminum have been decreasing. In 1988, samples from station SS4, which is located at the mouth of Mitchell Branch, showed concentration increases of all the metals except aluminum and manganese. Whereas concentrations at station SS4 have increased, samples from station SS5, located at the mouth of East Fork Poplar Creek, have shown decreases in all the metal concentrations. Samples from stations 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 Oak Ridge National Laboratory (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 (Fig. 2.4.4 and Table 2.6.1). 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

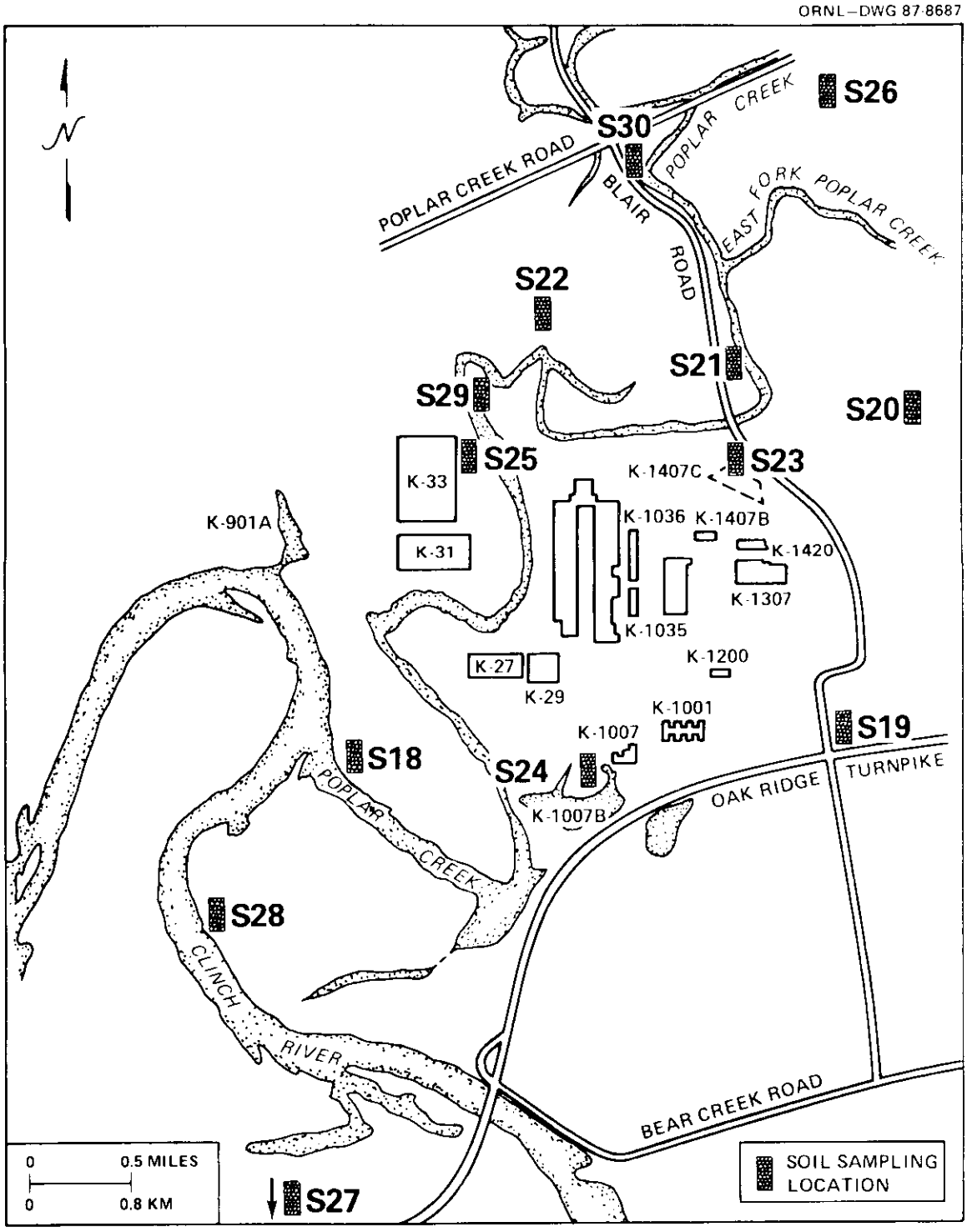

Fig. 2.5.1. Soil sampling locations around ORGDP.

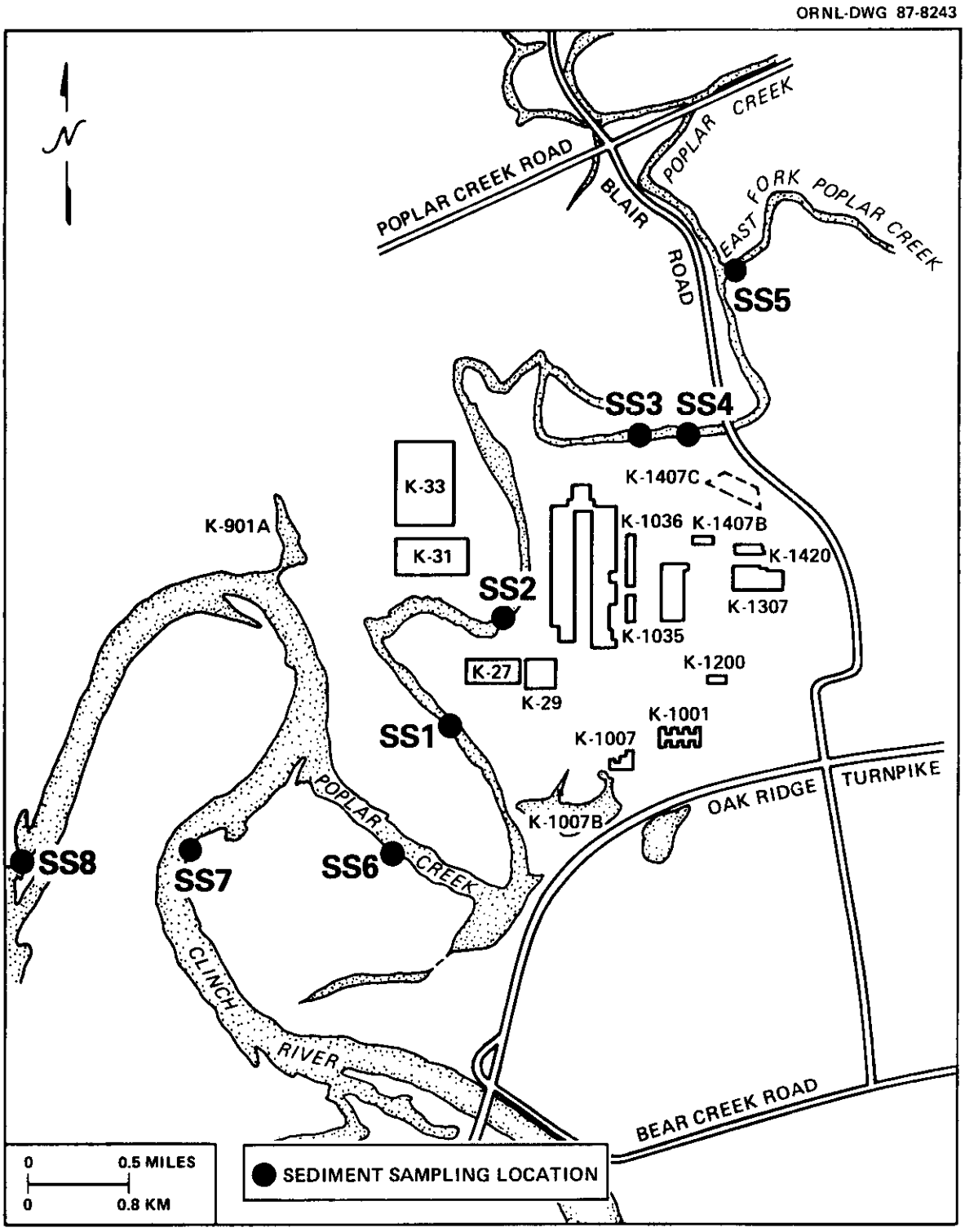

Fig. 2.5.2. Stream sediment sampling locations at ORGDP.

Table 2.6.1. Summary of collection and analysis frequencies of external gamma radiation measurements

Area[a]	Stations	Collection frequency	Analysis frequency (min)
ORNL perimeter	3, 4, 7, 20	Continuous	10
Oak Ridge Reservation	8, 31, 33, 34, 36 40–46	Continuous	10

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 which 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

Network summaries of external gamma radiation measurements are presented in Table 2.6.2. The average value for the ORNL perimeter stations was 44 μR/h, and the average for the Reservation stations was 8.1 μR/h. The higher value for the ORNL perimeter stations is because of the inclusion of station 4, which is located very close to the Process Waste Treatment Plant and the treatment ponds. External gamma values for station 4 are more than ten times the values for any of the other stations, which is to be expected considering the location of that particular station. 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 7.8 μR/h, or slightly less than the value for the reservation stations. 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 being between 7.5 and 15 μR/h (the distribution is positively skewed).

Table 2.6.2. 1988 external gamma radiation measurements

Location[a]	Number of samples	Concentration (μR/h)			Standard error[b]
		Max	Min	Av	
ORNL perimeter stations	166	330	4.2	44	6.0
Oak Ridge Reservation station	477	52	6.1	8.1	0.14

[a]See Fig. 2.4.4.
[b]Standard deviation of the average.

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 1988. 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 usually 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 11 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.

Whole-body dose equivalent. The dose equivalent received when the entire body is placed in a uniform radiation field. This condition can be achieved if the body is in a uniform external radiation field or if internally deposited radionuclides distribute uniformly throughout the body. For most radionuclides, the latter condition is not met; tritium is the only nuclide of interest herein that distributes uniformly. Therefore, in this report, whole-body doses are due only to external exposures unless tritium is involved. Use of this dose expression probably will be discontinued.

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, 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 1988 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 summarized in Table 3.1.7. Doses were calculated using a suite of computer codes (Moore et al. 1979; Begovich et al. 1981; Dunning et al. 1980;

Table 3.1.1. Dose equivalent conversion factors (rem/μCi) for inhalation[a]

Radionuclide (solubility)[b]	Effective	Lung	Endosteal bone	Thyroid
^{3}H	1.25×10^{-4}	1.25×10^{-4}	9.85×10^{-5}	1.25×10^{-4}
^{85}Kr	6.28×10^{-7}	2.00×10^{-6}	4.90×10^{-7}	4.90×10^{-7}
^{90}Sr (D)	2.22×10^{-1}	1.35×10^{-2}	2.53	9.43×10^{-3}
^{99}Tc (W)	8.39×10^{-3}	6.24×10^{-2}	1.55×10^{-4}	4.00×10^{-3}
^{131}I (D)	3.29×10^{-2}	2.50×10^{-3}	1.98×10^{-4}	1.08
^{133}I (D)	5.91×10^{-2}	3.22×10^{-3}	8.74×10^{-5}	1.80×10^{-1}
^{133}Xe	6.24×10^{-7}	1.40×10^{-6}	5.00×10^{-7}	5.71×10^{-7}
^{234}U (D)	2.67	1.20	3.97×10^{1}	9.40×10^{-2}
(W)	7.94	5.97×10^{1}	1.19×10^{1}	9.83×10^{-3}
(Y)	1.32×10^{2}	1.10×10^{3}	4.05	9.83×10^{-2}
^{235}U (D)	2.54	1.11	3.83×10^{1}	9.20×10^{-2}
(W)	7.37	5.53×10^{1}	1.15×10^{1}	2.79×10^{-2}
(Y)	1.22×10^{2}	1.02×10^{3}	3.95	1.55×10^{-2}
^{238}U (D)	2.40	1.06	3.44×10^{1}	8.40×10^{-2}
(W)	7.05	5.29×10^{1}	1.03×10^{1}	2.56×10^{-2}
(Y)	1.18×10^{2}	9.78×10^{2}	3.53	1.05×10^{-2}
^{191}Os (Y)	4.25×10^{-6}	2.66×10^{-2}	1.48×10^{-4}	5.69×10^{-5}
^{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	Lung	Endosteal bone	Thyroid
^{3}H		8.93×10^{-5}	8.36×10^{-5}	6.56×10^{-5}	8.28×10^{-5}
^{85}Kr		0	0	0	0
^{90}Sr	(D)[b]	1.30×10^{-1}	5.33×10^{-3}	1.44	5.33×10^{-3}
^{99}Tc	(D)	1.40×10^{-3}	2.31×10^{-4}	2.31×10^{-4}	5.98×10^{-3}
^{131}I	(D)	5.05×10^{-2}	3.67×10^{-4}	2.88×10^{-4}	1.67
^{133}Xe		0	0	0	0
^{234}U	(D&W)[b]	2.74×10^{-1}	9.60×10^{-3}	4.07	9.60×10^{-3}
	(Y)[b]	2.50×10^{-2}	3.84×10^{-4}	1.63×10^{-1}	3.84×10^{-4}
^{235}U	(D&W)	2.63×10^{-1}	9.40×10^{-3}	3.94	9.40×10^{-3}
	(Y)	2.58×10^{-2}	3.87×10^{-4}	1.57×10^{-1}	3.76×10^{-4}
^{236}U	(D&W)	2.60×10^{-1}	9.10×10^{-3}	3.84	9.10×10^{-3}
^{236}U	(Y)	2.38×10^{-2}	3.64×10^{-4}	1.54×10^{-1}	3.64×10^{-4}
^{238}U	(D&W)	2.47×10^{-1}	8.70×10^{-3}	3.52	8.70×10^{-3}
	(Y)	2.30×10^{-2}	3.47×10^{-4}	1.41×10^{-1}	3.46×10^{-4}
^{231}Th	(W)	1.23×10^{-3}	5.30×10^{-7}	1.20×10^{-5}	3.45×10^{-8}
^{234}Th	(W)	1.30×10^{-2}	2.45×10^{-6}	7.30×10^{-5}	1.08×10^{-6}
^{234m}Pa	(W)	5.80×10^{-6}	4.18×10^{-9}	1.86×10^{-9}	4.13×10^{-10}
^{60}Co	(W)	1.13×10^{-2}	2.11×10^{-5}	1.34×10^{-5}	2.38×10^{-5}
^{137}Cs	(D)	4.30×10^{-2}	4.44×10^{-2}	3.05×10^{-2}	5.08×10^{-2}
^{238}Pu	(W)	3.85	8.42×10^{-2}	6.76×10^{1}	8.42×10^{-2}
^{239}Pu	(W)	4.45	9.45×10^{-3}	7.59×10^{-1}	9.45×10^{-3}
^{241}Am	(W)	4.43	9.71×10^{-2}	7.80×10^{1}	9.70×10^{-2}
^{244}Cm	(W)	2.32	5.0×10^{-2}	4.03×10^{1}	5.0×10^{-2}
^{133}I	(D)	9.95×10^{-3}	1.63×10^{-3}	1.34×10^{-4}	3.18×10^{-1}
^{191}Os	(Y)	2.11×10^{-3}	1.92×10^{-5}	6.06×10^{-5}	1.45×10^{-5}

[a]Factors taken from the EPA Clean Air Act data tapes.
[b]D = soluble; W = moderately soluble; Y = insoluble.

Table 3.1.3. Dose equivalent rate conversion factors (mrem/year per μCi/cm^3) for immersion in air[a]

Radionuclide	Effective	Lung	Endosteal bone	Thyroid
^{3}H	0	0	0	0
^{85}Kr	1.09×10^{7}	9.73×10^{6}	1.14×10^{7}	1.21×10^{7}
^{90}Sr	0	0	0	0
^{99}Tc	2.50×10^{3}	2.09×10^{3}	3.65×10^{3}	3.07×10^{3}
^{131}I	1.86×10^{9}	1.64×10^{9}	2.02×10^{9}	2.07×10^{9}
^{133}Xe	1.66×10^{8}	1.30×10^{8}	2.31×10^{8}	2.01×10^{8}
^{234}U	7.36×10^{5}	4.11×10^{5}	7.10×10^{5}	6.07×10^{5}
^{235}U	7.37×10^{8}	6.32×10^{8}	9.36×10^{8}	8.51×10^{8}
^{236}U	5.80×10^{5}	2.99×10^{5}	5.40×10^{5}	4.48×10^{5}
^{238}U	5.00×10^{5}	2.50×10^{5}	4.51×10^{5}	3.77×10^{5}
^{231}Th	5.52×10^{7}	4.29×10^{7}	7.47×10^{7}	6.40×10^{7}
^{234}Th	3.65×10^{7}	3.01×10^{7}	5.29×10^{7}	4.48×10^{7}
^{234m}Pa	5.83×10^{7}	5.25×10^{7}	5.58×10^{7}	6.66×10^{7}
^{133}I	3.00×10^{9}	2.69×10^{9}	3.09×10^{9}	3.35×10^{9}
^{191}Os	3.28×10^{8}	2.72×10^{8}	4.66×10^{9}	4.00×10^{8}

[a]Factors taken from the EPA Clean Air Act data tapes.

Table 3.1.4. Dose equivalent rate conversion factors (mrem/year per $\mu Ci/cm^2$) for ground surface exposure[a]

Radionuclide	Effective	Lung	Endosteal bone	Thyroid
^{3}H	0	0	0	0
^{85}Kr	2.54×10^{3}	2.01×10^{3}	2.35×10^{3}	2.49×10^{3}
^{90}Sr	0	0	0	0
^{99}Tc	5.91×10^{-1}	4.92×10^{-1}	8.62×10^{-1}	7.25×10^{-1}
^{131}I	3.93×10^{5}	3.47×10^{5}	4.29×10^{5}	4.37×10^{5}
^{133}Xe	4.80×10^{4}	3.56×10^{4}	6.29×10^{4}	5.70×10^{4}
^{234}U	7.94×10^{2}	1.74×10^{2}	2.95×10^{2}	2.31×10^{2}
^{235}U	1.64×10^{5}	1.39×10^{5}	2.07×10^{5}	1.88×10^{5}
^{236}U	7.20×10^{2}	1.40×10^{2}	2.41×10^{2}	1.81×10^{2}
^{238}U	6.35×10^{2}	1.21×10^{2}	2.09×10^{2}	1.57×10^{2}
^{231}Th	1.83×10^{4}	1.11×10^{4}	1.93×10^{4}	1.66×10^{4}
^{234}Th	9.53×10^{3}	7.40×10^{3}	1.31×10^{4}	1.10×10^{4}
^{234m}Pa	1.11×10^{4}	9.95×10^{3}	1.11×10^{4}	1.26×10^{4}
^{133}I	6.01×10^{5}	5.40×10^{5}	6.22×10^{5}	6.73×10^{5}
^{191}Os	8.03×10^{4}	6.59×10^{4}	1.13×10^{5}	9.69×10^{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 1988

Release location	Dose equivalents (mrem/year)				
	Whole body	Effective	Lung	Endosteal bone	Thyroid
ORNL[a]	0.14	0.32	0.46	0.35	0.42
ORGDP[b]	0.000002	0.004	0.03	0.0001	0.0004
Y-12 Plant[c]	0.0007	0.68	5.5	0.31	0.0015
Entire ORR[d]	0.14	0.68	5.5	0.35	0.42

[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 4850 m (3 miles) WSW of Building K-1420 and 5100 m (3.2 miles) WSW of TSCA.

[c]The maximally exposed individual is located 770 m (0.5 miles) NNW of the center of the Y-12 Plant.

[d]The location of the maximally exposed individual for the entire ORR depends on the organ or tissue of interest. For whole-body, endosteal bone, and thyroid exposures, it is the ORNL individual; for effective and lung it is the Y-12 Plant individual.

Table 3.1.6. Calculated collective 50-year committed effective dose equivalents due to airborne releases in 1988

Release location	Dose equivalents (person-rem)
ORNL[a]	21
ORGDP[b]	0.14
Y-12[c]	15
ORR[d]	36

[a]The collective 50-year committed dose equivalents to the 836,000 persons residing within 80 km (50 miles) of the ORNL.

[b]The collective 50-year committed dose equivalents to the 837,000 persons residing within 80 km of the ORGDP.

[c]The collective 50-year committed dose equivalents to the 863,000 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.

Table 3.1.7. Annual report of radionuclides released to the atmosphere during 1988 per 40CFR61.94

ORNL[a]

Section I. Air emissions (Ci/year)

Radionuclide	Quantity
^{3}H	2.13×10^{4}
^{7}Be	2.15×10^{-6}
^{60}Co	1.69×10^{-4}
^{75}Se	4.90×10^{-4}
^{82}Br	5.40×10^{-4}
^{85}Kr	6.45×10^{3}
^{90}Sr	3.30×10^{-4}
^{125}Sb	2.40×10^{-6}
^{125}I	2.74×10^{-4}
^{129}I	5.14×10^{-4}
^{131}I	5.60×10^{-2}
^{132}I	7.50×10^{-5}
^{133}I	3.01×10^{-2}
^{134}I	5.50×10^{-5}
^{135}I	1.60×10^{-2}

Table 3.1.7 (continued)

^{133}Xe	3.13×10^{4}
^{137}Cs	1.63×10^{-4}
^{152}Eu	1.10×10^{-7}
^{154}Eu	1.50×10^{-7}
^{155}Eu	9.90×10^{-8}
^{191}Os	5.10
$^{212}Pb^{b}$	5.07×10^{-2}
$^{228}Th^{c}$	1.87×10^{-3}
U	6.50×10^{-8}
^{239}Pu	3.10×10^{-9}

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/year)

	EPA standard	Facility estimate	Percent of standard
Whole body	≤25	0.14	0.6
Any organ	≤75	0.46 (lung)	0.6

ORGDP[a]

Section I. Air emission (Ci/year)

Radionuclide	Quantity
^{234}U	4.93×10^{-4}
^{235}U	2.55×10^{-5}
^{238}U	6.07×10^{-5}
^{99}Tc	9.08×10^{-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/year)

	EPA standard	Facility estimate	Percent of standard
Whole body	≤25	0.000002	<0.0001
Any organ	≤75	0.03 (lung)	0.04

Table 3.1.7 (continued)

Y-12 Plant[a]

Section I. Air emissions (Ci/year)

Radionuclide	Quantity
^{234}U	9.8×10^{-2}
^{235}U	4.0×10^{-3}
^{238}U	1.8×10^{-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/year)

	EPA standard	Facility estimate	Percent of standard
Whole Body	≤25	0.0007	0.003
Any organ	≤75	5.5	7.3

[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.

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, 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), three 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

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	15.3	4970	SW
2026[a]	22.9	1.1	11.0	4970	SW
3020[a]	61.0	2.0	7.3	4970	SW
7911[b]	76.2	1.5	10.1	5160	WSW
7512[b]	30.5	0.9	6.5	5160	WSW
7025	4.3	0.5	6.6	6910	SW
7830[c]	3.7	0.2	12.7	3860	WSW
7877[c]	13.9	0.4	16.2	3860	WSW
			ORGDP		
K-1420[d]	16.2	0	0	4850	WSW
K-1423[d]	2.4	0.9	1.1	4850	WSW
K-1435	30.5	1.3	6.8	5100	WSW
			Y-12 Plant		
All	20.0	0	0	770	NNW

[a]Colocated stacks.
[b]Colocated stacks.
[c]Colocated stacks.
[d]Colocated stacks.

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 1988 meteorological data from the 100-m (328-ft) sensor on tower MT2. Releases from ORGDP were characterized using 1988 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 1988 were collected from the 30-m (98-ft) sensor on the Y-12 tower during 1988.

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 2026 stacks. The noble gas releases were assumed to be 83% ^{133}Xe and 17% ^{85m}Kr, a combination chosen to represent the spectrum of noble gas constituents from a reactor. The relative proportions of the two gases correspond to the proportion found in the High Flux Isotope Reactor core after 24 days of operation (Craddick and Cook, in press). 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. Calculated dose equivalents 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, are given in Table 3.1.5. Most of the doses (~87%) are from tritium and ^{191}Os released from the 3039 stack. The 0.32-mrem effective and the highest organ dose equivalents (0.46 mrem to the lungs) are well below the NESHAP requirements (Table 3.1.7). The 50-year collective committed effective dose equivalent to the ~836,000 persons residing within 80 km of ORNL was calculated to be 20.6 person-rem (Table 3.1.6).

Releases from ORGDP during 1988 came mainly from Building K-1420 and the TSCA incinerator. The total release was 5.7×10^{-4} Ci of U in an insoluble (class Y) form and 4.5×10^{-6} Ci of U in a soluble (class D) form. In addition, 9.1×10^{-3} Ci of ^{99}Tc was released. Calculated dose equivalents to the maximally exposed resident, are given in Table 3.1.5. Essentially all of the doses are due to inhalation and ingestion. All of the calculated dose equivalents are small when compared with background, as is the collective dose equivalent (Table 3.1.6). A total of 0.12 Ci of uranium was released from the Y-12 Plant during 1988 (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. Calculated dose equivalents to the maximally exposed resident, who is located 770 m (0.5 miles) NNW of the release point, are given in Table 3.1.5. The dominant exposure pathway is inhalation. The 0.68-mrem effective dose equivalent is well below the 25-mrem standard. The highest organ dose commitment, 5.5 mrem to the lung, also is well below the NESHAP requirements (Table 3.1.7). The collective 50-year committed effective dose equivalent to the ~863,000 persons residing within 80 km of the Y-12 Plant was calculated to be 15.1 person-rem (Table 3.1.6). For the entire ORR, the maximum individual doses depend on the dose of interest. Maximum whole-body, endosteal bone, and thyroid doses are attributable to releases from ORNL; maximum effective and endosteal bone doses are attributable to the Y-12 Plant. The total collective dose commitment due to operations at the ORR during 1988 is estimated to be 36 person-rem. This collective dose could produce a fatal cancer risk of ~0.005, based on a fatal cancer risk of 0.000125/rem of effective dose equivalent.

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. When average annual concentrations were less than a detection limit, the doses in Table 3.1.9 were considered as "less than" values as well. Doses estimated for consumption of water at Melton Hill Dam, 0.1 mrem effective and 1.0 mrem to endosteal bone, represent upstream (background) doses. Water sampled at the inlet to ORGDP (Gallaher process water) is the closest nonpublic water supply downstream. The calculated dose equivalents at this location are 0.3 mrem effective and 3.1 mrem to endosteal bone, the highest organ. 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 doses from drinking water are 0.1 mrem effective and 1.2 mrem to endosteal

Table 3.1.9. Potential 50-year committed dose equivalents from drinking water in 1988[a]

Location	Dose equivalent (mrem)		
	Effective	Endosteal bone	Stomach wall
Melton Hill Dam	<0.1	<1.0	<0.03
Gallaher process water	<0.3	<3.1	<0.1
ORNL tap water	<0.05	<0.5	<0.01
Kingston water plant	<0.1	<1.2	<0.02

[a]Assumes ingestion of 730 L of water per year (2 L per day).

bone. This could result in a collective committed effective dose of about 0.8 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; 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 doses, 0.2 mrem effective and 0.4 mrem to endosteal bone, are 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 0.04-mrem effective dose to an individual from eating 21 kg of fish caught at Kingston could result in a population dose of about 0.3 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 1.1 person-rem from drinking water and eating fish. This represents about 0.05% of the annual dose from background radiation (2250 person-rem) estimated for this population.

Table 3.1.10. Potential 50-year committed dose equivalents from eating fish in 1988[a]

Location	Dose equivalents (mrem)	
	Effective	Endosteal bone
CRK 8.0	0.04	0.1
CRK 33.3	0.2	0.4
CRK 40.0	0.03	0.03

[a]Assumes ingestion of 21 kg of fish per year.

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 365 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

Table 3.1.11. Potential 50-year committed dose equivalents from drinking milk in 1988[a]

Location[b]	Dose equivalents (mrem)		
	Effective	Endosteal bone	Thyroid
Immediate environs (stations 1, 2, 3, 4, 6, 8)	0.3	2.6	1.5
Remote environs (stations 51, 53, 56)	0.3	3.3	0.1

[a]Assumes ingestion of 365 L of milk per year using the average radionuclide concentrations at each location.
[b]See Fig. 2.4.1.

Sect. 2.4.1) were used to calculate the doses. Effective doses and doses to endosteal bone (from ^{90}Sr) and to the thyroid (from ^{131}I) are given in Table 3.1.11. Doses at immediate and remote environs stations are similar; for example, effective dose equivalents of 0.3 and 0.3, 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).

3.1.2.4 Direct radiation

External radiation exposure rates are measured at a number of locations on and off the ORR (see Sect. 2.5). 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 5.6 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 doses (effective and highest organ) to individuals via several pathways of 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 0.68 mrem from gaseous effluents, also drank milk from the sampled stations (0.3 mrem), ate fish from CRK 33 (0.2 mrem); drank Oak Ridge city water [which is the same as ORNL tap water (0.05 mrem)]; and fished the Clinch River between CRK 33 and 30 (5.6 mrem), he or she could receive a committed effective dose equivalent of about 6.8 mrem/year, or about 2% of the annual dose from background radiation.

3.1.4 Five-Year Trends

Dose equivalents associated with selected exposure pathways for the years 1984 through 1988 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

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[a]	
3	55
7	48
9	61
21	51
22	65
ORR stations[b]	
8	43
23	46
Clinch River stations[c]	
41	73
42	96
47	73
60	52
61	88
64	160
65	180
66	210
67	105
68	88
69	46
Background stations[d]	
Average of 12 locations in Tennessee	56

[a]Assumes an exposure of 8760 h/year.
[b]See Fig. 2.4.4.
[c]*Source: Environmental Surveillance of the U.S. Department of Energy Oak Ridge Reservation and Surrounding Environs during 1987*, ES/ESH-4/V1 (1988).
[d]*Source:* Myrick, T. E., B. A. Bervin, and F. F. Haywood, *State Background Radiation Levels*, ORNL/TM-7343 (1981).

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 higher than the detection limit reported. These doses should be considered "less than" values.

3.1.5 Findings and Conclusions

The doses to a maximally exposed off-site individual from airborne effluents are greatest from the Y-12 Plant (0.0007 mrem to whole body, 0.68 mrem effective, and 5.5 mrem to the lung). These are well within the dose limits, 25 mrem to whole body and 75 mrem to any organ, specified in the Clean Air Act for Department of Energy (DOE) facilities. For the entire ORR, maximum doses (Table 3.1.5) are 0.14 mrem to whole body, 0.7 mrem effective, and 5.5 mrem lung, well within the federal standards. The estimated collective committed effective dose to the approximately 8.7×10^5 persons living within 80 km (50 miles) of the ORR is 36 person-rem for 1988 airborne emissions. This represents about 0.01% of the 2.61×10^5 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 1988. Those releases are quantified in Tables 3.2.1 through 3.2.5 and are compared to 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,

Table 3.1.13. Summary of estimated radiation dose equivalents to an adult during 1988 at locations of maximum exposure

Pathway	Location	Effective (mrem)	Highest organ (mrem)
Gaseous effluents	Nearest resident:		
Inhalation plus direct radiation from air, ground, and food chains	Y-12 Plant	0.68	5.5 (lung)
	ORNL	0.32	0.5 (lung)
	ORGDP	0.004	0.03 (lung)
Terrestial food chain (milk)	Average of sampling stations	0.3	1.5 (thyroid) 2.6 (endosteal bone)
Liquid effluents			
Drinking water	ORNL	0.05	0.5 (endosteal bone)
	Kingston	0.1	1.2 (endosteal bone)
Eating fish	CRK 33 (ORNL discharge point)	0.2	0.4 (endosteal bone)
Direct radiation	Clinch River shoreline (33.3 to 30.0 CRK)	5.6 (250 h/year)	

Table 3.1.14. Five-year trends in committed effective dose equivalent for selected pathways

Pathway	Dose equivalent (mrem)				
	1984	1985	1986	1987	1988
Inhalation:					
Effective	4.6	2.4	3.6[a]	2.1	0.7
Lung	15	15	23[a]	17	5.5
Milk consumption:					
Effective	0.01	0.01	0.14	<0.26	0.3
Thyroid	0.07	0.2	1.6	<2.0	1.5
Fish consumption:					
Effective	1.1	1.3	0.8	0.3	0.2
Endosteal bone	2.1	3.5	1.2	0.6	0.4
Drinking water (Kingston):					
Effective	0.2	0.12	0.11	<0.5	0.1
Stomach wall	0.5	1.5	0.25	0.26	0.01
Direct irradiation:					
Effective	5.9	5.0	8.8	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.

Table 3.2.1. Potential chemical dose comparison for ORR surface waters annual 1988 average values

Chemical	Calculated daily intake[a] (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
	Melton Hill Dam		
Antimony (total)	<0.178	0.028	<6.36
Arsenic (total)	<0.172	0.100	<1.72
Barium (total)	0.52	3.50	0.15
Beryllium (total)	0.015	0.0002	75.00
Cadmium (total)	<0.010	0.0574	<0.17
Chromium (total)	<0.04	0.100	<0.40
Copper (total)	<0.054	2.6	<0.02
Lead (total)	<0.134	0.100	<1.34
Methylene chloride	0.007	0.093	0.08
Nickel (total)	<0.088	1.4	<0.06
PCB			
Aroclor 1016	<0.001	0.0002	<5.00
Aroclor 1221	<0.001	0.0002	<5.00
Aroclor 1232	<0.001	0.0002	<5.00
Aroclor 1242	<0.001	0.0002	<5.00
Aroclor 1248	<0.001	0.0002	<5.00
Aroclor 1254	<0.002	0.0002	<10.00
Aroclor 1260	<0.002	0.0002	<10.00
Selenium (total)	<0.22	0.21	<1.05
Silver (total)	<0.018	0.21	<0.09
Zinc (total)	<0.09	14.7	<0.01
	White Oak Creek Headwaters		
Antimony (total)	<0.088	0.028	<3.14
Arsenic (total)	<0.096	0.100	<0.96
Barium (total)	0.20	3.50	0.06
Beryllium (total)	<0.003	0.0002	<15.00
Cadmium (total)	<0.003	0.0574	<0.05
Chromium (total)	<0.018	0.100	<0.18
Copper (total)	<0.017	2.6	<0.01
Lead (total)	<0.052	0.100	<0.52
Methylene chloride	<0.006	0.093	<0.06
Nickel (total)	<0.010	1.4	<0.01
PCB			
Aroclor 1016	<0.001	0.0002	<5.00
Aroclor 1221	<0.001	0.0002	<5.00
Aroclor 1232	<0.001	0.0002	<5.00
Aroclor 1242	<0.001	0.0002	<5.00
Aroclor 1248	<0.001	0.0002	<5.00
Aroclor 1254	<0.002	0.0002	<10.00
Aroclor 1260	<0.002	0.0002	<10.00
Selenium (total)	<0.108	0.21	<0.51
Silver (total)	<0.011	0.21	<0.05
Zinc (total)	<0.02	14.7	<0.001

[a]Values represent annual averages.

