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**Environmental  
Surveillance of the  
U.S. Department of Energy  
Oak Ridge Reservation  
and Surrounding  
Environs During 1987**

VOLUME 1: NARRATIVE, SUMMARY, AND CONCLUSIONS

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PREPARED BY  
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DEPARTMENT OF ENERGY

**ENVIRONMENTAL SURVEILLANCE OF THE  
U.S. DEPARTMENT OF ENERGY OAK RIDGE  
RESERVATION AND SURROUNDING ENVIRONS  
DURING 1987**

**Volume 1: NARRATIVE, SUMMARY, AND CONCLUSIONS**

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U.S. DEPARTMENT OF ENERGY  
Under Contract No. DE-AC05-84OR21400**



## EXECUTIVE SUMMARY

### OVERVIEW OF 1987 ENVIRONMENTAL SURVEILLANCE REPORT

This two-volume report, *Environmental Surveillance of the U.S. Department of Energy Oak Ridge Reservation and Surrounding Environs During 1987*, is the seventeenth 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 DOE production and research installations in Oak Ridge on the immediate area 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 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 activities in support of that national defense mission;
- **Oak Ridge National Laboratory (ORNL)**, a multipurpose center for research and development in the biomedical, environmental, and physical sciences, nuclear and engineering technologies, and advanced energy systems;
- **Oak Ridge Gaseous Diffusion Plant (ORGDP)**, where production operations in uranium enrichment are shut down, but active research, development, and supporting activities continue; and the
- **Oak Ridge community**, particularly sites on the floodplain of East Fork Poplar Creek and on private properties, where special sampling programs were begun in 1983 to assess contamination of soils and sediments by mercury, uranium, chromium, zinc, and various other inorganic and organic compounds.

Volume 1 presents narratives, summaries, and conclusions based on environmental monitoring at the three DOE installations and in the surrounding environs during calendar year 1987. 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 1987 data. Volume 2 presents the detailed data from which these conclusions have been drawn and should be used in conjunction with Volume 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 51 stations located within and on the perimeters of each installation, throughout the Oak Ridge Reservation, 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;
- 400 surface water sampling stations;
- Over 300 on-site groundwater monitoring wells;
- 91 on-site exhaust stack monitors for detecting uranium releases;
- 3 river and stream points where fish are sampled;
- 53 locations where vegetation and soil samples are taken;
- 8 stream sediment monitoring points;
- 9 milk sampling locations;
- 33 locations for measuring external radiation; and
- 500 Oak Ridge community soil, sediment, sludge, and shallow well samples.

### **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 monitoring and reporting systems that match and 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 Environmental Protection Agency (EPA), its Federal Radiation Council, 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 National Pollutant Discharge Elimination System (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 5480.xx.

### **Summary Conclusion**

Comprehensive environmental monitoring data for 1987 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. This progress can best be put into perspective by looking back several years. For instance, since 1984, construction has been completed on 8 new wastewater collection and treatment facilities, 15 solid waste treatment and storage facilities, numerous airborne effluent treatment and monitoring facilities, and hundreds of spill containment facilities. Also, considerable work has been initiated on the characterization of many old waste disposal sites, primarily through the installation of groundwater monitoring wells. The total cost of all these facilities, as well as for the day-to-day activities of staff environmental personnel, was about \$425 million from 1984 through 1987. Approximately \$130 million was spent in 1987, and a continuation of these efforts will require a 1988 expenditure of about \$140 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**

As in the past, the 1987 environmental surveillance report gives particular attention to several areas of continuing 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; monitoring for mercury and other contaminants in the Oak Ridge community; 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 calendar year 1987.

## SUMMARY OF 1987 ENVIRONMENTAL SURVEILLANCE DATA

### AIRBORNE DISCHARGES AND AIR AND METEOROLOGICAL MEASUREMENTS

#### Permitting Status

More than 300 air permits representing over 900 sources have been granted by the TDHE for the three Oak Ridge installations. All facilities were in compliance in 1987, and no notices of violation were received on air emission sources.

#### Radioactive Discharges to the Atmosphere

During 1987, 71,400 Ci of radionuclides were released to the atmosphere from Oak Ridge installations, in comparison with 92,600 Ci released in 1986 and 59,000 Ci released in 1985. This difference from year to year can be accounted for almost totally by tritium and by two inert gases, xenon and krypton. These two inert gases have little or no interaction with the terrestrial biosphere, including humans. Stack discharges of most isotopes were lower than last year, with the exception of tritium. These gases are emitted at ORNL.

Uranium is the primary radioactive element of concern at the Y-12 Plant. Uranium emissions were lower than in recent years at the Plant. This was partly because of improved uranium emissions monitoring in 1987; the installation of new exhaust gas filtration systems, especially in the depleted uranium areas of the plant; and the 18-week-long Atomic Trades and Labor Council (ATLC) strike. During 1987, 0.14 Ci of uranium was discharged from the Y-12 Plant in comparison with 0.19 Ci in 1986. After uranium isotope differences are considered, this correlates to 116 kg of uranium discharged in 1987 as compared with 211 kg in 1986. Figure 1 shows the total curie discharge of uranium emitted into the atmosphere from the Y-12 Plant from 1983 through 1987. Figure 2 shows the comparable total mass of uranium emitted from the Y-12 Plant for the same years.

Uranium discharges from ORGDP were confined to three sources in 1987. The total emissions were estimated at 0.4 kg and 1% assay  $^{235}\text{U}$ . These discharges, as well as meteorological data, are input into dose models to predict the effect of the radiation on the maximally exposed individual and on the population within 80 km (50 miles) of the DOE Oak Ridge facilities. The doses to a maximally exposed off-site individual from airborne effluents are greatest from the Y-12 Plant—0.0021 mrem to whole body, 2.1 mrem effective, and 17 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 doses are 0.41 mrem to whole body, 2.1 mrem effective, and 17 mrem to lung, well within the federal standards. The estimated collective committed effective dose to the approximately 870,000 persons living within 80 km (50 miles) of the ORR is 55 person-rem for 1987 emissions. This represents about 0.02% of the  $2.59 \times 10^5$  person-rem that the surrounding population would receive from all sources of background radiation.

ORNL-DMG 842-782

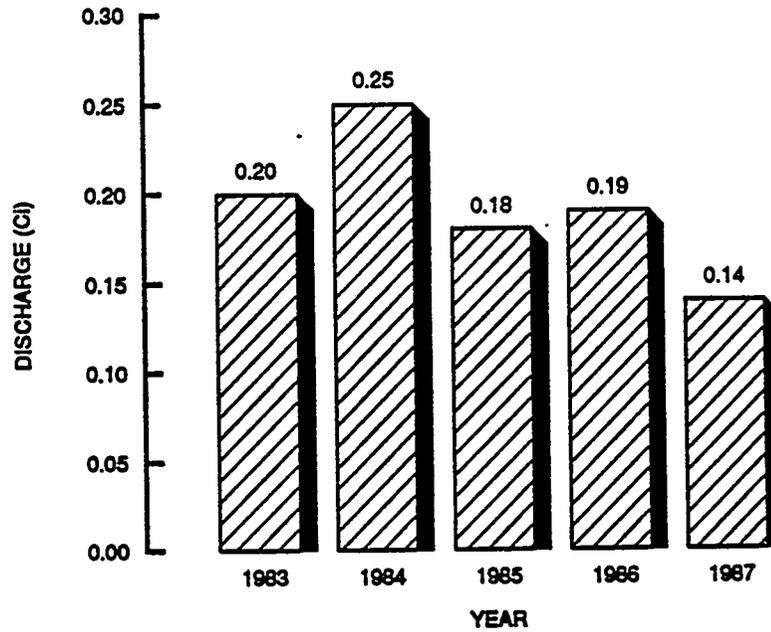


Fig. 1. Total curie discharges of uranium from the Y-12 Plant to the atmosphere (1983-1987).

ORNL-DMG 842-782

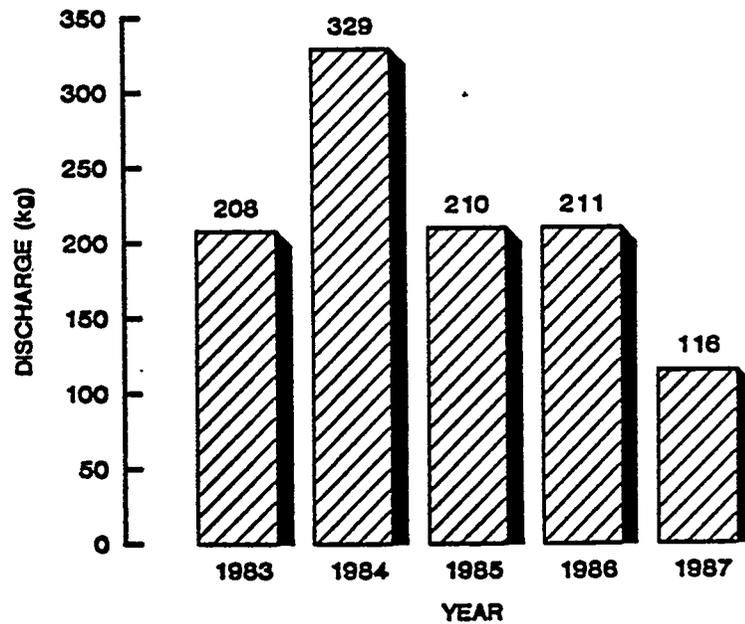


Fig. 2. Total kilograms of uranium discharged from the Y-12 Plant to the atmosphere (1983-1987).

### Radionuclide Concentrations in Air

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

Doses to the public were estimated using estimates of releases from the three installations, collected meteorological data, and calculations using EPA-approved computer models. These calculations show that DOE facilities are in compliance with EPA NESHAP standards for radiation doses to the public.

A number of the ORNL air monitoring stations were upgraded during 1987. Sampling capabilities were added to two stations near the ORNL perimeter. The remote air station samplers were replaced with new equipment that gives higher counting efficiencies. The maximum concentrations for the 12 isotopes and total radioactive strontium on the air filters did not exceed 5% of the standard specified by DOE orders.

### Chemical Discharges to the Atmosphere

In 1987, it is estimated that 7 million kg of gaseous chemicals (mostly nontoxic) were released to the atmosphere from all three installations. This estimate is based primarily on a listing of gases procured. The estimate includes steam plant discharges, which are based on permit information.

Hydrogen fluoride emissions are controlled to ensure compliance with ambient air standards. Y-12 Plant emissions of hydrogen fluoride to the atmosphere in 1987 were significantly lower than in previous years. This is illustrated in Fig. 3. These reductions were a result of both administrative controls implemented to minimize emissions and the 18-week-long ATLC strike, which impacted production and reduced hydrogen fluoride usage in some areas of the plant. Two new hydrogen fluoride scrubber systems are being installed to aid in continued reduction of emissions.

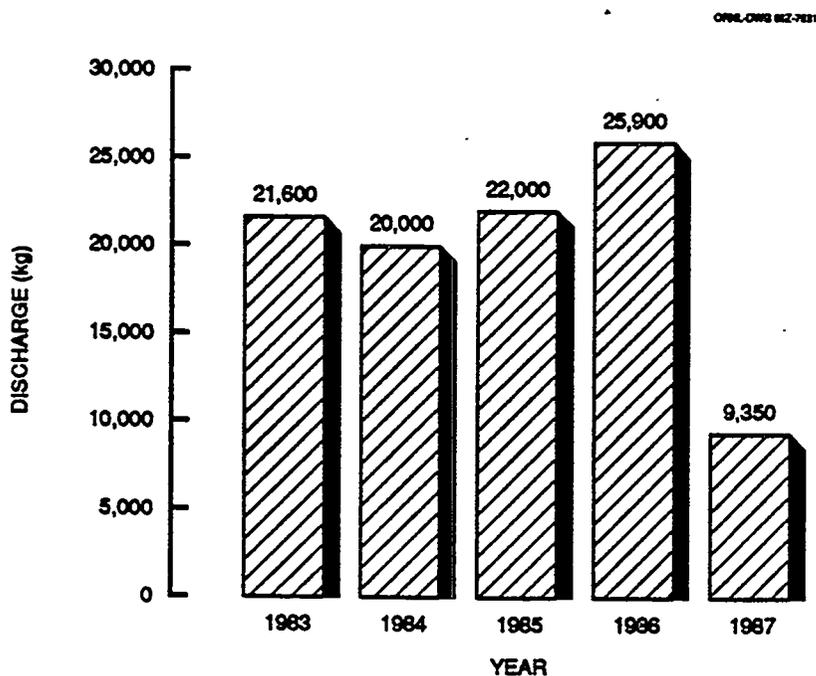


Fig. 3. Total kilograms of hydrogen fluoride discharged from the Y-12 Plant to the atmosphere (1983-1987).

### **Ambient Fluoride Monitoring**

Ambient fluoride sampling was not conducted at ORGDP in 1987 because the fluoride emission sources were shut down. Of the approximately 580 ambient air fluoride measurements taken at the Y-12 Plant, none exceeded the 7-day ( $1.6 \text{ mg/m}^3$ ) or 30-day ( $1.2 \text{ mg/m}^3$ ) Tennessee Air Pollution Control Standard.

### **Suspended Particulate Monitoring**

Of the 295 suspended particulate measurements taken at ORGDP, all were within primary and secondary Tennessee air pollution control standards. Particulate concentrations reached only 26% of the amount allowed by the primary standard and 45% of emissions allowed by the secondary standard.

At the Y-12 Plant, measured total suspended particulate (TSP) concentrations exceeded state standards four times during 1987. Additional laboratory analysis determined that road dust and pollen in the air, not the Y-12 processes, were the sources of particulates on all four occasions. The average concentration of the 118 TSP samples obtained at the Y-12 Plant was  $57 \text{ } \mu\text{g/m}^3$ , which is 22% of the Tennessee air quality 24-h standard of  $260 \text{ } \mu\text{g/m}^3$ .

### **Sulfur Dioxide Measurements**

Of the approximately 17,000 samples taken at the Y-12 Plant in 1987, all were within both 24-h and 3-h standards. The highest level of the 24-h measurements was 36% of the Tennessee air quality standard. The highest level of the 3-h measurements was 30% of the Tennessee air quality standard.

## **WATERBORNE DISCHARGES AND SURFACE WATER MONITORING**

Each of the Oak Ridge installations has a National Pollutant Discharge Elimination System (NPDES) permit. More than 380 NPDES stations were sampled, requiring more than 60,000 water analyses. During 1987, the Y-12 Plant, with 105 noncompliances, was 99.0% in compliance with NPDES standards; ORNL had 447 noncompliances and was 96.5% in compliance; with 40 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, Bear Creek, and Poplar Creek, all of which could be affected by operations at the DOE installations during 1987. Progress was made on several projects to minimize the release of pollutants to surface waters. At the Y-12 Plant, these facilities were the Central Pollution Control Facility Phase II (CPCF-II), West End Treatment Facility (WETF), Steam Plant Wastewater Treatment Facility (SPWTF), and the Plating Rinsewater Treatment Facility (PRWTF). The Central Neutralization Facility (CNF) was constructed at ORGDP.

With the completion of CPCF-II in late 1987, all nitrate-contaminated wastewaters produced at the Y-12 Plant are treated on-site and no longer transported to ORGDP for partial treatment and then back to the Y-12 Plant for final treatment. With the completion of the PRWTF in 1987, an estimated 8 million gal of untreated plating rinsewaters per year have been eliminated from East Fork Poplar Creek. During 1987, the construction at the SPWTF was on schedule, and in early 1988 approximately 47 million gal per year of untreated acid and caustic discharges from the Y-12 Plant coal yard and steam plant operations will be eliminated from East Fork Poplar Creek. The CNF at ORGDP will provide pH adjustment and chemical precipitation for several aqueous streams throughout the plant site.

### Radionuclide Discharges to Surface Streams

Discharges of most radionuclides into surface waters were similar to those of past years, with the exception of  $^{137}\text{Cs}$  and  $^{60}\text{Co}$ . Significant reductions noted at ORNL during 1987 are attributed to reductions in radionuclides discharged from the surface impoundments.

Maximum concentrations of radionuclides in surface waters and point source outfalls were below the standards specified in DOE orders, except for tritium at Melton Branch 1 station. Most of the tritium at station 1 is believed to come from solid waste storage area (SWSA) 5, particularly during rain events. Characterization of SWSA 5, especially the tritium releases, is one of the highest priorities of the Remedial Investigation/Feasibility Study subcontract that began in August 1987. This effort will determine measures to most effectively reduce the release of tritium and/or other contaminants from SWSA 5. The most significant contributor to surface water for 1987 was tritium (2500 Ci, as compared with 2600 Ci in 1986). In 1985, 3700 Ci of tritium was released. Decreased rainfall in the area has resulted in fewer releases of tritium from SWSA 5.

### GROUNDWATER

In all, 337 groundwater wells were installed in 1987 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. More than 1000 wells exist on the ORR, and more than 300 of these wells were sampled during 1987. The well sampling program required more than 150,000 laboratory analyses.

Groundwater detection and assessment monitoring is under way at RCRA sites, and problem areas are being identified. The groundwater monitoring program for solid waste management units (SWMUs) is in the early stages of design and installation.

At several Y-12 Plant RCRA sites, levels of volatile organics, nitrates, heavy metals, and radionuclides above applicable standards have been detected. For instance, at the S-3 Pond site, a plume containing heavy metals, nitrates, and radionuclides extends east and west of the site in the Bear Creek and East Fork Poplar Creek watersheds. The Y-12 Plant has initiated closure activities at this site under a TDHE-approved closure plan. In addition, when statistical analysis has indicated potential contamination, RCRA groundwater quality assessment plans have been prepared and submitted to the state. The assessment monitoring will continue on a quarterly basis until a postclosure permit is obtained for the facility.

At ORNL, groundwater sampling was conducted during 1987. Twenty-two wells were installed during 1985 around four surface impoundments as RCRA compliance wells. Based on analytical sludge data and other information submitted to TDHE, it has now been determined that these surface impoundments do not contain RCRA-hazardous waste and should never have been considered as hazardous waste impoundments.

During 1987, 185 groundwater wells were installed at ORNL and 250 additional RCRA water quality monitoring wells are planned by the Remedial Action Program to comply with RCRA 3004(u) requirements.

The ORGDP Groundwater Protection Program currently encompasses 35 sites. Twenty-three of the sites are being characterized, and a monitoring well network is being designed to monitor the groundwater chemistry of each site. Ten sites have a groundwater monitoring network in place and are in the first year of detection monitoring. Two of the sites are in the assessment phase to determine the rate and extent of possible contamination.

## OTHER MONITORING

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

Fish sampling results in 1987 are comparable to those of 1986. Samples were collected for the purpose of measuring concentrations of mercury, polychlorinated biphenyls (PCBs),  $^{60}\text{Co}$ ,  $^{137}\text{Cs}$ , and total radioactive strontium from bluegill in the Clinch River. For the 36 fish analyzed, the average mercury concentration was 9.4% of the U.S. Food and Drug Administration (FDA) guideline. For the PCBs, the percentage of the guideline was 3.5%. There are no guidelines 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 an annual population dose of about 4.8 person-rem from drinking water and eating fish. This represents about 0.2% of the annual dose from background radiation (2250 person-rem) estimated for this population.

Milk samples were collected from eight locations in the 80-km area around the ORR for  $^{131}\text{I}$  and total radioactive strontium. All the results were less than 4% of the applicable Range I Federal Radiation Council Guidelines.

During the 1987 deer hunts, 530 deer were harvested on the ORR in October, November, and December. Each hunter's deer was analyzed for a select group of radionuclides. Thirty deer had levels of 30 pCi/g or greater of  $^{90}\text{Sr}$  in bone, which is the confiscation level. These deer were retained and buried on-site at ORNL. The highest  $^{90}\text{Sr}$  concentration in retained deer was 520 pCi/g. Plans are under way to install fencing around the main source of the  $^{90}\text{Sr}$  near a retired waste disposal area. For several years, deer-vehicle collisions on the ORR have resulted in personal property losses and potential for human injury. An important effect of the hunts was a reduction in the number of these collisions from 272 in 1985 to 220 in 1986. In 1987 226 deer-vehicle collisions occurred.

Grass samples were collected at 36 locations, both on the ORR and off-site. Analyses are conducted for  $^{90}\text{Sr}$ ,  $^{239}\text{Pu}$ ,  $^{238}\text{Pu}$ ,  $^{234}\text{U}$ ,  $^{235}\text{U}$ ,  $^{238}\text{U}$ , total uranium,  $^{99}\text{Tc}$ , and fluoride. In addition, pine needles, which are sensitive to fluoride, were collected from six locations around ORGDP and analyzed for uranium and  $^{99}\text{Tc}$  concentrations. Slight elevations in  $^{99}\text{Tc}$  and total uranium were observed on-site. These elevated concentrations may have resulted from airborne releases from either the Y-12 Plant or past ORGDP plant operations.

### Soil Sampling

Soil sampling data show the same results as data for vegetation samples. Sampling locations for soils are in close proximity to those for vegetation. At ORGDP, the levels of uranium in the soil have stabilized at 2 to 4  $\mu\text{g/g}$  dry wt since the uranium enrichment process was shut down in 1985. At other locations on the reservation, concentrations in both soil and vegetation were variable, and correlations between releases and concentrations in soil and vegetation were not determined.

### Sediment Sampling

Sediment samples were collected twice during 1987 from each of eight locations in Poplar Creek, East Fork Poplar Creek, and the Clinch River. Samples were analyzed for mercury, nickel, lead, chromium, aluminum, uranium, cadmium, copper manganese, thorium, and zinc.

Concentrations in sediments varied widely according to time and place. Generally, concentrations of chromium, copper, lead, mercury, nickel, zinc, and uranium in 1987 were lower than concentrations in 1986.

## **RADIATION DOSE TO THE PUBLIC**

### **Collective Committed Effective Dose Equivalent to the Population Within 80 km of Oak Ridge Installations**

The total exposure (50-year collective committed effective dose equivalent) of the entire population within 80 km of the three installations is given in Fig. 4. For the entire Oak Ridge Reservation, 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 due to ORR operations during 1987 is estimated to be 55 person-rem. This collective dose could produce a fatal cancer risk of  $\sim 0.007$ /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 chance of one cancer developing in the population of approximately 850,000 living within 80 km of the reservation is less than 1 out of 100. The dose equivalent from natural radiation for this same population is also shown in Fig. 4. The whole-body, effective, and target organ doses from various pathways are shown in Figs. 5-7. It should be noted that the 50-year collective committed effective dose equivalent was incorrectly reported in the 1986 report. The ORR total dose commitment was reported as 45 person-rem. The correct value is 58 person-rem. In 1986, 0.13 Ci of enriched uranium and 0.06 Ci of depleted uranium were released from the Y-12 Plant. The 0.06 Ci of depleted uranium was not included in the airborne dose calculations. The Y-12 Plant value was reported in 1986 as 28 person-rem rather than the actual 41 person-rem.

## **CHEMICAL DOSE TO THE PUBLIC**

Where applicable surface water data were available at plant outfalls and in receiving streams, the calculated daily intake was compared with EPA standards for acceptable daily intake.

Surface water was analyzed for 18 water parameters (heavy metals and organics). The EPA standards for acceptable daily intake were exceeded at one or more outfalls for the following parameters: arsenic, chromium, lead, methylene chloride, nickel, tetrachloroethylene, trichloroethylene, and zinc.

One of the normal assumptions used for these types of calculations is the consumption of 2 L/d of raw water taken from the stream (which is unlikely). The EPA standards for acceptable daily intake were not exceeded in off-site streams.

## **REMEDIAL ACTION PROGRAM**

Past ORR practices in the storage, treatment, and disposal of hazardous materials and wastes have resulted in the release of hazardous wastes to the environment. A remedial action program has been established at all three plants to identify and assess hazardous waste sites that may contaminate the environment and to develop and implement remedial actions to control and minimize the release of these contaminants from the sites. To date, 320 sites have been identified as requiring investigation: 62 at the Y-12 Plant, 164 at ORNL, and 94 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.

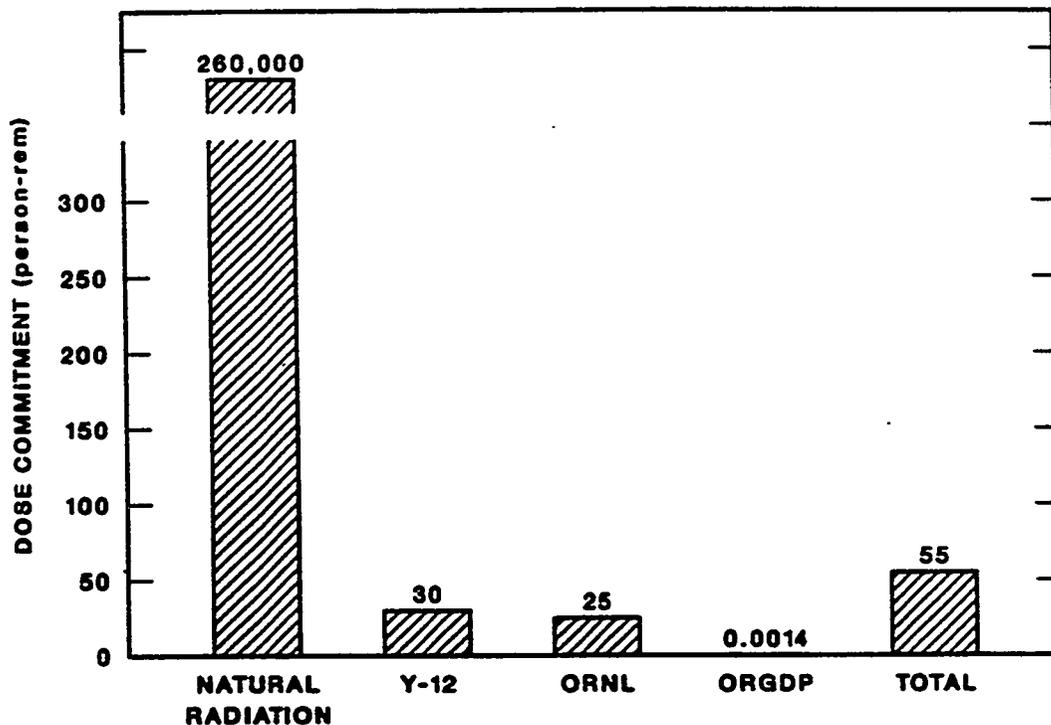


Fig. 4. The 50-year collective committed effective dose equivalent of the entire population within 80 km of the three installations.

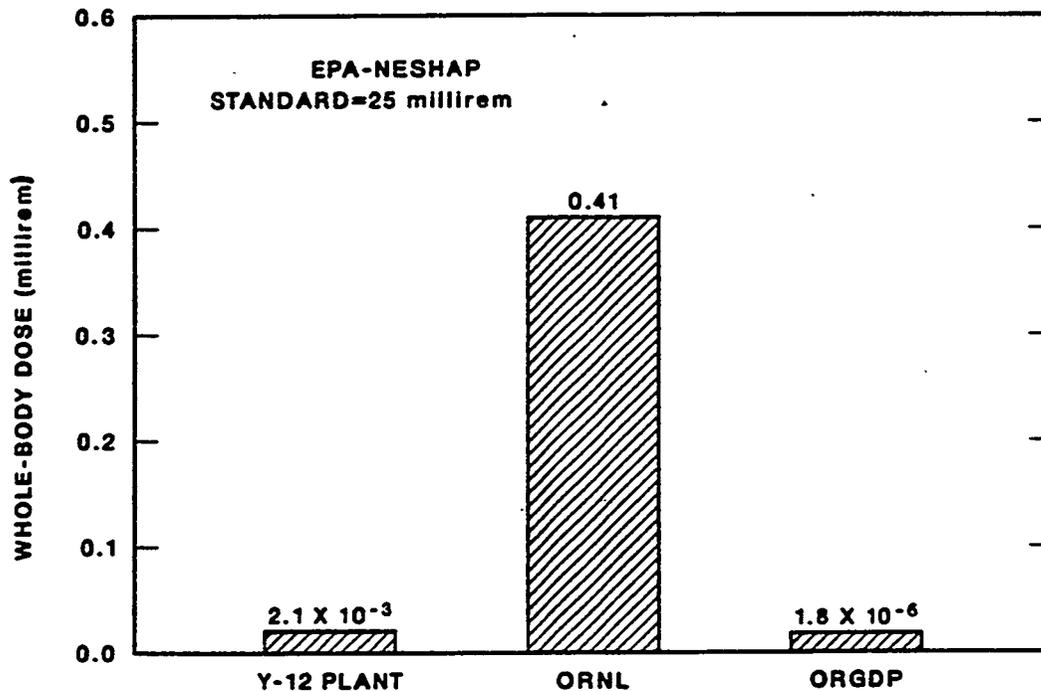


Fig. 5. The 50-year committed whole-body dose equivalent from inhalation pathway from ORR discharges during 1987.

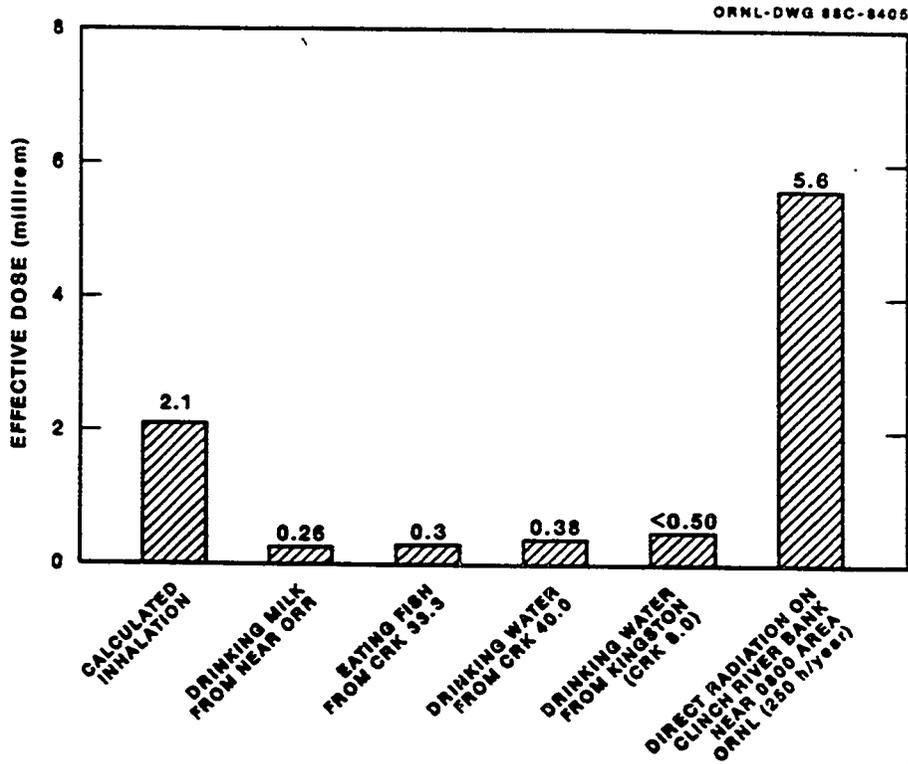


Fig. 6. The 50-year committed effective dose equivalent from various pathways from ORR discharges during 1987.

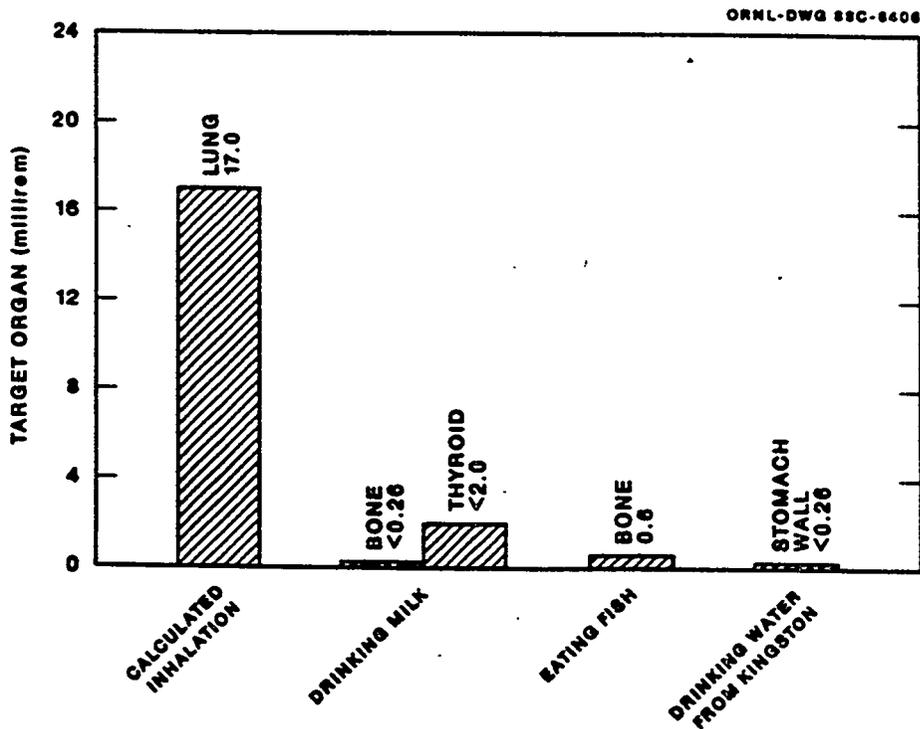


Fig. 7. The 50-year committed dose equivalents to selected organs from various pathways from ORR discharges during 1987.

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. 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. Assessments are currently focusing on the concepts of in situ waste stabilization, on-site waste treatment and disposal, and decontamination of facilities for reuse where practicable.

## **AUDITS AND REVIEWS**

The three major Oak Ridge installations experienced over 50 audits or inspections and reviews during 1987 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-ORO office; and internal audits by Martin Marietta Energy Systems. The major audits and reviews are listed below.

- NPDES performance audit inspection by EPA and associated NPDES compliance evaluation inspection by TDHE—conducted at ORNL and ORGDP (June 23–25).
- NPDES compliance evaluation inspection conducted by TDHE at the Y-12 Plant (June 3–5).
- RCRA interim status facility inspection by TDHE at the Y-12 Plant (July 13–16).
- RCRA generator inspection by TDHE at the Y-12 Plant (December 17–22).
- DOE-HQ site survey at the Y-12 Plant. Argonne National Laboratory sampled 16 areas of interest (June 1987).
- DOE-HQ site survey at ORNL (August 17–September 4).
- Martin Marietta Corporate technical operations audit of management systems, including environmental areas. (July 14–16).
- Environmental protection appraisal at ORNL by DOE-ORO (April 6–16).
- Environmental management appraisal at ORGDP by DOE-ORO (August).

## **ADDITIONAL ITEMS OF INTEREST**

### **Asbestos Notification Deficiency**

During 1987, DOE-ORO Environmental Protection Division conducted a thorough review of their records pertaining to asbestos removal notification. In the course of this review, they discovered six removals (one at ORNL, four at the Y-12 Plant, and one at ORGDP) that DOE had not properly forwarded to the Tennessee Department of Air Pollution Control (TDAPC). Upon notifying TDAPC of this reporting deficiency, DOE was issued a notice of violation and requested to attend a "show cause" meeting in Nashville on December 2, 1987, to discuss the circumstances regarding these removals. After reviewing the information presented, TDAPC advised DOE of their intent to seek a nominal civil penalty for violation of the notification requirements. Final resolution of this issue is still pending.

**Y-12 Plant Stack Radiological Monitoring Project**

The Y-12 Plant completed a \$9.5 million Stack Radiological Monitoring Project in 1987. This project installed new uranium stack monitors and samplers on 85 major process exhaust stacks. Included in this project were 27 real-time stack radiological monitors with alarms designed to alert operations personnel of uranium releases. The systems began operation in March 1987, and operating experience has been excellent.

**Installation of High-Efficiency Filters at the Y-12 Plant**

New high-efficiency filters have been installed on several major process systems for uranium emissions control at the Y-12 Plant. To date, this project has resulted in a reduction of over 90% in the total mass of uranium emitted due to production operations. Further improvements in emission controls are planned.

**Completion of Phase I of Y-12 Plant Area Source Pollution and Assessment Control Program**

A comprehensive sampling program plan has been written to complete Phase I of the Y-12 Plant Area Source Pollution and Assessment Control Program. The plan outlines a program to characterize non-point discharges to upper East Fork of Poplar Creek. Sampling will be conducted during 1988. The data will be used to design pollution control facilities and implement administrative controls.

**RCRA Closures at the Y-12 Plant**

- The following RCRA closures have been completed, certified closed, and accepted by TDHE:
- partial closure of the oil/solvent drum storage area of the salvage yard,
  - Old Steam Plant hazardous waste storage area,
  - Acetonitrile (ACN) Drum Yard, and
  - Precco Incinerator.

Final closure of the waste machine coolant biodegradation facility is in progress. Steps to certify the partial closure of Interim Drum Yard are under way.