Table 3.2.2. Potential chemical dose comparison for ORR surface waters annual 1988 average values—Y-12 Plant

Chemical	Calculated daily intake[a] (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
	Discharge Point: 301		
Arsenic (total)	<0.08	0.100	<0.80
Cadmium (total)	<0.012	0.0574	<0.21
Chromium (total)	<0.012	0.100	<0.12
Copper (total)	<0.006	2.6	<0.002
Lead (total)	<0.04	0.100	<0.40
Mercury (total)	<0.0004	0.0235	<0.02
Nickel (total)	<0.02	1.4	<0.01
Selenium (total)	<0.004	0.21	<0.02
Zinc (total)	0.018	14.7	0.001
	Discharge Point: 302		
Arsenic (total)	0.40	0.100	4.00
Cadmium (total)	<0.01	0.0574	<0.17
Chromium (total)	<0.012	0.100	<0.12
Copper (total)	<0.008	2.6	<0.003
Lead (total)	<0.04	0.100	<0.40
Mercury (total)	<0.0006	0.0235	<0.03
Nickel (total)	<0.018	1.4	<0.01
Selenium (total)	<0.04	0.21	<0.19
Zinc (total)	<0.01	14.7	<0.001
	Discharge Point: 303		
Beryllium (total)	<0.0002	0.0002	<1.00
Cadmium (total)	<0.008	0.0574	<0.14
Copper (total)	0.018	2.6	0.01
Lead (total)	<0.04	0.100	<0.40
Mercury (total)	0.004	0.0235	0.17
Nickel (total)	<0.02	1.4	<0.01
Tetrachloroethylene	<0.02	0.014	<1.43
Zinc (total)	0.12	14.7	0.01
	Discharge Point: Station 17		
Cadmium (total)	<0.008	0.0574	<0.14
Chromium (total)	<0.014	0.100	<0.14
Copper (total)	0.024	2.6	0.01
Lead (total)	<0.02	0.100	<0.20
Mercury (total)	<0.004	0.0235	<0.17
Nickel (total)	<0.022	1.4	<0.02
Selenium (total)	<0.004	0.21	<0.02
Zinc (total)	0.16	14.7	0.01
	Discharge Point: Upper Bear Creek		
Arsenic (total)	<0.10	0.100	<1.00
Barium (total)	1.33	3.50	0.38
Beryllium (total)	<0.003	0.0002	<15.00
Cadmium (total)	<0.038	0.0574	<0.66
Chromium (total)	<0.02	0.100	<0.20

Table 3.2.2 (continued)

Chemical	Calculated daily intake[a] (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
Copper (total)	<0.008	2.6	<0.003
Lead (total)	<0.06	0.100	<0.60
Mercury (total)	<0.0016	0.0235	<0.07
Nickel (total)	<0.14	1.4	<0.10
PCBs (total)	<0.001	0.0002	<5.00
Silver (total)	<0.012	0.21	<0.06
Zinc (total)	<0.036	14.7	<0.002
Discharge Point: 305			
Beryllium (total)	<0.0002	0.0002	<1.00
Cadmium (total)	<0.008	0.0574	<0.14
Lead (total)	<0.04	0.100	<0.40
Mercury (total)	<0.0004	0.0235	<0.02
Silver (total)	<0.008	0.21	<0.04
Discharge Point: 306			
Cadmium (total)	<0.006	0.0574	<0.10
Lead (total)	<0.04	0.100	<0.40
Mercury (total)	<0.0004	0.0235	<0.02
Nickel (total)	<0.018	1.4	<0.01
Silver (total)	<0.008	0.21	<0.04

[a]Values represent annual averages.

Table 3.2.3. Potential chemical dose comparison for ORR surface waters annual 1988 average values—ORNL

Chemical	Calculated daily intake[a] (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
	Discharge Point: X01		
Chromium (total)	<0.012	0.100	<0.12
Copper (total)	<0.022	2.6	<0.01
Mercury (total)	<0.0004	0.0235	<0.02
Silver (total)	<0.0098	0.21	<0.05
Trichloroethene	0.0096[b]	0.064	0.15[b]
Zinc (total)	0.124	14.7	0.01
	Discharge Point: X02		
Arsenic (total)	<0.114	0.100	<1.14
Cadmium (total)	0.0044	0.0574	0.08
Chromium (total)	<0.0146	0.100	<0.15
Copper (total)	<0.030	2.6	<0.01
Lead (total)	<0.072	0.100	<0.72
Nickel (total)	0.026	1.4	0.02
Selenium (total)	0.106	0.21	0.50
Silver (total)	0.0106	0.21	0.05
Zinc (total)	<0.070	14.7	<0.005
	Discharge Point: X03		
Arsenic (total)	<0.092	0.100	<0.92
Cadmium (total)	<0.0044	0.0574	<0.08
Chromium (total)	<0.011	0.100	<0.11
Copper (total)	<0.0340	2.6	<0.01
Lead (total)	<0.0660	0.100	<0.66
Nickel (total)	<0.0102	1.4	<0.01
Zinc (total)	0.198	14.7	0.01
	Discharge Point: X04		
Arsenic (total)	<0.094	0.100	<0.94
Cadmium (total)	<0.0028	0.0574	<0.05
Chromium (total)	<0.013	0.100	<0.13
Copper (total)	0.042	2.6	0.02
Lead (total)	<0.078	0.100	<0.78
Nickel (total)	<0.012	1.4	<0.01
Silver (total)	<0.019	0.21	<0.09
Zinc (total)	0.22	14.7	0.01
	Discharge Point: X06		
Arsenic (total)	<0.094	0.100	<0.94
Cadmium (total)	<0.011	0.0574	<0.19
Chromium (total)	<0.026	0.100	<0.26
Copper (total)	0.172	2.6	0.07
Lead (total)	<0.098	0.100	<0.98
Nickel (total)	<0.0152	1.4	<0.01
Selenium (total)	<0.096	0.21	<0.46
Zinc (total)	0.20	14.7	0.01

Table 3.2.3 (continued)

Chemical	Calculated daily intake[a] (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
	Discharge Point: X07		
Arsenic (total)	<0.094	0.100	<0.94
Cadmium (total)	<0.0028	0.0574	<0.05
Chromium (total)	<0.0138	0.100	<0.14
Copper (total)	<0.100	2.6	<0.04
Lead (total)	<0.072	0.100	<0.72
Nickel (total)	<0.0122	1.4	<0.01
Silver (total)	<0.0118	0.21	<0.06
Zinc (total)	<0.024	14.7	<0.002
	Discharge Point: X08		
Arsenic (total)	<0.072	0.100	<0.72
Cadmium (total)	<0.0024	0.0574	<0.04
Chromium (total)	<0.034	0.100	<0.34
Copper (total)	0.076	2.6	0.03
Lead (total)	<0.060	0.100	<0.60
Nickel (total)	<0.0106	1.4	<0.01
Zinc (total)	0.188	14.7	0.01
	Discharge Point: X09		
Arsenic (total)	<0.078	0.100	<0.78
Cadmium (total)	0.0038	0.0574	0.07
Chromium (total)	0.02	0.100	0.20
Copper (total)	0.09	2.6	0.03
Lead (total)	<0.048	0.100	<0.48
Nickel (total)	<0.0096	1.4	<0.01
Zinc (total)	0.118	14.7	0.01
	Discharge Point: X11		
Arsenic (total)	0.100	0.100	1.00
Cadmium (total)	<0.003	0.0574	<0.05
Chromium (total)	<0.0174	0.100	<0.17
Copper (total)	<0.048	2.6	<0.02
Lead (total)	<0.072	0.100	<0.72
Nickel (total)	<0.018	1.4	<0.01
Zinc (total)	0.92	14.7	0.06
	Discharge Point: X13		
Arsenic (total)	<0.09	0.100	<0.90
Cadmium (total)	<0.004	0.0574	<0.07
Chromium (total)	<0.0112	0.100	<0.11
Copper (total)	<0.0162	2.6	<0.01
Lead (total)	<0.008	0.100	<0.08
Mercury (total)	<0.0001	0.0235	<0.004
Nickel (total)	<0.010	1.4	<0.01
PCBs (total)	<0.0010	0.0002	<5.00
Silver (total)	<0.010	0.21	<0.05
Trichlorethene	<0.010	0.064	<0.16
Zinc (total)	0.030	14.7	0.002

Table 3.2.3 (continued)

Chemical	Calculated daily intake[a] (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
	Discharge Point: X14		
Arsenic (total)	<0.090	0.100	<0.90
Cadmium (total)	0.0038	0.0574	0.07
Chromium (total)	<0.0108	0.100	<0.11
Copper (total)	<0.022	2.6	<0.01
Lead (total)	<0.0124	0.100	<0.12
Mercury (total)	0.0002	0.0235	0.01
Nickel (total)	<0.0098	1.4	<0.01
PCBs (total)	<0.001	0.0002	<5.00
Silver (total)	<0.0096	0.21	<0.05
Trichlorethene	<0.010	0.064	<0.16
Zinc (total)	0.092	14.7	0.01
	Discharge Point: X15		
Arsenic (total)	<0.090	0.100	<0.90
Cadmium (total)	<0.004	0.0574	<0.07
Chromium (total)	<0.030	0.100	<0.30
Copper (total)	<0.020	2.6	<0.01
Lead (total)	<0.008	0.100	<0.08
Mercury (total)	0.0001	0.0235	0.004
Nickel (total)	<0.0104	1.4	<0.01
PCBs (total)	<0.0018	0.0002	<9.00
Silver (total)	<0.010	0.21	<0.05
Trichlorethene	<0.010	0.064	<0.16
Zinc (total)	0.056	14.7	0.0038
	Discharge Point: Cooling Systems		
Chromium (total)	<0.044	0.100	<0.44
Copper (total)	<0.26	2.6	<0.10
Zinc (total)	9.2	14.7	0.63

[a]Values represent annual averages.
[b]Estimated value.

Table 3.2.4. Potential chemical dose comparison for ORR surface waters annual 1988 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-1203		
Beryllium (total)	<0.002	0.0002	<10.00
Cadmium (total)	<0.004	0.0574	<0.07
Lead (total)	<0.01	0.100	<0.10
Mercury (total)	<0.001	0.0235	<0.03
Methyl chloroform	<0.01	6.3	<0.002
Methylene chloride	<0.01	0.093	<0.11
Selenium (total)	<0.01	0.21	<0.05
Silver (total)	<0.02	0.21	<0.10
Tetrachloroethylene	<0.01	0.014	<0.71
Trichloroethylene	<0.01	0.064	<0.16
Zinc (total)	<0.11	14.7	<0.01
	Discharge Point: K-1700		
Beryllium (total)	<0.01	6.3	<0.01
Cadmium (total)	<0.004	0.0574	<0.07
Chromium (total)	<0.02	0.100	<0.20
Lead (total)	<0.01	0.100	<0.10
Mercury (total)	<0.01	0.0235	<0.43
Methyl chloroform	<0.01	6.3	<0.01
Methylene chloride	<0.01	0.093	<0.11
Selenium (total)	<0.01	0.21	<0.05
Silver (total)	<0.02	0.21	<0.10
Tetrachloroethylene	<0.01	0.014	<0.36
Trichloroethylene	0.04	0.064	0.66
Zinc (total)	<0.04	14.7	<0.01

[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 (1988) Integrated Risk Information System (IRIS) data base. 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.

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. Represents an EPA-established value.

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, the ADI is the intake of a toxicant (measured in micrograms per day) that is not anticipated to result in any adverse health effects after chronic exposure to the general human population, including sensitive subgroups (Hoffman et al. 1984). 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.

All ADIs were derived primarily from the U.S. EPA Integrated Risk Information System (IRIS) data base, which contains updated ADIs for 1988. 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. 2.2.6) 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. Capabilities to make predictions of impacts on the food chain pathway are in development.

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

Chemicals where the CDI/ADI ratio exceeds unity warrant further investigation. No chemicals at ORNL or ORGDP met this criterion. At the Y-12 Plant, the CDI/ADI ratio for arsenic at Discharge Point 302 (Fig. 2.2.6) was found to be 4. However, taking into consideration a dilution factor for arsenic, a new CDI of 0.14 mg/d was determined (see Sect. 3.2.2), yielding a new CDI/ADI screening ratio of 0.14 for arsenic. Thus, concentrations of arsenic at the Y-12 Plant are within acceptable guidelines.

We recommend reevaluation of the analytical procedures used to detect chemicals to determine if improvements in the limits of detection are feasible. In addition, the ADIs used in this screening process are the most up-to-date values available from the EPA IRIS data base. These values should be updated annually to ensure that the most current ADIs are used in the derivation of the screening ratio.

4. REMEDIAL ACTION PROGRAM

4.1 DESCRIPTION

4.1.1 Objectives

Past Oak Ridge Reservation (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 Martin Marietta Energy Systems, Inc., policies to ensure protection of the public, environment, and company employees, the Energy Systems facilities established a remedial action program (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.

4.1.2 Regulatory Review

The RAP must comply with numerous environmental regulations as established by state and federal agencies. The four 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 Toxic Substances Control Act, must be complied with in the implementation of the RAP.

4.1.2.1 Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA), as promulgated by the U.S. Environmental Protection Agency (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 Tennessee Department of Health and Environment (TDHE) administers the Tennessee Hazardous Waste Management Regulations (THWMR), which are equivalent to RCRA regulations administered by the EPA. The THWMR also require closure and postclosure care

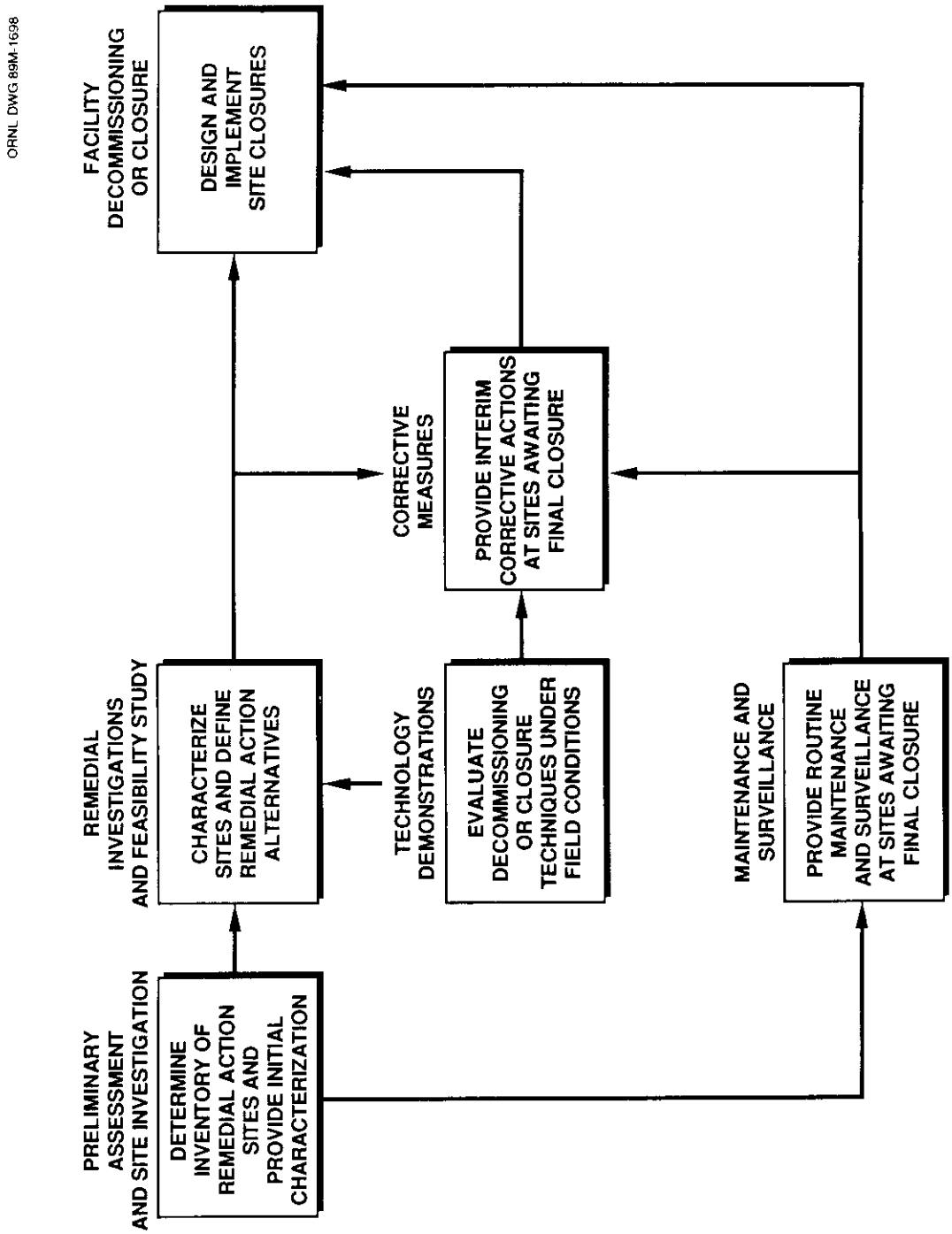

Fig. 4.1.1. Remedial action process flowchart.

of hazardous waste TSD facilities as previously described under RCRA.

4.1.2.4 Comprehensive Environmental Response, Compensation, and Liability Act

During 1980, the Comprehensive Environmental Response, Compensation, and Liability Act (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 Superfund Amendments and Reauthorization Act (SARA) of 1986 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. A draft CERCLA interagency agreement (IAG), which will establish the framework and schedules for CERCLA implementation at ORR sites, is being prepared.

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 funding sources: (1) environmental restoration budget category projects and (2) line item projects. A description of each component is presented in Sects. 4.2.1.1 and 4.2.1.2.

The Y-12 Plant RAP is managed by the Health, Safety, Environment, and Accountability (HSEA) Division. The departments within HSEA during 1988 that have major roles in the program are the Environmental Management Department; Programs Management Department; Waste Treatment Operations Department; and Waste Transportation, Storage, and Disposal 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 treated, stored, or disposed of in the facilities include waste acids containing heavy metals, chlorinated solvents, and polychlorinated biphenyls (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.

4.2.1.1 Environmental restoration budget category

The Environmental Restoration Budget Category (ERBC) has been subdivided into three groups consisting of RCRA closures, 3004(u) and 3004(v) corrective actions, and CERCLA remedial actions.

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 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. 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 investigated in this group are the S-2 Pond Site,

Table 4.2.1. Summary of remedial action projects at the Y-12 Plant

Project	Number
Environmental restoration budget category (ERBC)	
RCRA closures	
Incinerator	1
Drum storage areas	4
Treatment facilities	1
Storage tanks	1
Landfills	3
Surface impoundments	4
Land treatment	1
Subtotal: RCRA closures	15
3004(u) and (v) corrective actions[a]	
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
Subtotal: RFI investigations[b]	25
CERCLA projects[c]	
Interactive underground storage tanks	17
Material usage areas	3
Drum storage area	1
Subtotal: CERCLA sites	21
Total: ERBC projects	61
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]It is expected that the Y-12 Plant will be placed on the National Priorities List in 1989, thus formally beginning the CERCLA process.

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.

DOE 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 which 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.

4.2.1.2 Line item project: Disposal Area remedial actions

As a result of waste oil disposal practices in the Bear Creek Burial Ground (BCBG) 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 a National Pollutant Discharge Elimination System (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/ Toxic Substances Control Act (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.

4.2.1.3 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 an Environmental Assessment 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 either be removed from the ground or filled with an inert solid. Site assessment will require either 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 tanks that are potentially subject to the UST regulations. As of the end of December 1988, assessments were in progress at eight UST sites. The current status of the Y-12 UST program is discussed in Sect. 4.3.

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 plans to place 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.

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 33 underground low-level waste storage tanks, located at 11 sites.

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 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 the 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 grounds; process lines used to transport hazardous waste; abandoned storage tanks; shut-down treatment facilities; and RCRA treatment, 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 to document the materials buried in the K-1070-B facility. Interviews with plant employees indicate that the burial ground was used for classified

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

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

4.3.1.1 RCRA closures

During 1986, 1987, and 1988, the following RCRA closures were completed in accordance with TDHE-approved closure plans:

- partial closure of the Salvage Yard Oil/Solvent Drum Storage Area,
- 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 and postclosure 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.
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, 1988, the interim seep collection system was constructed and water from Oil Retention Ponds 1 and 2 was being treated and discharged in accordance with an NPDES permit.
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. As of December 31, 1988, the Contaminated Soils Storage Vault was constructed and excavation of PCB-contaminated material (approximately 325 yd^3) had been initiated.
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, 1988, contouring for construction of the engineered, multilayered cap for Burial Ground A had been initiated.
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. The draining of water from NHP was in process as of December 1988.
6. Closure of the Chestnut Ridge Sediment Disposal Basin (CRSDB) consisted of placement of clay backfill and installation of an engineered cap. As of December 31, 1988, closure activities were suspended at CRSDB pending resolution of a clay permeability problem.
7. The Chestnut Ridge Security Pits (CRSP) are being closed by installing a multilayer cap. As of December 31, 1988, closure activities were suspended at CRSP pending resolution of a clay permeability problem.
8. A clean closure is planned for Kerr Hollow Quarry (KHQ). 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, 1988, structures at KHQ were dismantled.

4.3.1.2 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 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. These plans covered the following sites:

- Beta-4 Tanks,
- Plating Shop Container Areas,
- Sanitary Landfill II,
- Tank 2101-U,
- Filled Coal Ash/Pond,
- Building 81-10 area,
- Coal Pile Trench,
- Tank 2104-U,
- Tank 2116-U, and
- Bear Creek.

RFI plans scheduled for 1989 and 1990 include the following sites:

- Line Yard,
- SY-200 Yard,
- Nitric Acid Pipeline,
- Upper East Fork of Poplar Creek (EFPC),
- Mercury-contaminated areas, and
- others to be determined.

As a result of an August 1988 meeting with EPA and TDHE, approximately 22 sites will require further assessment to determine if an RFI is needed. Some of these sites had been scheduled for RFI Plans in 1989 and 1990.

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.

4.3.1.3 CERCLA projects

Nineteen Y-12 Plant sites were included in the initial DOE 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

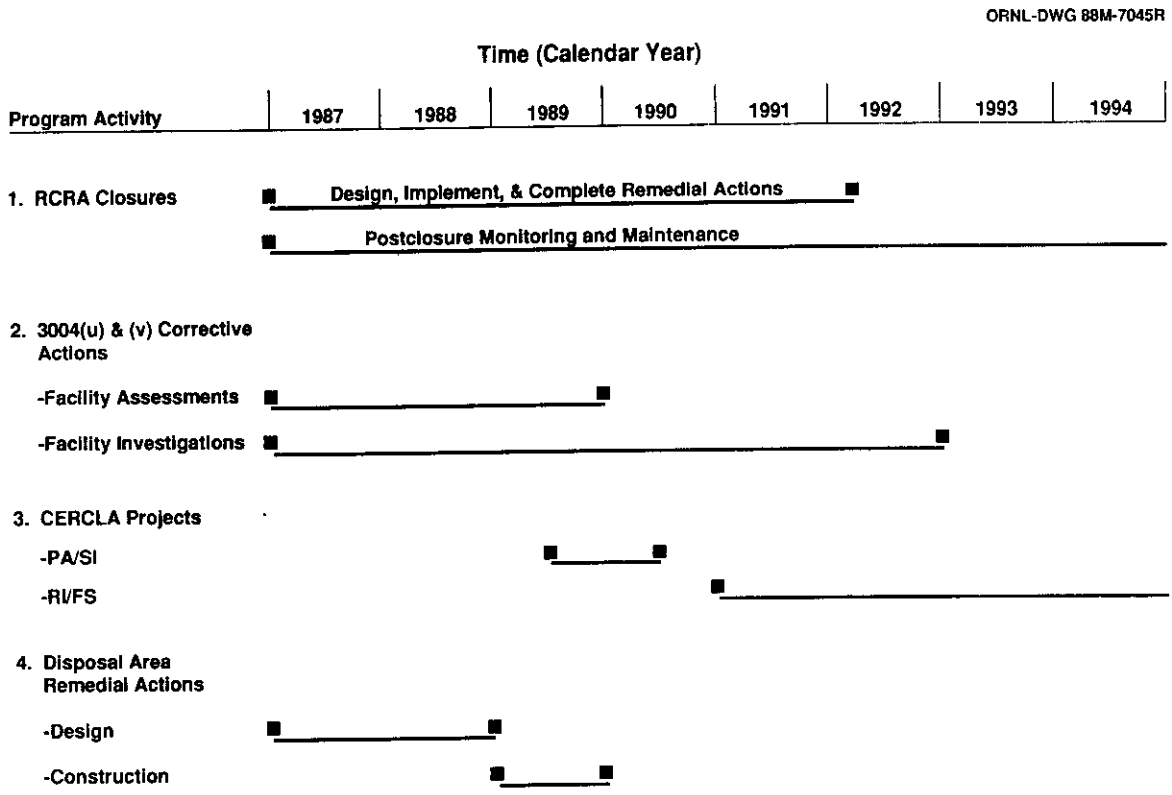

Fig. 4.3.1. Summary schedule of implementation of Y-12 Plant's remedial action program. (Future schedules for remedial action, construction, etc., will depend on results of assessments and investigations.)

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,* number Y/TS-487, which provides documentation equivalent to the RFA on these 21 proposed CERCLA sites, was prepared.

It is expected that the Y-12 Plant will be placed on the National Priorities List sometime in 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.

4.3.1.4 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, 1988, an interim seep collection facility had been installed to intercept seepage entering Oil Retention Pond 1 from the Burial Ground Trenches. Treatment and discharge of water from Oil Retention Ponds 1 and 2 has taken place. Diversion of surface water and construction of the Solid and Liquid Storage facilities are under way. An overview of the schedule for this project is shown in Fig. 4.3.1.

4.3.1.5 Underground storage tank program

The UST program at the Y-12 Plant has grown significantly in 1988; eight UST sites are currently undergoing or are scheduled for environmental assessments. They are described briefly below.

Rust Construction Garage Area. This is the site of several 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 were installed at the site to monitor groundwater levels and the presence of floating product. Product (apparently gasoline) has been discovered in one piezometer, and recovery operations are underway. 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.

Tank 2080-U. This 560-gal gasoline tank formerly served a fuel pump for fork lifts at Building 9996. Several years ago, a noticeable overnight loss of fuel was observed by the operator and the tank's use was discontinued. The tank failed a leak test by the Y-12 Equipment Testing and Inspection (ET&I) Department in October 1987. The tank has been removed, and an EAP is being prepared.

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. However, a small-scale soil gas survey (SGS) of the site indicated contamination by volatile organics, and an EAP is being prepared.

Gasoline tank east of 9201-1. In late September 1988, 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, and soil samples have been collected, and an EAP is being prepared.

Building 9754-2 fuel facility. In January 1986, gasoline contamination was found in the soil at the facility. At that time, there were no regulatory limits for cleanup of petroleum spills. Soil samples were collected and groundwater monitoring wells were installed to assess the site. Using the collected data, a determination was made that the contamination was not significant enough to warrant remedial actions. Natural biodegradation and volatilization processes were deemed sufficient to cleanse the soil and groundwater of contamination. However, in July 1987, the TDHE issued its cleanup standards for petroleum releases. When these standards were compared to the data collected at 9754-2 in 1986, several of the limits were exceeded. Therefore, an additional assessment of the site will be conducted. In addition to the 20,000-gal gasoline and 10,000-gal diesel fuel USTs at 9754-2, the assessment will also include three abandoned 1,000-gal USTs at the adjacent 9754 site.

Tank 2117-U. A 550-gal UST located north of Building 9929-1, this tank was used to serve 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. A UST used at the Y-12 Steam Plant to store fuel oil, this tank 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. A 200-gal tank located near the northeast corner of Building 9204-3, this tank is used to serve gasoline to an emergency generator in the area. The tank has failed tightness testing by ET&I, and an EAP is being prepared.

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 RCRA Facility Assessment 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 in ORNL's main plant area (WAG 1), comprehensive biological monitoring of the White Oak Creek system (Loar et al. 1987, 1988), and definition of the characteristics of the uppermost ORNL aquifer and potential pathways for off-site migration of contaminants.

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 groundwater quality monitoring (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 and 111 GQM wells have been installed to date. An additional 83 GQM wells are scheduled for drilling in FY 1989 and early FY 1990 to complete the initial WAG-perimeter monitoring system. Additional exploratory 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 through 10, and 17) have been completed and submitted for regulatory review; the remainder will be completed by the end of 1989. 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); the WAG-6 RI was formally implemented in late 1988. Work is scheduled to begin in WAG 1 (main plant area) and WAG 10 (hydrofracture injection wells and grout sheets) in late 1989; 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 clean-up 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 decommissioning, closure, 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 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. Work on both the TARA and ISV projects is expected to be completed in the early 1990s.

4.3.2.4 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 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 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, is under way and is expected to be complete by May 1989. 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 scheduled for the early 1990s, with completion expected in 1993.

Closure of 33 inactive LLW storage tanks and 23 tanks, currently active but scheduled for deactivation over the period from 1989 through 1995, will also require substantial resources over the next few years. During 1988, a sampling campaign was conducted to characterize the contents of these tanks. Continued sample analyses, waste treatability studies, and evaluation of potential alternatives for in situ stabilization will be conducted during FY 1989. Tank-specific alternatives evaluations will follow during future years. Alternatives for closure range from removal and processing of the contents, followed by exhumation of the tanks, to in situ stabilization of both tanks and contents. Actual closure operations are expected to begin in the 1990s.

4.3.2.5 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. All D&D projects were temporarily suspended in 1988 due to competition for funds with other remedial action work. One project has now been restarted, but future scheduling is somewhat uncertain. Based on projected funding and priorities, D&D work at ORNL is scheduled to begin in earnest during the early 1990s and extend to the year 2010.

4.3.2.6 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 is now in the RFI phase of the RAP. 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

5.1 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, and hazardous solid wastes. The terms *solid* and *hazardous* are used as defined in the Resource Conservation and Recovery Act (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 Department of Energy (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.

RCRA was amended in November 1984 by the Hazardous and Solid Waste Amendments, which have four principal purposes: (1) to regulate some previously exempt generators and sources; (2) to regulate land disposal more stringently, eliminating it where possible; (3) to regulate used oil and hazardous waste fuels; and (4) to regulate notification requirements for underground storage tanks (USTs) that contain petroleum products or nonhazardous chemicals reportable under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Requirements imposed by the new RCRA amendments are specific, detailing the standards they impose. The amendments reauthorize and expand RCRA through 1988 and require the U.S. Environmental Protection Agency (EPA) to promulgate new regulations governing several aspects of waste management.

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 were submitted in 1984, and Part B permit applications were submitted in 1985 and revised in 1988. 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.

Although of less pervasive impact, provisions of other environmental regulations must also be considered in solid waste management. The Toxic Substance Control Act (TSCA) governs the labeling, handling, and disposal of wastes or articles containing polychlorinated biphenyls (PCBs). The Clean Water Act (CWA) requires use of best management practices (BMPs) and compliance with the National Pollutant Discharge Elimination System (NPDES) permit, and the Clean Air Act (CAA) requires consideration of air emissions. In addition, DOE facilities comply with DOE Order 5820.2A for radioactive wastes, 5400.3 for hazardous and mixed wastes, and 5632.1 for classified wastes.

The Tennessee Solid Waste Management Act (TSWMA) regulates the operation of sanitary landfills and includes monitoring, analysis, and testing criteria. All Oak Ridge facilities' sanitary wastes are disposed of at the Y-12 Plant Centralized Sanitary Landfill.

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, low-level radioactive wastes (LLW), transuranic wastes (TRU), 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 post-closure 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, the Tennessee Department of Health and Environment (TDHE), DOE, and/or internal auditors to ensure RCRA compliance.

Through 1988, four Y-12 Plant RCRA facilities had been closed or partially closed in accordance with TDHE-approved closure plans. These were the Old Steam Plant, the Prenco Incinerator, the Interim Drum Yard, and the Salvage Yard Oil/Solvent Drum Storage Area. Closure activities were under way on an additional eight disposal areas as a part of the Closure and Post Closure Activities project. The eight facilities include the S-3 Ponds, New Hope Pond, Chestnut Ridge Sediment Disposal Basin, Kerr Hollow Quarry, Oil Landfarm, Oil Ponds, Bear Creek Burial Ground, and the Chestnut Ridge Security Pits.

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. Applicable discharges to surface waters are through monitored discharge points that comply with the plant's NPDES permit.

5.1.3.2 Oak Ridge National Laboratory (ORNL)

Waste treatment and disposal activities are regulated by TDHE and EPA through operating permits. ORNL operates (1) 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.

Transuranic 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 WIPP in New Mexico.

5.1.3.3 Oak Ridge Gaseous Diffusion Plant (ORGDP)

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.

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 best management practices and compliance with NPDES. CAA requires permitting of air emissions.

DOE facilities must comply with DOE orders for radioactive wastes, hazardous and mixed wastes, and classified wastes.