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## LIST OF ACRONYMS

ADI	acceptable daily intake
AEA	Atomic Energy Act
ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
ATLC	Atomic Trades and Labor Council
AVLIS	atomic vapor laser isotopic separation
BAT	best available technology
BCBG	Bear Creek Burial Grounds
BMAP	Biological Monitoring and Abatement Program
BMP	best management practices
BOD	biological oxygen demand
BSR	Bulk Shielding Reactor
BWWTF	Biology Wastewater Treatment Facility
CAA	Clean Air Act
CDI	calculated daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CNF	Central Neutralization Facility
COD	chemical oxygen demand
CPCF	Central Pollution Control Facility
CRK	Clinch River kilometer
CRSDB	Chestnut Ridge sediment disposal basin
CWA	Clean Water Act
DARA	disposal area remedial action
DCF	dose conversion factor

DCG	derived concentration guide
DMR	Discharge Monitoring Report
DOE	Department of Energy
DP/E	dye penetrant/emulsifier
DTF	decant treatment facility
EFPC	East Fork Poplar Creek
EIS	Environmental Information System
EMC	Environmental Monitoring and Compliance Department
EML	Environmental Measurements Laboratory
EMSL-LV	Environmental Monitoring System Laboratory at Las Vegas
EPA	Environmental Protection Agency
ERBC	environmental restoration budget category
ESD	Environmental Sciences Division
FDA	Food and Drug Administration
FWPCA	Federal Water Pollution Control Act
GC/MS	gas chromatography/mass spectroscopy
GWQAP	groundwater quality assessment plans
GWQAR	groundwater quality assessment reports
HEPA	high-efficiency particulate air (filters)
HFIR	High Flux Isotope Reactor
HQ	Headquarters
HSEA	Health, Safety, Environment, and Accountability
HWDU	hazardous waste disposal unit
HWSA	Hazardous and Solid Waste Amendments
LCC	life-cycle cost
LCR	lowest concentration reported
LLW	low-level radioactive waste
LLWDDD	low-level waste disposal, demonstration, and development project
LOEC	lowest observed effect concentration
LTF	Liquid Treatment Facility
MSRE	Molten-Salt Reactor Experiment Facility
NAAQS	National Ambient Air Quality Standards

<b>NBS</b>	<b>National Bureau of Standards</b>
<b>NESHAP</b>	<b>National Emissions Standards for Hazardous Air Pollutants</b>
<b>NIOSH</b>	<b>National Institute for Occupational Safety and Health</b>
<b>NOEC</b>	<b>no observed effect coefficient</b>
<b>NPDES</b>	<b>National Pollutant Discharge Elimination System</b>
<b>NRWTF</b>	<b>nonradiological waste treatment plant</b>
<b>ORAU</b>	<b>Oak Ridge Associated Universities</b>
<b>ORGDP</b>	<b>Oak Ridge Gaseous Diffusion Plant</b>
<b>ORNL</b>	<b>Oak Ridge National Laboratory</b>
<b>ORO</b>	<b>Oak Ridge Operations</b>
<b>ORR</b>	<b>Oak Ridge Reservation</b>
<b>ORRI</b>	<b>Oak Ridge Research Institute</b>
<b>PCB</b>	<b>polychlorinated biphenyl</b>
<b>PET</b>	<b>Proficiency Environmental Testing Program</b>
<b>PRWTF</b>	<b>Plating Rinsewater Treatment Facility</b>
<b>PWTF</b>	<b>Process Waste Treatment Plant</b>
<b>QA</b>	<b>quality assurance</b>
<b>QC</b>	<b>quality control</b>
<b>R&amp;D</b>	<b>research and development</b>
<b>RAM</b>	<b>reliability, availability, and maintainability</b>
<b>RAP</b>	<b>remedial action program</b>
<b>RCRA</b>	<b>Resource Conservation and Recovery Act</b>
<b>RCW</b>	<b>recirculating cooling water</b>
<b>RFA</b>	<b>RCRA Facility Assessment</b>
<b>RFI</b>	<b>RCRA Facility Investigation</b>
<b>RI/FS</b>	<b>remedial investigation/feasibility study</b>
<b>S&amp;A</b>	<b>sampling and analysis</b>
<b>SARA</b>	<b>Superfund Amendments and Reauthorization Act</b>
<b>SDWA</b>	<b>Safe Drinking Water Act</b>
<b>SFF</b>	<b>sludge fixation facility</b>
<b>SOP</b>	<b>standard operating procedures</b>
<b>SPWTF</b>	<b>Steam Plant Wastewater Treatment Facility</b>

SRMP	stack radiological monitoring project
STP	sewage treatment plant
SWDA	Solid Waste Disposal Act
SWMU	solid waste management units
SWSA	solid waste storage area
TCMP	Toxicity Control and Monitoring Program
TDAPC	Tennessee Department of Air Pollution Control
TDHE	Tennessee Department of Health and Environment
THWMR	Tennessee Hazardous Waste Management Regulations
TLD	thermoluminescent dosimeter
TOC	total organic carbon
TOX	total organic halides
TRK	Tennessee River kilometer
TRU	Transuranium Processing Plant
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal
TSP	total suspended particulates
TSS	total suspended solids
TSWMA	Tennessee Solid Waste Management Act
TURF	Thorium-Uranium Recycle Facility
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Association
UNC	United Nuclear Corporation
USGS	U.S. Geological Survey
VOC	volatile organic compound
WAG	waste area groupings
WCPF	Waste Coolant Processing Facility
WETF	West End Treatment Facility
WMCBF	Waste Machine Coolant Biodegradation Facility
WOC	White Oak Creek
WOCC	Waste Operations Control Center
WOD	White Oak Dam
WTSD	Waste, Transportation, Storage, and Disposal Department

CONVERSION TABLE					
Multiply	By	To obtain	Multiply	By	To obtain
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft
mile	1.61	km	km	0.621	mile
lb	0.4536	kg	kg	2.205	lb
liq qt-U.S.	0.946	L	L	1.057	liq qt-U.S.
ft <sup>2</sup>	0.093	m <sup>2</sup>	m <sup>2</sup>	10.764	ft <sup>2</sup>
mile <sup>2</sup>	2.59	km <sup>2</sup>	km <sup>2</sup>	0.386	mile <sup>2</sup>
ft <sup>3</sup>	0.028	m <sup>3</sup>	m <sup>3</sup>	35.31	ft <sup>3</sup>
Bq	27	pCi	pCi	0.037	Bq
nCi	$1 \times 10^3$	pCi	pCi	$1 \times 10^{-3}$	nCi
dpm/L	$0.45 \times 10^{-9}$	$\mu\text{Ci}/\text{cm}^3$	$\mu\text{Ci}/\text{cm}^3$	$2.22 \times 10^9$	dpm/L
pCi/L (water)	$10^{-9}$	$\mu\text{Ci}/\text{mL}$ (water)	$\mu\text{Ci}/\text{mL}$ (water)	$10^9$	pCi/L (water)
pCi/m <sup>3</sup> (air)	$10^{-12}$	$\mu\text{Ci}/\text{cm}^3$ (air)	$\mu\text{Ci}/\text{cm}^3$	$10^{12}$	pCi/m <sup>3</sup> (air)
mCi/km <sup>2</sup>	1	nCi/m <sup>2</sup>	nCi/m <sup>2</sup>	1	mCi/km <sup>2</sup>
sievert (Sv)	100	rem	rem	0.01	sievert (Sv)

# 1. INTRODUCTION AND GENERAL INFORMATION

The first two volumes of this report are devoted to a presentation of environmental data and supporting narratives for the U.S.

Department of Energy's (DOE's) Oak Ridge Reservation (ORR) and surrounding environs during 1987. Volume 1 includes all narrative descriptions, summaries, and conclusions and is intended to be a "stand-alone" report for the ORR for the reader who does not want to review in detail all of the 1987 data. Volume 2 includes the detailed data summarized in a format to ensure that all environmental data are represented in the tables. Narratives are not included in Vol. 2. The tables in Vol. 2 are addressed in Vol. 1. For this reason, Vol. 2 cannot be considered a stand-alone report but is intended to be used in conjunction with Vol. 1. This report is published annually to comply with DOE Order 5484.1.

The ORR is located within the corporate limits of the City of Oak Ridge in eastern Tennessee. The ORR consists of about 35,250 ha (14,260 acres) of federally owned lands. Routine monitoring and sampling for radiation, radioactive materials, and chemical substances on and off the ORR are used to document compliance with appropriate standards, identify trends, provide information for the public, and contribute to general environmental knowledge. The surveillance program assists in fulfilling the DOE policy of protecting the public, employees, and the environment from harm that could be caused by its activities and of reducing negative environmental impacts to the greatest degree practicable, as noted in DOE Orders 5480.1 and 5400.1. These orders include the requirement for compliance with both federal and state regulations.

## 1.1 OPERATIONS ON THE OAK RIDGE RESERVATION

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 northwest; 113 km 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, Freels' Cabin, 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), the American Museum of Science and Energy, the prime contractor's administrative support office buildings, and the former museum building. The administrative units 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

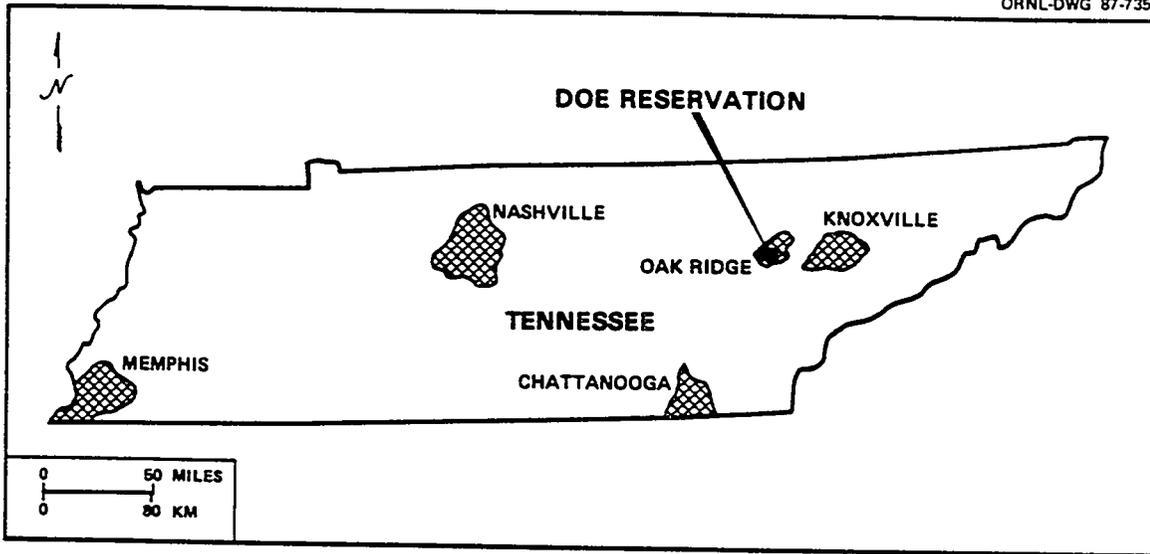


Fig. 1.1.1. Map showing the location of the Department of Energy's Oak Ridge Reservation in the state of Tennessee.

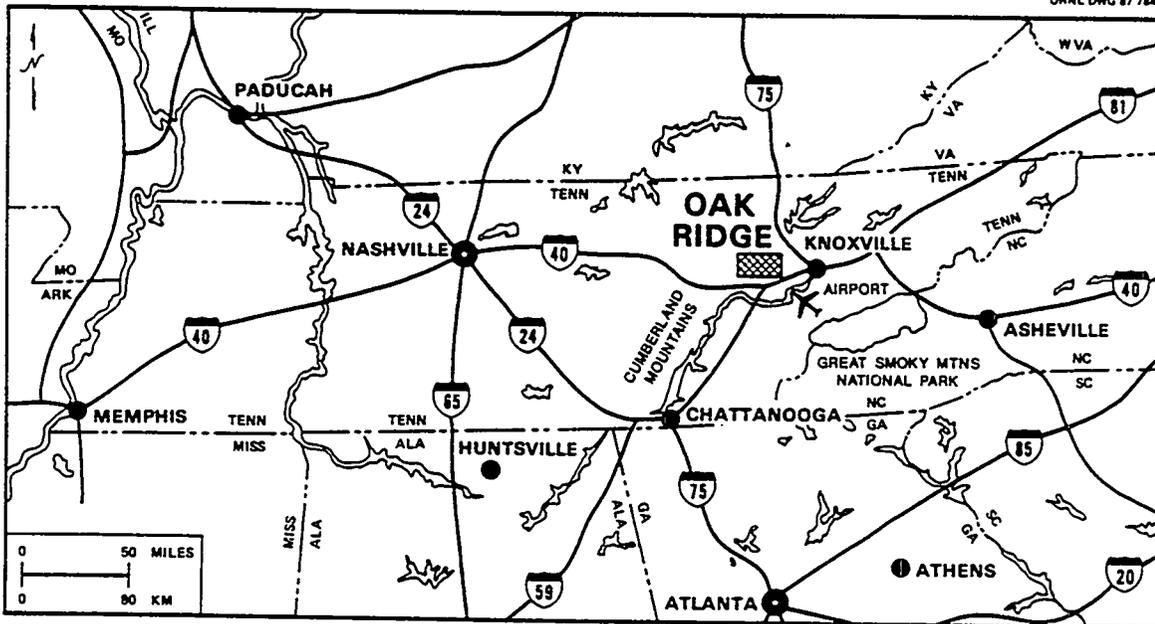


Fig. 1.1.2. Map showing location of Oak Ridge in relationship to geographic region.

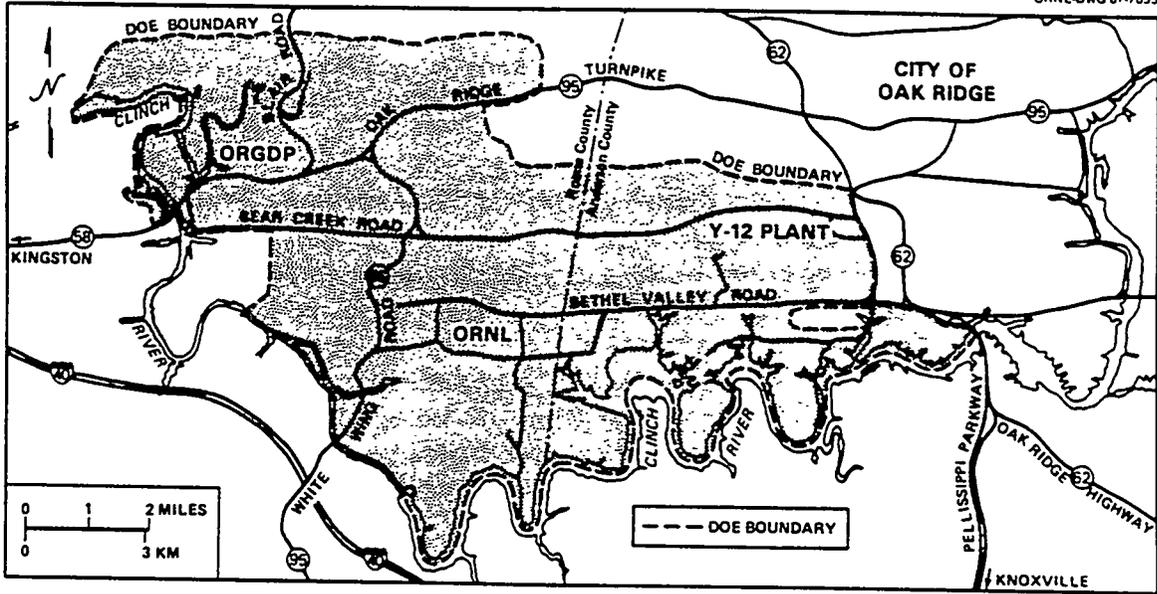


Fig. 1.1.3. Map showing the Department of Energy's Oak Ridge Reservation and the location of the three major installations.



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

process source and special nuclear materials, (3) to provide support to the weapons design laboratories, (4) to provide support to other Martin Marietta Energy Systems, Inc., installations, and (5) to provide support to other government agencies. Activities associated with these functions include production of lithium compounds, recovery of enriched uranium from scrap material, and fabrication of uranium and other materials into finished parts and assemblies. Fabrication operations include vacuum casting, arc melting, powder compaction, rolling, forming, heat treating, machining, inspection, and testing.

ORNL (Fig. 1.1.5), located toward the west end of Bethel Valley, is a large, multipurpose

research laboratory whose basic mission is to expand knowledge, both basic and applied, in areas related to energy. To accomplish this mission, ORNL conducts research in fields of modern science and technology. ORNL's facilities include nuclear reactors, chemical pilot plants, research laboratories, radioisotope production laboratories, and support facilities. The Oak Ridge National Environmental Research Park is managed by ORNL.

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



Fig. 1.1.5. ORNL (view looking west).

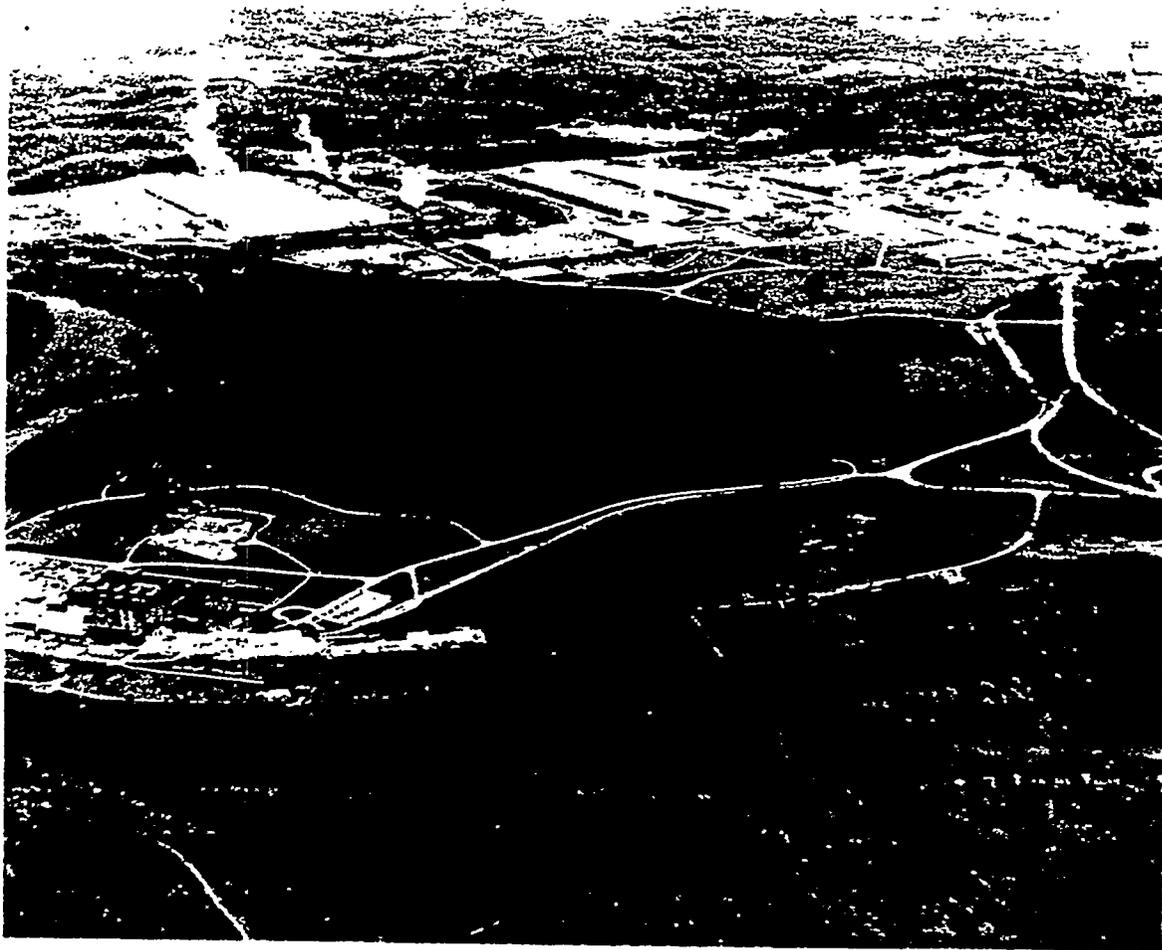


Fig. 1.1.6. ORGDP (view looking northeast).