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 disposed of.
- Minimize the amount of wastes disposed of off-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 on-site. No LLW 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 in order 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.
- Utilize 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 utilized 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 utilized. 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.
- Minimize the amount of DOE capital investment required. Cost-sharing demonstrations and the utilization 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 is being defined

by the Low-Level Waste Disposal Development and Demonstration Program (LLWDDD).

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 assuring 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, the LLWDDD Program has proposed five classes of LLW.

1. **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 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 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 III waste.** LLW consisting of radionuclides that have long half-lives and will be disposed of in facilities having intruder protection.
5. **Class 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

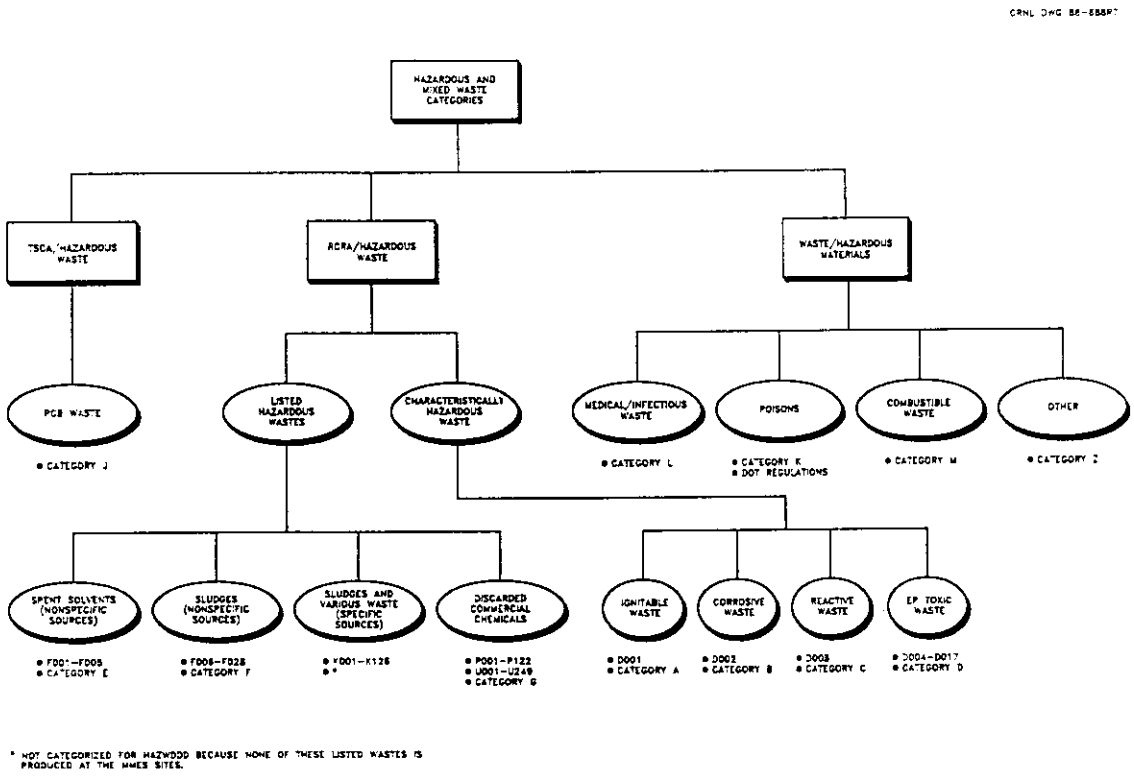

Fig. 5.1.1. Hazardous and mixed waste categories developed for the HAZWDDD Plan.

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 and disposal are identified and evaluated. Solid low-level wastes, with the exception of some special case wastes, are currently placed in interim storage at the Oak Ridge Gaseous Division Plant (ORGDP) awaiting development of treatment/disposal facilities under the LLWDDD Program.

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 (5400.3) 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. Each installation will be

preparing implementation plans and waste management plans to identify and implement the actions, schedules, and costs necessary to meet 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. 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 individual needs.

An example of a waste minimization option is the wastepaper recycle demonstration initiated in 1988 by the Waste Transportation, Storage, and Disposal Department. The purpose of the initiative was to demonstrate the ability to segregate and collect recyclable paper from within certain areas of the plant while ensuring that no hazardous, radioactive, classified, or other objectionable material was accepted. A follow-on study is planned.

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 continued 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. Additional demonstrations, including a uranium removal/fixation demonstration, are under consideration.

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 Environmental Impact Statement (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.

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 new acids and bases; recovering used solvent

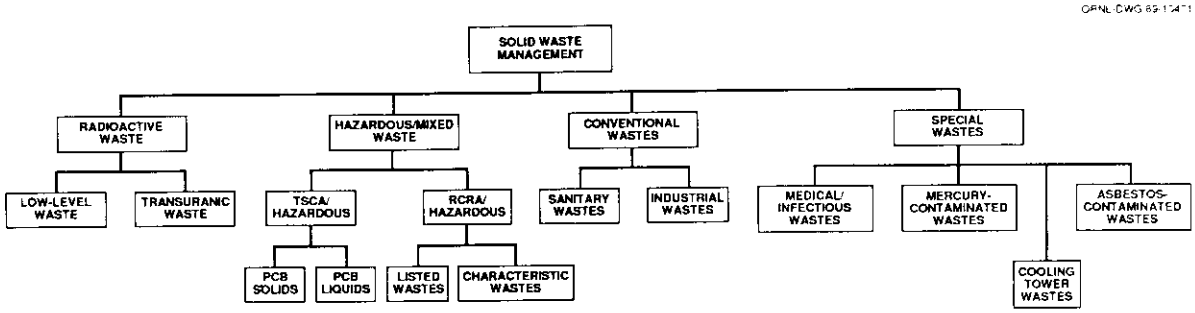

Fig. 5.1.2. Categories of solid waste sources and flow of mixed wastes.

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 other wastes, such as low-level solid wastes, are disposed of on-site in solid waste storage areas (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

The 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 by 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 at 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 5400.3 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 and Maintenance Engineering Procedure MEP-456. 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 1988, the Environmental Improvements–PCB Transformer Replacement line item project continued the draining, removal, off-site disposal, and subsequent replacement of PCB-filled transformers. (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 1988 is given in Tables 5.2.1 and 5.2.2.

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 1988 is given in Table 5.2.3.

Hazardous wastes are generated in laboratory research, electroplating operations, painting operations, descaling, demineralizer regeneration, and photographic processes.

Mixed wastes are generated by research projects and some facility operations. Facility

Table 5.2.1. Y-12 Plant waste generation summary for 1988

Waste	Quantity (kg)
Sanitary/industrial	5,217,800
Construction/demolition spoil	47,885,200
Fly ash	11,843,600
Asbestos/BeO	
Uncontaminated	84,900
Contaminated	5,400
Hazardous[a]	1,479,700
Mixed	4,776,700
PCB	91,300
PCB/uranium	14,600
Low-level contaminated waste[b]	1,585,800
Uranium solids	473,400
Scrap Metal	
Uncontaminated	2,462,700
Contaminated	867,700
Classified	130,200
Nonhazardous liquids[c]	5,279,300
Other[d]	37,300

[a]These data have been provided for FY 1988.

[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.

[d]This category includes waste characterization pending analytical results.

Table 5.2.2. Y-12 Plant radioactive waste data for 1988[a]

Radionuclide	Activity (Ci)
^{235}U	0.7
^{238}U	308.4
^{232}Th	<0.05
^{99}Tc	1.5
^{237}Np	0.05

[a]Does not include airborne emissions or effluent to waterways.

Table 5.2.3. 1988 ORNL waste generation summary

Waste	Volume (m^3)	Weight (kg)
Hazardous		73,000
Sanitary		
Radiological	110	
Nonradiological	11,000	
Industrial	2,200	
Mixed		4,100
PCB		
Radiological		2,500
Nonradiological		11,000
Transuranic		
Contact Handled	87	6,800
Remote Handled	33	3,900
Low-level		
Wastewater (L)	1,200,000	
Asbestos		
Radiological		1,400
Nonradiological		10,000
Scrap metal		
Radiological		29,000
Nonradiological		740,000
Miscellaneous		
Nonhazardous		3,600
Miscellaneous		
Radiological	3	

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. For example, in 1988 about 23,000 kg (50,830 lb) of contaminated soil were removed and shipped to Rollins Environmental Services in Louisiana to be landfilled. In addition, used oil is discarded from the maintenance of machinery throughout the laboratory. This oil is sometimes contaminated with hazardous or PCB wastes and must then be managed appropriately.

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 scrubbing operations and have been stored in K-1407-B and K-1407-C ponds. The sludges are being chemically 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.

Table 5.2.4. 1988 ORNL radioactive waste data

Radionuclide	Quantity (Ci)
^{118m}Ag	0.065
^{111m}Ag	1.1
^{241}Am	0.089
^{243}Am	1.01
^{39}Ar	0.0013
^{207}Bi	0.5
^{14}C	0.017
^{249}Cf	0.101
^{252}Cf	1.0
^{244}Cm	11
^{248}Cm	0.1
^{57}Co	0.011
^{60}Co	230
^{134}Cs	25
^{137}Cs	4,900
^{152}Eu	2,700
^{154}Eu	1,400
^{55}Fe	0.000068
^{59}Fe	0.076
^{153}Gd	0.5
^{68}Ge	0.023
^{3}H	250
^{125}I	0.017
^{131}I	3.4
^{192}Ir	2,200
^{85}Kr	0.031
MFP[a]	0.0017
^{54}Mn	0.076
^{63}Ni	0.14
^{237}Np	0.021
^{191}Os	0.036
^{103}Pd	1.5
^{107}Pd	0.065
^{147}Pm	52
^{195}Pt	0.00017
^{238}Pu	0.103
^{239}Pu	96
^{240}Pu	0.001
^{241}Pu	0.0028
^{242}Pu	0.0013
^{226}Ra	0.0039
^{35}S	0.0007
^{85}Sr	0.001
^{90}Sr	1,900
^{95m}Tc	0.0001
^{99}Tc	0.013
^{228}Th	0.00305
^{230}Th	0.00305
^{232}Th	0.305
^{234}Th	0.00051
^{232}U	0.000005
^{233}U	1,100
^{235}U	0.015
^{238}U	0.82
^{188}W	0.0017
^{90}Y	51
^{65}Zn	15
Total	14,941

[a]Mixed fission products.

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 Central Neutralization Facility; previously, it was discharged to the K-1407-B pond, which is now under closure. The K-1407-H facility began operation in 1988.

Radioactive waste streams generated at ORGDP are managed in strict accordance with 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. Minimal waste generation is assured by reduction, 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.

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.

New Hope Pond is an unlined surface impoundment with a surface area of approximately 5 acres. The pond served as a collection and settling basin for runoff and discharges from the plant and is currently in closure.

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 proposed.

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 facility is currently being evaluated for reuse.

The Plating Rinsewater Treatment Facility (PRWTF) (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. Disposals were halted in November 1988.

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. Closure activities began in 1988 at this site.

Security pits are deep trenches used for disposal of classified wastes. Hazardous materials were disposed in this facility prior to 1984. The facility began closure in November 1988.

Building 9720-9 is a warehouse used for storage of nonflammable 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.

PCBs and PCB/uranium

Oil Drum Storage Area OD3 was two 22,712-L (6000-gal) tanks used to store PCB-contaminated oils. The tanks are now empty.

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 are now empty.

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 1988, only low-level uranium-contaminated material (including asbestos and beryllium oxide), depleted uranium machine turnings, fines, lab 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.

Security Pits (D-023) are shallow trenches used for disposal of classified wastes, including uranium and uranium-contaminated wastes. Closure began on this facility in November 1988.

Oil Storage OD6 (S-017) is composed of one 113,562-L (30,000-gal) tank and two 10,000-gal tanks used for storage of contaminated oil.

M-Wing Coolant Storage is composed of four 22,712-L (6000-gal) tanks used to store uranium-contaminated coolants.

The Uranium Oxide Vaults (S-114) are two concrete vaults intended 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.

Under construction

Nonhazardous. Industrial Waste Landfill IV is a TDHE-permitted industrial landfill that will provide disposal for nonradioactive, nonhazardous, solid classified wastes.

RCRA hazardous/mixed. The Liquid Organic Waste Storage Facility is a bulk and drum storage facility that will provide 113,562 L (30,000 gal) of bulk storage and storage for about 300 drums of solvents.

The Contaminated Soil Storage Area will consist of three diked, roofed, concrete pads that will be used for storage of hazardous/mixed wastes.

The 9720-25 Classified Waste Storage Area will include a TDHE-permitted RCRA storage area for storage of classified wastes.

PCB and PCB/uranium. The Solids Storage Facility is a roofed concrete vault that is being constructed as a part of the disposal area remedial action (DARA) project to contain up to 3058 m^3 (4000 yd^3) of PCB-contaminated soils and wastes.

The liquid storage facility consists of two 283,906-L (75,000-gal) tanks and other ancillary equipment that is being constructed as a part of the DARA project to contain PCB-contaminated water from closure operations in Bear Creek burial ground.

The east end of Building 9720-9 is undergoing modification for storage of PCB and PCB/uranium-contaminated wastes.

Low-level radioactive. The crated waste assay monitor is a neutron interrogation monitoring facility that will be used to monitor wastes containing low-level uranium contamination.

The 9720-25 classified waste storage area will include warehouse storage for radioactive classified 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. Several facilities operate under interim status while permit applications are submitted to the TDHE. The Hazardous Waste Storage Facility, Building 7652 permit application was approved by TDHE in October 1986. The Mixed Waste Drum Storage Pad, 7507W, and the Long-Term Hazardous Waste Storage Facility, 7654, both interim status facilities, are currently receiving mixed waste. PCB-contaminated hazardous wastes are 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 Explosives 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. Mercury is recycled in Building 4500-N. Photographic wastes that are hazardous only because they contain silver have previously been recycled for silver recovery in Building 7934. The silver cake was then sold for its silver content. The silver recovery process was not operated during 1988 pending an NPDES permit. During this period, photographic wastes were shipped off site for silver recovery.

The Contractor's Landfill and SWSA 6 are the two active solid waste disposal units at ORNL. 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 near the site of small-quantity waste generation where wastes are accumulated to a sufficient quantity to be transferred to a permitted storage facility. 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.

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. During 1987, an extensive lead repackaging operation was begun to avoid possible environmental insult.

The K-1407-B holding pond contains approximately 7500 m^3 (10,125 yd^3) of sludge. To comply with 1984 reauthorized RCRA, the sludge

will be removed from this facility and fixed in concrete at the K-1419 sludge fixation facility.

The K-1407-C retention basin was an unlined surface impoundment containing about 9.48×10^6 L (2.46×10^6 gal). The wastes stored in this facility were potassium hydroxide scrubber blowdown and metal hydroxide sludges. The K-1407-C impoundment was constructed in the mid-1970s as a storage facility for sludges removed from the K-1407-B impoundment. The basin is also being closed to comply with 1984 reauthorized RCRA. The sludge has been removed and is being fixed in concrete at the K-1419 fixation facility and stored in steel drums at the K-1417 facility.

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 concrete mixture is discharged from the mixers into 337-L (89-gal) or 364-L (96-gal) epoxy-coated steel drums where it is stored at the K-1417 yard. Capabilities also allow for the concrete mixture to be transported by truck to K-1417 where it is then poured into the drums.

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.

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-900 bottle smasher is a thermal treatment unit, used to dispose of small quantities of highly ignitable or reactive chemical waste.

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 1200 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.

The K-1070-C pit is a burial trench for classified, non-RCRA-hazardous waste generated primarily at ORGDP. Hazardous waste, such as asbestos, has been disposed of in this burial site.

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 in 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 1988 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 description of these treatment units. During 1988 the K-900 unit was not used. Quantities and types of waste treated at these facilities are shown in Table 5.3.1.

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 1988 are shown in Table 5.3.3 of Vol. 2.

Table 5.3.1. ORGDP on-site waste treatment data for 1988

Type	Quantity (kg)	Treatment	Residue type	Quantity (kg)
Nonhazardous	8.9×10^7	Neutralization	None	
Hazardous	2.9×10^7	Neutralization Metal precipitation	Hazardous sludge	2.9×10^4
Mixed	1.1×10^{6a}	Sludge fixation	Mixed	3.2×10^{6b}

[a]Waste quantity removed and fixed.
[b]Waste quantity including the fixing materials.

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 1988 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 classified, nonhazardous waste. The disposal of this waste is summarized in Table 5.3.5 of Vol. 2.

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 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 exclusion limit and are not considered radioactive.

5.3.5.3 Oak Ridge Gaseous Diffusion Plant

The K-722 clean scrap yard provides storage for nonradioactive scrap metal. ORGDP, ORNL, and Oak Ridge Associated Universities (ORAU) use this facility. The scrap metal is stockpiled at K-722 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.

The K-1035-A satellite drum storage area has a storage capacity of 16 208-L (55-gal) drums. The wastes stored at this facility are generated from printed circuit board cleaning. Use of this facility ceased during 1988, and a closure plan has been submitted to the state.

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 1988 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 1988 are indicated in Table 5.3.11 of Vol. 2. Wastes remaining in storage at the end of 1988 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 1989.

6. SPECIAL STUDIES

Many environmentally related special studies are conducted on the Oak Ridge Reservation (ORR) annually. This chapter includes those studies that are not directly associated with the annual environmental monitoring activities but that 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 Water Quality Monitoring in Bear Creek During Blue Lagoon Excavation

During April–June 1988, two small lagoons (collectively known as "Blue Lagoon") in upper Bear Creek were excavated to remove contaminated sludge. Blue Lagoon was located southwest of the S-3 ponds and was constructed in 1972 to provide a source of nitrate water for a pilot forest-fertilization project. Subsequently, the lagoon acted as a settling basin for precipitates and sediments from the upstream S-3 ponds area. The precipitates formed over many years, apparently as a consequence of the natural neutralization of the acidic seepage of the S-3 ponds upon mixing with the naturally alkaline local groundwater. The purpose of this excavation was to remove the easily erodible materials from the upper Bear Creek stream channel.

Since 1983, water quality data had been collected on Bear Creek at a monitoring station between the two lagoons. During the excavation activities this monitoring point was relocated in the stream to a pool just west of the influent of the SS-1 and NT-1 streams. Composite and grab samples were collected throughout the operation to ensure that the water quality of Bear Creek was not altered as a result of excavation. These data were compared with the 1987 monitoring data from the station between the lagoons. The excavation activities had no apparent detrimental effect on the water quality of the stream. A summary of radiological and nonradiological data is shown in Tables 6.1.1 and 6.1.2.

6.1.2 East Fork Poplar Creek Area Source Pollution Assessment and Control Program

The Y-12 Plant National Pollutant Discharge Elimination System (NPDES) permit requires evaluation of area source discharges from within and around the plant to determine their impact on the water quality of East Fork Poplar Creek (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 pollutants 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 developed and implemented in 1988. 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 consists of flow monitoring and water quality sampling at 12 sites

Table 6.1.1. 1988 annual summary for upper Bear Creek radiological data during Blue Lagoon closure

Parameter	Number of samples	Concentration			Standard error	Percent DCG
		Max	Min	Av		
Alpha (pCi/L)	17	0.76	0	0.10	0.05	0.35
^{241}Am (pCi/L)	17	3700	110	490	200	NA[a]
Beta (pCi/L)	17	5900	130	1000	14	NA
^{237}Np (pCi/L)	17	4.5	0	1.5	0.36	5.1
^{238}Pu (pCi/L)	17	0.05	0	0.0004	0.0031	0.010
^{239,240}Pu (pCi/L)	17	0	0	0	0	0
^{99}Tc (pCi/L)	17	1.2	0.1	0.7	0.1	0.001
^{235}U (pCi/L)	17	3.5	0	0.49	0.29	0.25
^{235}U (%)	17	0.47	0.33	0.39	0.01	NA
Uranium (mg/L)	17	0.75	0.180	0.29	0.034	NA

[a]NA = not applicable.

Table 6.1.2. 1988 annual summary for upper Bear Creek nonradiological data during Blue Lagoon closure

Parameter	Number of samples	Concentration[a]			Standard error
		Max	Min	Av	
Mercury	17	0.003	<0.0002	<0.0007	0.00021
Cyanide	16	0.008	<0.002	<0.004	0.0005
Fluoride	17	7.9	0.88	0.12	0.38
Nitrate-nitrogen	17	300	92	210	15
Dissolved oxygen	17	4.4	7.9	10	0.36
pH (units)	17	7.5	7	7.3	0.036
Phenols	17	0.041	<0.001	<0.004	0.0023
Total dissolved solids	17	2000	<5	<250	623
Total suspended solids	17	15	<5	<6	0.63
PCB	17	<0.0005	<0.0005	<0.0005	0
Aluminum	17	5.3	0.31	1.4	0.29
Arsenic	17	<0.2	<0.04	<0.06	0.013
Barium	17	2	0.08	1.1	0.11
Beryllium	17	<0.04	<0.0001	<0.0027	0.0023
Cadmium	17	0.06	<0.003	<0.03	0.0033
Calcium	17	500	11	350	22
Chromium	17	<0.06	<0.006	<0.012	0.0036
Iron	17	0.13	0.03	0.6	0.23
Lead	17	<0.1	<0.02	<0.03	0.0064
Magnesium	17	59	29	46	2.1
Manganese	17	7.5	0.76	4.7	0.43
Nickel	17	0.20	0.01	0.12	0.012
Potassium	17	6.9	2.3	4.8	0.26
Silver	17	<0.02	<0.004	<0.006	0.0013
Sodium	17	76	19	46	3.5
Strontium	17	1.6	0.63	0.13	0.065
Zirconium	17	<0.01	<0.002	<0.003	0.00064
Turbidity	17	31	0.9	5.9	1.8
VOA >10 (μg/L)	17	<10	<10	<10	0

[a]Units are in mg/L unless noted otherwise.

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. During 1988, one wet weather event and five dry weather events were completed. The entire sampling program is expected to be completed by June 1989. The analysis of samples and evaluation of results will follow by the end of 1989.

6.1.3 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 polychlorinated biphenyl- (PCB-) contaminated oils] that had seeped from Burial Ground A-North burial trenches.

The closure activities for these ponds are covered by two projects, Disposal Area Remedial Action (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 (OR).

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. OR 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 Tennessee Department of Health and Environment (TDHE). The initial milestone of this closure was discharge of water from Oil Retention Pond 1 by September 21, 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 and could not be handled by the interim treatment system established at the pond.

Corrective actions and planning began on October 10, 1988, which included improvements in surface-water diversion around the contaminated areas and upgrades to the capacity and efficiency of the water treatment system.

It is anticipated that the remaining surface-water and groundwater inflow volume to pond 1 can be handled by a new 227 L/min (60 gpm) carbon adsorption system in all but the heaviest of rain events. Exclusive use of this system should eliminate water management plan excursions.

6.1.4 Y-12 Steam Plant Waste-Minimization Project

A study was made to determine the feasibility of installing an electrodialysis unit to pretreat feedwater for the Y-12 Steam Plant and the demineralized water system. Based on this study, an electrodialysis unit would allow estimated reductions of 75% in chemical consumption for water treatment, 95% in boiler blowdown, 5% in fuel consumption, 80% in wastewater requiring treatment, and 80% in chemicals to treat wastewater.

In addition, an electrodialysis unit sized for winter demand will have excess capacity in the summer season. If this excess capacity were used in supply make-up water for cooling towers, cooling-tower blowdown and the associated discharge of cooling-tower chemicals could be reduced by an estimated 90%, thus reducing net operating costs. This benefit of excess capacity depends on the results of the cooling-tower ozone treatment study.

Several issues must be resolved before installation of an electrodialysis unit will be pursued:

1. The state of Tennessee must approve the direct discharge of electrodialysis blowdown to EFPC. Because this blowdown passes the current

biological toxicity test for fathead minnow larvae and for *Ceriodaphnia* fecundity and net water quality in EFPC would be improved by the proposed installation, approval by the state is expected. The NPDES permit application for the electrodialysis unit was submitted to TDHE in December 1988.

2. A cost-benefit analysis incorporating the resolution of the discharge of the electrodialysis blowdown and use of ozone for cooling tower water treatment must be completed.

6.1.5 Development of Treatment Methods for Two Category-IV Rinsewaters

Rinsewater from the dye-penetrant process and from the automated X-ray film developers at the Y-12 Plant is discharged directly to the EFPC. The dye-penetrant rinsewater contains trace quantities of a fluorescent dye, an emulsifier, and a fixer. The developer rinsewater contains small quantities of silver from the X-ray film and some developer and fixer chemicals. The total contaminant concentration in each of these rinsewaters is less than 10 mg/L; however, routine biomonitoring tests of these rinsewaters showed that they adversely affected *Ceriodaphnia* and fathead minnows at low concentrations. Laboratory-scale tests were performed to develop treatment processes that would reduce the biotoxicity of these rinsewaters.

A small-scale interim treatment system, consisting of an activated-carbon bed and filter, removed the color and greatly reduced the toxicity of the dye-penetrant rinsewater. The treated water was not toxic at a 75% concentration, which was the highest tested. A full-scale long-term system will involve the collection of the effluent in polytanks and recirculation through a series of activated-carbon columns. Four columns will be installed at the treatment site; however, only two columns in series at one time will be necessary for treatment. The remaining two columns will be used for backup and changeout. These improvements will be completed in the summer of 1989.

An anion exchange resin was very effective in removing silver from the developer rinsewater in laboratory-scale tests. The treated water did not adversely affect fathead minnows at a concentration of 10%, which was the highest concentration tested. Previous samples of untreated rinsewater adversely affected the growth of fathead minnows at a concentration of 0.07%. A treatment unit for this type of wastewater, using anion exchange resin, has been ordered for testing and evaluation. Installation of treatment systems is planned by the summer of 1990.

6.1.6 Coal Ash Disposal

Fly ash and bottom ash generated at the Y-12 Steam Plant are currently pumped in a slurry form to the top of Chestnut Ridge. The ash slurry then flows across a filled ash-retention impoundment, through the emergency spillway of the ash impoundment dam, and into McCoy Branch. McCoy Branch then flows into Rogers Quarry, where the ash solids are deposited.

For several years, the Y-12 Plant has been making plans to eliminate the discharge of ash slurry to McCoy Branch. In April 1986, the Federal Facility Compliance Agreement was amended to include an evaluation schedule for investigating alternative ash disposal methods. In January 1987, TDHE determined that McCoy Branch and Rogers Quarry are waters of the state and requested that the ash sluice discharge be treated or eliminated. After a series of investigations and proposals, the Y-12 Plant reached an agreement with TDHE in October 1988 to bring the discharge into compliance.

Under the interim agreement, the Steam Plant is being converted to burn natural gas or coal as the primary fuel. Approximately 80% of the fuel needs will be supplied by natural gas, thus reducing the generation and discharge of ash sluice water. In addition, the ash sluice pipeline will be extended from the top of Chestnut Ridge to Rogers Quarry by December 1989, and dry fly-ash-handling facilities will be constructed by May 1990. In so doing, only bottom-ash sluice water will be discharged to Rogers Quarry and the fly ash will be collected dry for disposal in the Sanitary Landfill II. In the long term, bottom-ash dewatering bins will be constructed by July 1993 to completely eliminate the discharge of ash sluice

water to Rogers Quarry. The dewatered bottom ash will also be disposed of in the Sanitary Landfill.

6.1.7 Y-12 Plant Airborne Mercury Monitoring Program

During 1988, the Y-12 Plant continued and again expanded the on-site airborne (ambient) mercury monitoring program begun in July 1986. This program was established 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.

The Y-12 Plant established four ambient mercury sampling stations in 1986 (a station each on the east and west end of the plant and two stations near Building 9201-4) and added an additional site at New Hope Pond in late August of 1987. During February 1988, a control site was established at rain gage 2 on Chestnut Ridge in the Walker Branch watershed, bringing to six the number of mercury air-monitoring stations in operation during 1988. At each of these stations, airborne mercury is collected by pulling ambient air through a Teflon filter, a flow-limiting orifice, and an iodated-charcoal sampling tube. The flow-limiting orifice restricts air flow through the collection system to approximately 1 L/min (0.035 ft^3/min). The charcoal tubes, which absorb mercury vapor, are changed every 7 d, while Teflon filters for particulate mercury are changed every 28 d. Filters and charcoal tubes are analyzed by cold-vapor atomic absorption after digestion in nitric-perchloric acid.

Average airborne mercury 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 standard temperature and pressure (STP)] of air sampled during the sampling period. In 1988, hourmeters were installed in line with the air sampling pumps to record the number of hours of actual pump-operating time, thus allowing for a more accurate determination of air volume sampled in case of pump downtime because of power outages.

Table 6.1.3 shows the maximum, minimum, and average concentrations of airborne mercury recorded during 1988 for the six sampling stations. The results indicate that on-site airborne (ambient) mercury concentrations continue to be well below the U.S. Environmental Protection Agency (EPA) National Emissions Standards for Hazardous Air Pollutants guideline for mercury in ambient air of 1 $\mu g/m^3$ (30-d average) and the industrial hygiene standard of 50 $\mu g/m^3$. As would be expected, the control site (rain gage 2) had the lowest average concentration (0.006 $\mu g/m^3$) of mercury in ambient air for the six sites. The monitoring site located southwest of Building 9201-4 continued to show the highest average airborne mercury concentration among the five Y-12 Plant sites.

In general, with the exception of the New Hope Pond station, average concentrations in 1988 for the Y-12 sampling sites agreed well with the results from the 1986 and 1987 period, being approximately equal or slightly lower. The New Hope Pond station, however, showed a threefold increase in average airborne mercury concentration for 1988 over 1987 (9/19/87–12/29/87). This increase in average concentration for the New Hope Pond site appears to be an artifact of the different sampling periods for 1987 and 1988. Over the last two years of monitoring, seasonal trends in ambient air concentrations of mercury have been recorded at all six stations, with maximum concentrations recorded during the warm-weather months. Because the New Hope Pond monitoring station did not go into operation until late August of 1987, thus missing much of the warmest period of the year, the average air concentration calculated for this site for 1987 may be artificially low. Indeed, if 1988 data covering the same period (late August through December) is used to calculate the 1988 average concentration for the New Hope Pond station, the result is approximately the same as the 1987 average (0.013 $\mu g/m^3$ for 1988 vs 0.016 $\mu g/m^3$ for 1987).

Table 6.1.3. 1988 results of the Y-12 Plant airborne mercury monitoring program

Site	Sampling period	Mercury concentration ($\mu g/m^3$)		
		Max	Min	Av[a]
Ambient No. 2 (east end of Plant)	12/29/87–12/27/88	0.035	0.003	0.010
Ambient No. 8 (west end of Plant)	12/29/87–12/27/88	0.407	0.007	0.039
Building 9404-13 (SW of Building 9201-4)	12/29/87–12/27/88	0.340	0.028	0.138
Building 9805-1 (SE of Building 9201-4)	12/29/87–12/27/88	0.384	0.017	0.098
New Hope Pond (near discharge point)	12/29/87–12/27/88	0.412	0.004	0.046
Rain gage 2 (Walker Branch watershed)	02/09/88–12/27/88	0.016	0.002	0.006

[a]The average is calculated using the number of weekly samples during the sampling period.

Particulate mercury concentrations continue to be very low at all sites (<0.001 $\mu g/m^3$).

6.1.8 S-3 Pond Area Air Sampling

As the S-3 Pond waters at the Y-12 Plant were treated and discharged in 1985 and the area began to dry, concern was expressed over potential air contamination from sludge dusts. The Environmental Management Department at the Y-12 Plant placed two high-volume particulate samplers at the west and east sides of the four-pond site. With advice from Industrial Hygiene and Health Physics personnel, the Environmental Management Department selected the following parameters as probable S-3 Pond site indicators: ^{99}Tc, ^{90}Sr, ^{230}Th, ^{234}Th, and Zr. Total suspended particulates (TSP) were also measured. Data collection began January 23, 1986; the sampling schedule was set for 24 h every 3 d.

No health or environmental exceedances of the parameters were measured. As a result, the sampling schedule was adjusted to 24 h every 6 d, beginning in January 1987. Sample data for 1987 continued to show low values for all parameters.

As work began in 1988 to close the S-3 Ponds, the sampling frequency was again increased to 24 h every 3 d to adequately monitor the area. Particulate levels fluctuated as before with the dry weather conditions and other construction activities. No increase in the other indicator parameters was measured. The closure was essentially complete with the placement of the clay cap. The two TSP samplers were removed, decontaminated, and relocated to the Lake Realty/New Hope Pond construction site (see Sect. 6.1.13).

6.1.9 Y-12 Stack Sampling: Analysis and Data-Handling Improvements

In 1987, a study was made of the methods of laboratory analyses available for determining estimated uranium stack emission rates. The final report, *Uranium Stack Losses: Analytical Methods Review,* issued in October 1987, recommended changing the method of analysis for stack samples from alpha counting to fluorometric analysis. This change occurred in 1988.

Uranium stack samples were traditionally analyzed by alpha counting. The counts were converted to an emission rate by calculations that include the stack and sampler flow rates, sample time, alpha activity conversion factors, and other factors that account for sample loses in the probes and absorption of alpha particles by the filter paper. Fluorometry is a method of chemical analysis that is specific for uranium collected on the sample filter paper, thus doing away with activity conversion and paper absorption factors in converting calculations to estimated stack emission rates. The study also considered the holding time for samples analyzed by alpha counting; a 3-d wait is required to allow alpha-emitting radon daughter products to decay. This waiting period is not required for fluorometric analysis.

In connection with changes being made in the laboratory, improvements in data handling were made within the Environmental Management Department at the Y-12 Plant with the installation of the Flow Gemini Environmental Information System (EIS). The EIS currently maintains data only from stack sampling but in the future will also manage data from all other environmental sampling programs.

Completing the package was the inception of bar code labeling for environmental stack samples. All three improvement projects were tested in 1988 and were simultaneously put into full production in October. These improvements in sample handling, analysis, and data management have increased the accuracy and efficiency of the uranium stack sampling program.

6.1.10 Y-12 Spill Report

The Y-12 Plant had a total of 153 spills or releases of various types of materials during CY 1988. This compares with 175 such spills or releases during CY 1987. Each of those events was investigated by the Y-12 Spill Coordinator and staff members of the Y-12 spill response crew to determine the environmental impact, provide input for reducing any harmful effects, and assist with cleanup efforts. Cleanup activities were conducted by trained staff member of the Y-12 Waste Transportation Storage and Disposal department. All cleanup materials were handled according to the Y-12 standard operating procedures. The Y-12 Plant Environmental Management Department reports all spills or releases to various levels of Y-12 management and/or Department of Energy (DOE) officials as appropriate. The magnitude of the material releases ranges from 0.4 to 208 L (0.1 to 55 gal).

As in CY 1987, many of the spills for CY 1988 were related to petroleum products (Fig. 6.1.1). Efforts to enhance spill prevention, not only of petroleum products but of all materials, are ongoing.

6.1.11 Effects of Post-Closure Remedial Actions at the S-3 Ponds on Ecological Conditions in Bear Creek

Past disposal of nitric acid wastes in the headwaters of Bear Creek has produced a plume of contaminated groundwater that contributes to the surface flow of Bear Creek. The infiltrating groundwater produces elevated concentrations of dissolved salts throughout most of Bear Creek and episodic toxic conditions in its upper reaches. Closure of the S-3 ponds, mandated by the Resource Conservation and Recovery Act (RCRA), requires the consideration of postclosure remedial actions. Proposed actions at this site include (1) no remedial action, (2) capping the pond to prevent further infiltration of rainwater, and (3) capping combined with the installation of groundwater wells to withdraw and treat the most contaminated region of the plume and prevent its 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 Oak Ridge National Laboratory (ORNL) Environmental Sciences Division (ESD). Chemical and ecological monitoring data and results of toxicity tests on Bear Creek surface water and S-3 plume water were used in conjunction with estimates of the

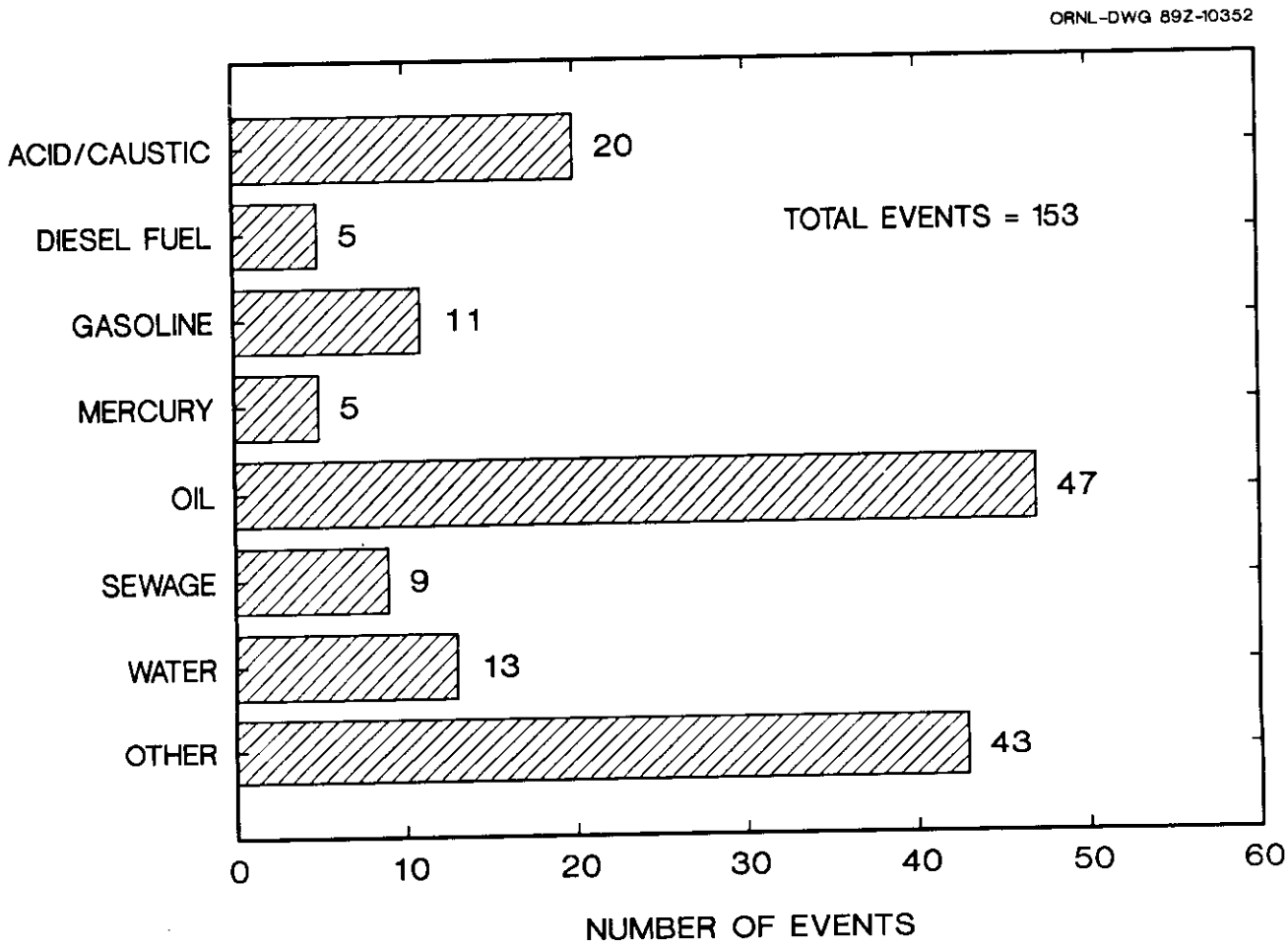

Fig. 6.1.1. 1988 Y-12 Plant spills summary.

effects of remedial actions on surface flow and solute concentrations to estimate likely environmental changes in Bear Creek and EFPC, the receiving stream for the treated water removed from the S-3 plume.

Predictions of future solute concentrations in Bear Creek under each proposed action varied widely among three alternative estimation methods: (1) a groundwater transport model, (2) the empirical rate of change in nitrate concentration from well data, and (3) a mass balance of nitrate exported in Bear Creek surface flow versus that remaining in the plume. The no-action option resulted in either very rapid (several years) improvement in water quality or relatively slow (decades) improvement, depending on the method used to predict future water chemistry. Aggressive actions involving groundwater withdrawals predict more rapid improvement in water quality at downstream sites where substantial ecological recovery has already occurred, but would dewater headwater reaches where plume toxicity is now evident. Groundwater removal also posed risks to EFPC, where the discharge of treated plume water would probably consume much of the effluent-assimilation capacity of the stream.

In view of the large uncertainty associated with the rate of dispersion of the S-3 plume and the likelihood that plume withdrawal may replace one adverse impact with another, the option of capping the S-3 site without installing a groundwater recovery system was viewed as the

procedure most likely to improve ecological conditions in Bear Creek without impacting aquatic habitat by flow reductions or effluent additions. If future monitoring demonstrates that additional remedial actions are necessary, this option would not preclude their eventual implementation.

6.1.12 Value of Reference Sites in Assessing Disturbance and Recovery of Bear Creek

Past waste disposal practices at the Y-12 Plant have resulted in the contamination of Bear Creek Valley with a variety of materials, including eroding sediments, acids, heavy metals, and chlorinated hydrocarbons. Assessment of both the impact on aquatic biota in Bear Creek and their recovery in response to remedial action is constrained by the presence of a major source of contaminants in the headwaters. Thus, there are no upstream control sites against which to compare changes.

Benthic invertebrate communities were sampled monthly at a number of sites along Bear Creek by ORNL ESD staff, both at and downstream from the sources of contamination. These samples allowed an examination of the impact and degree of recovery over time and distance. Because the entire stream has been exposed to pollutants, the reestablishment of the benthic invertebrate community at each of the Bear Creek sites was evaluated through comparison with communities at 11 similar but uncontaminated reference sites on nearby streams that correspond in size to differences between the headwaters and the lower reaches of Bear Creek.

Density, number of taxa, and diversity generally declined, and the statistical significance of the differences between Bear Creek and the reference sites increased as proximity to the contaminant sources increased. Many of the invertebrate taxa that were distributed only in the lower reaches of Bear Creek were found at many of the reference sites. Although remedial action has improved upper Bear Creek (as indicated by a recovering fish community and reduced toxicity of water samples), there are still significant differences in the benthic invertebrate communities of the most impacted, upstream sites, on the one hand, and the downstream, recovering sites and nearby reference streams, on the other. These differences result partly from sediment loading in the upper reaches of Bear Creek, which affects the bottom-dwelling organisms most directly.

This study shows that reference sites can serve as standards when the preservation (or restoration) of a balanced indigenous community is the goal and adequate upstream controls are lacking. Indeed, a key factor in judging the ultimate success of the remedial action program in the Bear Creek watershed may be the degree of similarity between the impacted and reference sites in terms of the types of benthic invertebrate community parameters examined in this study.

6.1.13 New Hope Pond Area Air Sampling

When the capping was complete at the S-3 Pond closure site, the two high-volume air samplers were decontaminated and relocated to the Lake Reality construction and New Hope Pond closure sites. Sampling began in July 1988: a 24-h sample was collected every 3 d (average). Parameters selected for monitoring were TSP and gross alpha and beta activities.

TSP levels fluctuated from <1 to 411 $\mu g/m^3$, which was as expected with the earth-moving activities in the area. Alpha and beta activity levels remained less than 45×10^{-15} and 58×10^{-15} $\mu Ci/cm^3$, respectively, except for one sample. On August 30, 1988, both samplers recorded higher alpha and beta activities: alpha reached 98×10^{-15} and beta reached 662×10^{-15} $\mu Ci/cm^3$. The cause of this single higher reading is unknown.

Lake Reality is complete and in use, but air sampling will continue during the New Hope Pond closure into 1989. When closure is completed, the samplers will again be relocated to other remedial action sites.

6.1.14 Sanitary Sewer Study at the Y-12 Plant

Elevated levels of uranium (~300 $\mu g/g$) were reported in the Oak Ridge city sewer sludge in October. The sludge typically contains 30–50 $\mu g/g$

of uranium. It was established that the elevated levels were the result of emissions from another business in Oak Ridge and not from Y-12. However, concerns about Y-12 emission levels still remained. In November, a daily sampling plan for uranium on the Y-12 and industrial park sewers was initiated to characterize uranium effluents from the Y-12 Plant.

Daily samples were drawn from the city monitoring station (which carries the combined flow), the Y-12 east pipe, and the industrial park pipe. It was concluded that, although the Y-12 Plant was not the source of the sludge uranium problem, there were abnormalities in the Y-12 uranium effluents. Uranium concentrations peaked weekly at the city monitoring sites. This lead to the conclusion that uranium emissions from the west end of the Y-12 Plant, although not above any federal or state standards, should be further investigated until the source of these emissions could be found and eliminated. These studies are continuing.

6.1.15 9204-4 Billet Grinder Emissions Incident

On February 17, 1988, the depleted uranium billet grinding operations in Building 9204-4 were shut down after a high-level alarm was received from the stack radiological breakthrough monitoring system. Laboratory analysis of the stack sampler filter indicated that approximately 453 g (16 oz) of depleted uranium dust had been exhausted to the atmosphere. The sample time covered a 9.5-h period, but the release was believed to have occurred during the billet grinding operation time of only 0.5 h just before the alarm sounded.

Y-12 Plant ambient air samples were collected from the 12 perimeter stations on the morning of February 18. Although most of the samplers showed the ambient uranium levels for the week of February 11–18 to be below average, the two stations nearest and northeast of the building (Stations 6 and 7) indicated levels approximately one standard deviation higher than average. These data correlated well with the meteorological data, indicating that the predominant wind direction was from the SSW. However, another station (Station 9) also showed higher than average concentrations of uranium, which conflicted with all other information. These readings were actually the result of the Uranium Oxide Storage Vault emissions incident (see Sect. 6.1.16), which occurred during the same week.

ORNL personnel were contacted and asked to check their monitoring stations located at the east end of the Y-12 Plant and at the American Museum of Science and Energy. The data did not show any increase in radiation levels at either station during or after the time of the release. Other ORNL personnel were asked to perform the dose model calculations, based on the Y-12 Plant meteorological data and the total amount of depleted uranium released. The calculated dose to the nearest resident to Y-12 was <0.10 mrem to the critical organ (lung) from this incident; this value is <0.1% of the annual EPA dose standard of 75 mrem/year to the critical organ and <1% of the normal annual Y-12 Plant calculated dose.

The incident was reported to DOE, which reported it to the EPA, the state of Tennessee, and the National Response Center, according to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) for accidental releases in excess of the "reportable quantity" (RQ). The RQ for uranium is 453 g (16 oz) released over a 24-h period.

The billet grinding operations were shut down until the cause of the problem could be found and corrected. Restart of the operation has not been scheduled at this time.

6.1.16 Uranium Oxide Storage Vault Emissions Incident

On February 11, 1988, placement of depleted uranium oxide in the Uranium Oxide Storage Vault (UOSV), Building 9825-1, was resumed after an inactive period of approximately 12 months. Three disposals were made from February 11–18, totalling approximately 6700 kg. The exhaust stack for UOSV ventilation system is equipped with a continuous sampler to monitor uranium emissions. Stack samples collected on

February 18 and 19 indicated that a total of 598 g (21 oz) of depleted uranium had been exhausted to the atmosphere over the 1-week period.

Inspection of the filter housing revealed that the prefilters were collapsed and that a section of the foam-rubber gasket had separated from around the final filters, leaving an unfiltered pathway to the environment. DOE was notified of the event and an Unusual Occurrence Report was prepared. Recommendations included some modifications to the UOSV operating procedures, a specified filter changeout schedule, an engineering study to determine the need for and feasibility of making modifications to the filter housing to install high-efficiency particulate air (HEPA) filters, and a restart testing program.

The filter housing and ductwork were cleaned and new prefilters and B-2000 (95%) filters were installed. Testing began with the disposal of 1 drum of depleted uranium oxide. Ambient air samples were taken at the vault disposal port and exhaust stack samples were collected. Several tests were made in which the ventilation flow rate was adjusted and the amount of oxide disposed of was increased. The results of these tests indicated the following: (1) higher flow rates increased the amount of material emitted to the atmosphere through the exhaust to an unacceptable level, (2) lower flow rates were not sufficient to keep the oxide dust from "boiling" back out the disposal port, and (3) the filter system in place was not adequate to capture the fine oxide particles.

As a result, the vault was closed to disposals until a new HEPA filter system could be designed, obtained, and installed. Operations will begin with similar restart testing in 1989.

6.2 OAK RIDGE NATIONAL LABORATORY

6.2.1 Radioiodine Concentrations in Deer: Vehicle-Killed and Hunter-Harvested Animals

Environmental transport of radioiodine isotopes has been followed by determining thyroid radioiodine burdens in vehicle- and hunter-killed deer as well as in other bioindicator animals. Since the initial discovery of ^{125}I in the thyroid of a vehicle-killed deer in 1983 by Peter Stegnar and J. S. Eldridge, followed by verification of an airborne pathway by documenting an 8-mCi release of this nuclide from the 3039 stack, analysis of thyroid glands has provided useful information concerning radioiodine releases from ORNL.

During 1988, 66 deer thyroid glands were analyzed for ^{125}I, ^{129}I, and ^{131}I. Sixteen of the deer were killed by vehicles during the period from January 14 through October 7. Nine animals were sacrificed on a single day (August 18) as part of a Tennessee Wildlife Resources Agency (TWRA) study of parasites in the herd. The other 41 deer were killed by hunters during the managed hunts on October 15 and 22, as well as on November 13 and December 10. Iodine-125 was quantitatively measured in 60 out of the 66 animals in concentrations ranging from 1 to 284 pCi/g. The deer containing the maximum ^{125}I (284 pCi/g) was killed on August 18 as one of the animals in the parasite study. That animal also contained the highest concentration of ^{131}I (28 pCi/g) measured during the year. The ^{131}I isotope was found in only 15 of the 66 animals. However, more than 30 days' decay elapsed for many of the samples. This decay period of approximately four half-lives of ^{131}I reduces the sensitivity for detection of this isotope.

Iodine-129 was detected in 11 thyroids from the collection. The maximum concentration of the isotope was 43 pCi/g and was found in one of the deer confiscated from a hunter because of excess ^{90}Sr in the deer bones. In fact, ^{129}I was found only in deer having measurable ^{90}Sr in their bones.

As a result of the thyroid analyses, temporal variations in airborne releases of radioiodine during 1988 have been documented. An experimental test of releases of ^{125}I during the latter part of 1988 was inconclusive because the quantity released was quite small and no thyroids were taken after December 10. This test was a cooperative one in which the users of the ^{125}I were asked to stop releases of liquid wastes containing the radionuclide. Following a suitable delay period, releases were permitted to occur. Thyroid glands were collected from hunt-killed deer during and after the delay period. No appreciable differences were observed.

The previously observed correlation between ^{90}Sr in bone with ^{129}I in confiscated deer thyroids was again verified in this year's collection. The deer thyroid as a useful bioindicator of radioiodine in the ORR environment continues to play an active role in the overall environmental surveillance program. Results from the analysis of the 66 thyroid glands are presented in Table 6.2.1.

Samples listed in the "Deer number" column having an "R" prefix were taken from "road-kills," those with a P were taken from animals from the parasite study, and the numbers without a prefix came from the DOE-TWRA–managed hunts.

6.2.2 Low-Level Waste Disposal Development Demonstration Project

The Low-Level Waste Disposal Development Demonstration (LLWDDD) program is in the process of developing new low-level radioactive

Table 6.2.1. Radioiodine in deer thyroid glands: 1988

Deer number	Kill date	Thyroid activity (pCi/g fresh wt)			^{90}Sr in bone (pCi/g)
		I-129	I-125	I-131	
R07	14 Jan.	0.00	18.5	0.2	*a*
R08	01 Feb.	0.00	2.7	0.0	*a*
R10	05 Feb.	0.00	0.0	1.4	*a*
R12	11 Feb.	0.00	0.0	0.0	*a*
R15	24 Feb.	0.00	2.9	0.0	*a*
R17	08 Mar.	0.00	33.6	0.2	*a*
R18	14 Mar.	0.00	0.0	0.0	*a*
R19	22 Apr.	0.00	0.0	*b*	*a*
R22	29 June	0.00	0.0	0.0	*a*
R24	29 June	0.00	10.5	0.0	*a*
R25	05 July	0.00	1.2	0.2	*a*
R37	13 July	0.00	0.0	0.0	*a*
R38	26 July	0.00	110.8	4.8	*a*
R39	10 Aug.	0.00	42.6	0.0	*a*
P 1	18 Aug.	0.00	19.1	3.2	*a*
P 2	18 Aug.	3.51	11.5	3.6	35
P 3	18 Aug.	0.00	10.2	1.5	*a*
P 4	18 Aug.	0.00	4.5	0.2	*a*
P 6	18 Aug.	0.00	3.1	0.2	*a*
P 7	18 Aug.	0.00	3.9	0.0	*a*
P 8	18 Aug.	0.00	88.0	1.9	*a*
P 9	18 Aug.	0.00	4.9	0.0	*a*
P10	18 Aug.	0.00	283.7	28.5	*a*
R40	09 Sept.	0.00	33.5	6.7	*a*
R41	07 Oct.	0.00	8.4	0.0	*c*
26	15 Oct.	4.89	6.5	0.1	120
104	22 Oct.	0.00	1.6	0.0	37
142	12 Nov.	0.00	63.5	0.0	*d*
144	12 Nov.	0.00	7.7	0.0	*d*
153	12 Nov.	0.00	4.1	0.0	*d*
154	12 Nov.	15.89	7.0	0.0	60
161	12 Nov.	0.00	4.2	0.0	*d*
179	12 Nov.	0.00	3.0	0.0	*d*
184	12 Nov.	0.00	2.5	0.0	*d*
195	12 Nov.	4.06	8.7	Trace	190
215	12 Nov.	0.00	21.4	0.0	190
220	12 Nov.	14.17	10.2	0.0	10

Table 6.2.1 (continued)

Deer number	Kill date	Thyroid activity (pCi/g fresh wt)			^{90}Sr in bone (pCi/g)
		I-129	I-125	I-131	
225	12 Nov.	0.00	1.6	0.0	90
233	12 Nov.	0.00	7.7	0.0	*d*
240	12 Nov.	Trace	24.0	0.0	180
244	12 Nov.	0.00	3.2	0.0	10
245	12 Nov.	0.00	9.3	0.0	*d*
275	12 Nov.	0.00	14.7	0.0	*d*
290	13 Nov.	0.00	3.8	0.0	*d*
327	13 Nov.	0.00	6.7	0.0	*d*
333	13 Nov.	0.00	6.4	0.0	*d*
334	13 Nov.	0.00	4.4	0.0	*d*
343	10 Dec.	0.59	3.9	*b*	250
360	10 Dec.	0.00	3.0	*b*	*d*
362	10 Dec.	0.00	4.3	*b*	*d*
363	10 Dec.	14.77	7.7	*b*	20
367	10 Dec.	0.00	6.3	*b*	*d*
372	10 Dec.	0.00	20.9	*b*	90
400	10 Dec.	0.00	6.2	*b*	*d*
405	10 Dec.	0.00	11.9	*b*	*d*
408	10 Dec.	0.00	3.5	*b*	*d*
409	10 Dec.	0.00	4.6	*b*	*d*
410	10 Dec.	0.00	1.0	*b*	*d*
411	10 Dec.	0.00	2.3	*b*	*d*
413	10 Dec.	0.00	3.0	*b*	*d*
415	10 Dec.	0.00	3.7	*b*	*d*
417	10 Dec.	1.41	9.0	*b*	10
452	11 Dec.	42.83	4.7	*b*	400
453	11 Dec.	0.00	2.7	*b*	*d*
460	11 Dec.	39.81	17.0	*b*	20
491	11 Dec.	0.00	14.9	*b*	*d*

[a]Would have been released to a hunter on field-screen basis.

[b]Iodine-131 more than 30 d decayed. Iodine-131 may not be seen if present in small amounts.

[c]Unknown, no tests performed.

[d]Released to a hunter on a field-screen basis.

waste disposal technology for the Oak Ridge facilities. Part of this effort involves characterization of sites on which to construct low-level waste disposal tumuli. ORNL is providing technical support for baseline sampling for characterization of groundwater and surface-water quality at three proposed LLWDDD sites. The areas being investigated include an area north of Bear Creek Road and east of State Highway 95 (West Bear Creek Valley), Chestnut Ridge west of State Highway 95 and south of Bear Creek Road (West Chestnut Ridge), and an area east of the High Flux Isotope Reactor and north of Melton Branch. The effort includes sampling the wells and surface-water discharge stations on a quarterly basis and submitting the samples to the ORNL Analytical Chemistry Division for analysis. During 1988 a total of 683 samples were collected,

representing 2186 analyses. Among the analyses, 9280 constituents were identified. Included among the analyses are anions, alkalinity, inductive coupled plasma metals, specified metals (As, Hg, Se), total uranium, and radioactive constituents.

6.2.3 Fish Kills

Fish kills occurred four times in the ORNL area during 1988. Two of these were discovered in White Oak Lake; one occurred during the period of March 21–25, 1988, and involved six carp and one shad. Although no reason for the deaths of the fish was found, it is believed that the mortalities were related to a seasonal die-off rather than an environmental insult. On September 27, 1988, one dead fish was reported in White Oak Lake, but no reason for its death was found. All fish kills were reported to DOE as required.

Two fish kills were recorded in WOC during 1988. The first occurred during the March 2–17, 1988, period and involved 41 dead fish (primarily fathead minnows), 13 crayfish, 2 salamanders, and 1 frog. Although the cause of this fish kill was not determined, elevated chlorine levels in the creek were believed to have contributed to it.

The second WOC fish kill was discovered on December 9, 1988, and extended into 1989. Collections by ESD up through February 1, 1989, included 100 fish (mostly fathead minnows), 1 salamander, and a number of crayfish. As in the March 1988 fish kill on WOC, elevated chlorine levels in the creek are believed to have contributed to these mortalities. An investigation is under way to try to identify sources of chlorine that may be creating problems in the creek.

6.2.4 Biomonitoring Evidence of Ecological Impact and Recovery in Area Streams

Biomonitoring is a major component of environmental compliance programs at the Y-12 Plant, ORNL, and Oak Ridge Gaseous Diffusion Plant (ORGDP). The recent emphasis on biomonitoring by regulatory agencies reflects a shift from a strictly engineering approach to wastewater treatment to a water-quality-based policy that emphasizes impacts on the receiving waters, in addition to best available technology (BAT). Biomonitoring at the three Oak Ridge facilities also provides the framework for establishment of interim, less-restrictive effluent limits until new wastewater treatment facilities and other remedial actions are completed and water quality standards can be met.

The NPDES permits issued in 1985–1986 required implementation of a Biological Monitoring and Abatement Program (BMAP) at each of the three plants. Results of toxicity testing and in-stream community surveys indicate that reaches varying in length from ~200 m to 1.7 km (~656 ft to 1.1 mile) of six receiving streams [total of 4 km (2.5 miles)] are toxic to biota. In approximately 3.4 km (2.1 miles), or 83%, of these streams, the toxicity patterns are dominated by episodic discharges of chlorine.

Many of these streams also show evidence of ecological recovery over both spatial (i.e., downstream of the toxic reaches) and temporal scales. For example, a significant recovery of the fish communities has occurred between 1980 and 1985 in lower WOC below ORNL and between 1974 and 1984 in upper Bear Creek. Additional improvement in the fish community of upper Bear Creek was observed in 1985 in association with neutralization of the S-3 ponds. Almost a tenfold increase in fish abundance occurred between May and October of 1986 in EFPC just below New Hope Pond, and this high density has been sustained through 1988. Unlike the fish community, the rate of recovery of the benthic invertebrate community (bottom-dwelling organisms) has been much slower, especially in Bear Creek and EFPC just below New Hope Pond, partly because of the loss of an upstream source area for recolonization (the Y-12 Plant is situated on the headwaters of the two streams).

In addition to determining environmental compliance by evaluating the ecological status of receiving streams, the BMAP can also be used to investigate cause-effect relationships associated with adverse impacts. Identification of chlorine as the variable controlling toxicity in several different streams will guide efforts toward developing appropriate remedial action plans to address a generic problem. Biomonitoring can also be used to assess the effectiveness of these and other remedial

actions through documentation of the process of ecological recovery.

6.2.5 Nonradiological Waste Treatment Plant

The construction of the new nonradiological waste treatment plant (NRWTP) has required a number of different types of sampling. Initial site characterization was carried out for the main site, water used for tank testing was approved for discharge after tests, and potential problem areas along the piping routes were sampled. Details of each type of sampling follow.

6.2.5.1 Tank testing

Included in the design of the new NRWTP are many tanks for holding, treating, and collecting effluent. As part of the leak-testing procedure, the tanks are filled with tap water. After the tanks are tested for tightness in this manner, the test water must pass NPDES limits for discharge to a receiving stream before the tanks can be drained. Water parameters analyzed and the acceptable NDPES-set limits are listed below.

Parameter	Limit/unit
Oil and grease	15 ppm
Total suspended solids	45 ppm
Total residual chlorine	0.5 ppm
pH	6.0–9.0 units
Temperature	30.5 °C

Turbidity, dissolved oxygen (DO), sheen, color, and floating solids are also observed or measured. The only problem encountered has been meeting the chlorine limit. ORNL tap water comes from the city of Oak Ridge reservoir and has been treated with chlorine; normal levels range from 0.8 to 2.0 ppm. Depending on the volume of the tanks and the resulting surface area and the length of time the leak test requires, it is not uncommon for the chlorine levels to exceed the 0.5-ppm limit. When this occurs, the water is held and checked for chlorine until the level drops below the limit as a result of dissipation.

Approximately 15 tank tests were made in association with this project.

6.2.5.2 Piping route characterization

Piping modifications were made in order to deliver process waste streams to the NRWTP from both Melton and Bethel valleys. In most cases the routes were not along any suspect areas, but on a few occasions the area was questionable because of stream crossings or known potential contaminant areas. These areas were sampled in order to determine (1) the disposal method for excavated soil and (2) potential worker and equipment exposure. Sampling parameters included heavy metals and RAD contaminants to the depth of the excavation—usually about 1.2 m (4 ft). The results of this sampling indicated no areas of concern along the piping routes.

6.2.6 Plant and Equipment Building Site Characterization

In order to attain a preliminary "site characterization" for the Plant and Equipment Division building site, a random sample design was developed for the proposed building site. The site consisted of a grassy area, a gravel area used for overflow parking, and approximately one-third of both the east and west sewage treatment plant basins. Because of the heterogeneous nature of the area, the area was divided into two separate sampling units.

Unit number one consisted of the basins. If the basin area was to be used, it was important to establish the contaminant level of the sludge because the sludge would have to be disposed of. Of particular concern was the possible presence of a mixed waste. Sludge samples were collected to the depth of the plastic liner. Parameters included RAD contaminants, metals, volatiles, and semivolatiles. Results indicated low levels of radiological contamination, specifically cesium.

Unit number two consisted of the grassy and parking areas. Since no historical information indicated a use of this area and since it could be documented that the area had not been used in the past 20 years for any activity other than parking, there was no reason to sample for any contaminant that would have a vertical migration potential (such as organics). RAD contaminants and metals

were selected as parameters that would not migrate to a depth greater than the proposed excavation depth. Metals would also be most indicative of an old unmapped burial area. Sampling was done to a depth of 1.2 m (4 ft) (to cover the depth of footings) for RAD contaminants and metal parameters. No indication of contaminants was found.

6.2.7 Leakage of ^{90}Sr from the Old Hydrofracture Facility Impoundment Verified To Be in the Form of Fractured Flow

ORNL has used unlined surface impoundments to collect, treat, and dispose of liquid low-level radioactive wastes. These impoundments represent one of the earliest forms of waste management at ORNL, and some are still in use at certain locations. Construction is under way to convert to more environmentally acceptable methods for the collection, treatment, and disposal of liquid wastes. Over the past few years, considerable effort has been devoted to characterizing the contents of these wastes and evaluating their impact on groundwater quality. As these impoundments are replaced by new treatment facilities, some form of remedial action or disposal of the sediment contained in these impoundments will be required.

To aid in the validation of the effectiveness of the proposed solidification/fixation of sediment in the Old Hydrofracture Facility (OHF) impoundment, a ^{85}Sr tracer study was conducted to determine the transport velocity of ^{90}Sr from the impoundment to groundwater. Approximately 3.5 Ci (13 GBq) of ^{85}Sr was added to the 6- by 30.4-m (20- by 100-ft) impoundment on March 17, 1987. Levels of ^{85}Sr, ^{90}Sr, ^{137}Cs, stable strontium, and other stable elements were monitored in the impoundment water for 1 year. Concentrations of ^{85}Sr in filtered (0.45 μm) pond water rapidly decreased with time. Approximately 50% of the added ^{85}Sr was lost from the pond water in 10 d, although chemical equilibrium of ^{85}Sr and stable strontium was on the order of 150 to 200 d. A material balance of the quantity of ^{85}Sr added to the impoundment and of that measured in pond water and sediment indicated losses of ^{85}Sr in groundwater on the order of 25 to 38% in 50 d. Monitoring of groundwater showed detectable levels of ^{85}Sr at approximately 50 d and a peak in ^{85}Sr concentration at about 100 d (Fig. 6.2.1). The transport velocity of ^{85}Sr was calculated to be on the order of 4.6 cm/d (1.8 in./d). This velocity is generally consistent with values for hydraulic conductivity, effective porosity, and the retardation for strontium in these materials.

These data confirm that movement of ^{90}Sr from the OHF impoundment is not simple seepage through porous media, but rather leakage in the form of flow along fractures in the underlying rock.

6.2.8 7000 Area Leaking Gas Tank

Based on inventories, a 10,000-gal unleaded-gasoline tank was suspected of leaking. Soil gas analysis of the area confirmed the presence of volatiles. The tank was removed, and the contaminated soil was collected into a pile for further study. The dirt pile was approximately 1.2 m (4 ft) high, 22.8 m (75 ft) long, and 7.6 m (25 ft) wide. Air was pumped through the dirt pile to increase the volatilization rate. Random samples were collected as vertical composites, from 0.0–0.6 m (0–2 ft) and 0.6–1.2 m (2–4 ft), and analyzed specifically for xylene, benzene, and toluene (for disposal, the state requires that the total of these three volatiles not exceed 10 ppm). The results of the first analysis indicated that the total was still above the state limit. Xylene ranged from 0.005 to 38 ppm, toluene from 0.005 to 8.1 ppm, and benzene from 0.005 to 1.2 ppm. After additional treatment, samples were collected from the area that had the highest levels in the previous sampling. Results indicated that the three constituents of interest were below the state limits.