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 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 much of ORGDP is 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)-contaminated wastes 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, various analytical laboratory programs, engineering and computer support, and various waste treatment services.

Operations associated with the DOE research and production facilities in Oak Ridge give rise to 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 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 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, small tributaries of the Clinch River.

## 1.2 REGIONAL DEMOGRAPHY

Except for the City of Oak Ridge, the land within 8 km of the ORR is predominantly rural, used largely for residences, small farms, and cattle pasture land. 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 to the northwest; Clinton (pop. 5300), 16 km 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 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 to the east and has a population of about 183,000. Table 1.2.1 in Vol. 2 lists cities and population centers within an 80-km 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 radius is the ORR. Fewer than 5000 people live within those 10 km of the ORR center. The Tennessee Valley Authority's (TVA) Melton Hill and Watts Bar reservoirs on the Clinch River form the southern, eastern, and western boundaries of the ORR, and the residential sector of the City of Oak Ridge forms the northern boundary. The ORR is within the Oak Ridge city limits.

## 1.3 GEOLOGY, TOPOGRAPHY, AND SOILS

### 1.3.1 Geology

The ORR is located in the Valley and Ridge Physiographic Province of East Tennessee

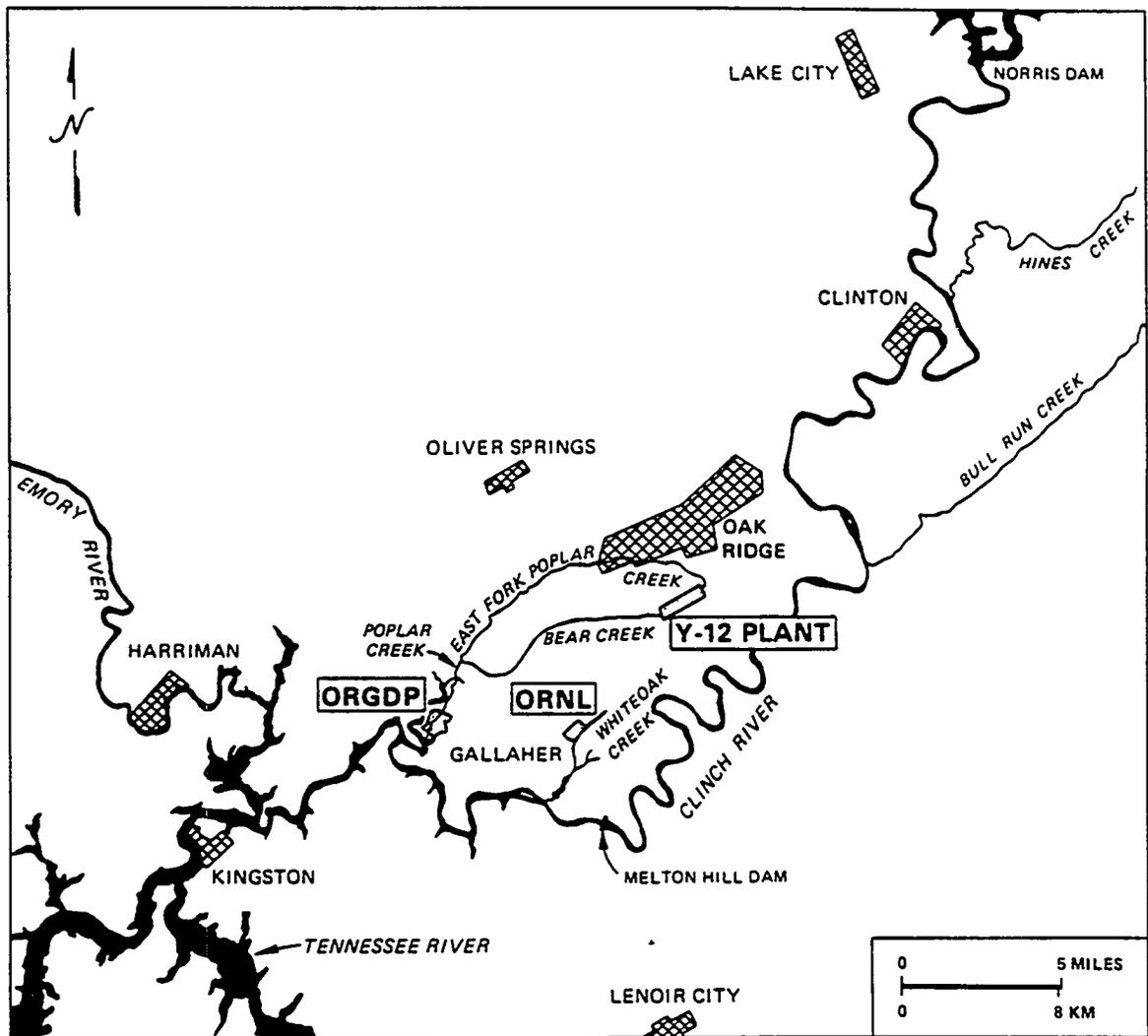


Fig. 1.2.1. Location map of towns nearest the ORR.

between the Cumberland Plateau to the northwest and the Blue Ridge Mountains to the southeast (see Fig. 1.3.1, Vol. 2). The province, which is 13 to 20 km wide in this area, extends approximately 2000 km from the Canadian St. Lawrence lowland into Alabama. Bounded by the Appalachian Plateau Province to the west and the Blue Ridge Province to the east, the Valley and Ridge Province is a complex zone characterized by a succession of southwest-trending ridges and valleys. A geologic map of the ORR is shown in Fig. 1.3.2, Vol. 2. The characteristic topography of the Oak Ridge area is influenced by the

underlying geologic structures and differential erosion. Compressive forces that produced folding and thrusting created a southeast dip to nearly all the units on the ORR (Buchananne and Richardson 1956). The ridges remain because they consist of relatively resistant material such as dolomite, cherty limestone, and shaly sandstone. Valleys develop in areas of more soluble limestone and easily eroded shale.

Each geologic unit within the ORR presents a unique set of characteristics dictated by composition, structural configuration, and modifications brought about by chemical and

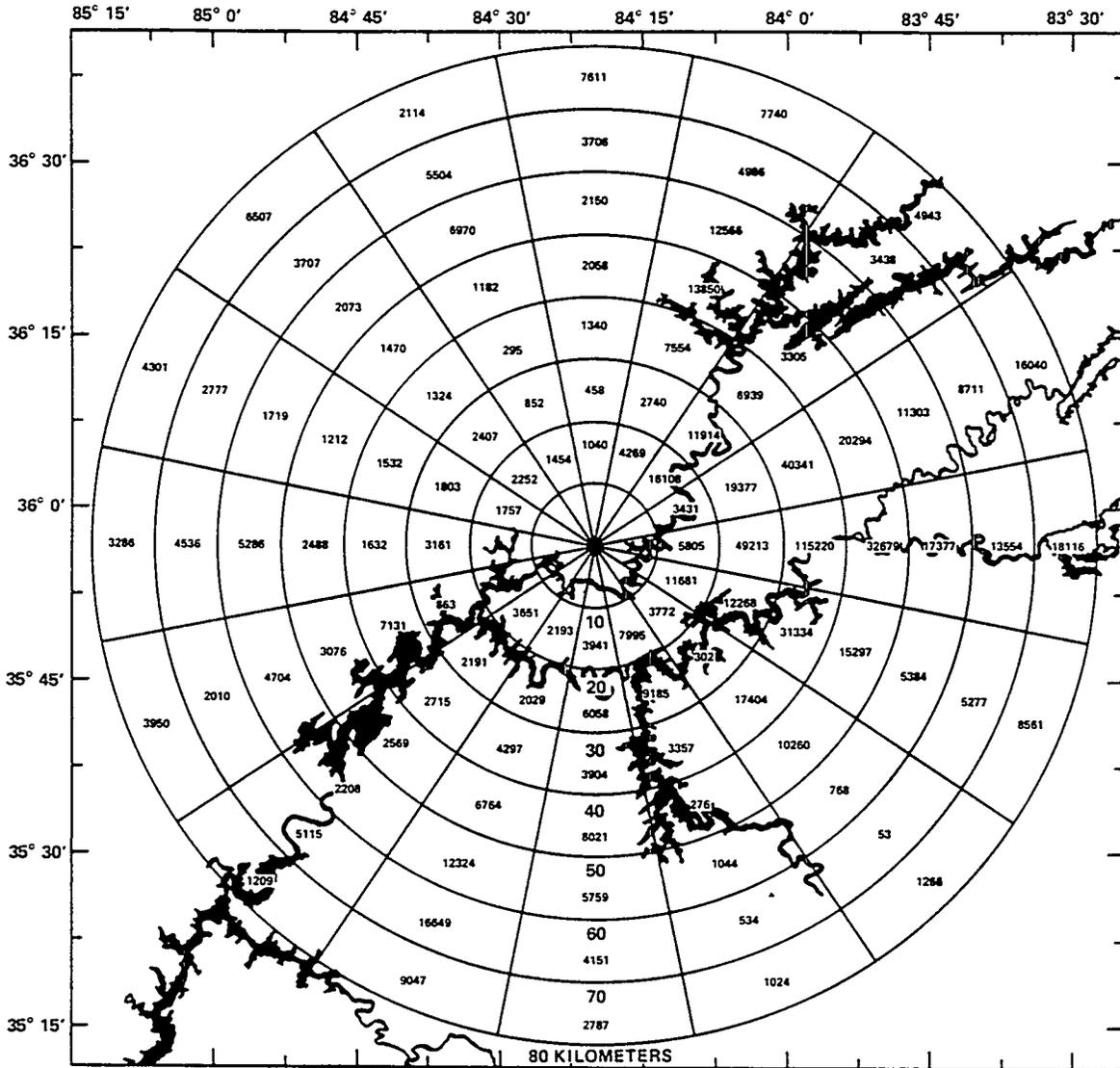


Fig. 1.2.2. Population by sector from the center of the Oak Ridge Reservation, based on 1980 census data.

mechanical weathering through geologic time. Understanding the geology of the site will aid in waste management and monitoring.

### 1.3.2 Topography

The entire Reservation is characterized by a rolling topography of gentle-to-steep slopes with little or no expanse of flat land. Elevations range from 226 to 415 m above mean sea level—a maximum relief of 189 m. The slopes are

categorized into three ranges. The gentlest slopes, 0 to 15%, offer the easiest and most flexible opportunities for development. Slopes of 15 to 25% require great care and sensitivity in siting utilities and structures and pose moderate constraints to development. Although erosion potential exists, these sites offer the opportunity for architectural innovation. Steep slopes of more than 25% are the most difficult to develop: erosion potential is greatest, disturbance is most visible, revegetation is most difficult, and

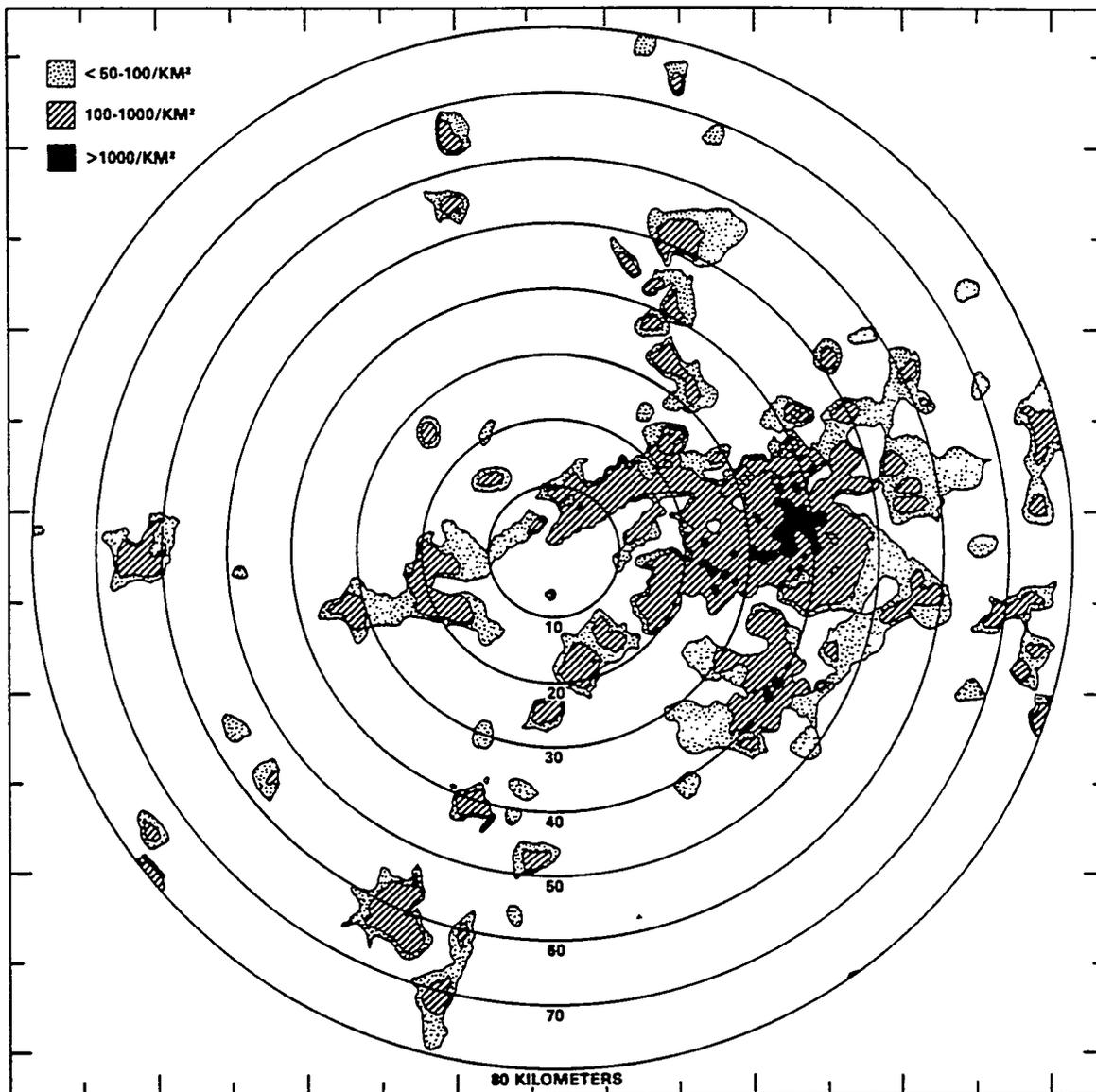


Fig. 1.2.3. Population densities by 10-km section of East Tennessee area, based on 1980 census data.

construction costs are highest. A vast amount of the ORR appears to fall within the gentle slope classification [62%, or more than 8,900 ha (22,000 acres)].

### 1.3.3 Reservation Soils

The ORR is overlain primarily by residual soils and, to a much lesser extent, by alluvial soils. The alluvium (water-deposited soil) occurs on low terraces and floodplains along streambeds.

Residual soils are formed in place by the weathering of their underlying rock.

Decomposition of rock occurs as a result of physical weathering and chemical action. The nature of a residual soil depends on the type of source rock, solubility of the source rock components, degree of weathering, climate, vegetation, and drainage. Soils also exhibit different characteristics after being disturbed by excavation and recompaction.

## 1.4 SURFACE WATER

Surface water in the Tennessee Valley region supplies water to most nonrural areas. 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 area 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 Loudoun 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 use classifications for the Clinch River and its tributaries on or near the ORR. Classifications are based on water quality.

### 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, 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 drains into the Tennessee, the seventh largest river in the United States. Water levels in the Clinch are regulated by TVA, and fluctuations on the river have an impact on the tributary streams and creeks 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 at Kingston, Tennessee. 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 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 9 public water supply systems serving about 91,500 people that withdraw surface water within a 32-km 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 Tennessee River kilometer (TRK) 914.2, about 0.6 km above the confluence of the Clinch and Tennessee rivers and 34.1 km 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. Rockwood withdraws about 1% of its average daily supply from Watts Bar Reservoir. Its intake is located 2 km from the mouth of King Creek embayment near TRK 890.

## 1.5 GROUNDWATER

Groundwater in the Tennessee Valley region supplies water to many rural residences, industries, public water supplies, and the base flow to streams and rivers. Most farm use is for animals 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 or in residual soil accumulations near the bedrock surface and in a few alluvial aquifers along the largest rivers. Permeability in the shales and carbonate rocks that dominate the region 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 aquifers have been identified in Tennessee, as illustrated in Fig. 1.5.1. The major portion of the industrial and drinking water supply in the Oak Ridge area is taken from surface water sources. However, single-family wells are common in adjacent rural areas not served by public water supply systems. As in most of East Tennessee, groundwater on the ORR and in areas adjacent to the ORR occurs primarily 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, EVAPOTRANSPIRATION, AND RUNOFF

Precipitation is not evenly distributed through time, and it also varies on an annual scale as shown in Fig. 1.7.1. Total annual precipitation (water equivalent) is 1.36 m, including approximately 0.25 m of snowfall, with monthly precipitation peaking in January and February. The winter months are characterized by passing storm fronts, and this is the period of highest rainfall. 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 1987 was 102.1 cm, about 37 cm short of the annual average.