6.2.9 Development of a Dispersion Model for the Clinch River

The Strontium-90 Action Plan identified a need for the capability to predict the effects of contaminant releases from WOD. This task was completed in FY 1987 by the ORNL Environmental Sciences Division staff and the

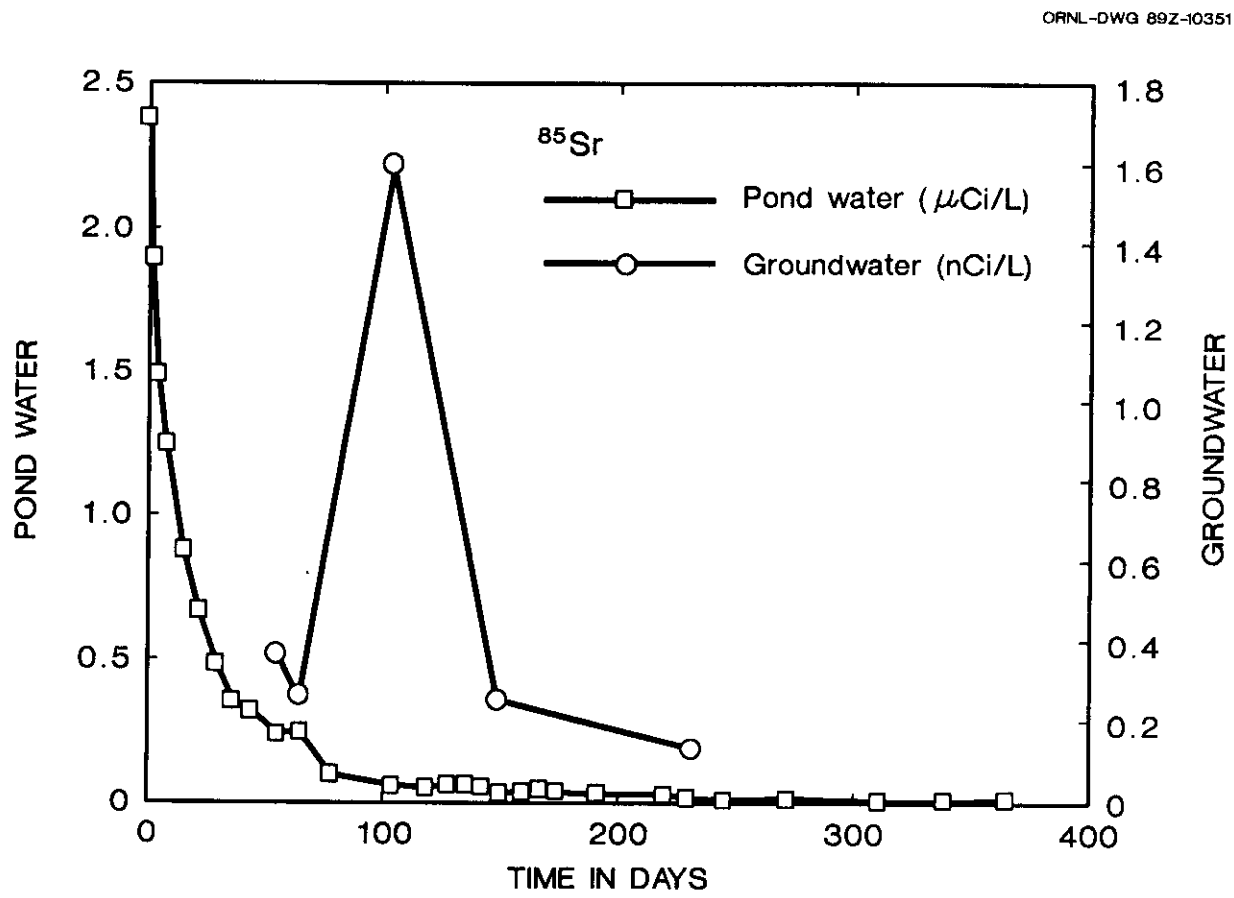

Fig. 6.2.1. Concentrations and transport of ^{85}Sr in groundwater and pond water near the Old Hydrofracture Facility impoundment.

Tennessee Valley Authority (TVA) Engineering Laboratory in Norris, Tennessee. A dispersion model was designed to allow rapid prediction of contaminant concentrations over time at critical locations in the Clinch River below ORNL over the highly variable reservoir flows that prevail.

A dispersion modeling system developed by the TVA Engineering Laboratory was adapted to the Clinch River below WOC. This system consists of three major modeling steps, each implemented in a separate computer program. The first step is prediction of hourly water velocities throughout the Clinch River, which depend on reservoir releases. A flow model was adapted and modified for simple use. The second modeling step is prediction of average travel times of releases from WOC down the Clinch River. Travel times are estimated by using the predicted water velocities to track each hourly release downstream and determining the location of each release every hour until the release arrives at the downstream location of interest. The third modeling step is prediction of contaminant concentrations at the downstream location of interest. The model assumes that contaminants disperse in a Gaussian plume across the Clinch River and longitudinally up and down the river; that is, it is assumed that a plot of concentration vs distance across or along the river channel for an individual puff of contaminant would have the shape of a normally distributed probability function, or bell curve. The height of this bell curve is determined by dispersion coefficients, which are important input parameters for the model.

To calibrate and evaluate the dispersion model, a dye tracer study was conducted in May 1987. A fluorescent dye was released (1) above the ORGDP water intake to study travel times and dispersion in the Clinch River below ORGDP and (2) at the mouth of WOC to study dispersion from the creek to ORGDP. The results of this study are being used to evaluate the dispersion coefficients used in the model and to determine how well the model works.

One result of this research is a computer modeling system that has been implemented on ORNL computers, simplified and made accessible for emergency and planning use, and documented well. An equally important result is expertise both in how the model works, including a knowledge of its internal methods and its limitations, and in the hydraulics of the Clinch River. Together, they provide the capability to quickly make reasonable predictions of contaminant concentrations below WOC.

6.2.10 Forecasting Travel Time and Dilution of Spills in the White Oak Creek Watershed

As a consequence of the abnormal release of radionuclides from White Oak Creek (WOC) late in 1985, several notable problems became evident. It was recognized that no predetermined criteria existed for operation of White Oak Dam (WOD) for emergency response under such conditions. Furthermore, contaminant transport and dispersion within the WOC drainage system and downstream in the Clinch River were not adequately characterized to support requests for modified reservoir releases by TVA.

To provide a framework for data collection and organization, a combination of models was selected and used to simulate typical spill conditions. The Streamflow Synthesis and Reservoir Regulation (SSARR) model has been used to simulate rainfall runoff and streamflows within the WOC watershed (Fig. 6.2.2), water levels and storage volumes in White Oak Lake (WOL), and the routing of contaminants released from ORNL facilities through stream reaches and WOL to subsequent release at WOD. SSARR model output includes discharge and contaminant mass flux from WOD. To predict the fate of these contaminant releases, TVA's Clinch River dispersion model has been used to calculate the time of travel and concentrations of contaminants at downstream locations at the water intakes to ORGDP and to the city of Kingston (Fig. 6.2.3). The Clinch River dispersion model uses SSARR model output as well as TVA reservoir elevations and releases to calculate hourly concentrations resulting from contaminants released at WOD.

An emergency response casebook of spill scenarios has been developed to facilitate the rapid response and decision making required in the event of an accidental release of contaminants into the surface waters of the WOC watershed. The casebook contains a summary of expected travel times and dilution factors for spills originating from ORNL facilities. It can be used to evaluate possible courses of action, such as closing the gates at WOD or requesting modification of release schedules at Melton Hill Dam on the Clinch River. The intent of the guide is to provide a set of basic graphs and quantitative methods to serve as a basis for valid decision making. Under actual spill conditions, the models will be used to provide the flexibility needed to adapt to changing conditions and to supplement information in the casebook. The scope of the casebook will expand continuously as the models are upgraded and additional scenarios are modeled.

Figure 6.2.4 depicts relative concentration at downstream locations at WOD and the water intake at ORGDP resulting from a hypothetical accidental release of contaminants from ORNL facilities. The contaminant is assumed to enter WOC at a constant rate for a duration of 24 h. The plot represents the relative concentration of (C/Co) vs time, where Co is the peak concentration at Monitoring Station 3 (MS3) on WOC downstream from ORNL. The prevailing conditions for this simulation consist of baseflow (low-flow conditions) in WOC, no regulation of the gates on WOD (gates left open for free-flow conditions), and seasonal low flow in the Clinch River. Results are plotted on a log scale to display concentrations that vary by two orders of magnitude or more. The diurnal fluctuations in concentration at the ORGDP site reflect the

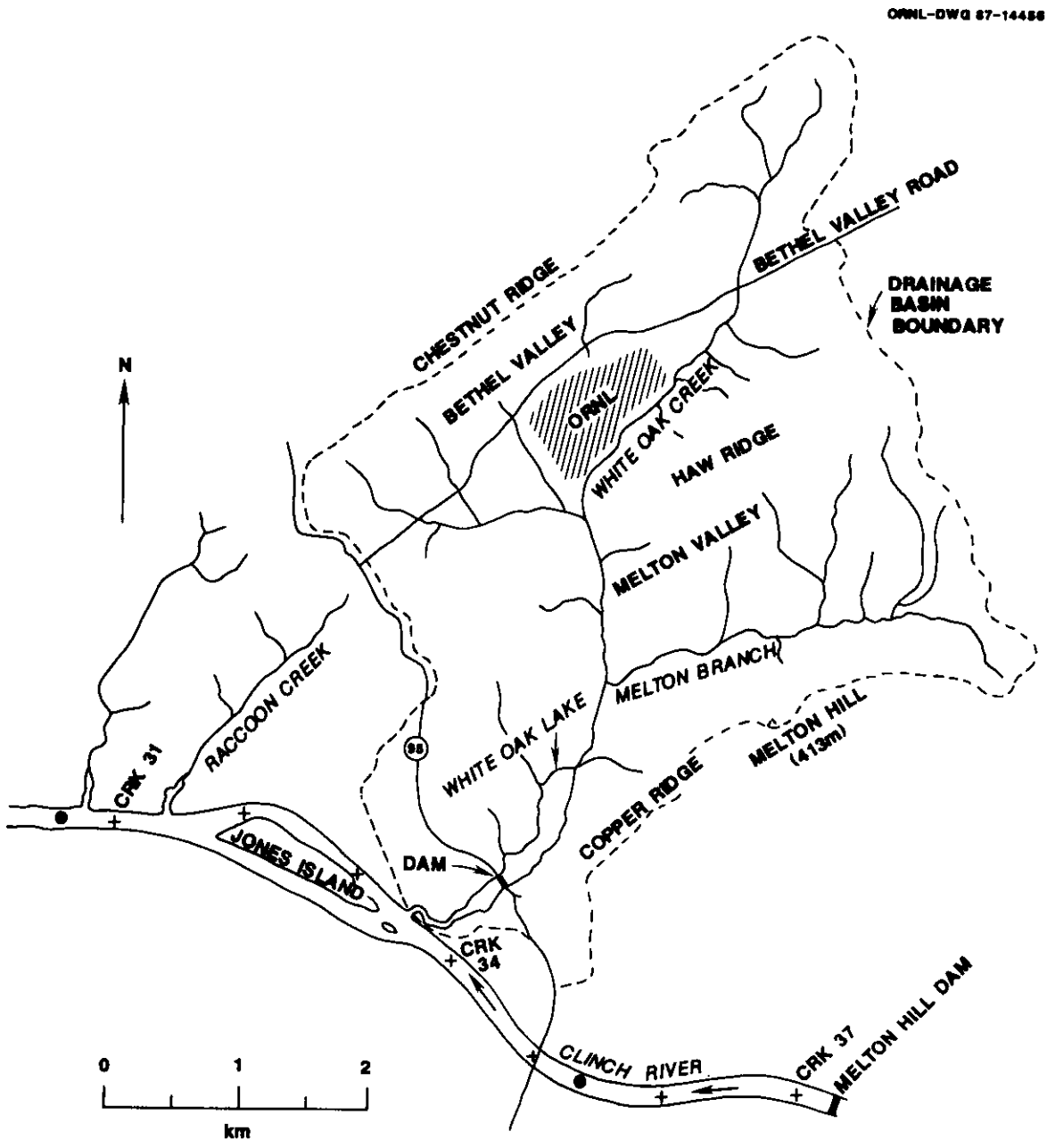

Fig. 6.2.2. White Oak Creek watershed.

periodic releases for power generation at Melton Hill Dam. In an alternative scenario in which the gates at WOD are closed after a spill occurs, the time to peak concentration at ORGDP can be extended for a period of approximately 1 week.

Project goals include the improvement of the quality and quantity of data to better calibrate the streamflow-forecasting portion of the modeling effort. The project has served to identify limitations in data-acquisition processes and provide a framework for organizing and using the data that are gathered. In addition, the project objectives are to continue to approach the goal of achieving a continuously operational model and to

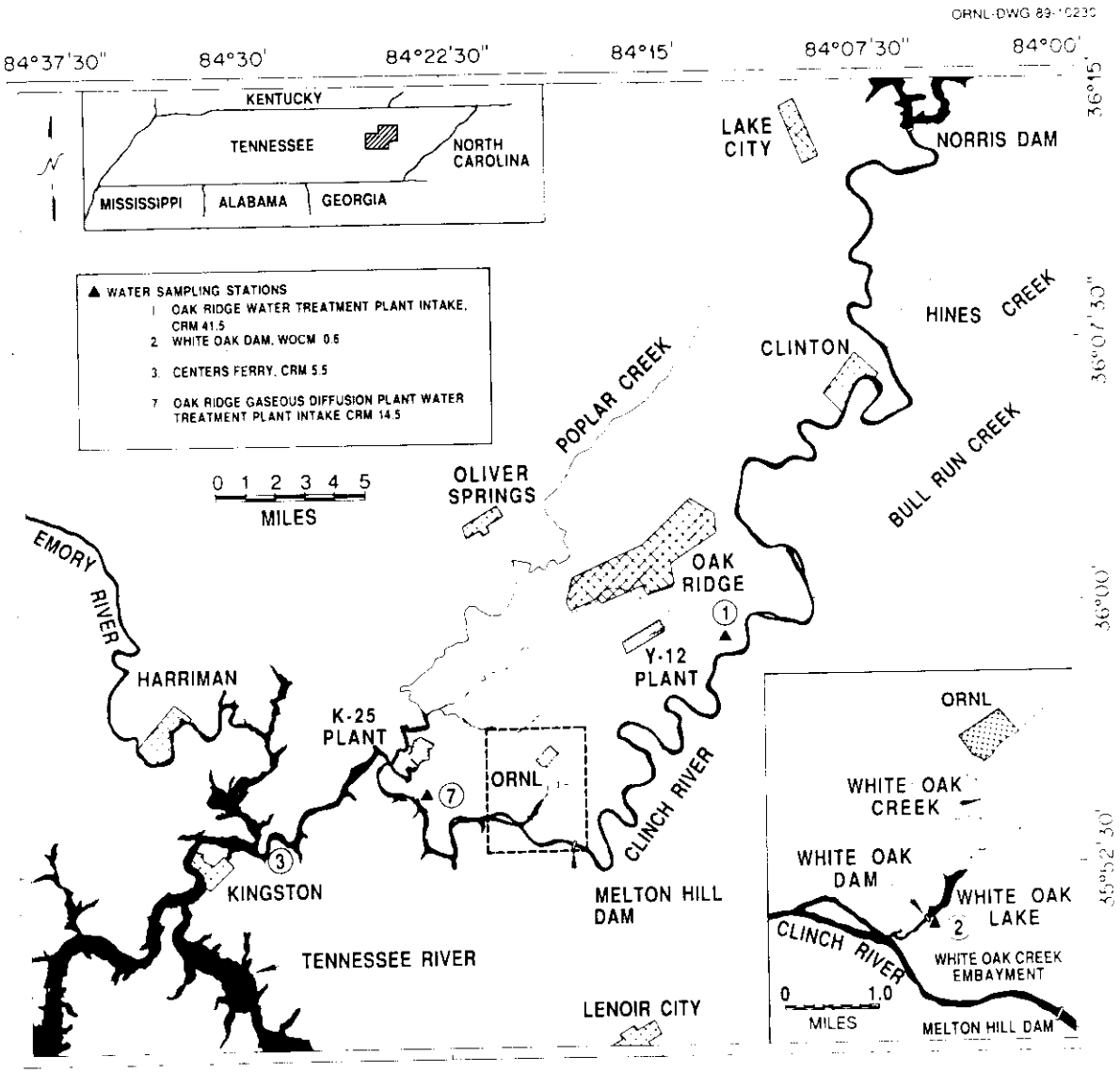

Fig. 6.2.3. Water-sampling stations on White Oak Creek and Clinch River.

develop a true forecasting center having a high level of operational emergency response preparedness to most effectively aid management decisions under emergency conditions. Considering the improved performance of the forecasting models on the WOC system for ORNL facilities, future applications of similar forecasting systems to facilities at the Y-12 Plant (EFPC) and other installations would be highly feasible. Subsequent forecast modeling systems patterned after the ORNL system would profit from the experience gained in establishing ORNL's forecasting operations.

6.2.11 Miscellaneous ORNL Spills

During 1988, ORNL had a total of 119 spills or releases of various types of materials (Figs. 6.2.5 and 6.2.6), compared with 109 for 1986 and 92 for 1987. ORNL has defined a spill as any material outside of its containment vessel. A spill is not necessarily a release to the environment;

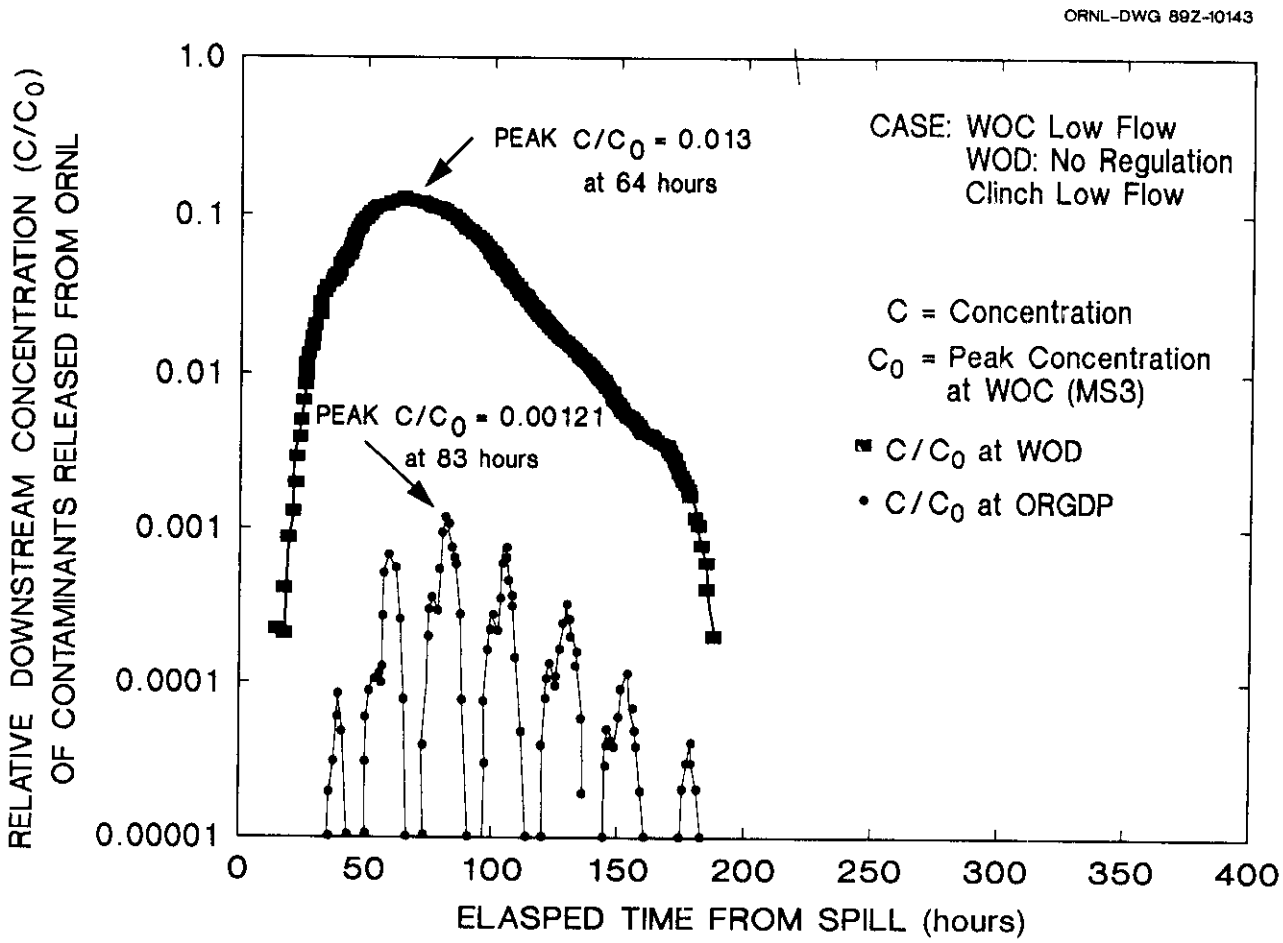

Fig. 6.2.4. Simulated response of contaminant release at White Oak Dam and ORGDP on the Clinch River.

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. Part of the increase in the total number of spills may be attributed to (1) increased awareness of the need to report even small spills and (2) increased construction activities.

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 and 1987, 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 900 site assessments

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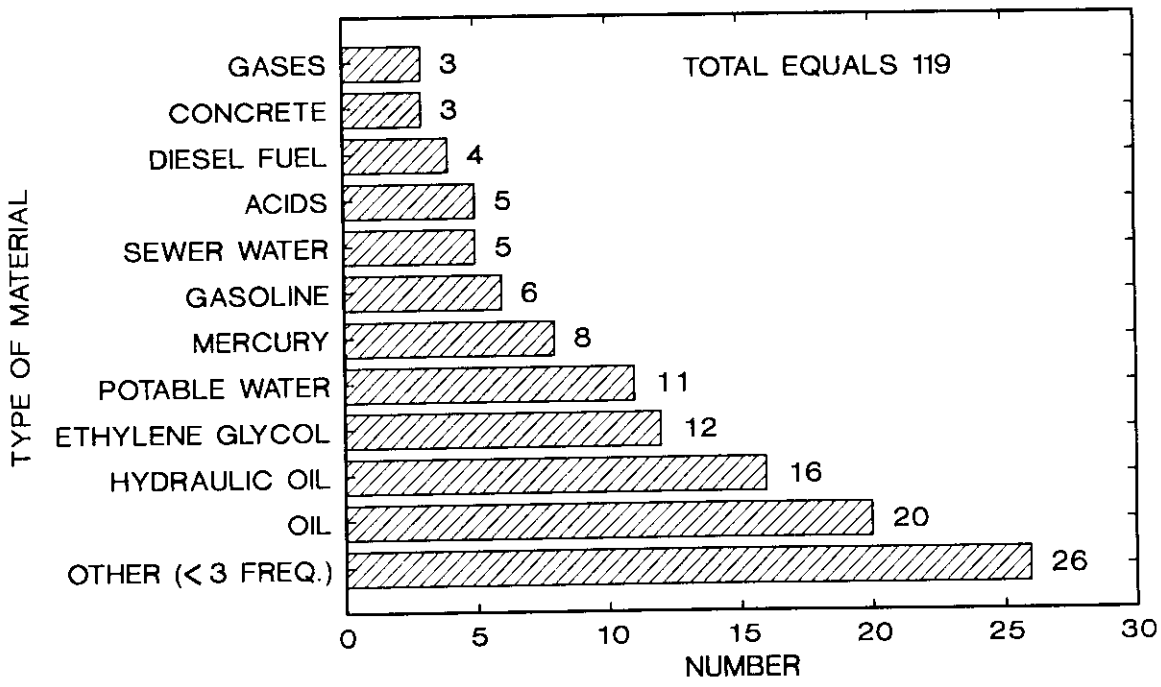

Fig. 6.2.5. 1988 ORNL spill summary: material frequency.

were conducted, and the site assessment reports were distributed throughout ORNL.

6.2.12 Toxicity Tests in Mitchell Branch

As a condition of the modified NPDES permit issued to the ORGDP on September 11, 1986, a Biological Monitoring and Abatement Program was developed for the receiving stream (Mitchell Branch). Four discharges [effluents from the K-1407-B holding pond and storm drains (SDs) 170, 180, and 190] and water from six ambient sites were evaluated for toxicity from October 1986 to December 1987. Toxicity was measured using 7-d static renewal tests (test solutions are replaced daily) based on the survival and growth of fathead minnow larvae and survival and fecundity of a microcrustacean (*Ceriodaphnia*).

Toxicity was detected in all four discharged effluents. Full-strength effluent from the K-1407-B pond was chronically toxic in eight of ten tests with *Ceriodaphnia* and two of eight tests with fathead minnows. Mean survival of *Ceriodaphnia* was ≤40% in seven of ten tests. The cause of toxicity in effluent from the K-1407-B pond has not yet been identified, but it appears to be related to periods when concentrations of calcium are high. Effluent from SD170 was toxic at full-strength in three of three tests. Full-strength effluent from SD180 and SD190 was periodically toxic. The toxicity of the SD effluents appears to be primarily the result of high concentrations of chlorine; in 8 of 12 tests, total residual chlorine (TRC) was ≥0.10 mg/L. However, the dechlorination of SD effluents did not always reduce the toxicity, indicating the periodic presence of other toxic constituents.

In the ambient toxicity tests, the site located above ORGDP operations [1.43 km (8.9 miles) above the confluence with Poplar Creek] was toxic to fathead minnows but not to *Ceriodaphnia*. The source of this toxicity is not yet known, but it is

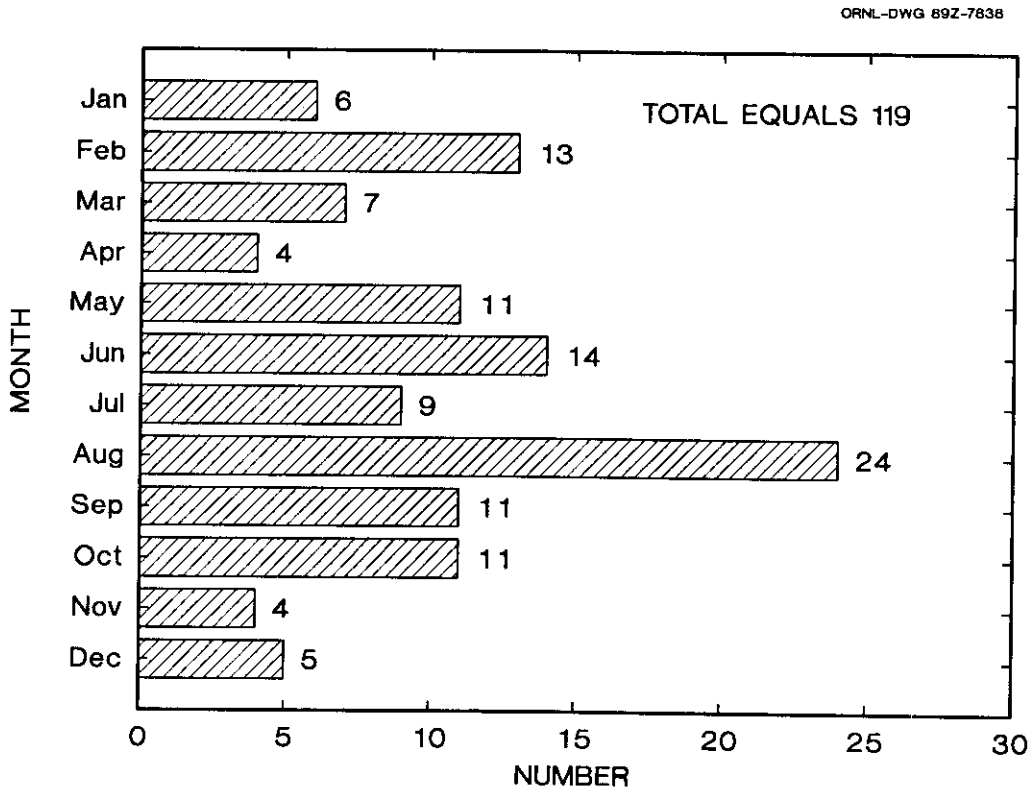

Fig. 6.2.6. 1988 ORNL spill summary: monthly frequency.

hypothesized to be caused by a fungal pathogen. Water in the midreach section of Mitchell Branch (below the discharge point of SD170 to just below the discharge point of SD190) was periodically toxic to both test organisms, showing the strong influence of the effluents from the K-1407-B pond and from SDs 170, 180, and 190 on Mitchell Branch. Mean survival and reproduction of *Ceriodaphnia* in water from Mitchell Branch correlated negatively with concentrations of TRC, and in at least half of the tests using water below the discharge point of SD170, no fathead minnows or *Ceriodaphnia* survived. These findings, plus the high variability in survival of the test animals and the lack of consistent evidence of chronic toxicity, indicate that the ambient toxicity pattern exhibited in Mitchell Branch may be controlled primarily by episodic releases of one or more toxicants, particularly chlorine. On a positive note, there was little evidence of chronic toxicity in water from the site furthest downstream of operations [0.12 km (0.07 miles) upstream from the confluence with Poplar Creek], where concentrations of TRC are typically zero.

6.2.13 Volatilization, Methylation, and Demethylation of Mercury in East Fork Poplar Creek

Volatilization, methylation, and demethylation of mercury compounds were investigated by staff in the ORNL Environmental Sciences Division by comparing the relative rates of these processes in EFPC. These processes are important in evaluating and predicting the natural rate of decontamination (recovery) of EFPC. Radiolabelled inorganic and organic mercury compounds introduced into water and sediment samples from this site and from the Clinch River at the Oak Ridge Marina (the uncontaminated reference site) exhibited both abiotic and biotic chemical transformations. Abiotic reduction of mercuric ion accounted for

most of the volatilization of elemental mercury from water samples from both sites (up to 56% of added mercury within 2 d). Presence of suspended sediment inhibited reduction and subsequent volatilization because of the adsorption of mercuric ion to suspended sediment. Direct biotic reduction of mercuric ion was difficult to discriminate because of rapid abiotic reduction and volatilization. However, abiotic plus biotic reduction of mercuric ion showed two distinct phases in the samples from the Clinch River, the later phase possibly resulting from biotic processes.

Biotic methylation of mercuric ion was unexpectedly low (<0.1% of the added inorganic mercury was methylated in 2 d) in samples from EFPC and was consistently detectable only in water samples having added sediment (1% solids). Although the presence of sediment appears to promote methylation of added mercuric ion, one experiment with radiolabelled sediment showed that <0.02% of mercury already bound to sediment was available for methylation.

Biotic demethylation of introduced methylmercury chloride was very efficient [>80% of radiolabelled methylmercury (CH_3Hg) was demethylated and evolved as elemental mercury in <5 d] in samples from EFPC (Fig. 6.2.7), but demethylation was not detected in samples from the Clinch River. These results suggest either (1) that microorganisms preexposed to mercury in

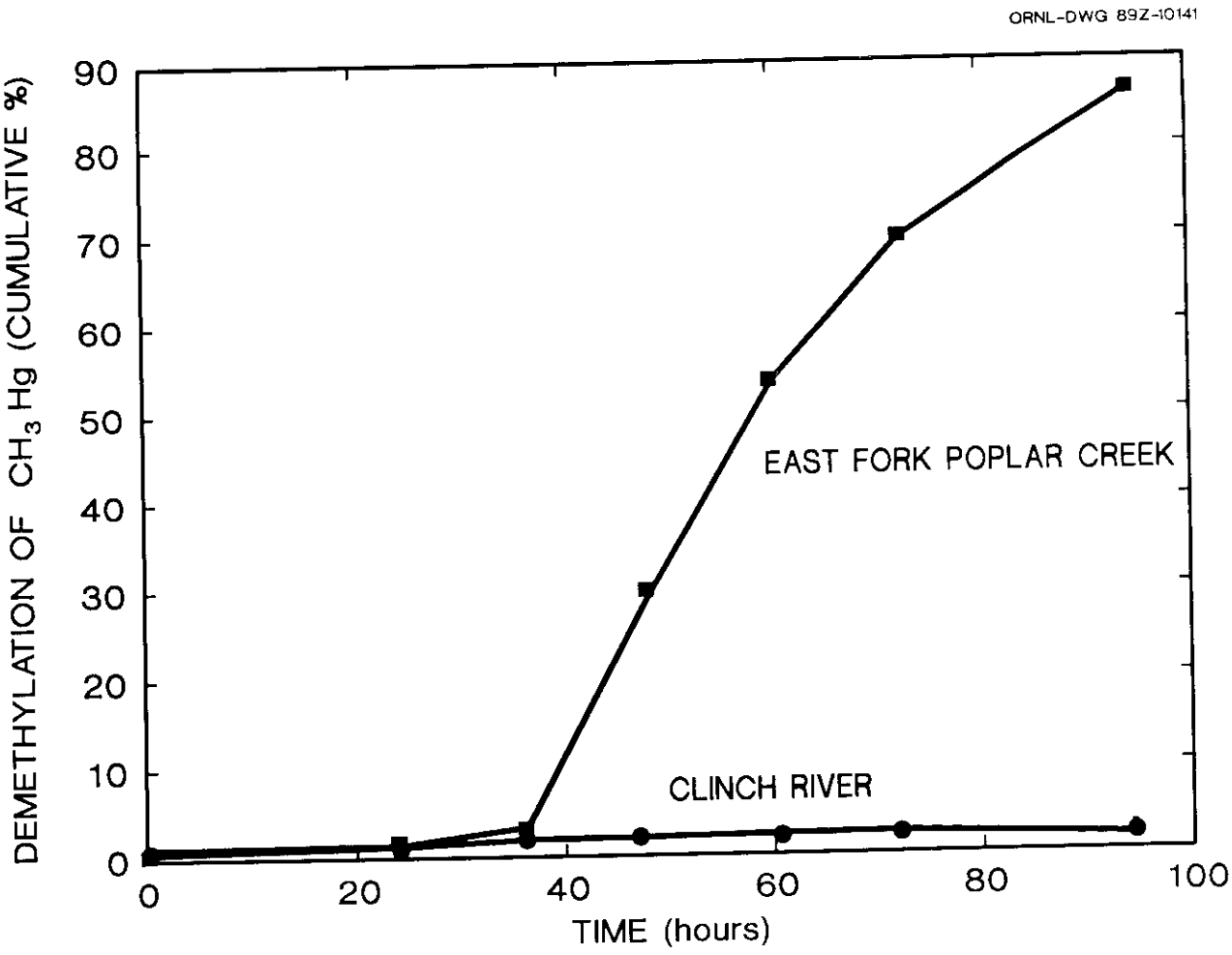

Fig. 6.2.7. Demethylation of methylmercury, over time, in East Fork Poplar Creek and the Clinch River.

EFPC have adapted to the elevated mercury concentrations by developing the ability to more readily reduce inorganic mercury and demethylate methylmercury than microorganisms without a history of mercury exposure or (2) that mercury-reducing and demethylating microorganisms are more abundant in EFPC.