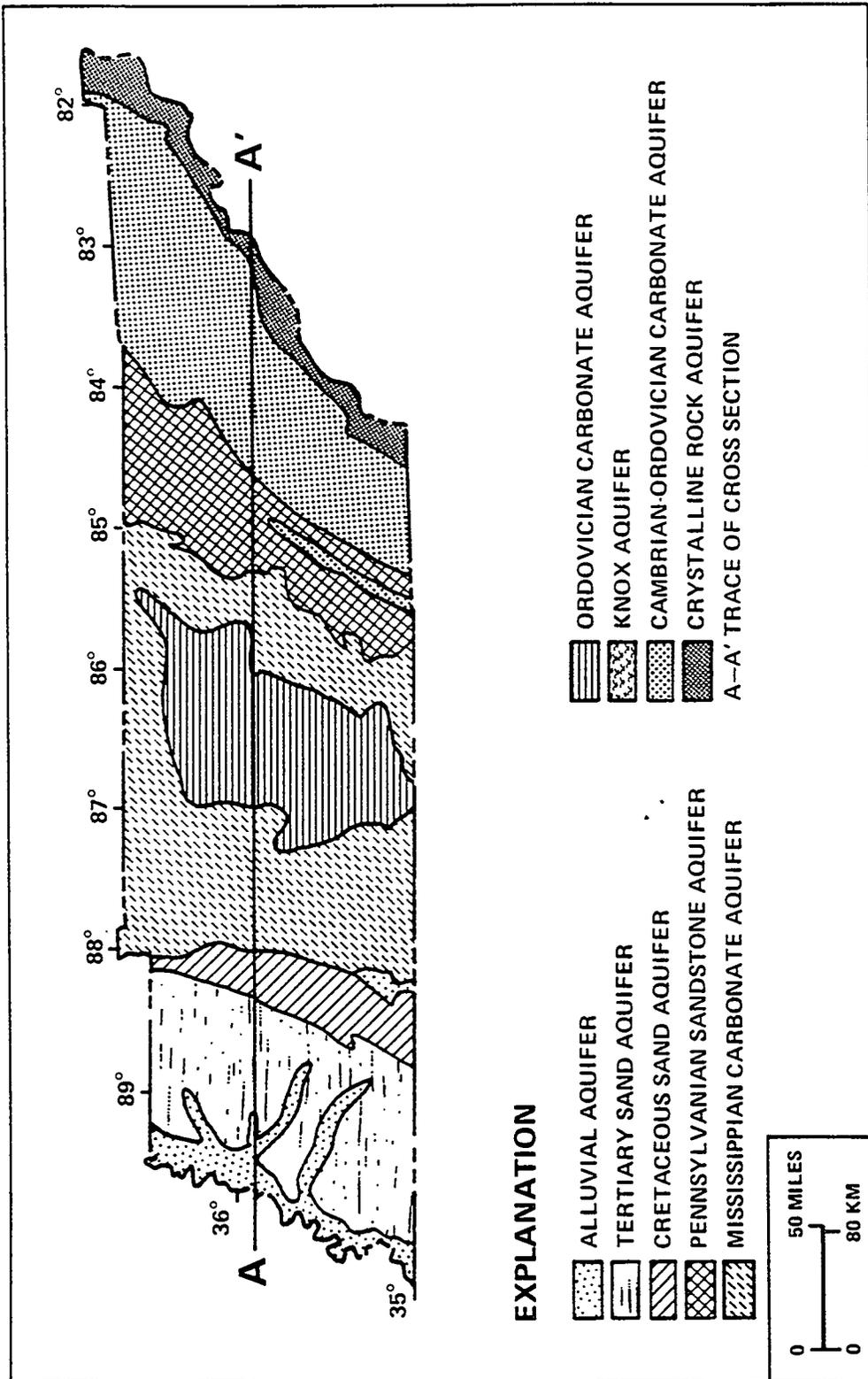


Fig. 1.5.1. Principal aquifers in Tennessee.

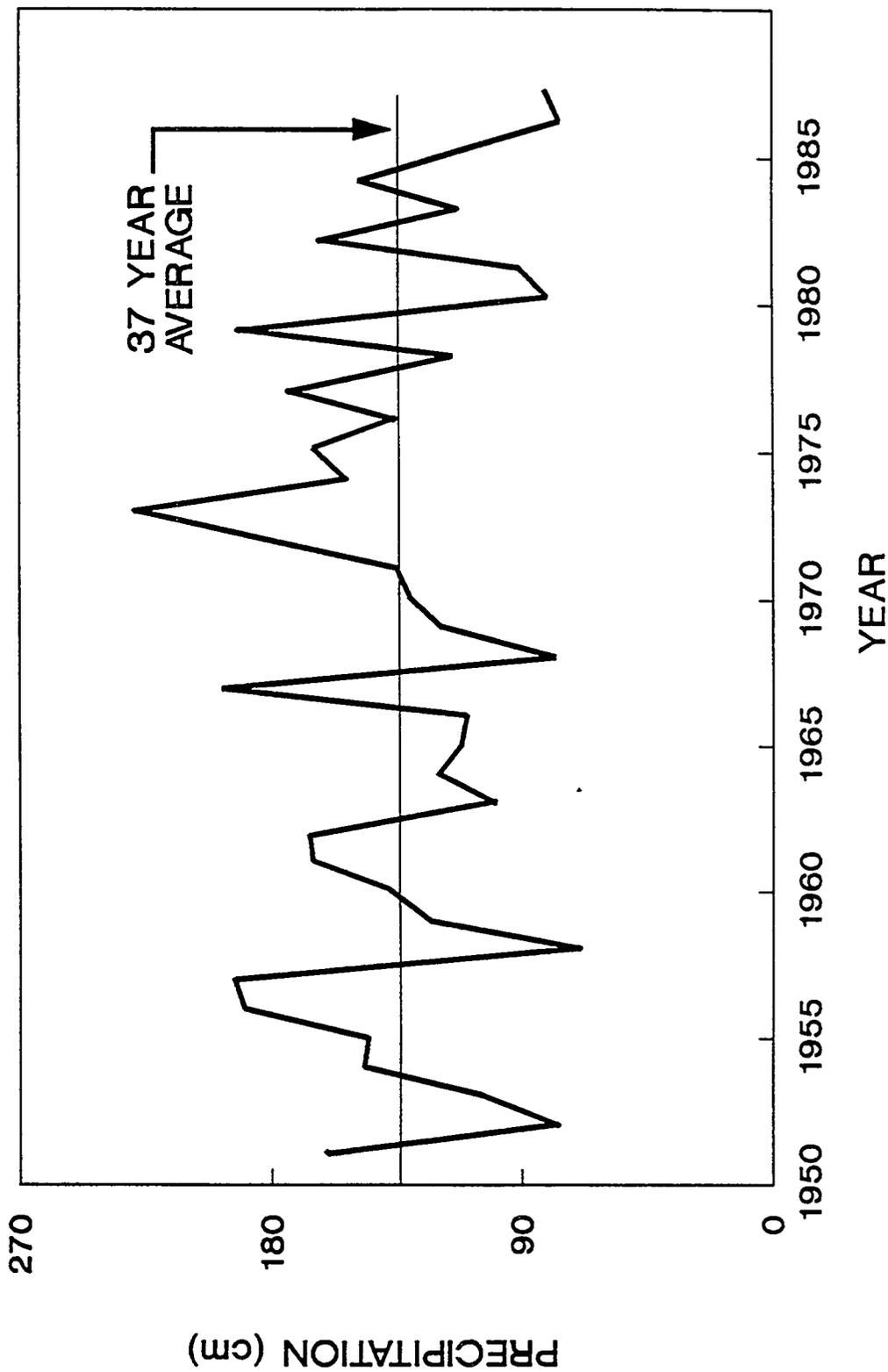


Fig. 1.7.1. Annual precipitation history of the Oak Ridge area.



## 2. ENVIRONMENTAL MONITORING AND SAMPLING SUMMARY

Routine monitoring and sampling for radiation, radioactive materials, and chemical substances on and off the DOE Oak Ridge Reservation and the three DOE Oak Ridge facilities are used to document compliance with appropriate standards, identify trends, provide information for the public, and contribute to general environmental knowledge. The surveillance program assists in fulfilling the DOE policy of protecting the public, employees, and the environment from harm that could be caused by its activities and reducing negative environmental impacts to the greatest degree practicable.

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

Environmental surveillance includes both monitoring and sampling. In general, monitoring refers to instrumentation that sends continuous data to a computer for review. Sampling involves collection of a physical sample and chemical analysis of that sample in a laboratory. Sampling is generally more sensitive than monitoring and provides estimates of quantities of the parameter of interest. Monitoring is more useful in the establishment of trends or deviation from a background. Environmental surveillance includes source monitoring for airborne pollutants; ambient air sampling on site and off site for radioactive particulates and gaseous fluorides; meteorological monitoring; surface water sampling at treatment plant effluents, plant ditches, and in receiving waters; groundwater sampling around various waste disposal areas and the plant perimeter; and milk, fish, wildlife,

vegetation, soil, and sediment sampling to help characterize the condition of the Oak Ridge environs.

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, and average values of parameters for which determinations were made. The 95% confidence coefficients about the average were calculated where possible. The reader can interpret this to mean that "we are 95% confident that the true average is between the average minus the 95% confidence coefficient and the average plus the 95% confidence coefficient." Average values or maximum values have been compared where possible with applicable guidelines, criteria, or standards as a means of evaluating the impact of effluent releases or environmental concentrations.

In some of the tables, radionuclide concentrations are compared with derived concentration guides (DCGs) as published in DOE's Draft Order 5480.xx, published in March 1987. These concentrations were established for drinking water and inhaled air and are guidelines for protection of the public.

Results that may be negative (values less than instrument background) are also reported for some radionuclides. For some analytical instruments, the program software is not designed for calculation of negative values and thus "less than" (<) values are being reported for these radionuclides. Radiation measurements are given in curies (Ci). The curie is defined as  $1 \text{ Ci} = 3.7 \times 10^{10} \text{ Bq}$ . A becquerel (Bq) is a metric 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.

## 2.1 AIRBORNE DISCHARGES AND AIR AND METEOROLOGICAL MONITORING

Airborne emissions from each Energy Systems Oak Ridge facility are regulated under provisions of the Clean Air Act (CAA) of 1970 and the Tennessee Air Quality Control Act. In Tennessee, the Tennessee Department of Health and Environment (TDHE), Division of Air Pollution Control, has the primary responsibility for enforcing the provisions of the CAA and the Tennessee Air Quality Control Act. In addition, the U.S. Environmental Protection Agency (EPA) oversees operations of the Oak Ridge facilities to ensure that airborne emissions are maintained within CAA standards and that appropriate emissions monitoring and reporting criteria are being met.

The CAA is the basis from which all regulations for the control of air pollution within the United States are mandated. The CAA includes provisions setting forth maximum allowable air pollution emission rates as well as

defining ambient air quality standards for the protection of the public health and welfare. The CAA separates potential air pollutants into two specific classes: (1) criteria and (2) noncriteria pollutants. Pollutant categories addressed by the CAA 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 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 strictly regulated under the National Emissions Standards for Hazardous Air Pollutants (NESHAP) regulations of the CAA.

### 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, bag-houses, and exhaust filtration systems designed to remove airborne pollution from the exhaust gas before it is released into the

Table 2.1.1. Clean Air Act (CAA) pollutant categories

Criteria pollutants	Noncriteria pollutants
Total suspended particulates <sup>a</sup>	Hazardous air contaminants
Sulfur dioxide	Asbestos
Nitrogen oxides	Beryllium
Carbon monoxide	Mercury
Ozone	Vinyl chloride
Volatile organic compounds	Radionuclides
Hydrocarbons (nonmethane)	Nonhazardous air contaminants
Lead	Fluorides
	Sulfuric acid mists
	Hydrogen sulfide
	Total reduced sulfur

<sup>a</sup>Under regulations promulgated July 1, 1987, particulate matter smaller than 10  $\mu\text{m}$  in diameter will replace total suspended particulates as the primary air quality standard.

atmosphere. In addition, administrative controls play a critical role in regulating emissions. Each installation has developed an extensive air pollution emissions monitoring program to measure pollutants that are not removed and to monitor the effectiveness of air pollution control equipment. Ambient air pollution 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 section describes airborne pollutants emitted from the three Oak Ridge facilities during 1987. This section also describes the emissions monitoring performed at each facility and presents data on measured pollutant concentrations within the surrounding communities. A brief section is also included on meteorological measurements conducted during 1987 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 exhausts provide ventilation to plant fabrication operations. The Y-12 Plant has over 700 TDHE-permitted air pollution sources that are tied into the exhaust ventilation systems. 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 extensively 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, bag-houses, 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

Estimates of Y-12 Plant airborne emissions are summarized in Table 2.1.2. As previously mentioned, atmospheric discharges are primarily a result of plant production operations. Emission estimates were obtained from stack testing data, tracking chemical uses by plant operations, and estimating emissions by engineering analysis. When stack testing data were not available, conservative emission estimates were made. Emission totals listed in Table 2.1.2 are intended to be conservative and may overestimate 1987 Y-12 Plant airborne discharges.

As is illustrated by Table 2.1.2, the Y-12 Plant uses a variety of organic chemicals and solvents to carry out fabrication operations. The majority of these chemicals are lost to the atmosphere through volatilization and are discharged through exhaust ventilation systems. Of particular importance to the Y-12 Plant is the emission of chlorofluorocarbons into the atmosphere. Significant quantities of these halogenated hydrocarbons are used in plant operations as machine coolants, solvents, and refrigerants. The Y-12 Plant is actively pursuing the use of alternative chemicals in areas of the plant where significant quantities of halogenated hydrocarbons are used. Chemicals of the highest priority are perchloroethylene, methyl chloroform, and Freon, which have been listed by EPA as pollutants that may be regulated under NESHAP regulations in the future. Calculations involving

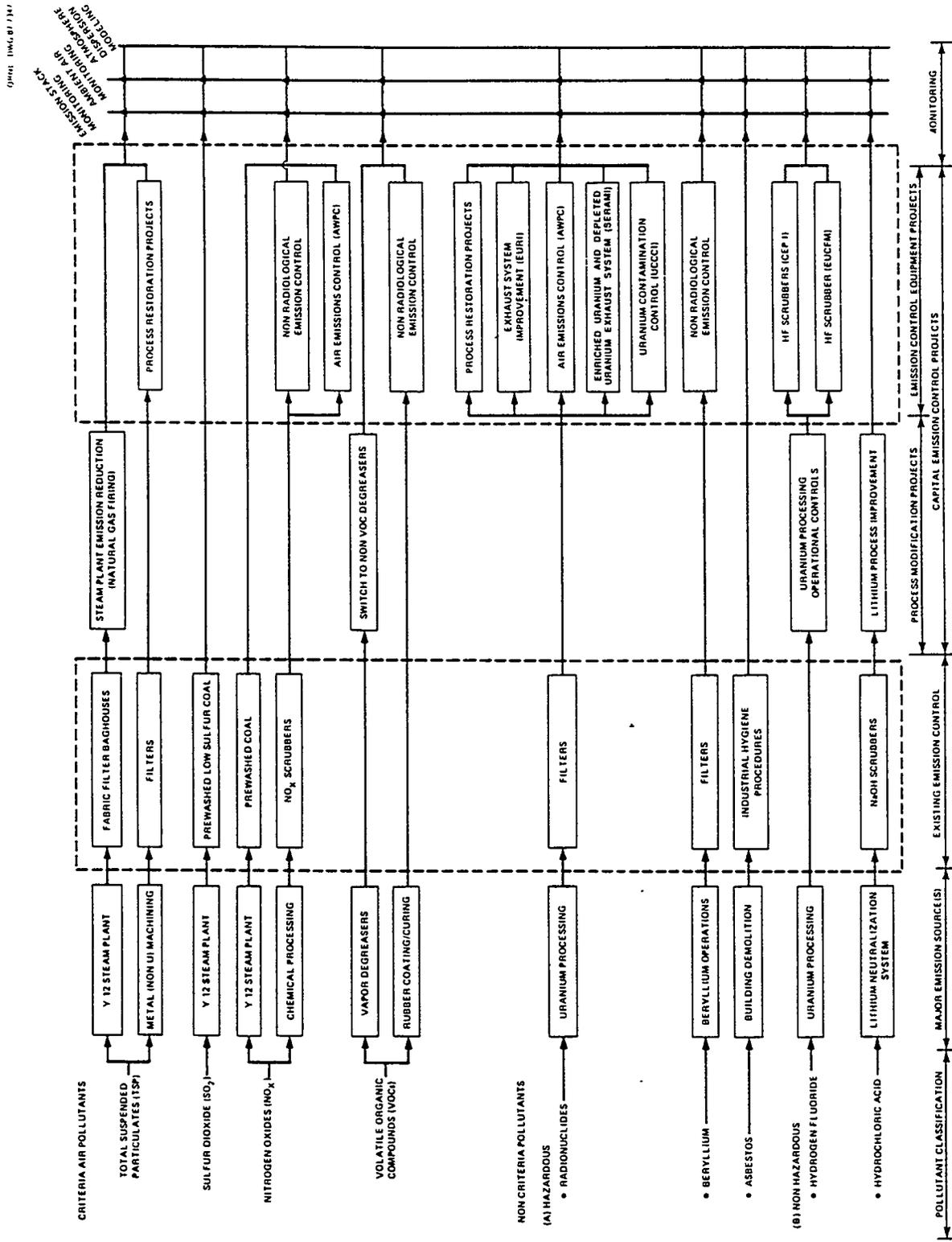


Fig. 2.1.1. Air pollution control program at the Y-12 Plant.

Table 2.1.2. Estimates of 1987 emissions to the atmosphere from the Y-12 Plant<sup>a</sup>

Chemical item	Amount used in 1987 (kg)	Percentage of item assumed emitted	Estimated emissions (kg)
Acetone	800	100	800
Ammonia	1160	75	870
Freon	141,700	100	141,700
Hydrochloric acid	295,000	3	8,800
Methanol	71,400	100	71,400
Methyl chloroform	44,500	100	44,500
Perchloroethylene	31,200	100	31,200
Tolulene	475	100	475
Beryllium and beryllium oxide			<0.005
Hydrogen fluoride			10,100
Uranium particulates			116
Steam plant emissions			
Carbon monoxide			43,500
Nitrogen oxides			1,304,000
Sulfur dioxide			2,362,000
Particulates			67,800

<sup>a</sup>Steam plant emissions were calculated based upon AP-42 emission factors and 1987 Y-12 Plant coal usage/analysis records.

the quantities of these chemicals emitted from the Y-12 Plant and listed in Table 2.1.2 were based upon an estimated volatilization rate of the specific chemical and a review of plant chemical usage records for 1987.

Y-12 Plant uranium emission estimates are further broken down in Table 2.1.3. 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 (see Sect. 6). 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 and analyzed in the Y-12 Plant laboratory to determine uranium stack emissions. In addition, engineering analysis was used to estimate uranium emissions on exhaust stacks operated during January and February 1987 prior to the startup of the new stack monitoring equipment. 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 2.1.3.

Emission estimates of hydrogen fluoride and hydrochloric acid are also listed in Table 2.1.2. These emission estimates were made by tracking chemical uses from purchased inventories and an assumed volatilization rate. Emissions of sulfur dioxide, nitrogen oxides, carbon monoxide, and total suspended particulates primarily result from steam plant operations and are also listed in Table 2.1.2. Steam Plant emissions were calculated using EPA-developed emission factors and records of 1987 coal analysis and usage records at the Y-12 Plant. The Y-12 Plant beryllium emission estimate is also listed in Table 2.1.2 and was obtained from actual stack sampling data on six exhaust stacks.

Although emission estimates have been made for a number of major pollutant categories, several special studies are under way at the Y-12 Plant to characterize emissions resulting from fugitive (nonpoint) sources (see Sect. 6).

Table 2.1.3. 1987 Y-12 Plant airborne uranium emissions estimates<sup>a</sup>

Source of emissions	Quantity emitted	
	(kg)	(Ci)
Enriched uranium process exhaust	1.6	0.10
Depleted uranium process exhaust	49.5	0.02
Enriched uranium room exhaust	0.0	0.00
Depleted uranium room exhaust	65.0	0.02
Total	116.1	0.14

<sup>a</sup>See Table 3.1.5 for off-site committed dose equivalents resulting from Y-12 Plant uranium emissions.

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). In addition, special sampling is also under way to characterize potential fugitive emissions from the S-3 ponds and Bear Creek burial grounds. Emissions from these facilities are very low, but continued monitoring is required to ensure that ongoing remedial action activities do not adversely affect long-term ambient air quality.