The high mercury-demethylating capacity of microorganisms indigenous to EFPC demonstrated by this special study is germane to the on-going consideration of possible remedial actions to restore the creek. Observed lower-than-expected concentration of mercury in fish from EFPC relative to fish from much-less-contaminated aquatic systems in the United States and Canada may be one consequence of the observed high demethylation capacity at this site. Enhancing, or at least preserving, this capacity could represent an inexpensive remedial alternative.

6.2.14 Water Balance Data for Rogers Quarry

Water balance, calculated from measurements or estimates of surface-water inflow and outflow, precipitation, evaporation, and change in storage volume, is used to estimate losses to groundwater from ponds, lakes, and reservoirs. The water balance of Rogers Quarry, used as a waste disposal facility for the Oak Ridge Y-12 Plant from ~1962 to the present, is pertinent to future remediation and closure of the quarry because this data can be used, in conjunction with groundwater-level data, to determine whether waste contaminants disposed of in the quarry are migrating or have the potential to migrate into the groundwater. If water balance data indicate that the quarry functions as a sealed basin with respect to groundwater, then contaminant migration, except via surface-water outflow, is unlikely.

To determine a water budget for Rogers Quarry, ORNL Environmental Sciences Division staff has collected and analyzed data for five of the six components of the water balance equation (i.e., inflow, outflow, precipitation, evaporation, and change-in-storage data). Collection of surface-water inflow and outflow for the quarry necessitated the installation of a Palmer-Bowlus flume and Manning water-level monitoring system at the inflow and a Stevens digital water-level recorder calibrated to the Cipolletti weir at the outflow. The Stevens data were used for calculating daily changes in storage as well as daily flow. Daily precipitation data were obtained by averaging precipitation values for three recording rain gauges in the vicinity of Rogers Quarry. Estimates of daily evaporation for Rogers Quarry are based on data for a standard class A evaporation pan maintained by The University of Tennessee. Data for these parameters were then entered into a Lotus spreadsheet. With five of the six elements of the water balance equation measured, the sixth and unmeasured element, daily seepage residual (equivalent to loss to or gain from groundwater), was automatically calculated by the spreadsheet using the water balance equation

$$\text{seepage residual} = \text{outflow} + \text{evaporation} + (\text{change in storage}) - \text{inflow} - \text{precipitation}\ .$$

The spreadsheet was also used to calculate monthly totals for the six elements of the water balance equation.

Analysis of the Rogers Quarry water balance data for the period January 1987 through June 1988 suggests that the quarry is relatively tight with respect to exchanges with local groundwater (Fig. 6.2.8). For the 7-month period for which the most reliable hydrologic data is available (December 1987–June 1988), the quarry measured inputs and outputs appear to be nearly balanced (i.e., the unmeasured parameter, seepage residual, fluctuates closely around zero). A slight negative residual exists over these 7 months (average cumulative residual $= -1.74 \times 10^6$ L/month (-0.46×10^6 gal/month), suggesting that the quarry is a minor recharge source into the shallow groundwater system. However, because the average seepage residual is <2% of the average monthly inflow or outflow and because uncertainties in the two major components of the water balance equation, inflow and outflow, are at least ≥2%, the actual seepage residual could be positive. From these preliminary results it appears that contaminant migration from Rogers Quarry into local groundwater may be only a slight concern during future remediations.

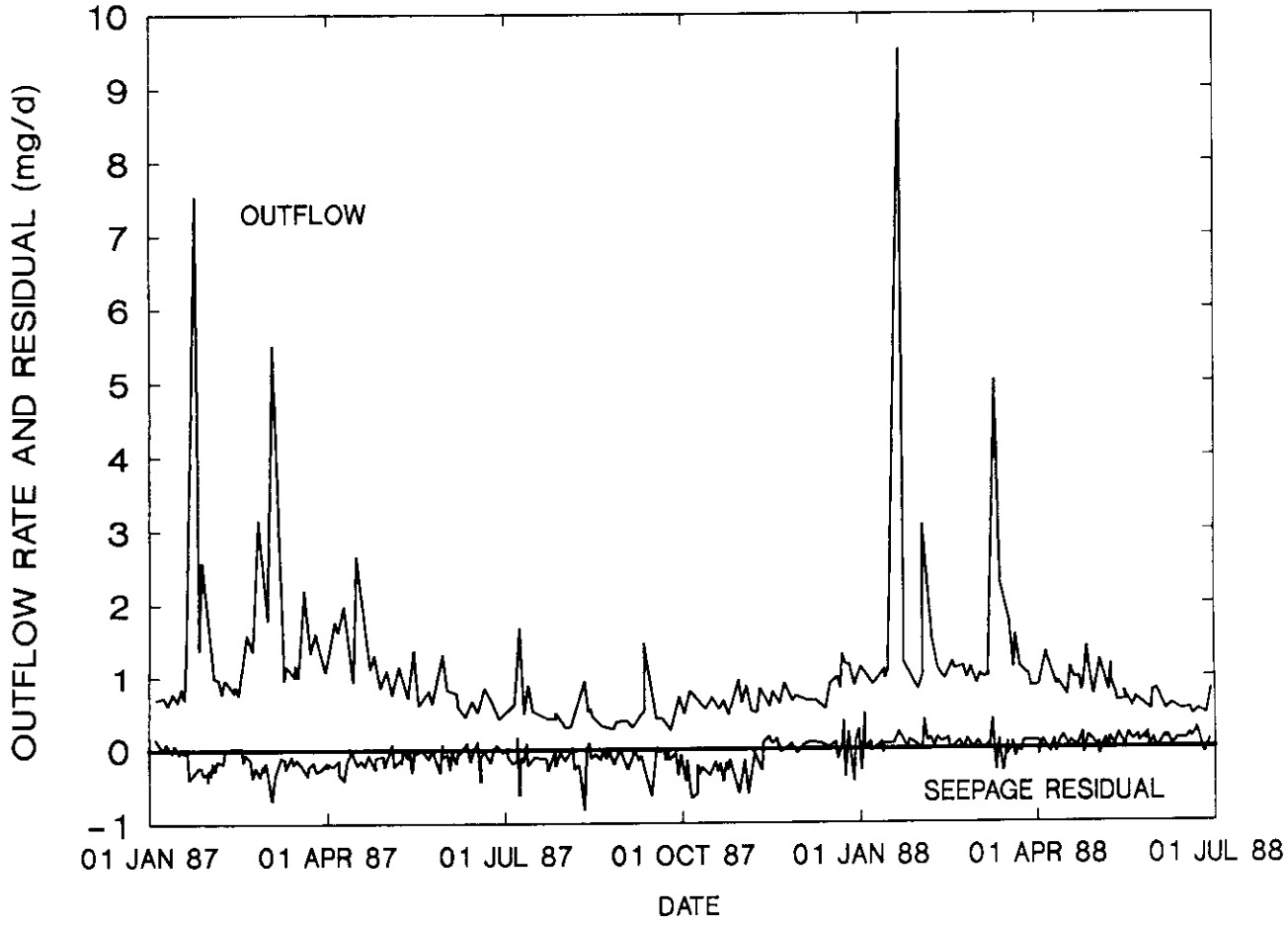

Fig. 6.2.8. Rogers Quarry outflow and seepage residual for the period January 1, 1987, through June 30, 1988.

6.2.15 Land Application of Sludge from the Oak Ridge Sewage Treatment Plant

Digested sewage sludge from the city of Oak Ridge is being applied to forests on the DOE Oak Ridge Reservation to (1) improve soil quality and enhance tree growth, as part of DOE's biofuels program and (2) to develop information to serve as a basis for new guidelines for environmental monitoring and operations for the land application of municipal sludge. As part of this program, the city of Oak Ridge and researchers at ORNL monitor the constituents in the sludge to determine application rates to provide the maximal soil improvement, with minimal risk of environmental contamination (Table 6.2.2). In most regards, sewage sludge from the city of Oak Ridge is typical of municipal sludge nationwide. The concentrations of mercury, uranium, ^{137}Cs, ^{60}Co, and ^{131}I are higher than typically found in municipal sludge. The concentrations of ^{137}Cs and ^{60}Co have been steadily decreasing during the past several years and are no longer considered problematic. Iodine-131 is present intermittently and does not persist (~8-day half-life). Concentrations of uranium reached a maximum of 300 ppm (dry wt) during October 1988. Steps were taken to reduce uranium release to the sewer system, and by December the concentration of uranium was reduced to about 50 ppm.

Table 6.2.2. Concentration (dry weight basis) of selected constituents in digested sewage sludge from the city of Oak Ridge during 1988

Constituent	Units	Concentration		No. of samples analyzed
		Average	Range	
Solids	Percent	2.4	1.8−2.8	44
N	Percent	8.8	7.2−10	5
P	Percent	2.8	2.3−3.5	7
K	Percent	0.71	0.38−1.1	6
S	Percent	1.6	1.4−1.7	2
Fe	Percent	1.7	1.4−2.0	3
Al	Percent	1.9	1.7−2.1	5
Ca	Percent	3.7	3.3−3.9	4
Mg	Percent	0.60	0.48−0.69	4
Na	Percent	0.24	0.19−0.3	3
Ag	μg/g	123	110−140	3
Au	μg/g	1.4		1
As	μg/g	5.6		1
Ba	μg/g	790	720−851	3
Be	μg/g	3.2	3.2	2
Cd	μg/g	9.9	7.2−17	6
Co	μg/g	17		1
Cr	μg/g	219	131−276	8
Cu	μg/g	574	512−667	7
Hg	μg/g	16	15−17	2
Mn	μg/g	773	360−1197	5
Mo	μg/g	48	37−60	2
Ni	μg/g	67	31−88	7
Pb	μg/g	165	130−200	7
U	μg/g	160	30−300	31
Zn	μg/g	2219	1720−3530	7
^{60}Co	pCi/g	5.2	1−20	31
^{137}Cs	pCi/g	2.2	0.5−12	31
^{131}I	pCi/g	7.1	0−20	31

6.2.16 Stabilization and Closure of Low-Level Radioactive Waste Trenches

As part of a low-level radioactive waste (LLW) burial ground stabilization and closure technology demonstration project, a group of five burial trenches in ORNL Solid Waste Storage Area (SWSA) 6 was selected as a demonstration site for testing trench compaction, trench grouting, and trench cap installation and performance.

The five trenches, known as the Test Area for Remedial Actions (TARA) site, are contained within a hydrologically isolated area of SWSA 6; for that reason, any effects of stabilization activities on site performance and groundwater quality will be separable from the influence of other waste disposal units in SWSA 6. To obviate the chronic problem of burial trench subsidence and to provide support for an infiltration barrier cap, these five trenches were dynamically compacted by repeated dropping of a 4-ton weight onto each trench from heights of approximately 7 m (23 ft). Such a procedure was found to be effective in collapsing trench voids in a previous demonstration using a trench in SWSA 6.

However, experience with more than one trench is desirable to substantiate the technique's effectiveness.

Before trench dynamic compaction, a group of 13 groundwater monitoring wells was installed at the TARA site for purposes of collecting background information on site water quality and monitoring water table elevation fluctuations. Sampling has shown that the groundwater contains tritium (^3H) in concentrations as high as 270,000 Bq/L and is dominated by sulfate, bicarbonate, and chloride anions and potassium, calcium, magnesium, and sodium cations. Water table fluctuations are monitored using an automated data-logging system and appear to be similar to other areas within SWSA 6 [on the order of 1 to 2 m (3.3 to 6.6 ft) between winter high and summer low]. The water table at the site has not been observed to intersect the trench bottoms as is the case with waste trenches located in lower topographic areas of SWSA 6.

Soil-penetration-resistance tests carried out at the site before compaction show a significant difference between the stability of the existing trench coves and the native Conasauga Shale in which the waste trenches were placed. Trench void space, which causes this lack of stability, was measured before compaction by means of water pump-in tests. Results indicated that from 26 to 61 m^3 (918 to 2156 ft^3) of water-accessible voids existed in the trenches, accounting for between 8 and 23% of the total trench volume.

From July 27 to August 4, 1988, the five TARA trenches were compacted to a maximum depth of 1.2 m (3.9 ft) and the site was graded to facilitate surface runoff. A total of 2141 7-m (23-ft) drops of the 4-ton weight were required, or approximately 5.5 drops per square meter of trench. Measurement of the volume reduction achieved through compaction was made by determining the volume of the resulting trench crater. Results indicate that an average water-accessible-void volume reduction of 77% was achieved. As further tests at the TARA site evaluate the effectiveness of trench grouting and cap performance, ORNL will be in a better position to select effective stabilization techniques for closure of its existing radioactive waste disposal sites.

To ensure good control of future in situ grouting of the five compacted trenches, samples of leachate and bottom soil were collected from each trench and tested for compatibility with the polyacrylamide grout. Addition of trench soil or leachate did not significantly retard the setting time of the grout, and it was determined that the percentage polymerization of the acrylamide in the presence of soil or leachate was identical to that achieved with unamended or neat grout (i.e., 99.5%). In addition, specimens of the burial trench soil were converted from high to immeasurably low hydraulic conductivity by percolation with reacting grout. Thus, it appears that these burial trenches pose no threat of interference with polyacrylamide grout set.

Laboratory degradation studies using ^{14}C-labeled acrylate and acrylamide grouts have been monitored for periods of up to two years. The microbiological half-lives of polyacrylate grouts, under steady-state conditions, range between 50 and 60 years, whereas polyacrylamide grouts have half-lives greater than 300 years. Specimens of 10 and 20% polyacrylamide failed to lose detectable water even when equilibrated against 15 bars of moisture tension. Thus, desiccation in the subsurface soil environment will probably not be a significant problem for polyacrylamide grout performance.

Performance monitoring of groundwater around two small transuranic waste burial trenches in SWSA 4, which were grouted with polyacrylamide in 1986, has not revealed any contamination by grout constituents. Background water quality in the area has not been perturbed by either the grouting operations or by the buried waste, except for occasional elevated levels of ^3H and gross beta activities.

6.2.17 Department of Energy Headquarters Environmental Survey of ORNL

The DOE Environmental Survey of ORNL is part of a comprehensive DOE Environmental

Survey encompassing all major DOE operating facilities. The first phase of the DOE survey of ORNL was conducted August 17 through September 4, 1987. The second phase, sampling analysis, was conducted at a limited number of ORNL sites by a team from the Idaho National Engineering Laboratory from November 16–22, 1988. Analytical results from Phase II have not been received.

An environmental survey preliminary report detailing preliminary findings based on the first phase of the ORNL survey was issued in July 1988. Categories used by the environmental survey to segregate findings vary in terms of magnitude and risk from category I, which presents an immediate threat to human life, to category IV, which includes management practices indirectly related to environmental risk. None of the ORNL findings represented an immediate threat to human life; most represented environmental problems which are, for the most part, a legacy from past practices. Generally, they are conditions that ORNL staff had previously identified and are characterizing. Of the 47 findings, 45 were in categories II and IV (i.e., those that pose or may pose a hazard to human health and the environment or instances of administrative noncompliance and management practices that are indirectly related to environmental risk). Two category II findings addressed the potential for unplanned release from underground storage tanks (USTs).

A draft action plan that responded to each of the findings was submitted to DOE on January 15, 1988. The plan addressed each of the 47 findings and included corrective actions, time schedules, and, whenever possible, estimates of resources required for completion.

Status reports detailing progress on the action plan were submitted July 1, 1988, and January 27, 1989. As of January 1989, action has been completed on ten findings. While progress toward closure of all the remaining 37 findings continues, significant accomplishments were made in several areas. These include (1) implementation of the approved RCRA Closure Plan for SWSA 6, (2) initiation of remedial investigation activities at SWSA 6, and (3) development of a UST management program that addresses all environmental protection measures associated with USTs used to store petroleum products.

Because many of the findings pertain to conditions that are being addressed by ORNL's remedial action program (RAP), they will remain open items until implementation of corrective measures.

6.2.18 Low-Level Contamination of Vegetation

A number of trees and grass in the central ORNL complex were found to have low-level radioactive contamination. An area of about 4.5 ha (11 acres), bounded on the west and east by Third and Fifth streets, respectively, and on the north and south by Hillside and Central avenues, was gridded to a 20-m (65.6 ft) resolution (Fig. 6.2.9). A walk-over radiation survey revealed several loci where vegetation exhibited elevated radiation. At these locations grass and tree foliage was collected (August 1988) and submitted for spectral identification and radionuclide content analysis. Among the radioisotopes present were ^{7}Be, ^{60}Co, ^{137}Cs, ^{131}I, and ^{191}Os; gross alpha and beta activity was also found. Table 6.2.3 provides a summary of the levels of contamination by life form (grass and tree). Beryllium-7 is a cosmogenic radionuclide, whereas ^{40}K is a naturally occurring primordial radionuclide. Both nuclides are present in foliage as a result of uptake mechanisms from natural sources. The gross alpha and beta radiations are from ORNL stack 3039 effluents, and the contamination mostly depicts foliar surface deposition. Some of the gross beta activity could result from the naturally occurring ^{40}K. The ^{131}I and ^{191}Os are also stack effluents from ORNL activities in Buildings 3025 and 3026. The mechanism of contamination is deposition.

The ^{60}Co and ^{137}Cs activities are the major contaminants and are derived from ORNL sources (tank farm and transfer line leakage) through root uptake. Cesium concentrations ranged from 0.17 to 12 pCi/g in grass and 0.054 to 36 pCi/g in tree leaves. Cobalt-60 was present in grass and tree leaves at similar concentrations of 0.92 to 1.5 pCi/g. The cesium concentrations detected probably did not represent the maximum

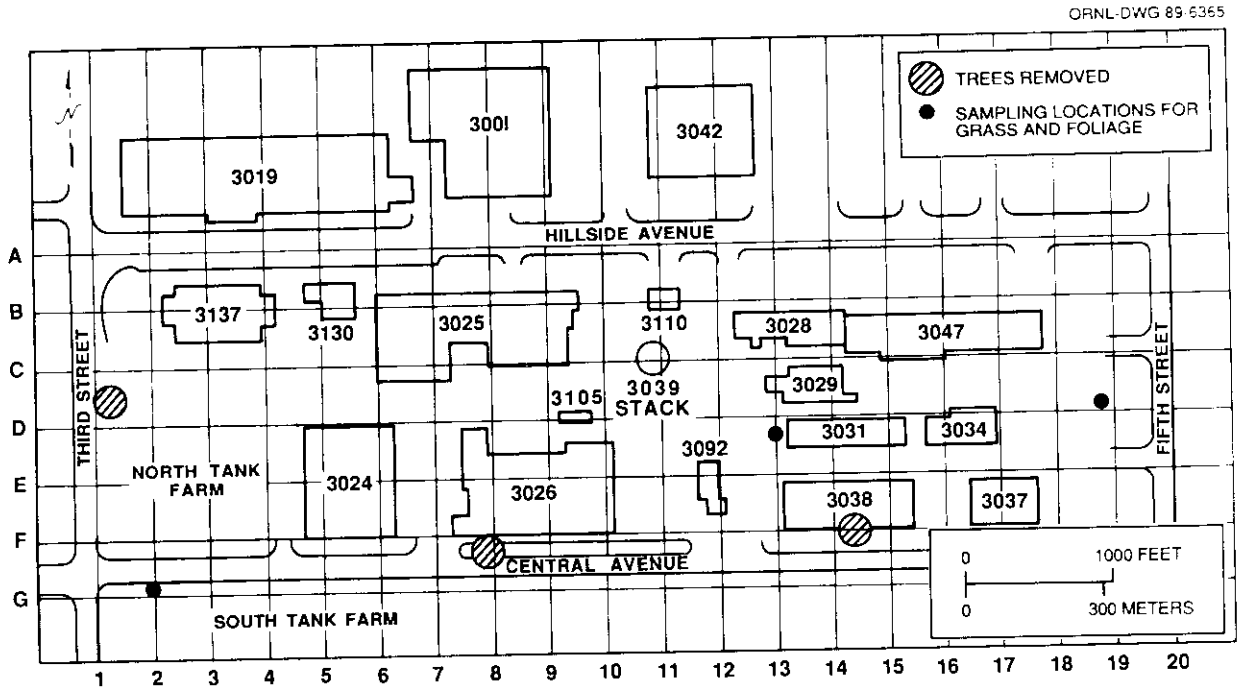

Fig. 6.2.9. ORNL area gridded for low-level radioactive contamination measurements. Circles indicate contamination.

Table 6.2.3. Radionuclide concentrations in foliage of plants (grasses and trees) in the central ORNL complex

Grid location[a]	Isotope	Concentration (pCi/g dry wt)
	Life-form: grass	
G2	^{60}Co	1.2
E13	^{60}Co	1.02
E13	^{137}Cs	12
G2	^{137}Cs	0.97
D19	^{137}Cs	0.43
D1	^{137}Cs	0.18
F14	^{137}Cs	0.17
	Life-form: trees	
F8	^{60}Co	1.5
G2	^{60}Co	0.92
F8	^{137}Cs	36
D1	^{137}Cs	0.70
G2	^{137}Cs	0.14
F14	^{137}Cs	0.14
D19	^{137}Cs	0.054

[a]Grid locations are identified in Fig. 6.10.

concentrations attained during the growing season because cesium follows the transpiration stream and usually reaches maximum concentrations with leaf initiation and growth. During senescence (August to October), the cesium remobilizes from foliage and moves downward to the roots. The fraction left in the foliage is subject to wind dispersion on the landscape by leaf-fall. Because of the active "mining" of the ^{60}Co and the ^{137}Cs each growing season, a potential has existed for periodic transfer of these low-level concentrations throughout ORNL. A management decision was made in keeping with health physics practices to remove those trees that represented low-level contaminant sources. The areas where the trees and turf were located are depicted in Fig. 6.2.9 by the circles. The trees were harvested, properly contained, and disposed of in SWSA 6.

6.3 OAK RIDGE GASEOUS DIFFUSION PLANT

6.3.1 PCBs Found in Building Ventilation Duct Gaskets

Polychlorinated biphenyls (PCBs) were identified during 1988 in the ventilation duct gaskets of three of the large shutdown process buildings at the ORGDP. PCBs are regulated under the Toxic Substances Control Act (TSCA) of 1976 (40 CFR 761). Specifically, the rules provide that no PCBs may be used except in a totally enclosed manner.

Currently, lubricating oil, which collected in the exhaust ducts while the facility was in operation, leaks onto the operating floor through PCB-impregnated gaskets. As the oil passes through the gaskets, PCBs are leached into the oil and the oil becomes PCB contaminated. The PCB-contaminated oil leaks are being treated as spills, with cleanup according to Subpart G of TSCA. Daily inspections are performed to identify any new leaks, to initiate cleanup if any are found, and to check and document all previously identified leaks. Leakage areas are also flagged off and labeled as PCB-hazard areas. Sealed troughs will be placed under the gaskets that continue to leak.

Studies were initiated in 1988 to determine the magnitude of the problem in the shutdown process buildings and also to determine whether PCB-contaminated ventilation duct gaskets are present in other shutdown or operating buildings. These actions will not bring the ventilation systems into compliance with the TSCA regulations, but they will greatly reduce the possibility of personnel exposure and environmental insult.

The EPA has authorized 15 nontotally enclosed PCB activities pursuant to Sect. 6(e). As in the case of the Paducah and Portsmouth plants, ORGDP is requesting a rulemaking change to allow the use of the gaskets in an open system that minimizes risk to human health and the environment until funding is available to remove the gaskets and/or ducts. Cost estimates and a feasibility study for removal of the gaskets and/or ducts were initiated in 1988.

6.3.2 DOE Headquarters Environmental Survey of ORGDP

The DOE environmental survey of ORGDP was conducted March 14–25, 1988. Nine members of the survey team reviewed ORGDP's environmental and waste management programs, including air and water emissions, soil contamination, and hazardous waste management.

The survey reported 30 preliminary findings, which were categorized into four categories. There were no category I findings (items that would pose immediate threat to life and require immediate response). Three category II items were found that relate mostly to the storage of mixed and hazardous wastes. There were eight category III findings related to actual or potential sources of soil and groundwater contamination. The remaining 19 category IV findings were related to hazardous, PCB, and chemical storage areas and the quality assurance of surface-water and groundwater monitoring data.

Generally, the survey findings reported conditions that the plant personnel are aware of and have taken or are planning to take action to mitigate.

6.3.3 Y-12 Plant Sludge Detoxification Demonstration at ORGDP

The Waste Management Technology Center, in conjunction with Chem-Nuclear Systems, Inc., demonstrated a technology for the treatment and detoxification of certain wastewater treatment sludges. The demonstration was conducted at ORGDP.

The raw material for the demonstration was generated at the Y-12 Plant from wastewaters treated at two different locations—the ORGDP K-1232 facility and the Y-12 CPCF. These sludges are a RCRA hazardous waste and are also contaminated with uranium and other trace radioisotopes and, as such, are classified as mixed waste, which cannot be readily treated under current disposal criteria.

The purpose of the demonstration was to apply a thermal technology that, when operated under proper conditions, will separate the

hazardous organic component from the sludges, leaving a dry material that, when stabilized, may be disposed of as a low-level radioactive waste. The organic components removed from the sludge were condensed during the process and collected in a liquid that will be disposed of in the ORGDP K-1435 Toxic Substances Control Act (TSCA) incinerator.

On October 3, 1988, the sludge thermal processing began. The K-1232 sludge was processed first, totaling seven drums. Next, the equipment was cleaned and prepared for the first run of CPCF sludge. Chem-Nuclear was able to process only a little more than one drum of the CPCF sludge before the unit condensing system became clogged. Chem-Nuclear recommended, and Martin Marietta Energy Systems, Inc., and DOE agreed, that the CPCF sludge could not be processed without major equipment adjustments. After the decision was made to not attempt to process more of the CPCF sludge, the unit was disassembled, decontaminated, and cleaned in preparation for the second run of K-1232 sludge. An additional 17 drums were processed. After thermal treatment was completed, the unit was decontaminated, cleaned, and preparations were made for shipment off-site.

The stabilization of the dried sludge is to be completed as the final phase of the demonstration. A delisting petition will then be submitted to the EPA.

6.3.4 K-1435 Toxic Substances Control Act Incinerator

The K-1435 TSCA incinerator, which was designed to thermally destroy PCBs and other hazardous organic waste, has gone through extensive startup/shakedown testing and compliance testing in 1988. In May and June of 1988, representatives of the EPA and the Tennessee Department of TDHE were present to observe the TSCA and the RCRA trial burns, which were designed to demonstrate that the incinerator could meet the regulatory performance standards at design conditions. In November, the TDHE was present to observe the air compliance test in order to obtain the air operating permit.

An outside contractor was hired to perform the sampling and analyses to meet requirements for RCRA and TSCA, and test reports for both the RCRA and the TSCA trial were submitted to the TDHE and the EPA for approval. Currently, DOE has received authorization from the EPA to allow the incinerator to burn PCBs. In February 1989, DOE received word from the TDHE that data submitted for the RCRA test were inconclusive and that a retest would be required. The retest is currently scheduled for June 1989.

The TDHE air compliance test, conducted by Energy Systems stack sampling personnel, showed that the limits for Pb and Be emissions exceeded permit limits. A study revealed that the exceedances occurred due to stratification of the lead and beryllium in the feed tank that led to a miscalculation of the feed input to the incinerator. The test will be repeated after the RCRA test is completed.

6.3.5 Ambient Air Monitoring System for K-1435 Toxic Substances Control Act Incinerator Emissions

Two ambient air monitoring stations (shown on Fig. 6.3.1 as TSCA 1 and TSCA 2) were designed to detect certain pollutants that might occur in an event resulting in significant releases from the K-1435 TSCA incinerator. The major technical considerations in deploying these units are purpose, monitor siting, sampling technology, and system operations.

6.3.5.1 System purpose

This ambient air monitoring system is not required by any federal, state, or municipal regulations. Furthermore, the criteria for siting and designing this system differs from any type of compliance ambient air monitoring. The purpose of this system is to evaluate any foreseeable release from the TSCA incinerator to ORGDP's nearest resident or most affected resident.

6.3.5.2 Monitor siting

To fulfill the system's purpose, predicted normal and accidental releases from the TSCA

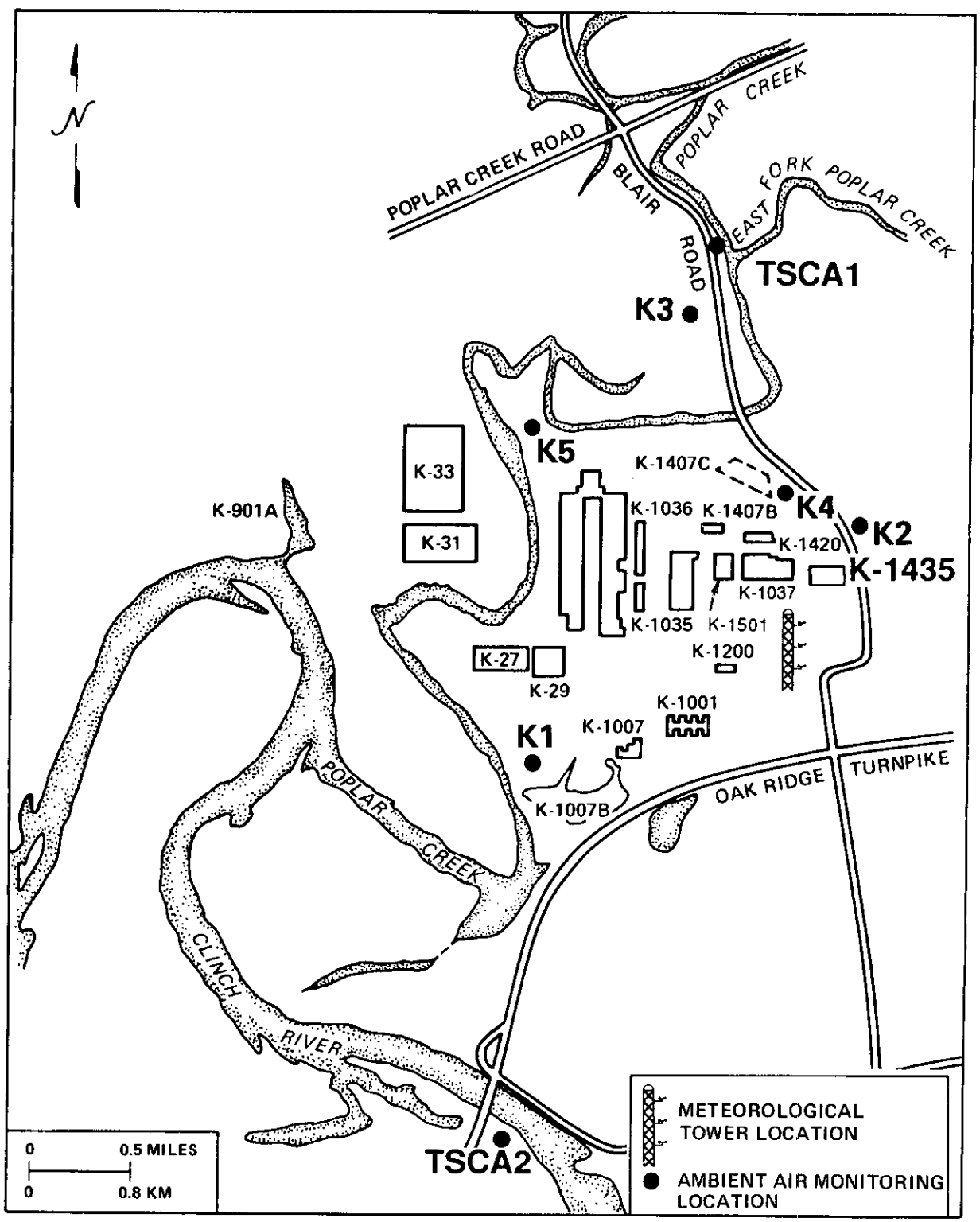

Fig. 6.3.1. Location of ORGDP ambient air monitors and meteorological tower.

incinerator were modeled in all directions with various conditions to determine the potential risk to residents in each direction. As a result of these models, two things were determined: (1) normal emissions from the TSCA incinerator would not be expected to impact the health of any resident near ORGDP and (2) only events that would emit more pollutants than a thermal relief vent event could impact any resident near ORGDP. The only two areas where residents could be affected by foreseeable emissions greater than those released by a thermal relief vent event were the "nearest resident," positioned near Hartland Estates, and the "most affected resident" (predicted by model), across the Clinch River near Gallaher Bridge. No residential areas near ORGDP, other than those two, would be exposed to concentrations from the TSCA incinerator that were detectable with state-of-the-art technology. Therefore, the only technically defensible positions for ambient air monitors for TSCA incinerator emissions would be near Hartland Estates and across the Clinch River near the Gallaher Bridge. All monitor positions were selected by Frank Kornegay, senior meteorologist, Energy Systems.

6.3.5.3 Sampling technology

Each monitoring station will consist of three sampling systems. The first sampling system will have the capability to sample for PCBs and hexachlorobenzene. The second sampling system will be able to sample for dioxins and furans. The third sampling system will have the capability to sample for uranium particulates. PCBs, hexachlorobenzenes, dioxins, furans, and uranium were chosen as the parameters of interest because of health risk considerations. These are also reasonable indicators for emissions from the TSCA incinerator. The first and second sampling systems will consist of a modified TSP sampler (with a critical flow orifice flow control) and the collection media. The collection media will be in series: a 15.2-cm- (6-in.-) diam quartz filter, a 7.6-cm- (3-in.-) thick polyurethane foam plug, and a 2.54-cm (1-in.-) thick polyurethane foam plug backup. The flow through the PCB, hexachlorobenzene, dioxin, and furan systems will be 1.1 m^3/min (40 ft^3/min). The uranium particulate sampler will consist of a TSP sampler with an 20.3- by 25.4-cm (8- by 10-in.) quartz filter; the flow rate on this system will be 60 ft^3/min.

The analyses of the PCBs, hexachlorobenzene, dioxins, and furans will be done by the IT Corporation. The analysis for the uranium will be done by the ORGDP laboratory. All appropriate quality assurance (QA) procedures will be implemented.