**Discussion**

It is estimated that a total of 0.14 Ci (116.1 kg) of uranium was released into the atmosphere in 1987 as a result of Y-12 Plant fabrication operations. Because of the significantly higher specific activity of enriched uranium over that of depleted uranium, approximately 70% of the curie release was due to emissions of enriched uranium particulates, while only 1% of the total mass of uranium released was due to enriched uranium losses.

As illustrated in Figs. 2.1.2 and 2.1.3, 1987 Y-12 Plant uranium emissions estimates were significantly lower than in recent years. This 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

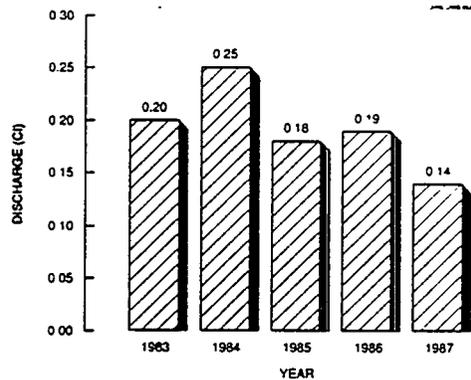


Fig. 2.1.2. Total curie discharges of uranium from the Y-12 Plant to the atmosphere.

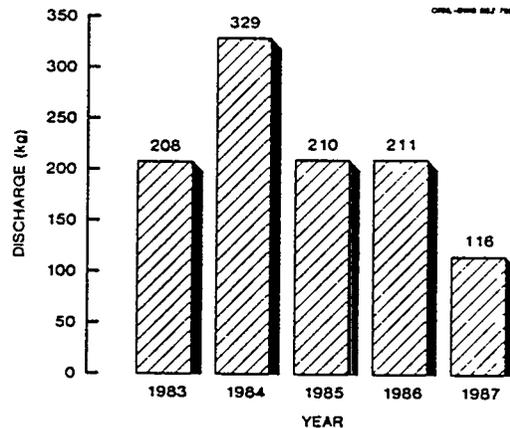


Fig. 2.1.3. Total kilograms of uranium discharged from the Y-12 Plant to the atmosphere.

filtration system efficiencies decline. Another factor contributing to decreased uranium emissions during 1987 was a reduction in plant operations because of an 18-week-long strike by the Atomic Trades and Labor Council (ATLC).

Y-12 Plant emissions of hydrogen fluoride to the atmosphere in 1987 were also significantly lower than in previous years. Atmospheric hydrogen fluoride emissions were significantly lower than in previous years as a result of both administrative controls implemented to minimize emissions and the strike by the ATLC, which significantly reduced fluoride annual usage in some areas of the plant. Continued reduction in Y-12 Plant atmospheric hydrogen fluoride emissions is expected in the future as the plant begins operation of two new hydrogen fluoride scrubber systems.

### 2.1.1.2 Oak Ridge National Laboratory

#### Description

Most gaseous releases from ORNL originate from one of eight major stacks that are located in Melton Valley and Bethel Valley (Fig. 2.1.4). Discharges from each stack are unique because of the wide variety of research activities performed at ORNL. However, radioactive gaseous emissions from ORNL typically could consist of solid particulates, absorbable gas (i.e., iodine), tritium, or nonabsorbable gas.

Gaseous waste streams at ORNL consist mainly of ventilation air from contaminated or potentially contaminated areas, vents from tanks and processes, and ventilation of reactor facilities. All contaminated and potentially contaminated gaseous wastes are treated and filtered by HEPA filters before discharge to ensure that any radioactivity released is within acceptable levels.

During 1987, the first phase of a stack upgrade program was implemented for the major stacks—7911, 3039, and 7025. As a result of being involved in a multiphase upgrade program, ORNL currently has either the previous or the new monitoring systems operating at various stacks.

**Upgraded monitoring system.** Each stack except 7830 (hydrofracture) will be upgraded to continuous monitoring using electronic instruments. Monitoring at each stack will be designed for the specific radiological parameters of concern at that discharge point. However, the monitoring stations will generally consist of gross

alpha, gross beta, radioiodine, tritium, and noble gas monitors. The 7025 stack will have only tritium monitors. Samplers will be designed to provide sampling capability, where necessary, for particulate solids, iodine, and tritium.

The primary purpose of the stack monitoring system is to serve as a first line of detection and alert for discharges from ORNL stacks. Continuous monitoring of the stacks determines the relative radiation levels being discharged at one time. If radiation levels appear to be above set levels, the ORNL Shift Supervisor notifies compliance personnel, who evaluate the situation and may take further action. Such action may include initiating additional sampling and informing other responsible personnel. Monitoring for noble gases is the only exception to the monitoring and sampling scheme. All quantifiable data used for noble gases are generated via the continuous monitors located at the stacks.

Sampling is performed at each stack to quantify levels of radioiodine, gross alpha, gross beta, and tritium where required. Sampling and analysis frequencies for each stack are given in Table 2.1.4.

Airborne radioactive particulate samples are collected by pumping a continuous flow of air through a 47-mm paper filter and then through a  $5.7 \times 2.54$ -cm-thick activated charcoal cartridge. To minimize artifacts from short-lived radionuclides, the filter papers are analyzed three or four days after collection. The initial and final dates and flow rates are recorded when a sample is mounted or removed.

All new sampling equipment installed at the stacks will have a flow totalizer to allow direct recording of the total flow through the sample. Flow rates for the 7911 stack sampler are tied to a stack flow rate tracking system that varies the sample flow rate as the stack flow rate changes.

Complete monitoring records and sampling data for 1987 are not available for the 7025 and 7911 stacks because of downtime of the previous monitoring system and installation of the new equipment. This downtime was extensive as a result of the ATLC strike. Data from the 3039 stack were not affected by installation of new equipment because of the location of the new monitoring and sampling equipment in the ducts.

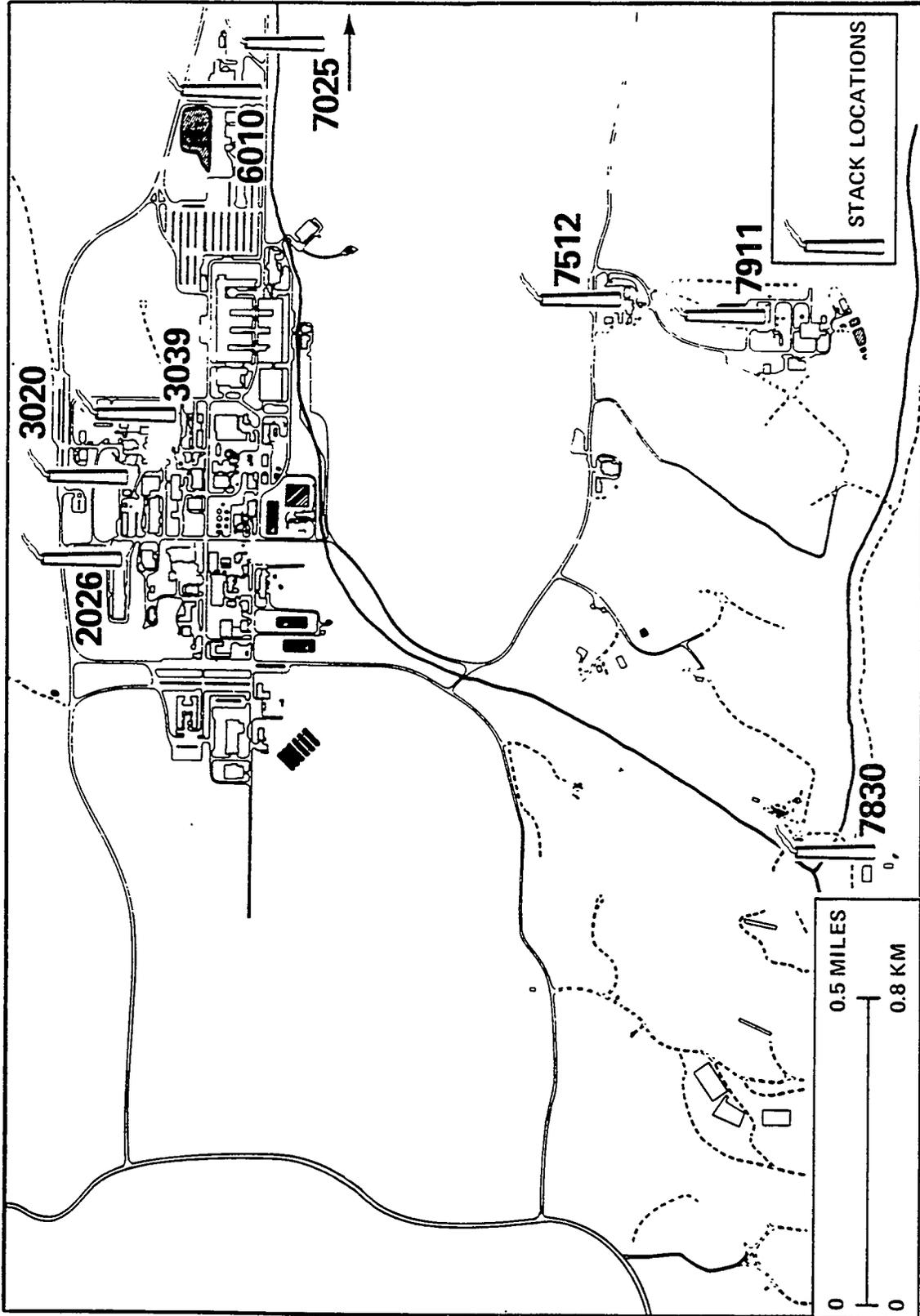


Fig. 2.1.4. Locations of major stacks (emission points) at ORNL.

Table 2.1.4. Summary of stack monitoring capabilities at ORNL

Stack	Sampling					Real-time direct measurement					Remarks	
	Particulate alpha	Particulate beta	Radioiodine	Tritium	Replacement frequency	Particulate alpha	Particulate beta	Radioiodine	Tritium	Noble gas		Flow
2026	X	X	X		Weekly		X				X	
3020	X	X	X		Weekly	X	X	X			X	
3039	X	X	X		3 times per week	X	X	X		X	X	
6010					Weekly					X		
7025				X	Weekly				X		X	
7512	X	X	X		Weekly	X	X				X	
7911	X	X	X	X	Weekly	X	X	X	X	X	X	
7830	X	X	X		Weekly							

New direct measurement system in four ducts; samples still withdrawn from stack

New system installed in 1987

New system installed in 1987; data not telemetered

The previous stack monitoring and sampling system in use at ORNL was designed and installed in the early 1960s. Monitoring equipment consists mainly of tape deck monitors for gross beta-gamma and for gross alpha. A monitor embedded in activated charcoal is used to read radioiodine releases. Continuous data from the monitors are read in the Waste Operations Control Center (WOCC). These levels have not been related to radionuclide concentrations and are used primarily to identify trends, malfunctions, and equipment breakdowns.

Air is withdrawn from the stacks through extractor assemblies inserted into the exhaust streams. Sampling paper and activated charcoal are contained in a metal housing within the stack. Procedures for holdup of the filter paper to allow for decay of the artifacts from short-lived radionuclides are the same as those for the new sampling system. Flow rates through the samplers and monitors are set manually by a rotometer. Total flow through the sample is determined only at the 50-ft level of the 3039 stack. This information is provided by a standard flow totalizer. The sampling and monitoring system is not designed to provide an isokinetic sample as required by American National Standards Institute standard N13.1. This ensures that all particulate materials are sampled at the same rate as they are being discharged.

During 1985, a sampling program at stacks 3020, 7911, and 7025 was conducted by the ORGDP Technical Services Division. To continue the progress made in 1985 and to cover stacks and areas not addressed, an independent stack sampling program was initiated during 1987. Sampling activities were again provided by the Quality and Technical Services Division of ORGDP, and all work was done in accordance with standard EPA procedures.

The 1987 sampling program provided data necessary for current and ongoing monitoring and sampling upgrade programs and also a quality assurance check with the new and existing equipment. All sampling data from this program will be compared with the monitoring and sampling data to determine the relative accuracy of the monitoring and sampling system. Sampling by ORGDP in 1987 of ORNL stacks included obtaining velocity profiles, particle size distribution, isotopic determinations of filter

particles, and noble gas identification using a cryogenic technique. Currently, no EPA method exists that would allow ORNL to sample noble gases and detect the level of radioactivity present. Because the cryogenic sampling method is not an EPA-approved method, additional developmental work is needed in the area of calibration procedures. However, once the method is established, it will provide for quantification of the noble gases.

To date, all of the ORGDP stack work except cryogenic sampling was completed on five of the eight stacks. All field sampling developmental activities required to establish procedures for the cryogenic sampling have also been completed.

The testing indicated that discharges from the stacks were below the submicron level. Testing of the velocity profiles indicates that the stack flow rates do not vary by more than the 20% limit imposed for the sampling to remain isokinetic.

### Summary

During 1987, airborne discharges were estimated in three ways: (1) with continuous sampling data, (2) with monitoring data, and (3) from inventories. Under the previous system, two samplers were located at the 50-ft level of both the 3039 and 7911 stacks. In each of these stacks, air passes through a filter paper and then through a small and a large charcoal sampler. Filter papers and charcoals are collected three times a week at the 3039 stack and weekly at stacks 7911, 3020, 2026, and 7512. The area serviced by the 6010 stack does not normally have any radioactivity present. The only activity produced by the facility involved certain gases that cannot be sampled. Because there is little or no activity on the monitors at the 6010 stack, samples are not collected at this location.

Discharges of radioiodine from the stacks were estimated from charcoal samples collected three times per week at the 3039 stack and weekly from stacks 7911, 3020, 2026, and 7512. The sampling flow rate was assumed to be 0.5 cfm for stacks 3039 and 7911 and 2 cfm for the other stacks. The average activities on the two samplers at 3039 and 7911 were used to estimate discharges. Calculations of noble gases discharged

were based on monitoring equipment in the 7911 and 3039 stacks, which are maintained by the Operations Division at ORNL. Data for radioiodine and noble gas discharges were obtained from the Operations Division monthly internal reports. Discharges were calculated using an estimate of the total flow through the stacks. The numbers in this report have been adjusted for new stack flow rates obtained by the ORGDP Technical Services Division. Because the previous system was not designed isokinetically, results may not be representative of stack discharges; however, these are the best available data until the upgrades are complete.

Discharges of tritium occur from stacks 3039 and 7025. Estimates of the quantities discharged are based on inventories of tritium purchased and used.

Airborne emissions are broken down into two

categories, radioactive and chemical, and are discussed in the following sections.

**Radioactive emissions.** The total airborne emissions from the ORNL plant were about 71,000 Ci during 1987 (see Figs. 2.1.5–2.1.8). Table 2.1.5 depicts these emissions. The annual emissions from each ORNL stack and the total activity in curies either from sampling or monitoring data or from radionuclide inventories are given in Table 2.1.5. All data, including the totals, are reported to two significant figures.

The total filterable particulate activity was measured either weekly or three times per week at each of five stacks at ORNL. The filter papers were allowed to decay for a period of four days before counting. No samples were collected at the 6010, 7030, or 7025 stacks because of the extremely low activity from these stacks. Total activity on the filter papers was divided by the

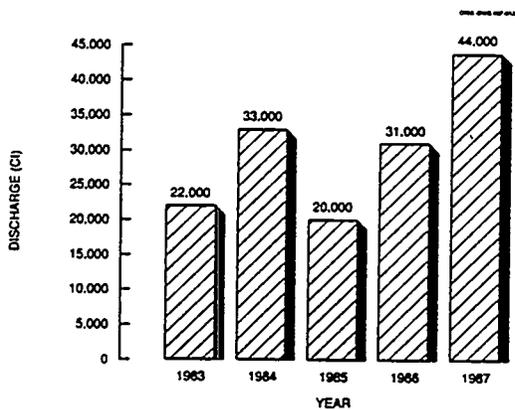


Fig. 2.1.5. Total curie discharges of tritium from ORNL to the atmosphere.

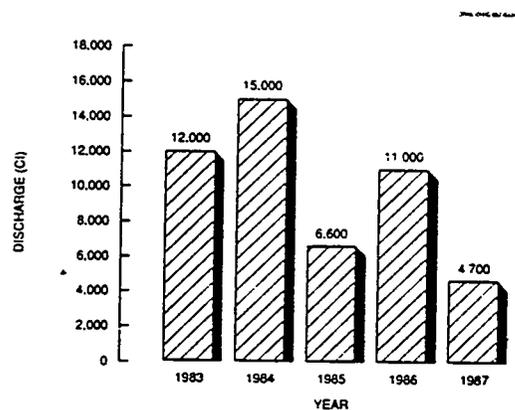


Fig. 2.1.7. Total discharges of krypton-85 from ORNL to the atmosphere.

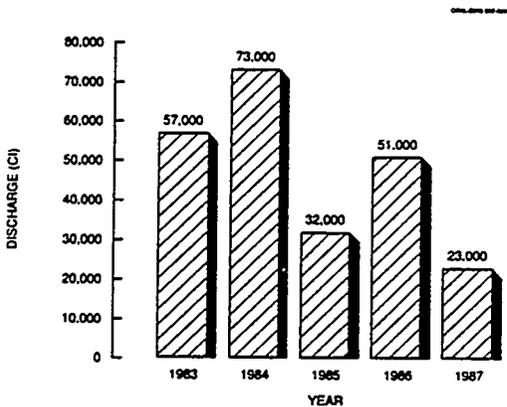


Fig. 2.1.6. Total discharges of xenon-133 from ORNL to the atmosphere.

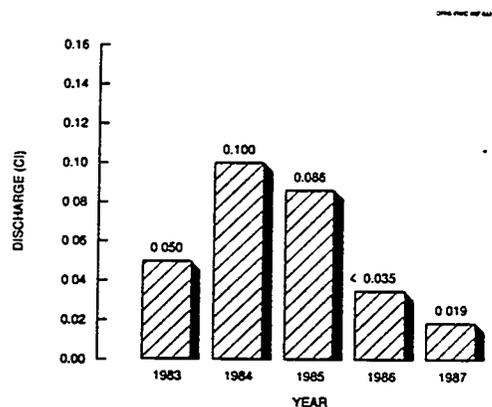


Fig. 2.1.8. Total discharges of iodine-131 from ORNL to the atmosphere.

Table 2.1.5. 1987 stack emissions from ORNL

Stack	Filterable particulate activity (Ci)	Noble gases <sup>a</sup> (Ci)	<sup>131</sup> I (Ci)	<sup>3</sup> H (Ci)
2026	0.000039	NA	0.00097	NA <sup>b</sup>
3020	0.00008	NA	0.000012	NA
3039	0.0045	16,000	0.0036	44,000
7025	NA	NA	NA	50
7512	0.000012	NA	0.0000081	NA
7911 <sup>c</sup>	0.00023	11,400	0.014	NA
Total	0.0049	28,000	0.019	44,000

<sup>a</sup>Assumed to be <sup>133</sup>Xe and <sup>85</sup>Kr.

<sup>b</sup>NA = Not applicable.

<sup>c</sup>Sampling data were collected only during the first 4 months of the year because of system upgrade. These values are calculated by multiplying the first 4 months' value by 3 to estimate the yearly total.

flow rate of the sampler to give the concentration on the filter paper. For the 3039 and 7911 stacks, where there were two samplers, the average activity of the two samplers was used for the calculations. These values were then multiplied by the flow rate of the stack to estimate the total activity emitted from the stack for the year. The flow rates derived by the ORGDP stack monitoring study were used for these calculations. In most cases, these rates are higher than those used during previous years. No sampling was performed on the 7911 stack after April 1987 because of the upgrade in progress. The High Flux Isotope Reactor (HFIR), which vents through the 7911 stack, was shut down in November 1986. Data collected during the first four months of the year are believed to be representative of the processes for the remainder of the year. Emissions for the first four months were multiplied by three to estimate the total emissions for the year. Of the total filterable activity emitted from ORNL, about 92% of it comes from the central stack in Bethel Valley, 3039.

Releases of noble gases are monitored from the 3039 and 7911 stacks. Approximately 59% of the total activity released comes from the 3039 stack; the remainder is from the 7911 stack (see Table 2.1.5). Based on historical information on reactor emissions, about 83% of the total noble

gases emitted is assumed to be <sup>133</sup>Xe. The remainder (17%) is assumed to be <sup>85</sup>Kr.

Iodine-131 is measured on charcoal cartridges taken from the stacks either weekly or three times per week. The total activity released from the stack is calculated in a manner similar to that used for total filterable particulate activity. That is, the activity on the charcoal is divided by the sampler flow rate and then multiplied by the flow rate of the stack. Stack flow rates measured by the ORGDP team were used in the calculations. Most of the <sup>131</sup>I released is from the HFIR and TRU facilities (stack 7911) in Melton Valley. About 75% of the total <sup>131</sup>I activity was generated at the 7911 stack (see Table 2.1.5).

Estimates of tritium released from the 3039 and 7025 stacks are based on inventories. Tritium received from the Savannah River Plant is stored and processed in Building 3033 before being shipped to users outside the Oak Ridge Reservation (ORR). Radioactivity in the stack emission is estimated based on the measured amount of tritium received, corrected for radioactive decay, minus the amount shipped. All of this difference is assumed to be released through stack 3039. According to this estimate, stack releases are slightly less than 2% of the amount shipped to users. These amounted to about 44,000 Ci during 1987 and constitute about

Table 2.1.6. Estimates of 1987 emissions of gaseous chemicals to the atmosphere at ORNL

Chemical item	Amount used in 1987 (kg)	Percentage of item assumed emitted	Estimated emissions (kg)
Acetylene	1,000	25	250
Ammonia	35	75	27
Argon	46,000	90	41,000
Carbon dioxide	330	100	330
Carbon monoxide	67	100	67
Chlorine	200	75	150
Helium	1,000	100	1,000
Hydrogen	440	50	220
Hydrogen fluoride	12	100	12
Hydrogen sulfide	4	100	4
Freon	12,000	95	11,000
Methane	21	75	16
Methylene chloride	120	100	120
Nitrogen	2,100,000	100	2,100,000
Oxygen	65,000	50	33,000
Perchloroethylene	1,500	100	1,500
Propane	650	25	160
Steam plant discharges			
Particulates			190,000
Sulfur dioxide			300,000
Nitrogen oxide			44,000
Carbon monoxide			15,000
Sulfur hexafluoride	6,800	100	6,800
Trichloroethylene	120	100	120

99.9% of the tritium released from ORNL (see Table 2.1.5). Additionally, about 50 Ci of tritium was released from the Tritium Target Facility (stack 7025) during 1987.

**Chemical emissions.** Because the total particulate discharges from ORNL processes are low, there are no permit requirements for sampling or monitoring of chemical emissions at ORNL. Table 2.1.6 gives the estimated usage of chemicals at ORNL, the estimated percentage discharged, and total estimated kilograms of each chemical emitted. This table is based primarily on a listing of gases procured at ORNL during 1987. Steam plant discharges are based on permit information, while the organic cleaning solvents listed are based on investigations related to NESHAP regulations. All assumptions on the percentage of the chemical discharged are based on ORNL Environmental Monitoring and Compliance Department staff experience. If no information was available on use, then 100% of

the chemical was assumed to be released. Data were originally expressed in pounds and have been converted to kilograms, rounded, and expressed in two significant figures.

### 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

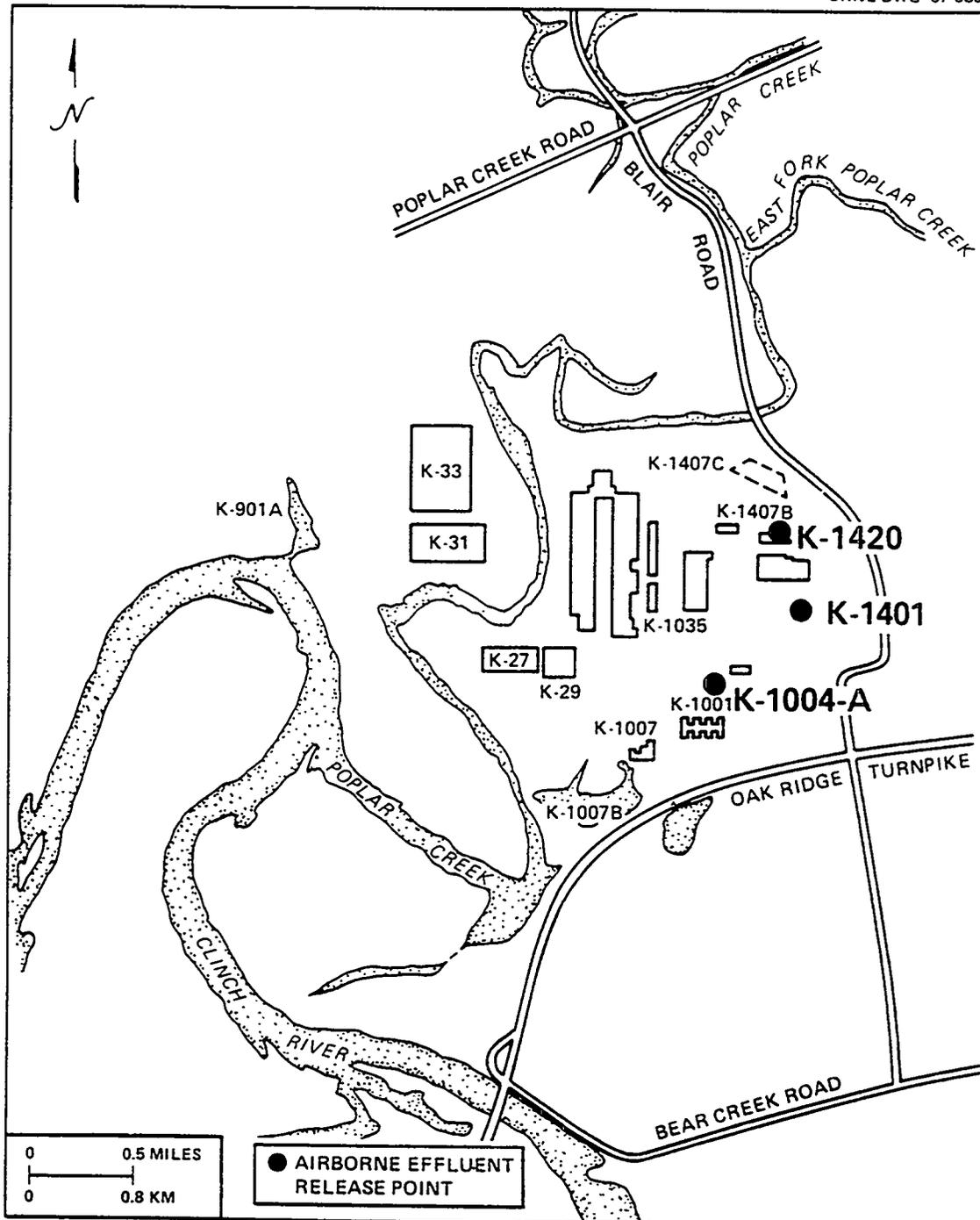


Fig. 2.1.9. Locations of airborne radioactive effluent release points at ORGDP.

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.

The locations of airborne radioactive effluent release points at ORGDP are shown in Fig. 2.1.9. 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 source operating is the K-1501 steam plant. The K-1435 Toxic Substances Control Act (TSCA) incinerator, which is scheduled to operate in 1988, will be a new source.

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.

Table 2.1.7 gives estimates for quantities of pollutants discharged from ORGDP in 1987 from permitted sources. A majority of the emissions occurred from either the K-1501 steam plant or the K-1420 decontamination facility. In these cases, the estimates of the amount of pollutants emitted are based on actual operating activity. The estimates for emissions from the steam plant were based on 69 d of coal operation in 1987. The estimates for emissions from the various stacks at K-1420 are based on both actual operating time in 1987 and stack sampling data obtained in 1984 and 1985. The remaining emissions depicted in Table 2.1.7 are overestimated because active sources were considered to be operating full time when, in fact, most of those sources operated at a reduced level in 1987.

Figures 2.1.12 and 2.1.13 compare ORGDP's discharges of uranium for 1987 with those of previous years. Uranium emissions for 1986 and 1987 resulted from an increase in operational hours in the K-1420 decontamination facility and a test on compressors conducted in K-1401.

There are no permit requirements to sample or monitor all chemical emissions from ORGDP; however, an estimate of the major gaseous chemicals emitted to the atmosphere in 1987 was made based primarily on gas cylinder purchases (see Table 2.1.8).

### 2.1.2 Ambient Air Monitoring

In addition to actual stack monitoring conducted at the Energy Systems Oak Ridge installations, an extensive ambient air monitoring program has been developed to directly measure ambient air quality within each facility and in the surrounding communities. Ambient air monitoring provides direct measurement of air pollution concentrations in the surrounding environment and allows plant operators to determine what effects stack and other emissions have on the region's air quality. Ambient air monitoring also is used to determine the compliance status of an area with ambient air quality standards and to ensure that plant workers and other personnel are adequately protected from potential hazards associated with emissions.

The following sections discuss the ambient air monitoring network that has been developed at the Energy Systems Oak Ridge installations.

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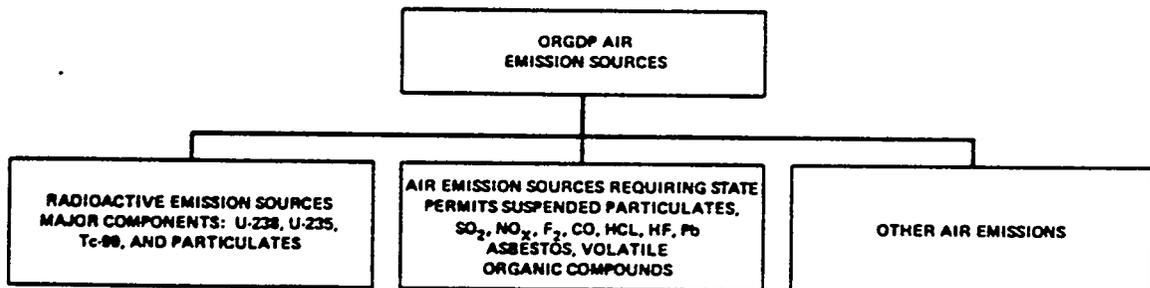


Fig. 2.1.10. Air emission sources at ORGDP.

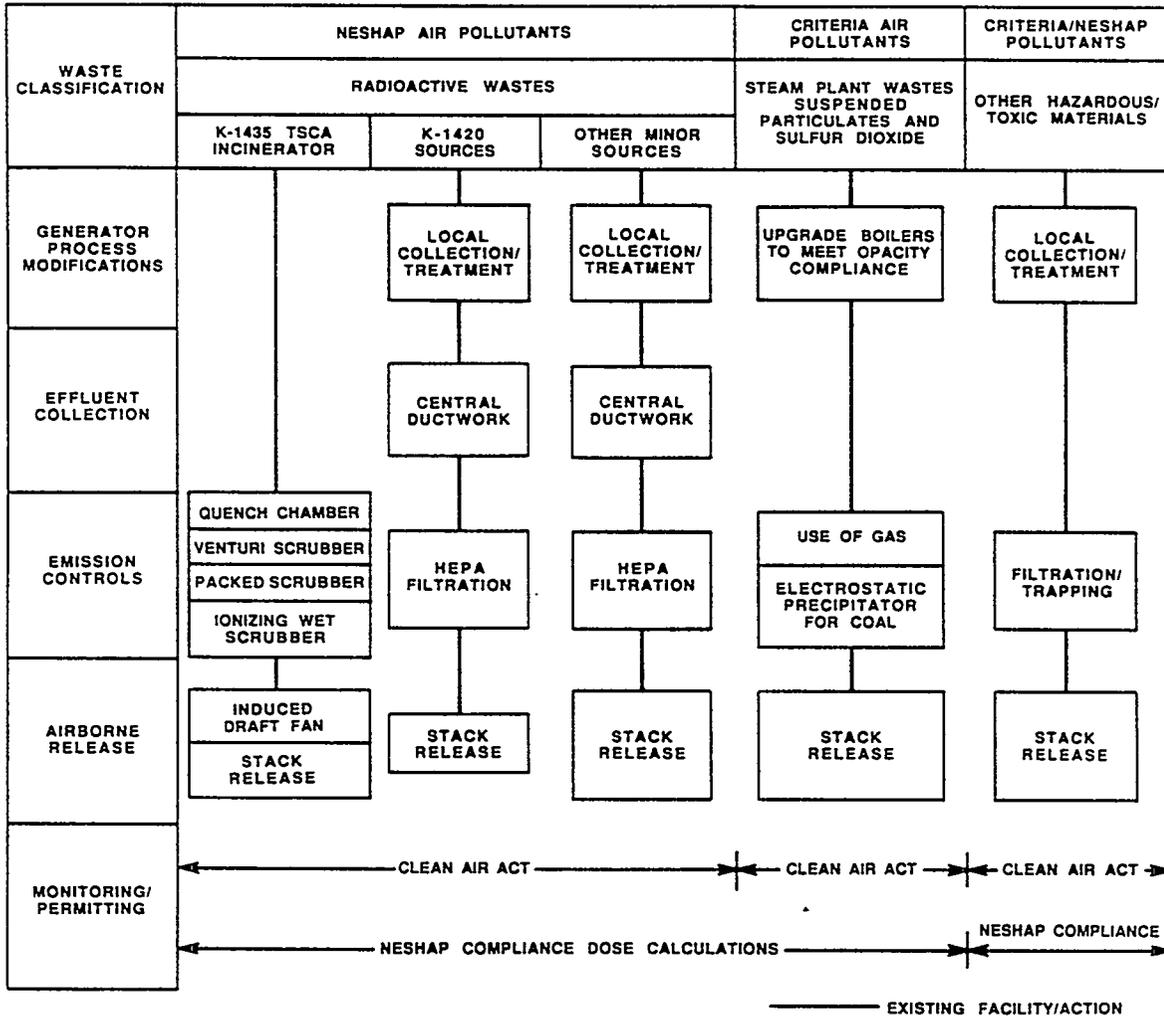


Fig. 2.1.11. Air pollution control program at ORGDP.

This network consists of a number of ambient air monitors located around the perimeter of each Oak Ridge 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 are operated by ORNL. The following discussions include data summary tables in which 1987 ambient air monitoring results for each station are summarized. For a more complete presentation of these data, see Vol. 2.

### 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.

Table 2.1.7. Estimated 1987 pollutant emissions for ORGDP

Pollutant	Emissions (tons/year)
SO <sub>2</sub>	414.7
NO <sub>x</sub>	93.5
Uranium	0.0004 (0.0003 Ci)
CO	13.3
Particulates	8.2
Ammonia	0.6
Fluorides	0.2
VOC <sup>a</sup>	40.6
Other <sup>b</sup>	3.4

<sup>a</sup>The degreaser baths in K-1401 use 1,1,1-trichloroethane, which is not defined by TDHE as a volatile organic compound. However, this material is a volatile organic.

<sup>b</sup>The "Other" category consists mainly of several acid vapors from decontamination and parts cleaning processes.

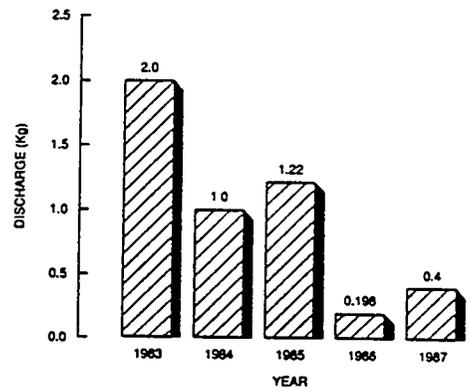


Fig. 2.1.13. Total kilograms of uranium discharged from ORGDP to the atmosphere.

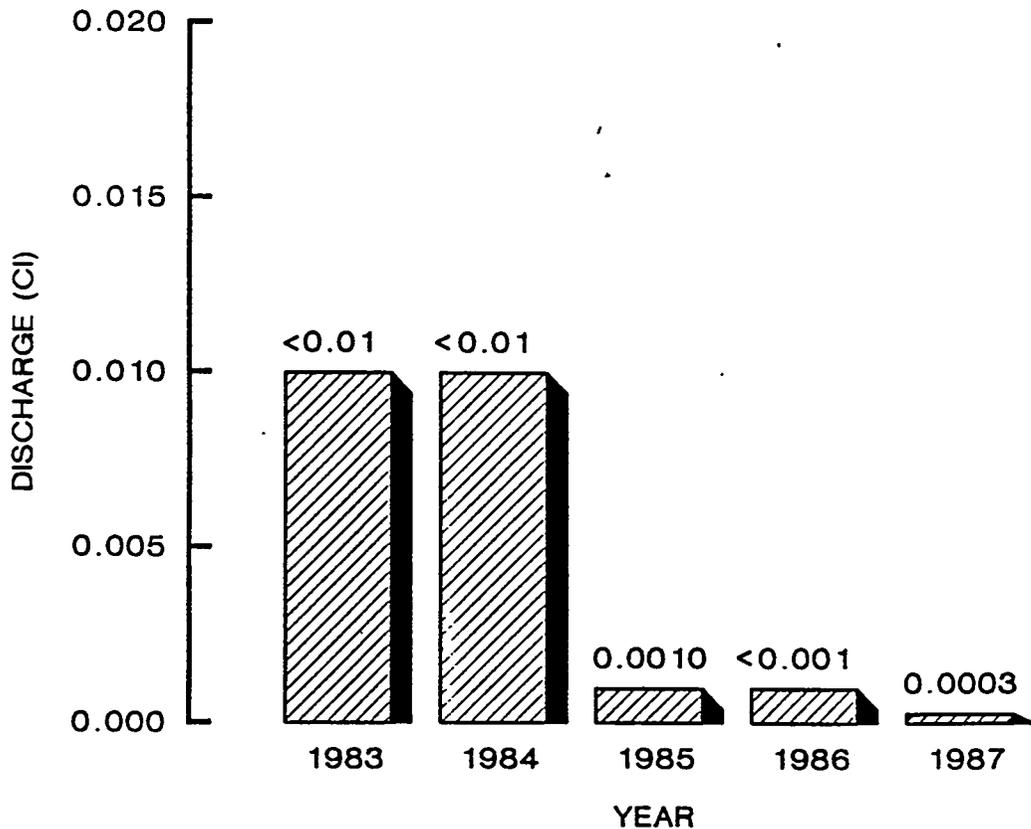


Fig. 2.1.12. Total curie discharges of uranium from ORGDP to the atmosphere.