6.3.5.4 System operations

During CY 1988, both TSCA 1 and TSCA 2 were installed. TSCA 1 was operational in November and December 1988; however, data from these sampling runs were not available in 1988. TSCA 2 will be operational in January 1989.

6.3.6 Removal of Sludge from the K-1407C Pond

The hazardous sludge from the K-1407C pond has been removed, and the pond is ready for closure. In all, 12.5 million L (3.3 million gal) of sludge has been removed, with 7.9 million L (2.1 million gal) of the sludge being fixed in a concrete matrix and stored in drums. The remainder of the sludge is being stored in drums awaiting scheduling through the K-1419 sludge fixation facility (SFF). A plan is under way to delist the sludge as a hazardous waste so that it can be managed only as a LLW.

Currently, the impoundment is being closed under RCRA as a "clean" closure. The closure plan has been approved by the TDHE, and the final closure is scheduled to be completed by June 1, 1989.

6.4 BIOLOGICAL MONITORING AND ABATEMENT PROGRAM (BMAP)

6.4.1 Bioaccumulation Studies

Biological Monitoring and Abatement Programs 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) to determine 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 semiannually at five sites in EFPC downstream from the Y-12 Plant (Fig. 6.4.1) since 1985. A clear trend of decreasing mercury concentrations in sunfish with increasing distance below the New Hope Pond 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 the Oak Ridge Task Force Study in 1984 (TVA 1985). Mean mercury concentrations in fish have continued to exceed the 1 μg/g Food and Drug Administration (FDA) action level at sites in the upper third of EFPC. A similar pattern is apparent for PCBs in redbreast sunfish (Fig. 6.4.3). Although relatively few sunfish exceed the FDA tolerance limit (2 μg/g), concentrations in carp from EFPC average 3–4 times higher than concentrations in sunfish and are more likely to exceed this level.

Bluegill sunfish (*Lepomis macrochirus*) were collected in fall 1987 at sites near discharge sources and in the Clinch River/Watts Bar Reservoir to evaluate whether or not mercury and PCB inputs from upstream sources could be discerned in this species in those larger bodies of water downstream from DOE facilities. Results of this survey are presented in Figs. 6.4.4 and 6.4.5. Elevated concentrations of mercury were clearly evident in fish from EFPC, Poplar Creek, Bear Creek, and 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

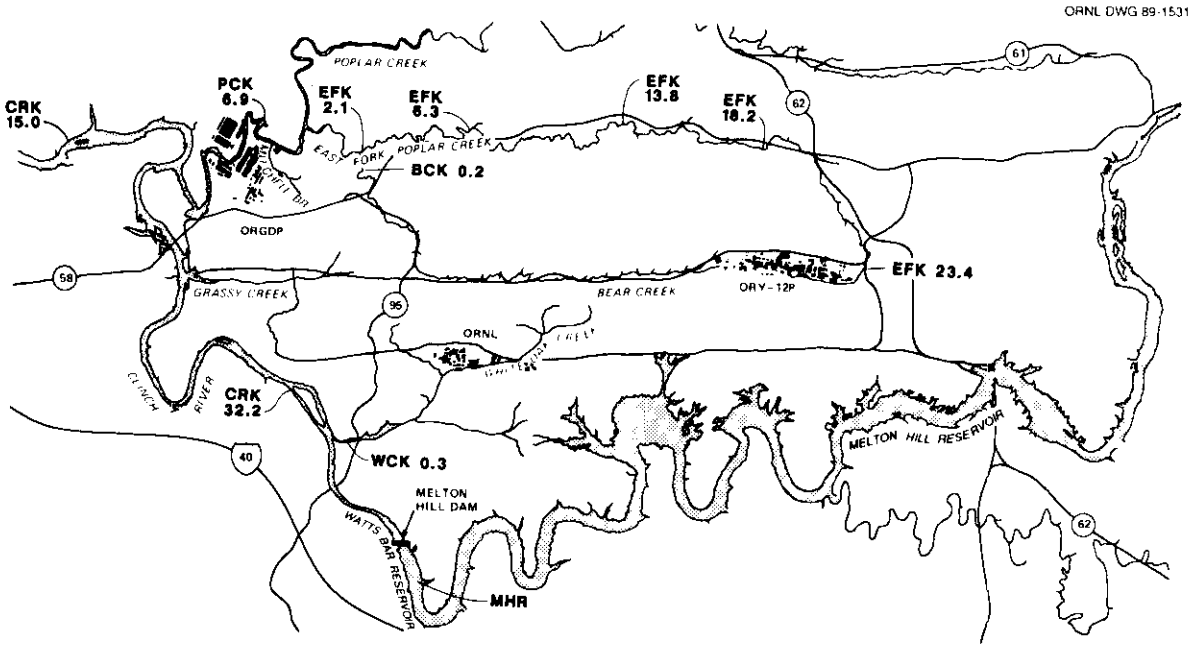

Fig. 6.4.1. Locations of channel catfish and redbreast sunfish collection sites for BMAP bioaccumulation studies.

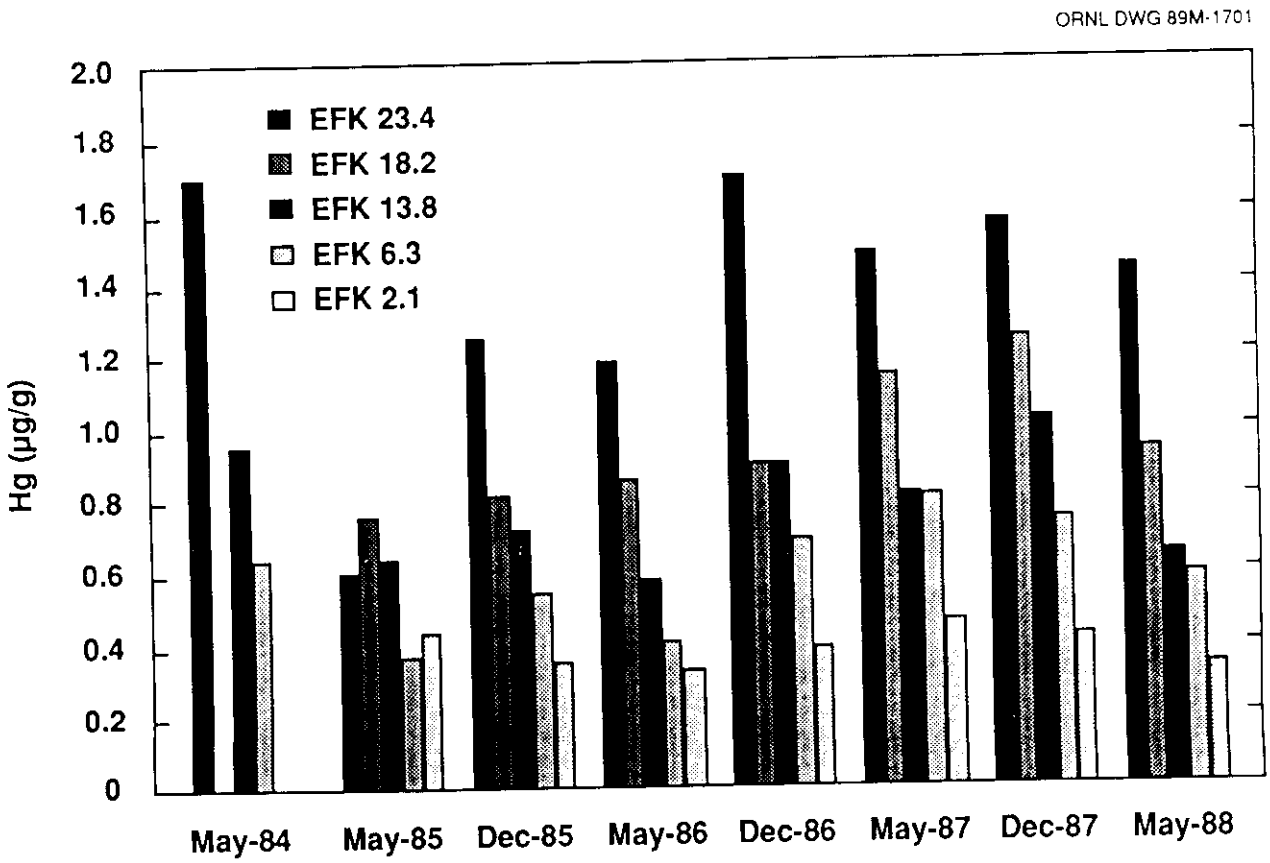

Fig. 6.4.2. Average concentrations of mercury in redbreast sunfish (n = 8) collected at sites in East Fork Poplar Creek, 1984–1988. The 1984 data are from the Oak Ridge Task Force Study (TVA 1985).

mean concentration of mercury exceeded the FDA limit at only one site, EFK 23.4. Any mercury inputs to the Clinch River from WOC or to Poplar Creek from Mitchell Branch did not result in detectable increases in mercury concentrations in fish.

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 EFK 23.4, and PCBs were elevated in fish from WOC, EFPC, lower Poplar Creek, and Bear Creek. PCB concentrations in bluegill from the Clinch River below ORNL did not show a detectable increase, but a very slight increase in mean PCB concentration was observed in Clinch River bluegill below the mouth of Poplar Creek.

Sunfish serve as good indicators of PCB contamination, particularly in small streams close to specific sources, but they do not accumulate PCBs to the extent that longer-lived, fattier fish such as catfish and carp do. Channel catfish (*Ictalurus punctataus*) have been found to contain concentrations of 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, monitoring for PCBs in this species at that site and nearby reaches of the Clinch River was included in the BMAP for ORNL. In 1988, this task included sampling channel catfish from lower Poplar Creek and the Clinch River below the mouth of Poplar Creek to distinguish the relative importance of PCB sources in the WOC and Poplar Creek drainages in contributing to PCB

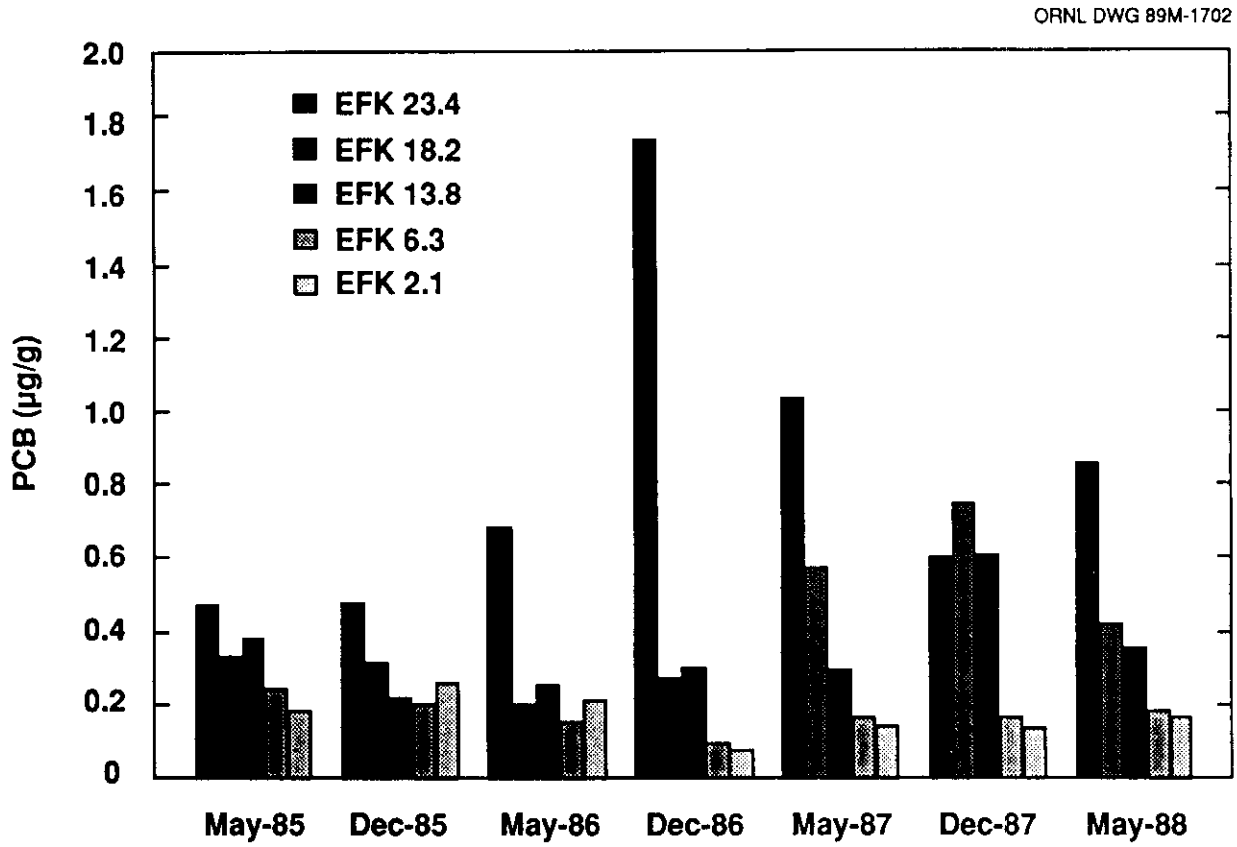

Fig. 6.4.3. Average concentrations of PCBs in redbreast sunfish (n = 8) collected semiannually at sites in East Fork Poplar Creek, 1985–1988.

concentrations in Clinch River catfish. Results of monitoring in 1986–1988 at sites shown on Fig. 6.4.1 are depicted in Table 6.4.1. PCB contamination was evident in catfish at all sites, with the highest mean concentrations occuring in WOC embayment and lower Poplar Creek. Fish from Melton Hill Reservoir (upstream from inputs from DOE NPDES discharges) contained mean PCB concentrations that were generally about 50% of the highest mean concentration found downstream in the same year, indicating that a substantial fraction of the PCB burden of Clinch River catfish may originate from upstream sources. Measurements of ^{90}Sr in catfish vertebrae were used to identify fish that had been exposed to the WOC discharge and indicated that catfish residing for periods of time in WOC embayment moved around enough to be vulnerable to capture by Clinch River anglers.

6.4.2 Waterfowl on the Oak Ridge Reservation

The resident and migratory waterfowl that inhabit waste disposal ponds and settling basins on the ORR 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 most of the waterfowl are migratory and reside on these ponds and settling basins for only a few days or weeks and that the amount of radioactivity they accumulate in their tissue is insignificant. It was also assumed that the number of waterfowl using these contaminated habitats was so small that the probability of a hunter harvesting these waterfowl and receiving a significant dose of radioactivity was very small. However, the issue of radioactivity in waterfowl received increased attention when deer hunts were initiated on the ORR in 1985 and

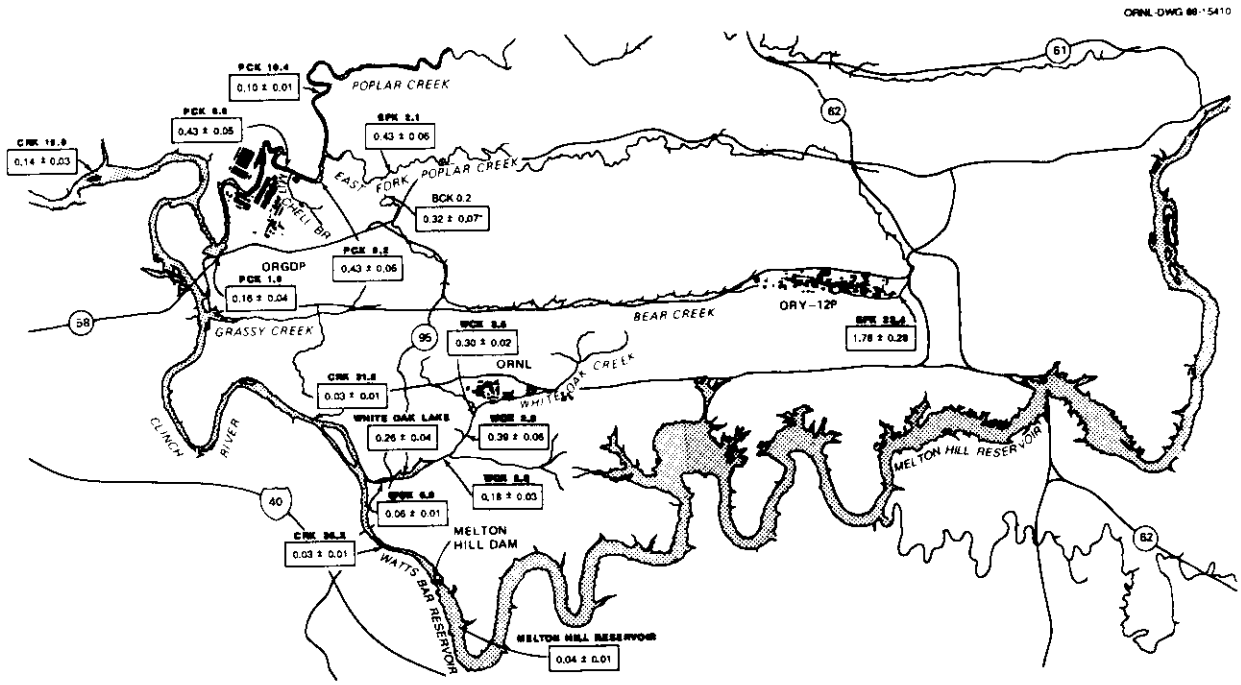

Fig. 6.4.4. Average concentrations (± 1 SE) of mercury (μg/g, wet weight) in bluegill (n = 8) collected in fall/winter 1987 at sites on the Oak Ridge Reservation.

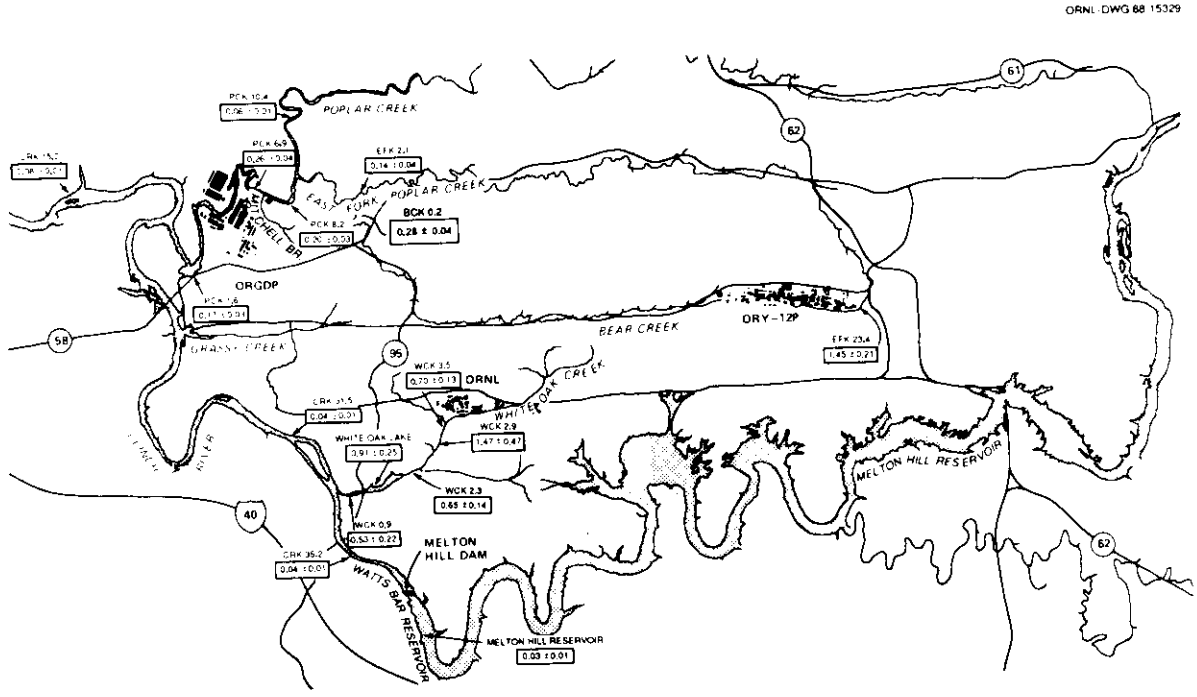

Fig. 6.4.5. Average concentrations (± 1 SE) of PCBs (μg/g, wet weight) in bluegill (n = 8) collected in fall/winter 1987 at sites on the Oak Ridge Reservation.

Table 6.4.1. Changes from 1986–1988 in average concentrations of PCBs (μg/g wet wt), ^{90}Sr (pCi/g dry wt bone), and fraction of fish exceeding the Food and Drug Administration (FDA) limit for channel catfish from White Oak Creek embayment (WCK), the Clinch River (CRK), lower Poplar Creek (PCK) and Melton Hill Reservoir

Site	PCBs			^{90}Sr			Fraction over FDA limit		
	1986	1987	1988	1986	1987	1988	1986	1987	1988
WCK 0.3[a]	1.30	1.59	0.96	20	9.5	16	3/12	2/8	2/8
CRK 32.2	1.01	1.61	0.58	1.5	4.3	20	0/8	2/8	1/8
Melton Hill Reservoir	0.46	0.81	0.52	0.38	0.30	1.6	0/6	1/7	0/10
PCK 6.9			0.71			0.89			0/8
CRK 15.0			0.50			5.9			0/9

[a]In 1986, two fish from WOK 0.9 in the WCK were included.

some animals were confiscated because the screening level for radioactivity in their tissues was exceeded, and when Canada geese nesting near an inactive waste disposal pond were found to have high levels of ^{137}Cs (Oakes et al. 1987). Consequently, a study of waterfowl use of waste disposal ponds and settling basins near ORNL was initiated in 1987. The purpose of the study was to (1) characterize the resident and migratory waterfowl populations that inhabited these habitats and (2) determine the potential exposure to humans from consuming these waterfowl.

Waterfowl have been observed on WOL and pond 3513, both of which are contaminated with radioactivity. Most of the waterfowl on WOL are migrants and inhabit the lake only for a few days or weeks, usually during migration. The weekly census of WOL waterfowl showed that the number observed at any one time may vary from a few to several hundred birds (Fig. 6.4.6).

Radionuclide concentrations (^{137}Cs and ^{60}Co) were measured in seven mallard ducks and three American coots collected from WOL in 1987 and 1988. The mallards were considered migrants because they had been observed on the lake for only a few days; the coots were considered residents because they had been observed on the lake for more than 3 months. The concentration of ^{137}Cs and ^{60}Co in the whole body, muscle (breast tissue), and liver is given in Table 6.4.2. The concentration of ^{137}Cs, which accounts for most of the radioactivity in the waterfowl, was about a factor of 5 higher in the coots that lived on the lake than in the mallards that only visited the lake.

The coot with the highest ^{137}Cs concentration weighed 640 g (22.4 oz). If a hunter harvested this bird immediately after it left WOL and consumed 256 g (9 oz.) of the edible tissue (40% of the total weight of the coot), he would receive a dose of approximately 0.25 mrem. At this level of radioactivity, a hunter would have to consume 99 kg (218 lb) of coot tissue (equivalent to 155 birds) to attain a dose of 100 mrem/year, which is the regulatory standard at ORNL for exposure to humans if the hunters received no other doses from ORNL or any of the other Oak Ridge facilities.

In cooperation with the TWRA, a banding study of Canada geese on the ORR was initiated in 1988. The purpose of the study was to determine the probability that geese inhabiting waste disposal ponds and settling basins would be harvested by a hunter. In July 1988, 168 geese were leg-banded, but no returns have been received to date. It should be noted that geese residing on many of these ponds are not contaminated with radioactivity above background levels.

In addition to the banding operation, 11 geese (3 adults and 8 juveniles) were captured at ORNL in the vicinity of pond 3513, a former waste disposal pond that received radioactive effluents in

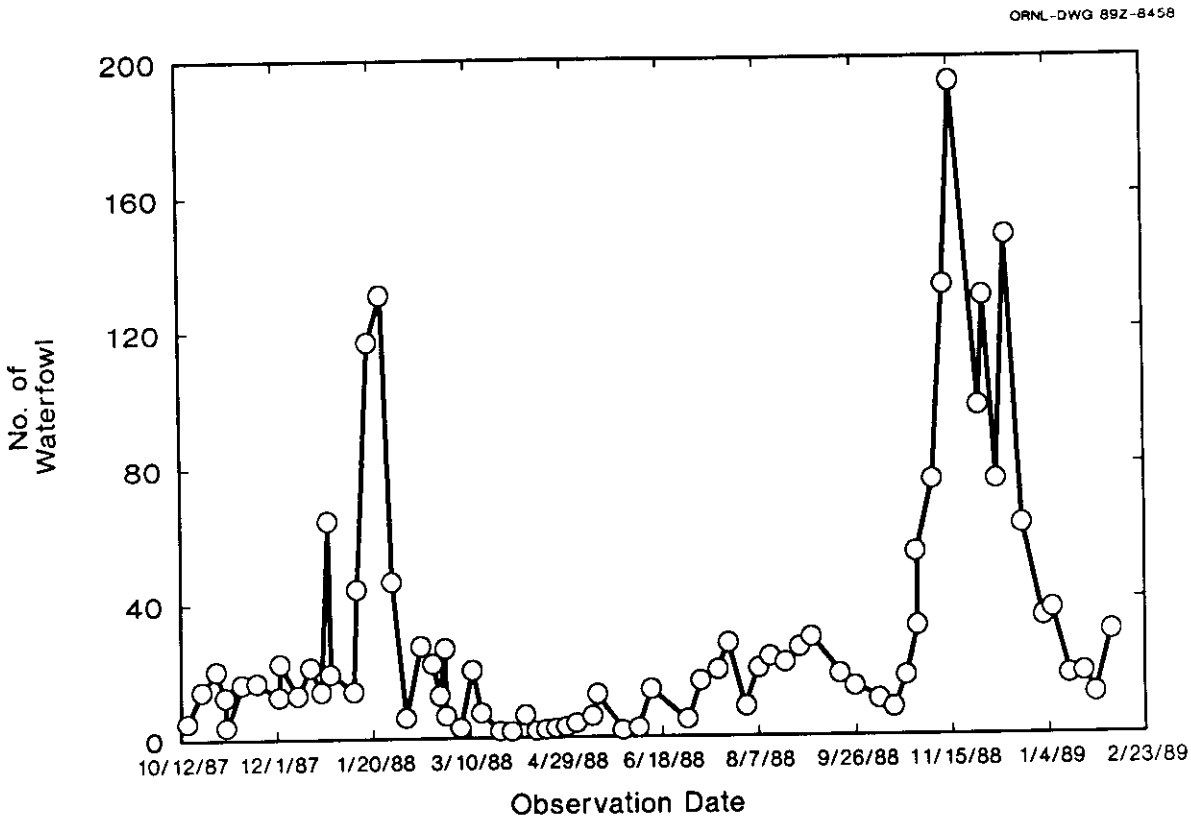

Fig. 6.4.6. Total number of waterfowl observed on White Oak Lake during weekly census from 1987 to 1989.

Table 6.4.2. Average concentrations (± 1 s.d.) of ^{137}Cs and ^{60}Co in mallard ducks and American coots from White Oak Lake

Sample type	Number of samples	Concentration (pCi/g wet wt)	
		^{137}Cs	^{60}Co
	Mallards		
Whole-body	7	7.0 ± 1.5	0.49 ± 0.1
Liver	7	1.6 ± 7.3	*a*
Muscle	7	3.8 ± 1.9	*a*
	Coots		
Whole-body	3	39.0 ± 5.8	3.3 ± 0.8
Liver	3	9.5 ± 0.8	*a*
Muscle	3	16.9 ± 3.1	*a*

[a]Not detectable.

the past but has been inactive recently prior to implementation of remedial actions. Previously, the maximum concentration of ^{137}Cs detected in the edible tissue of Canada geese nesting in the vicinity of pond 3513 was 3800 pCi/g fresh wt (Oakes et al. 1987). Because this concentration would result in a dose of 100 mrem to an individual who consumed 1.2 lb of this tissue, geese were discouraged from nesting in the vicinity of the pond. However, they still occasionally graze in this area. Live whole-body gamma counting of the 11 geese collected in 1988 in the vicinity of pond 3513 indicated the presence of ^{137}Cs. Concentrations of ^{137}Cs were measured in muscle (breast) and liver tissue of five of these geese (Table 6.4.3). The average concentration in muscle was 32.1 pCi/g with a maximum

Table 6.4.3. Concentration of ^{137}Cs in tissues of Canada geese collected near pond 3513 at ORNL

Tissue	Number of samples	Concentration (pCi/g wet wt)	
		Average (±1 s.d.)	Max
Muscle	5	32.1 ± 18.0	47.2
Liver	5	16.9 ± 4.6	19.6

concentration of 47.2 pCi/g fresh wt. If a hunter consumed 40% of the total weight (2.8 kg), or 1120 g (2.5 lb) of the edible tissue from the goose with the maximum concentration of ^{137}Cs in muscle, the resulting dose would be 2.6 mrem. At this level of radioactivity, an individual would have to consume 42.4 kg (93.2 lb) of the edible tissue from 15 geese to obtain a dose of 100 mrem/year.

The results obtained from waterfowl data collected in 1988 show that it is highly unlikely that an individual would receive a dose of 100 mrem or greater from consuming waterfowl that inhabit WOL or other aquatic habitats near ORNL. The waterfowl study is continuing and will be expanded to include other aquatic habitats on the ORR, including those at the Y-12 Plant and ORGDP.

6.4.3 Effluent Discharges into Upper East Fork Poplar Creek Reduce Survival and Growth of Introduced Clams

Past wastewater discharges from Y-12 Plant have significantly impacted the benthic macroinvertebrate community in the upper reaches of EFPC. Since the Y-12 Biological Monitoring and Abatement Program was initiated in June 1985, several new wastewater treatment facilities [e.g., the Central Pollution Control Facility (CPFC) have gone on line. It is anticipated that along with improvements in water quality, the benthic invertebrate community should also recover, although recovery may be slow since recolonization of the stream's upper reaches will be limited to aerial and upstream migration. The objectives of this study were to determine (1) if clams (*Sphaerium fabale*) from a local, minimally impacted reference stream, Brushy Fork, could survive and grow in EFPC and (2) the possible casual factors if clams were unable to survive and/or grow.

In the first experiment, which was conducted from midsummer through early fall 1988, a tray containing 25 individually marked and measured clams [lengths of 7.5 to 8.5 mm (0.3 to 0.34 in.)] was placed securely in a riffle at EFPC kilometer (EFK) 23.4 (creek mile 14.5) and another at EFK 13.8 (creek mile 8.6); one site in Brushy Fork served as a reference. At 3-week intervals, lengths were taken and mortality noted. Only 42% of the clams at EFK 23.4 were alive after 18 d, and none were alive after 81 d. Survival in Brushy Fork after 81 d was 87.5%. After 38 d, 100% of the clams at EFK 13.8 were alive, but the tray was lost during the next 3-week exposure period. The mean instantaneous growth rate of clams at EFK 13.8 after 38 d was significantly greater ($p < 0.05$) than at EFK 23.4 but significantly less ($p < 0.05$) than in Brushy Fork. The growth rate of clams in Brushy Fork was significantly greater ($p < 0.05$) than at EFK 23.4 after periods of both 38 d and 59 d.

Following the same procedures used in the first experiment, a second experiment was conducted from early through late fall 1988. Trays containing clams were placed at each site used in the first experiment plus an additional site on each

of two reference streams: Bull Run and Hinds Creek. Survival of clams after 66 d was 93.7 and 20.8% at EFK 13.8 and EFK 23.4, respectively, and 100% at all reference sites. The mean instantaneous growth rate of clams at EFK 23.4 was significantly less ($p < 0.05$) than at all sites except EFK 13.8 after 66 d, while the growth rate of clams at EFK 13.8 was significantly less ($p < 0.05$) than that at only one control site (Bull Run) over this same time period.

Results from these preliminary studies with clams suggest that the water quality of upper EFPC has not yet improved sufficiently to allow the establishment of this or other equally or more sensitive invertebrate taxa. The apparently higher rate of mortality during the first experiment (about one individual per day) than the second experiment (about one individual every 3 d) suggests that elevated temperatures may be a contributing factor, although siltation resulting from upstream construction activities may have also been a factor. Additional in situ and laboratory studies with this and other more and less pollution-sensitive taxa will help document improving water quality in upper EFPC and will help identify the critical factors impacting the benthic invertebrate community.

6.4.4 Radioactive Contamination in Canada Geese from the Oak Ridge Reservation

Previous studies (Oakes 1987, p. 125) of Canada geese residing near contaminated ponds within ORNL have shown that there is a possibility of off-site transport of radioactive materials by these birds. Cesium-137 and ^{90}Sr were found to be the major radionuclides accumulated from pond sediments.

Prior to a planned roundup of Canada geese on the ORR for tagging for population studies, a flock of 11 geese was observed to use the WOC basin and the 3500 area settling ponds within ORNL as part of their range. This flock had left excrement on the streets and sidewalks at the rear of Building 4508. To check for possible radioactivity transport by the geese, random samples of scat were collected at several locations in the affected area. All scat samples contained measurable ^{137}Cs, with a maximum concentration of 460 pCi/g (dry wt).

Geese from four locations [the Y-12 Plant, ORGDP, Clark Center Park, and ORNL] were trapped in the roundup and tagged. Twenty-six birds from the first three locations were measured in a lead-shielded whole-body counter containing a 15- by 15-cm (6- by 6-in.) Na(Tl) principal detector with a minimum-detectable concentration limit of 1 pCi/g for ^{137}Cs. None of the 26 geese from the first three locations showed any detectable ^{137}Cs. Following the whole-body count, those geese were returned to their capture location and released.

The flock of 11 geese at ORNL was captured and measured on the same day as the other birds. Whole-body screening measurements showed measurable contamination in the three adult and eight juvenile geese. Subsequent sacrifice followed by laboratory measurement of autopsy samples yielded ^{137}Cs concentrations in muscle of 20 to 110 pCi/g (wet wt).

The removal of the 11 contaminated geese temporarily solved the problem of radioactive transport from the settling basins. Future plans include the addition of some mechanism for preventing access to the ponds by migratory waterfowl. Suggested mechanisms include supported covers for the ponds or the use of streamers to frighten the birds.

The screening and autopsy results are presented in Table 6.4.4.

6.4.5 Monitoring of Conservative Water Quality Factors in ORNL Streams

Waste treatment systems can improve wastewater quality but often actually increase loading rates of relatively innocuous chemicals to receiving waters in the process. Treatment systems to remove uranium, for example, use reactions that require additions of lime, acids, and/or bases, all of which increase the effluent's soluble salt load. Ion-exchange systems remove metals from dilute solutions but must be regenerated by using acids, bases, or salts; column regeneration, in turn, creates a strongly saline waste. Toxic waste incinerators can destroy PCBs but leave saline

Table 6.4.4. Radioactivity in contaminated geese sacrificed on 7/12/88

Goose number	Weight (kg)	Screen (counts/min)	^{137}Cs[a] in muscle
26[b]	2.6	80	40
27	2.7	100	60
28[c]	2.1	100	60
29	2.5	115	110
30[d]	3.9	50	20
31	2.6	170	110
32	2.8	95	65
33	1.9	95	60
34	2.7	55	20
35[e]	3.8	55	20
36[f]	4.5	175	70

[a]Results in pCi/g (wet wt) for muscle.
[b]Contained 3 pCi/g ^{125}I in thyroid.
[c]Contained 6 pCi/g ^{125}I in thyroid.
[d]Contained 10 pCi/g ^{60}Co in muscle.
[e]Contained 24 pCi/g ^{125}I in thyroid.
[f]Contained 30 pCi/g ^{125}I in thyroid.

residues that are later discharged. Some kinds of noncontaminated wastewaters that are not treated can also increase the amount of salts within a receiving stream. Cooling tower blowdown, for example, is high in salts because salts that occur naturally in the water are concentrated by evaporation.

Salts added to receiving waters by wastewater treatment systems can often be detected as changes in water conductivity, hardness, and/or alkalinity. These three water quality factors are conservative, because their concentrations are controlled more by weathering processes and dilution events than by biota. In natural waters, conductivity, hardness, and alkalinity are usually highly correlated but measure different properties: conductivity reflects concentrations of all dissolved salts; hardness measures largely concentrations of Ca and Mg; and alkalinity is an estimate of the water's acid-neutralizing capacity, which is controlled by the concentrations and types of soluble carbonates.

To see how relationships between conductivity, hardness, and alkalinity can be influenced by wastewater discharges at ORNL, measurements were made of conductivity, hardness, and alkalinity at 11 sites in three streams that receive wastewaters of various types. A site upstream from ORNL operations on each stream was used as a reference site. Each site was sampled 80 to 84 times during a 12-month period. An index of the degree of chemical perturbation (the sum of the values of the Pearson correlation coefficients between conductivity, hardness, and alkalinity) was used as an index of the relatedness of the three factors at each site. This index can range from -3 to $+3$ and should be highest in sites that are not perturbed chemically. Changes in the index with distance downstream were used to rank the streams with respect to their degree of chemical perturbation.

As expected, the reference sites on First Creek, Fifth Creek, and White Oak Creek all had high values (2.65 to 2.86); thus, these sites were chemically similar, and conductivity, hardness, and alkalinity were highly related. The index declined with distance downstream in all three streams, but at different rates: the decline rates per kilometer for First Creek, Fifth Creek, and for a midreach segment of White Oak Creek were 14.6%, 39.4%, and 59.9%, respectively. The index for White Oak Creek was lowest (0.70) just downstream from ORNL's coal yard runoff treatment facility. The overall degree of chemical perturbation in the streams could be ranked in the following sequence: First Creek < Fifth Creek < White Oak Creek.

This study shows that ORNL operations detectably alter relationships between fundamental, easily measured water quality factors. In-stream monitoring of conservative properties (e.g., conductivity, hardness, and/or alkalinity) would provide information that is operationally more useful than more dynamic parameters, such as dissolved oxygen, pH, and water temperature, which are now monitored.

6.5 OFF-SITE

6.5.1 Accumulation and Retention of ^{137}Cs from ORNL in the Clinch River and Watts Bar Reservoir System

From the late 1940s through the 1960s, a large quantity of fission products was produced and processed at ORNL. Many of these fission

products, which included ^{137}Cs (half-life 30 years), were retained in impoundment basins and became associated with suspended particulate material and the sediments. During periods of large-storm events, along with the drainage of WOL (one of the impoundment basins) in 1956, a portion of these contaminated sediments was resuspended and transported to the Clinch River and impounded in Watts Bar Reservoir.

In an attempt to quantify the amount of ^{137}Cs that has been retained in the reservoir sediments, approximately 60 cores and 180 surface grab samples were collected (Fig. 6.5.1) and analyzed for their radioactive components by ORNL ESD staff. The vertical distribution of ^{137}Cs in the sediment cores collected from Watts Bar Reservoir is strongly correlated with the historical release record of ^{137}Cs originating from WOL. Such cores exhibit a large subsurface peak concentration of ^{137}Cs. The depth of this subsurface peak as well as the thickness of ^{137}Cs-contaminated sediment varies with the rate of sediment accumulation. In areas of rapid sediment accumulation, such as in the upper portion of the reservoir and along the old river channel, the highest ^{137}Cs concentrations occur at sediment depths as great as 1.5 m (5 ft). In areas of less sediment accumulation, such as along the reservoir margins, the highest ^{137}Cs concentrations often occur closer to the sediment surface. This distribution may have important

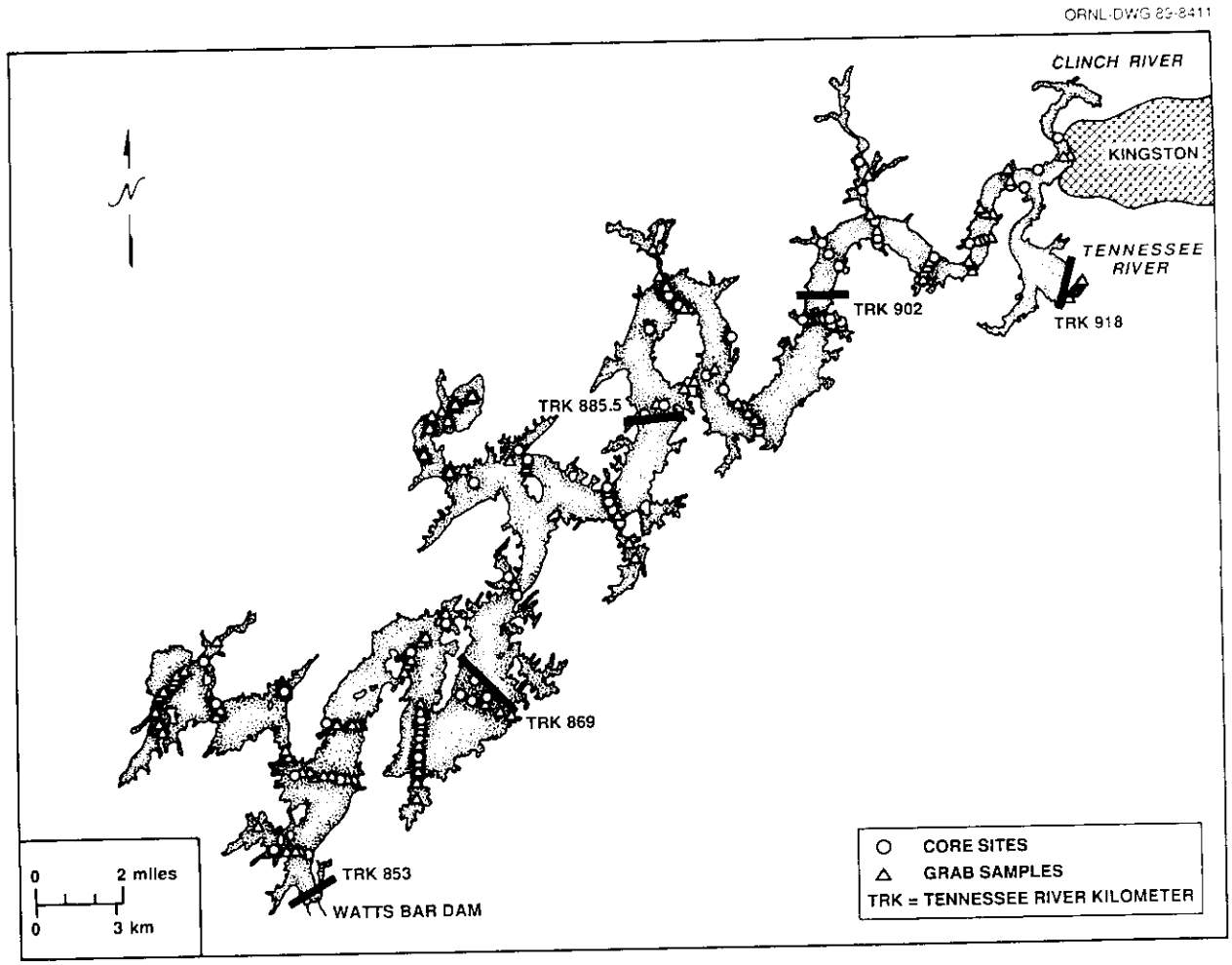

Fig. 6.5.1. Locations of ^{137}Cs sediment cores and grab sampling sites in the Clinch River and Watts Bar Reservoir.

uptake and exposure implications to aquatic organisms, which live in or feed on surface sedimentary material, as well as for humans, when lake levels are lowered.

The total accumulation of ^{137}Cs in Watts Bar Reservoir sediments was estimated by measuring the inventory of ^{137}Cs in each sediment core and in the surface grab samples and integrating these data over the entire reservoir [$\sim$115 km^2 ($\sim$45 $miles^2$)]. Initial results of this integration reveal that about 290 Ci of ^{137}Cs resides in the sediments of Watts Bar Reservoir, of which <5% is attributed to fallout from atmospheric nuclear weapons testing. Releases of ^{137}Cs from WOL (decay corrected to 1986) into the Clinch River have introduced an estimated $\sim$335 Ci. This indicates that about 85% of ^{137}Cs from WOL has been deposited within the sediments of Watts Bar Reservoir. These results demonstrate that the reservoir serves as an effective trap for the accumulation of particle-reactive substances originating from ORNL and that they are accumulating in the benthic environment.

This work represents the initial scoping phase for a Clinch River RCRA Facility Investigation (RFI) that will be conducted in compliance with Section 3004(v) of the Hazardous and Solid Waste Amendments of 1984 to the RCRA of 1976, which addresses requirements for corrective actions for releases of hazardous wastes or constituents beyond the boundaries of RCRA-permitted facilities. The three primary objectives of this RFI are to (1) define the nature and extent of off-site contamination; (2) quantify any risk to human health and to the environment resulting from the existing off-site contamination; and (3) evaluate potential remedial actions and to implement, if necessary, the most appropriate remediation alternatives.

7. QUALITY ASSURANCE AND GENERAL REVIEWS

An adequate quality assurance (QA) program for environmental monitoring requires the identification and quantification/control of all sources of error associated with each step in the monitoring program. 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.

Martin Marietta Energy Systems plants 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.

Documentation for standardized procedures (SOPs) for use and guidance at the Oak Ridge facilities have been under way for some time. In 1988, these procedures were compiled, reviewed internally, and submitted to Region IV EPA for review and comment. The document titled "Environmental Surveillance Procedures Quality Control Program" has since been revised to reflect Region IV's comments and has been approved by EPA 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 for the collection and analysis of environmental samples. The SOPs are reviewed and updated periodically, normally on an annual basis. The analytical laboratories use certified standards from the U.S. Environmental Protection Agency (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.

The analytical laboratories have QA and QC officers appointed to work with them to monitor the quality of analytical data. The QA/QC officers administer a program generating QC samples of known composition and submit these 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 occasionally 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 facilitate the programs for sampling technician and laboratory analyst training.

In addition to internal QC programs, analytical laboratories at Energy Systems installations participated in several external QA programs in 1988 (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 one sampling unit, and the size of the sampling unit depends upon the type of sampler used. A group of sampling units selected from the entire aggregate as representative of the whole population forms a sample or a set of samples. The units forming the sample are of equal size, are taken within a defined period of time, and are usually selected at random from the whole population of sampling units.

Variability among sampling units collected from a population is an expected result. Therefore, drawing conclusions from the results and extrapolating to the population is difficult. Statistical theories of estimation and of hypothesis testing provide a solution in the form of definite statements that have a known and controllable probability of being correct. Statistics can provide limits that are almost certain to enclose the true population value. The degree of certainty, as measured by the probability, can be selected by the sampler. These probabilities are called confidence probabilities, and the limits are called confidence limits.

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 then becomes 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.

To evaluate and validate sampling data, field quality control samples must be collected. 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. The area of evaluation and validation of sampling results is one in which additional improvement must be made. Although determining the uncertainties at each step of the monitoring process is difficult, particularly in the area of sampling, efforts must be made to meet this challenge.

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 total suspended particulates (TSP) and procedures for sampling of continuous uranium stack samplers and breakthrough monitors. Flowmeters are in a recall program for calibration certification by Maintenance. Meteorological tower sensors are calibrated quarterly by Maintenance. The total suspended particulate (TSP) samplers are calibrated quarterly by technicians from the Y-12 Plant Environmental Monitoring Group. Samplers for SO_2 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 adopted SOPs for collection of air samples from ambient air monitoring stations. Chain-of-custody procedures and sample tracking are used for all ambient air samples. The 15 ambient air monitoring stations, which are equipped with real-time monitoring capabilities, contain check sources that are used to verify that equipment is functioning properly. These check sources are called upon automatically at prespecified time intervals by the host computer. The values obtained are then compared with the expected range of values, and all discrepancies are noted and reported.

Station ingress/egress control

Ingress and egress to the monitoring stations (ambient air and water) are controlled by locks to the surrounding fences and dead-bolt locks on the station doors. Keys to the stations are administratively controlled and limited to persons requiring access for sampling, maintenance, or system repairs.

Each environmental monitoring station connected to the electronic data acquisition system has a logbook of entrances and departures. Persons who enter the stations are required to sign the entry log, state their purpose, and list the name of their organization. Upon departure, they are required to record the time.

Environmental monitoring forms

Two forms were developed to assist in the implementation of the environmental monitoring software (ambient air and water). These forms are "Unusual System Occurrence Notice" and "Desired System Change Notice."

The "Unusual System Occurrence Notice" is used by all users of the environmental monitoring system to report changes in the operating status of the system (data perturbations, persistent alarms, etc.). The "Desired System Change Notice" is used by individuals to express a desire for a new system feature or a change in the way a current feature functions.

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 ORGDP's 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, such as 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 routinely standardized daily and calibrated every two 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 manual is being developed by the Environmental Management Department for water monitoring activities at ORGDP. This manual cites procedures and activities that must exist within the plant laboratory, maintenance, and operation groups to ensure the overall quality of the program. This manual will be revised during 1989. Major changes to be made in the document are the separation of NPDES and perimeter surface water monitoring and separation of radiological and nonradiological monitoring descriptions. Chain-of-custody is used on all samples collected.

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. 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 Tennessee Department of Health and Environment (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

ORGDP laboratory staff provide all well sampling and analysis of groundwater samples at the Y-12 Plant and ORGDP. QA procedures are

the same as those described in Sect. 7.1.4.1 for the Y-12 Plant.

The 1987 audit by EPA (ES/ESH-4/V1, p. 241, Pt. 7.3.3.1) contained a recommendation to assign the actual NPDES sampling operation to laboratory personnel. Based upon this recommendation, a management decision was made to assign regulatory sampling to the Analytical Chemistry Department. All samples for which the data are reported to regulatory agencies or used to obtain environmental or waste disposal data are presently obtained by the Analytical Chemistry personnel. These personnel have formal technical backgrounds and have received training and instruction at specialized schools conducted in various locations within the United States to become qualified in sampling operations. This specialized sampling group's services have been utilized at various locations outside the Oak Ridge area.

In response to corrective actions from an EPA audit, special QA documents were issued: (1) K/QT-168 QA-QC Documentation for Groundwater Monitoring, (2) K/QT-167 Groundwater Sampling and Analysis Plan, K-25 Site, (3) K/QT-191 Quality Assurance for NPDES Monitoring, and (4) NPDES Sampling Procedures.

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, grass, and fish samples at all the Oak Ridge facilities. Milk samples are collected on a bi-weekly basis, and four or more fish and grass samples are collected at each location each sampling period in order 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 around the Plant. 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 in 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 Remedial Facilities Investigations 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 (1986b) 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 (1986b) 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 employ highly trained and well-qualified staffs who 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. Quality assurance and quality control 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.

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 implemented with standard materials from NIST or other reliable sources used 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 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 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. QC data are stored retrievably 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 allow 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 of these programs. 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 installation laboratories participated in several external radiological QC programs in 1988. 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 laboratory certification of radionuclide analysis. These samples consist mainly of water and air filters. Samples are received each month; however, the parameters to be measured each month are varied by requesting the same parameter from a maximum of two samples per year. Results are furnished to the state of Tennessee for evaluation relating to 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. Of the 48 measurements made by the Y-12 laboratory in this program, 41 were acceptable and 7 were unacceptable, based on EPA guidelines. Five of the

seven unacceptable results were from a single sample. Follow-up investigation revealed that an inappropriate background correction had been applied for that sample. The results were recalculated using the correct background factor. The corrected results were all within acceptable limits. Thirty-six of the 38 values for ORNL were acceptable. The two unacceptable results were for water analyses for ^{226}Ra, for which the mean score for all participating laboratories was lower than the ORNL score, and for ^{89}Sr. Five results for ORGDP were determined to be unacceptable.

DOE Environmental Measurements Laboratory (EML) Radionuclide Quality Assessment Program

The DOE-EML 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 1988 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 depends upon 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 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 May 1988 EML samples, the Y-12 laboratory made 30 measurements; 21 of these were acceptable and 9 were unacceptable. In November 1988, there were 29 measurements; 26 were acceptable and 3 were unacceptable. Except for one low uranium ORNL/EML ratio in February 1988 of 0.22 pCi/g, ORNL/EML ratios were all between 0.73 and 1.36 for 1988.

7.2.2.2 Nonradioactive Quality Control

DOE-ORO installation laboratories participated in several external nonradiological QC programs in 1988. Each installation has provided results from its participation in these programs.

Proficiency Environmental Testing (PET) Program

All Energy Systems analytical laboratories participate in the PET Program supplied by the Analytical Products Group, Inc., a commercial supplier in 1988. At the Oak Ridge laboratories and the DOE plant laboratories at Paducah, Kentucky, and at Piketon and Fernald, Ohio, samples at two concentration levels (a high and a low concentration denoted as level 1 and level 2) are analyzed monthly and reported to the supplier. About three weeks later, each of the six laboratories receives a report of the evaluated data. The report 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 for those parameters required on the laboratory's NPDES permit or for 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 that of other corporate laboratories. As part of the purchase contract, the data from the six laboratories within the DOE-ORO complex 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 use statistical evaluations to determine acceptability. 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 or levels are reported. In Y-12 laboratory testing, 479 of 493 level 1 results were acceptable, 10 were marginal, and 4 were unacceptable. Of 492 level 2

results, 469 were acceptable, 11 were marginal, and 12 were unacceptable. An investigation was performed on each marginal and unacceptable result.

Of the 410 level 1 results reported by ORNL, 403 were acceptable, 3 were marginal, and 4 were unacceptable. No parameter yielded more than one unacceptable result. Of the 452 level 2 results reported by ORNL, 449 were acceptable, 2 were marginal, and one was unacceptable.

Of the 516 level 1 results for ORGDP, 497 were acceptable, 12 were marginal, and 7 were unacceptable. Of the 516 level 2 results for ORGDP, 487 were acceptable, 15 were marginal, and 14 were unacceptable. Twelve of the unacceptable results were caused by an error in sample preparation for April.

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 through 7.2.23 of Vol. 2 show the results for each of the Oak Ridge installations. All results from the Y-12 Plant were acceptable. No results from ORNL were outside the acceptance limits. Total residual chlorine data from ORGDP were determined to be unacceptable. The follow-up investigation revealed that a delay in performing the analysis produced the unacceptable results. Investigations by the QA/QC coordinator and laboratory supervision are undertaken for 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 62 total measurements for certification purposes. Some of these represent two separate concentration levels for a given parameter. Of these, 56 were rated as acceptable and 6 as not acceptable. The laboratory performs a follow-up investigation on each unacceptable result. As a result of this evaluation, the calcium hardness and the toxaphene were downgraded to provisional certification. No parameters were decertified as a result of the unacceptable results. Investigations and corrective actions have been taken for the parameters shown to be unacceptable.

During 1988, the ORGDP laboratory received results from WS-021, which was submitted in 1987. In 1988, sets WS-022 and WS-023 were analyzed, but as of February 15, 1989, only data from WS-022 had been received. Data for the two evaluated sets are shown in Tables 7.2.24, 7.2.27, and 7.2.28 of Vol. 2. The final report showed two analytes as having provisional certification and no decertifications.

In 1988, ORNL participated in the multi-laboratory study for the analysis of water pollution samples that is administered by EPA's Environmental Monitoring Systems Laboratory in Las Vegas. ORNL analyzed two sets of samples, WP-020 and WP-021 (Tables 7.2.25 and 7.2.26 of Vol. 2), in 1988. All results on both sets of samples were acceptable, except for one fluoride analysis on the WP-020 set, which was unacceptably high.

Analytical environmental support programs

These programs were listed under "Quality assurance for military activities" in the 1987 report and involve both ORNL and ORGDP technical groups. ORNL provides program management to

the military for surveys and remedial actions at waste disposal sites. One phase of the program is the certification of private laboratories to perform environmental analyses under criteria similar to the Contract Laboratory Program (CLP) administered by the EPA under superfund activities. The environmental analyses are for engineering companies performing environmental assessment of military waste sites. The ORGDP laboratory has been assigned the program management for certification and monitoring of the private laboratories.

ORGDP laboratory activities in the support of ORNL were expanded in 1988, with an increase in technical personnel and the extent of the assigned tasks. The activities now include the review of sampling plans and proposed cleanup activities, scope of work, etc. This group has been requested to assist other DOE laboratories in meeting the CLP requirements. DOE laboratories will not be performing CLP work, but the CLP criteria form a working standard for all environmental laboratory analyses.

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.

ORNL and ORGDP laboratories participated in the DOE Headquarters, Washington, Environmental Site Survey Program in 1988. This national program involves extensive sampling and analysis of the environs of current and prior DOE installations and requires that analyses be in accordance with the EPA regulations for hazardous waste sites. The laboratories operated under the CLP protocols for the site survey samples.

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 7.2.29 through 7.2.32 of Vol. 2. At ORNL, the average score for the inorganic laboratories was 91.6% and the average score for the organic laboratories (three water and one soil sample) was 78.5%. At ORGDP, the average score for the inorganic laboratories was 84.8% and that for the organic laboratories was 89.8%. Scores are based on a maximum 100 point system. The average score for all CLP laboratories participating in the program in 1987 was 88.2% for the inorganics and 88.5% for the organics.

7.3 AUDITS, REVIEWS, AND ASSESSMENTS

7.3.1 Y-12 Plant

7.3.1.1 External regulatory

Several reviews by regulatory agencies were conducted at the Y-12 Plant during 1988 (see Table 7.3.1 of Vol. 2). TDHE conducted its annual NPDES Compliance Evaluation Inspection in June 1988. The review examined the wastewater treatment facilities, NPDES discharge points, sampling, and the plant's compliance with the NPDES permit. Overall, the TDHE's evaluation of activities at the Y-12 Plant was favorable, noting that general housekeeping has been improved throughout the plant. Concerns cited by the evaluation team included the need for eliminating or treating category IV discharges and verification of several outfalls along the creek. A report of TDHE's findings has not been received.

Other reviews conducted during 1988 included a TDHE and EPA joint inspection of RCRA facilities at the plant, as well as several other inspections by TDHE of facilities and erosion control activities at the Y-12 Plant. Deficiencies noted during the inspections included the need for improving inspection activities at several container storage areas, posting appropriate warning signs at container storage areas, adding spill control equipment and material, and improving erosion

control activities. All deficiencies have been corrected or resolved.

7.3.1.2 Department of Energy

Activities to address findings identified during the DOE Headquarters survey are continuing. The preliminary report of findings was received from DOE Headquarters in December 1987. An action plan was submitted in February 1988 to DOE-ORO in response to the findings noted in the preliminary report. In addition, a status report is issued to DOE each quarter updating the on-site activities related to the survey findings.

DOE-ORO conducted an Environmental Protection Appraisal February 29 through March 3, 1988. Recommendations were made by the appraisal team for various programs within the Y-12 Environmental Management Department, including identifying potential sources of contaminated storm water runoff that may be subject to permitting, developing or revising procedures for certain activities within the department, installing protective posts around groundwater wells, and providing documented recurrent training. Action plans have been developed to address the recommendations made by the appraisal team.

7.3.1.3 Internal

The Y-12 Plant laboratory has a program for internal audits of methods, programs, and procedures. Audits for 1988 were done in the following areas of the environmental and radiochemical laboratories: tritium, mercury, neptunium, uranium isotopes (radiochemical), sulfate, cyanide, uranium (mass spectrometric), laboratory logbooks, sulfide, sample workcards and records, Kjeldahl-ammonia nitrogen, and fluoride.

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 at the five sites in CY 1989.

7.3.2 Oak Ridge National Laboratory

In 1988, ORNL experienced over 40 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 audit of ORNL by an outside regulatory agency during 1988 was the NPDES Performance Inspection Audit by EPA and the associated NPDES Compliance Evaluation Inspection by TDHE. This audit looked at NPDES sampling procedures, analysis procedures, chain-of-custody and sample control, data management and data analysis procedures, reporting and recordkeeping procedures, and QA. The audit found a number of problems and inconsistencies. The problems generally involved the lack of complete documentation or failure to consistently follow required documentation procedures. A number of problems in the way samples were handled or analyzed in the laboratory were identified also. While none of the problems individually was major, together they resulted in the generation of some data that could be considered of questionable quality. Corrective actions, such as implementation of an NPDES Sampling and Analysis Quality Assurance Program, revisions of SOPs, and

additional training of personnel are under way to correct these deficiencies.

7.3.2.2 Department of Energy

Table 7.3.2 of Vol. 2 summarizes the major environmentally related audits and reviews of ORNL by the DOE-HQ and ORO offices. The two major DOE audits/reviews in 1988 were the DOE-HQ Environmental Survey, which occurred in August, and the ORO Office Environmental Protection Appraisal, which was performed in April. The Environmental Protection Appraisal identified a number of areas that, if addressed, would strengthen ORNL's environmental program. Corrective actions to eliminate deficiencies identified by this appraisal have been implemented or scheduled for implementation.

The DOE-HQ Environmental Survey was initiated in September 1985 by the Secretary of Energy, John S. Herrington. It was designed to systematically catalog and establish priorities relating to correcting environmental problems and areas of environmental risk at DOE facilities. Three features set the environmental survey apart from conventional environmental audits. First, the survey involves a "no-fault" review of site environmental conditions, not merely a "check-off" for regulatory compliance. Second, a sampling and analysis effort enables the survey teams to fill gaps in environmental monitoring data. Third, the survey, when completed, will include a department-wide prioritization of environmental problems and areas of environmental risk requiring corrective action. The NUS Corporation, under contract to DOE-HQ, provides technical environmental specialists to conduct the site surveys.

The site survey at ORNL was conducted from August 17 to September 4, 1987. While the survey team identified a number of known or potential environmental problems at ORNL, the survey's findings generally supported ORNL's knowledge concerning the status of environmental conditions at ORNL. The sampling phase of the environmental survey for ORNL was scheduled to occur in April 1988; however, based on the survey team's findings and recommendations, budget considerations, and site-sampling priorities, it was postponed until November 1988.

As a result of ORNL's involvement in the DOE Headquarters Environmental Survey Program as a sampling and analysis team, the EPA's EMSL-LV, with assistance from Lockheed Engineering and Management Services Company, Inc., and TechLaw, Inc., audited ORNL field sampling activities on three occasions and performed two audits and one surveillance on the ORNL laboratories in 1987. While few deficiencies were noted in the field sampling audits, the ORNL sampling team did gain a great deal of knowledge from the audit inspections. Several deficiencies were identified and corrected, and a number of improved operating methods, such as improved custody and documentation procedures and development of new and/or improved sampling techniques, were identified and instituted. The analytical laboratory audits conducted at ORNL involved the Organic, Inorganic, and Radiochemical sections.

7.3.2.3 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 approximately 30 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 Regulatory

Table 7.3.3 of Vol. 2 summarizes the major environmentally related audits and reviews of ORGDP. In March a survey of the Analytical Laboratory was conducted by the NUS Corporation for DOE in relation to the DOE Site Survey Program for the ORGDP area. No

deficiencies were found in the laboratory operation, and the only recommendation related to rapid disposal of chemicals with expired shelf life and of chemicals for which the laboratory has no immediate need.

In April, the Energy Systems Central Staff reviewed laboratory activities associated with the DOE Headquarters Environmental Site Survey Sampling and Analysis Activity. An action plan was developed to implement the recommendations.

In June, the EPA, Region 4, Athens, Georgia, conducted an audit to determine if deficiencies noted in the June 1987 findings of the NPDES sampling and analysis activities had been corrected. The major deficiencies had been corrected, and the rating of the plant was upgraded from a 2 to a 4 on a scale of 1 to 5.

In June, DOE contracted with C-E Environmental, Inc., of Camarillo, California, to perform an audit of the analytical data generated by the ORGDP laboratory for the site survey samples from the Mound Facility in Ohio. A closeout meeting was held, and a letter summarizing the findings as understood by the laboratory was forwarded by ORGDP. All of the deficiencies were known and had been addressed by the laboratory in prior correspondence with DOE. The deficiencies were the result of the samples being received and analyzed prior to receipt of the final set of DOE-approved manuals for the Site Survey Program.

In August, DOE-ORO contracted with PEER Consultants to perform an audit and survey of the ORGDP NPDES sampling activity. ORGDP was found to have both a specific QA plan and acceptable sampling procedures.

7.3.3.2 Department of Energy

An audit was conducted by EPA-LV and TechLaw because of ORGDP's involvement with the DOE-HQ environmental survey. The ORGDP laboratory staff serves as an analytical team for the survey.

Some deficiencies were noted that were related mainly to the recording and verification of data. For example, there were computer programs for calculations that had no record of verification; correct number of duplicates were analyzed, but there was no assurance that each batch processed contained duplicates; and there was a lack of equipment in the radiochemistry section to produce a copy of raw count data for historical files. Equipment for retaining raw data is a major expense item, and needed equipment has not been approved for purchase.

7.3.3.3 Internal

The ORGDP laboratory has a policy of taking notes during an audit and at the closeout meeting for the purpose of taking immediate corrective action on deficiencies, where possible. This also provides a basis for dealing with any misunderstandings between the laboratory and the auditors. The laboratory utilizes the services of analytical support program personnel to conduct audits on all phases of the sampling and analyses work.

Special emphasis was given during the year to the management activities related to sampling. All sampling for regulatory purposes was transfered by management from chemical operation personnel to laboratory personnel. Two preliminary audits were performed on the NPDES sampling activities prior to June 1988; a final audit was made on May 31, 1988, to ensure that the newly assigned tasks were being performed in accordance with EPA regulations. Appropriate corrective measures were taken.

Analytical support program personnel audited the entire ORGDP laboratory operation on June 1, 2, and 3, 1988. No serious problems were found, and most of the deficiencies related to the recording and retention of complete records relating to all phases of the analytical work.

An internal audit was performed on the organic preparation laboratory as a result of contaminants appearing in blanks. The problem was traced to multiple causes, including glassware washer problems, reagent water problems, and miscellaneous minor problems. Corrective actions were taken.

7.3.4 Ambient Environmental Monitoring Program Assessment—Oak Ridge, Paducah, and Portsmouth Reservations

During 1988, the ambient environmental monitoring programs at the five DOE installations operated by Martin Marietta Energy Systems, Inc., were reviewed for compliance and consistency with DOE and Energy Systems policies and strategies, DOE orders, environmental laws and regulations, and the current best monitoring practices (BMP). The review was performed for Energy Systems by CH2M Hill with H&R Technical Associates, Inc., as their subcontractor. The scope of the assessment included the ambient air, water, groundwater, biological, and radiological environmental monitoring performed near plant perimeter fences, in receiving streams, and at off-site locations. The assessment was conducted because the results of previous environmental appraisals at the five installations recognized a duplication of monitoring in some areas and the need for a reevaluation and perhaps additional monitoring in other areas. The objective of the assessment was to recommend improvements in the current ambient environmental monitoring programs while providing more sampling and monitoring consistency from installation to installation.

On December 15, 1988, CH2M Hill issued three assessment reports, one each for the Oak Ridge, Paducah, and Portsmouth Reservations. During 1989, implementation teams, with representatives from all five installations, will develop action plans to address each of the recommendations and to ensure that changes in the monitoring programs are consistent with the most current DOE orders. These teams will prioritize the changes and initiate the implementation of the recommendations.

Appendix A

GENERALIZED STRATIGRAPHIC DESCRIPTIONS OF GEOLOGIC FORMATIONS IN THE ORR

ROME FORMATION

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 Oak Ridge Reservation (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.

CONASAUGA GROUP

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 maroon-gray mudstone occurs toward the base of this formation and serves as a marker bed within the lower Conasauga Group throughout Bear Creek Valley (Law Engineering, 1975).

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; Haase, King and Baxter in prep).

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 (Haase, King, and Baxter, in prep).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 (Haase, King, and Baxter, in prep).

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.

KNOX GROUP

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.

CHICKAMAUGA GROUP

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 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.

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 Gauss)

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)	$v_x = \frac{s_x}{\bar{x}}(100)$

distribution, which is completely characterized by the mean and variance, is assumed. For some 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)	Probability of x having a value within this inverval (%)
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. 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.

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