Table 2.1.8. Emissions of gaseous chemicals to the atmosphere at ORGDP

Chemical item	Amount used in 1987 (kg)	Percentage of item assumed emitted	Estimated emissions (kg)
Acetylene	1,300	1	13 <sup>a</sup>
Alcohol	2,100	100	2,100
Argon	5,100	100	5,100
Mixed gases <sup>b</sup>	2,700	100	2,700
Carbon dioxide (gas)	2,500	100	2,500
Chlorine (liquid)	28,100	100	28,100 <sup>c</sup>
Fluorocarbons	11,000	100	11,000
Fluorine, hydrogen fluoride	6.7	100	6.7
Freon	2,500	100	2,500
Helium	170	100	170
Hydrogen	40	100	40
Nitrogen (gas)	16,000	100	16,000
Oxygen (gas)	3,700	5	185
Trichloroethane, perchloroethylene, methylene, chlorine, and acetone	6,800	100	6,800
Steam plant discharges, including SO <sub>2</sub> , NO <sub>x</sub> , and particulates			485,000

<sup>a</sup>Majority consumed by acetylene torches.

<sup>b</sup>The major constituent is argon.

<sup>c</sup>Used in the treatment of drinking water and sewage.

The Y-12 Plant operates 12 ambient air monitoring stations around the perimeter of the plant to routinely measure total suspended uranium particulates. Two additional ambient air monitoring stations are operated to monitor for total suspended particulates (TSP), and two stations are operated to continuously monitor ambient sulfur dioxide concentrations. The locations of the ambient air monitoring stations operated by the Y-12 Plant are shown in Fig. 2.1.14.

Ambient air fluoride sampling is conducted continuously at 11 of the 12 Y-12 Plant perimeter air monitors. Atmospheric fluoride is collected by absorption on 50-mm-diam 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 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 and around the plant perimeter. Monitoring of area ambient air quality ensures that plant workers and other personnel 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. The west TSP station was relocated in June 1987 because of problems associated with construction activity around the previous site and heavy traffic on a nearby roadway. 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

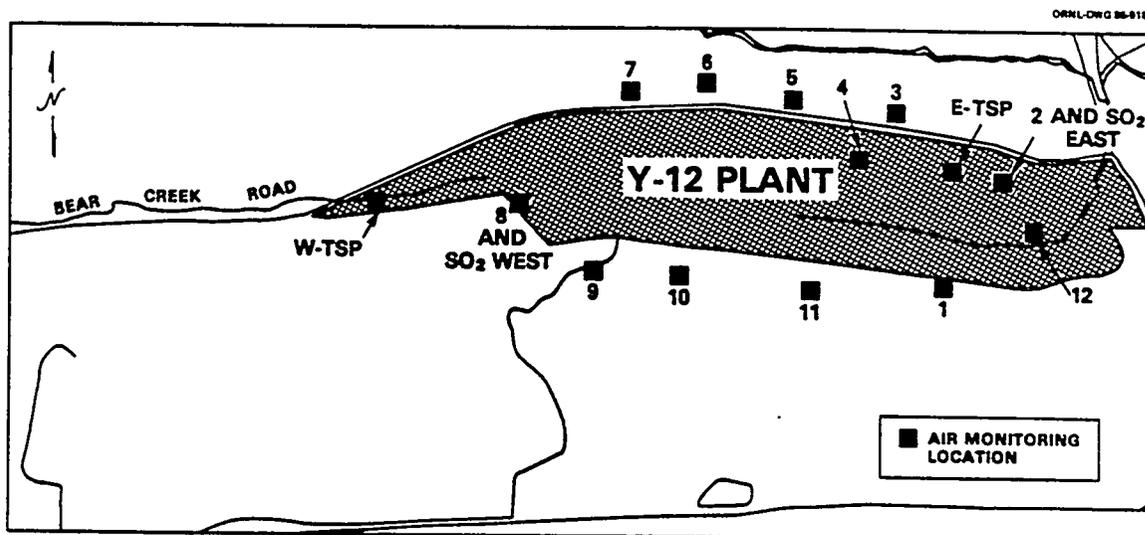


Fig. 2.1.14. Ambient air monitoring stations operated by the Y-12 Plant.

in  $\mu\text{g}/\text{m}^3$ ) 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 study the filter under a microscope to determine if the majority of the filter is covered with road dust, pollen, insects, and other particles arising from the natural environment.

Sulfur dioxide ( $\text{SO}_2$ ) 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  $\text{SO}_2$  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  $\text{SO}_2$  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 2.1.9 through 2.1.13. Table 2.1.9 shows the maximum, minimum, and average gross alpha and gross beta concentrations measured at each of the 12 stations during 1987. Similarly, the  $^{234}\text{U}$ ,  $^{235}\text{U}$ ,  $^{236}\text{U}$ , and  $^{238}\text{U}$  average uranium concentrations are shown in Table 2.1.10. Table 2.1.11 shows similar data for ambient fluoride concentration during 1987 as well as a comparison with the state standard for fluorides.

Table 2.1.12 summarizes the measured  $\text{SO}_2$  concentrations at each of the two Y-12 Plant  $\text{SO}_2$  monitoring stations during 1987. Table 2.1.13 shows TSP data for the two Y-12 Plant TSP ambient air monitoring stations during 1987. More detailed data are available in Sect. 2.1 in Vol. 2.

#### Discussion

Ambient air concentrations of fluorides measured during 1987 at each of the Y-12 Plant perimeter air monitoring fluoride stations were well within TDHE standards. As illustrated in Table 2.1.1 of Vol. 2, measured ambient air fluoride concentrations were considerably lower during the months of June through September 1987, when production operations were halted because of a strike by the ATLC. However, even

**Table 2.1.9. 1987 gross alpha and gross beta in air—Y-12 Plant perimeter ambient air monitoring stations**

Station ID	No. of samples	Concentration ( $10^{-15}$ $\mu\text{Ci}/\text{cm}^3$ ) <sup>a</sup>		
		Max	Min	Av
<i>Gross alpha<sup>b</sup></i>				
1	4	5.15	0.92	2.53
2	4	5.67	0.99	3.32
3	4	8.07	0.92	5.50
4	4	9.83	1.78	7.25
5	4	12.1	1.78	7.70
6	4	7.34	1.06	4.99
7	4	8.58	1.98	5.41
8	4	20.8	0.92	8.30
9	4	23.0	0.99	8.36
10	4	4.35	0.86	2.65
11	4	3.50	0.79	2.50
12	3	3.43	0.47	2.78
<i>Gross beta<sup>b</sup></i>				
1	4	23.1	9.43	17.1
2	4	22.6	9.94	16.5
3	4	24.1	10.1	19.6
4	4	25.7	8.68	19.7
5	4	24.9	10.3	20.0
6	4	23.5	9.68	18.9
7	4	25.2	11.8	20.3
8	4	25.8	9.48	19.0
9	4	22.9	9.08	18.2
10	4	20.8	8.97	16.1
11	4	21.3	6.87	15.7
12	3	19.4	7.67	12.1

<sup>a</sup>To convert from  $10^{-15}$   $\mu\text{Ci}/\text{cm}^3$  to  $10^{-11}$   $\text{Bq}/\text{cm}^3$ , multiply by 3.7

<sup>b</sup>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.

Table 2.1.10. 1987 uranium concentrations in air at the Y-12 Plant<sup>a</sup>

Station ID	No. of samples	Concentration ( $\mu\text{g}/\text{m}^3$ )			Percent DCG <sup>b</sup>
		Max	Min	Av	
<i><sup>234</sup>U</i>					
1	4	1.4	0.18	0.99	1.7
2	4	2.7	0.24	1.3	3.3
3	4	5.9	0.46	3.5	7.3
4	4	5.8	0.68	4.1	7.2
5	4	8.3	1.2	4.8	10
6	4	4.9	0.51	2.9	6.0
7	4	4.3	0.59	3.0	5.3
8	4	20	0.45	6.3	25
9	4	24	0.42	7.0	30
10	4	1.7	0.25	1.1	2.1
11	4	1.3	0.18	0.89	1.6
12	3 <sup>c</sup>	0.87	0.13	0.52	1.1
<i><sup>235</sup>U</i>					
1	4	0.088	0.016	0.05	0.082
2	3 <sup>d</sup>	0.056	0.043	0.05	0.052
3	4	0.23	0.036	0.13	0.21
4	4	0.26	0.024	0.18	0.24
5	4	0.39	0.079	0.21	0.36
6	3 <sup>d</sup>	0.18	0.063	0.11	0.17
7	4	0.13	0.013	0.084	0.12
8	4	0.6	0.12	0.29	0.56
9	4	0.72	0.025	0.22	0.67
10	4	0.049	0.028	0.037	0.045
11	4	0.096	0.014	0.043	0.089
12	3 <sup>c</sup>	0.082	0.036	0.061	0.076
<i><sup>236</sup>U</i>					
1	2 <sup>d</sup>	0.12	0.042	0.081	0.11
2	4	0.14	0.017	0.082	0.13
3	4	0.39	0.015	0.16	0.36
4	4	0.38	0.0098	0.21	0.35
5	3 <sup>d</sup>	0.37	0.11	0.25	0.34
6	3 <sup>d</sup>	0.27	0.14	0.22	0.25
7	4	0.25	0.011	0.14	0.23
8	4	0.35	0.044	0.20	0.32
9	3 <sup>d</sup>	0.37	0.11	0.24	0.34
10	4	0.31	0.013	0.11	0.29
11	3 <sup>d</sup>	0.081	0.073	0.078	0.075
12	3 <sup>c</sup>	0.15	0.02	0.07	0.14

Table 2.1.10 (continued)

Station ID	No. of samples	Concentration ( $\mu\text{g}/\text{m}^3$ )			Percent DCG <sup>b</sup>
		Max	Min	Av	
<sup>238</sup> U					
01	4	0.13	0.028	0.079	0.12
02	4	0.19	0.064	0.13	0.18
03	4	0.69	0.053	0.31	0.64
04	4	0.55	0.035	0.34	0.51
05	3 <sup>d</sup>	0.34	0.23	0.28	0.31
06	4	0.39	0.057	0.23	0.36
07	4	0.68	0.14	0.34	0.63
08	4	0.69	0.19	0.37	0.64
09	4	0.33	0.055	0.32	0.31
10	4	0.34	0.059	0.21	0.31
11	4	0.29	0.051	0.19	0.27
12	3 <sup>c</sup>	0.12	0.019	0.057	0.11

<sup>a</sup>See Fig. 2.1.14.

<sup>b</sup>Percent DCG = Maximum  $\times$  100/derived concentration guide (DCG). The DCG =  $81 \times 10^{-15} \mu\text{Ci}/\text{cm}^3$ .

<sup>c</sup>Installed in April 1987.

Table 2.1.11. 1987 fluorides in air at the Y-12 Plant

Station ID	No. of samples	Concentration ( $\mu\text{g}/\text{m}^3$ )				Percentage of standard <sup>b</sup>
		Max	Min	Av	Tenn. std. <sup>a</sup>	
1	53	0.0982	<0.007	<0.0156	1.6	0.98
2	53	0.1298	<0.007	<0.022	1.6	1.38
3	53	0.0947	<0.007	<0.0265	1.6	1.66
4	53	0.3228	<0.007	<0.0444	1.6	2.78
5	53	0.1439	<0.007	<0.0248	1.6	1.55
6	53	0.1018	<0.007	<0.0226	1.6	1.41
7	53	0.1123	<0.007	<0.0257	1.6	1.61
8	53	0.2105	<0.007	<0.0259	1.6	1.62
9	53	0.1298	<0.007	<0.0302	1.6	1.89
10	53	0.107	<0.007	<0.0166	1.6	1.04
11	53	0.0474	<0.007	<0.0135	1.6	0.84

<sup>a</sup>Tennessee standard 7-d average =  $1.6 \mu\text{g}/\text{m}^3$ .

<sup>b</sup>Percent of standard calculated using average fluoride concentration.

Table 2.1.12. 1987 sulfur dioxide in air—Y-12 Plant sulfur dioxide monitoring stations

Station ID	Concentration (ppm SO <sub>2</sub> )				
	Monthly av	Max 3-h av	Tenn. std. 3-h av	Max 24-h av	Tenn. std. 24-h av
East (004)	0.012	0.109	0.50	0.038	0.140
West (005)	0.008	0.152	0.50	0.051	0.140

Table 2.1.13. 1987 total suspended particulates in air—Y-12 Plant TSP monitoring stations

Station ID	No. of samples	Concentration (μg/m <sup>3</sup> )					
		Max	Min	Av	Tennessee standard <sup>a</sup>	Percent of standard <sup>b</sup>	Number of exceedances
East	59	129	0	45	260	17.3	0
West	59	558	0	69	260	26.5	3

<sup>a</sup>Tennessee primary air quality 24-h standard = 260 μg/m<sup>3</sup>.

<sup>b</sup>Percent of standard calculated using average TSP concentration.

during the months of full production, measured ambient air fluoride concentrations averaged less than 5% of the state standards.

Ambient uranium isotope concentrations measured at each of the 12 perimeter air monitoring stations around the Y-12 Plant were also very low. Although there is no federal or state standard that applies to ambient uranium or uranium isotope concentrations, measured values are within guidelines set forth under DOE Order 5480.xx. As shown in Table 2.1.2 of Vol. 2, measured uranium isotope concentrations were also considerably lower during the summer months (see Tables 2.1.2 and 2.1.5, Vol. 2) when production operations were affected by the ATLC strike.

Measured SO<sub>2</sub> concentrations at the two Y-12 Plant air monitoring stations were well within state standards throughout 1987 with the exception of a single 3-h average during the month of January (see Table 2.1.3 in Vol. 2). Although measured TSP concentrations did exceed state standards four times during 1987 at the west TSP station (see Table 2.1.4 in Vol. 2), these exceedances could be attributed to road

dust in the area of the station before its relocation in June.

Table 2.1.5 in Vol. 2 gives gross alpha and gross beta concentrations in air at the Y-12 Plant for 1987.

### 2.1.2.2 Oak Ridge National Laboratory

#### Description

Most gaseous wastes from ORNL are released to the atmosphere through stacks. Radioactivity may be present in gaseous waste streams as a solid (particulates), as an absorbable gas (radioiodine), tritium, or as a nonabsorbable species (noble gas). Gaseous wastes that may contain radioactivity are processed to reduce the radioactivity to acceptable levels before being discharged. In addition to monitoring stack effluents, atmospheric concentrations of materials occurring in the general environment around ORNL, the ORR, and the vicinity are monitored continuously by an air monitoring network of 24 stations. Relative locations of these stations are shown in Figs. 2.1.15 and 2.1.16. 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, 7, 9, 21, and 22. These stations are located at or near the ORNL boundary (shown in Fig. 2.1.15). Previously, stations 21 and 22 were used only for external gamma radiation measurements; there were no air sampling capabilities. However, sampling equipment has now been installed at station 22, which will begin operating in March 1988. Station 21 is currently being upgraded to provide sampling capability.
2. The DOE ORR perimeter air monitoring network consists of stations 8, 23, 31, 33, 34, 36, and 40-46 (see Fig. 2.1.15). Stations 31 through 45 have the capability to perform both sampling and continuous monitoring. Station 46 is currently being redeveloped to collect real-time data.
3. The remote air monitoring network consists of stations 51-53 and 55-57. These stations are located within a 120-km radius of ORNL outside the ORR (see Fig. 2.1.16).

At each real-time monitoring station, there are monitors for five radiation parameters (gross alpha, gross beta, iodine, gross gamma, and noble gas) and a rain gauge. A central processor collects 10-min-average readings and transmits the data to a computer for further analysis and reporting. The central processor checks the values against alarm limits. All alarms are reported to a printer as they occur. The primary purpose of the monitoring system is to determine if radiation levels on the Reservation are above background levels. If radiation levels appear to be higher than normal, additional sampling can be initiated to provide quantitative measures of concentrations in the atmosphere. In addition, three process sensors are used to calculate the volume of the sample collected. Sampling is done at each station to quantify levels of iodine, gross alpha, and gross beta. Sampling and analysis frequencies for each station are given in Table 2.1.14. The real-time monitoring system is the only measure of radioactive noble gases in the area.

Airborne radioactive particulates are collected weekly by pumping a continuous flow of air through a paper filter and then through a charcoal cartridge. The square paper filters previously used at the ORNL perimeter stations

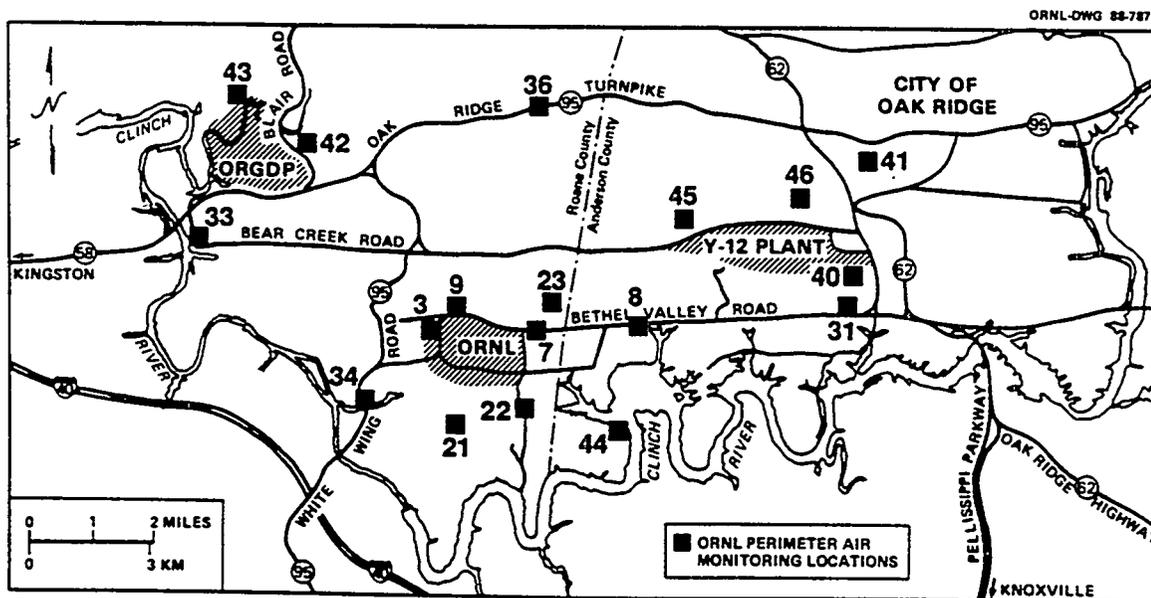
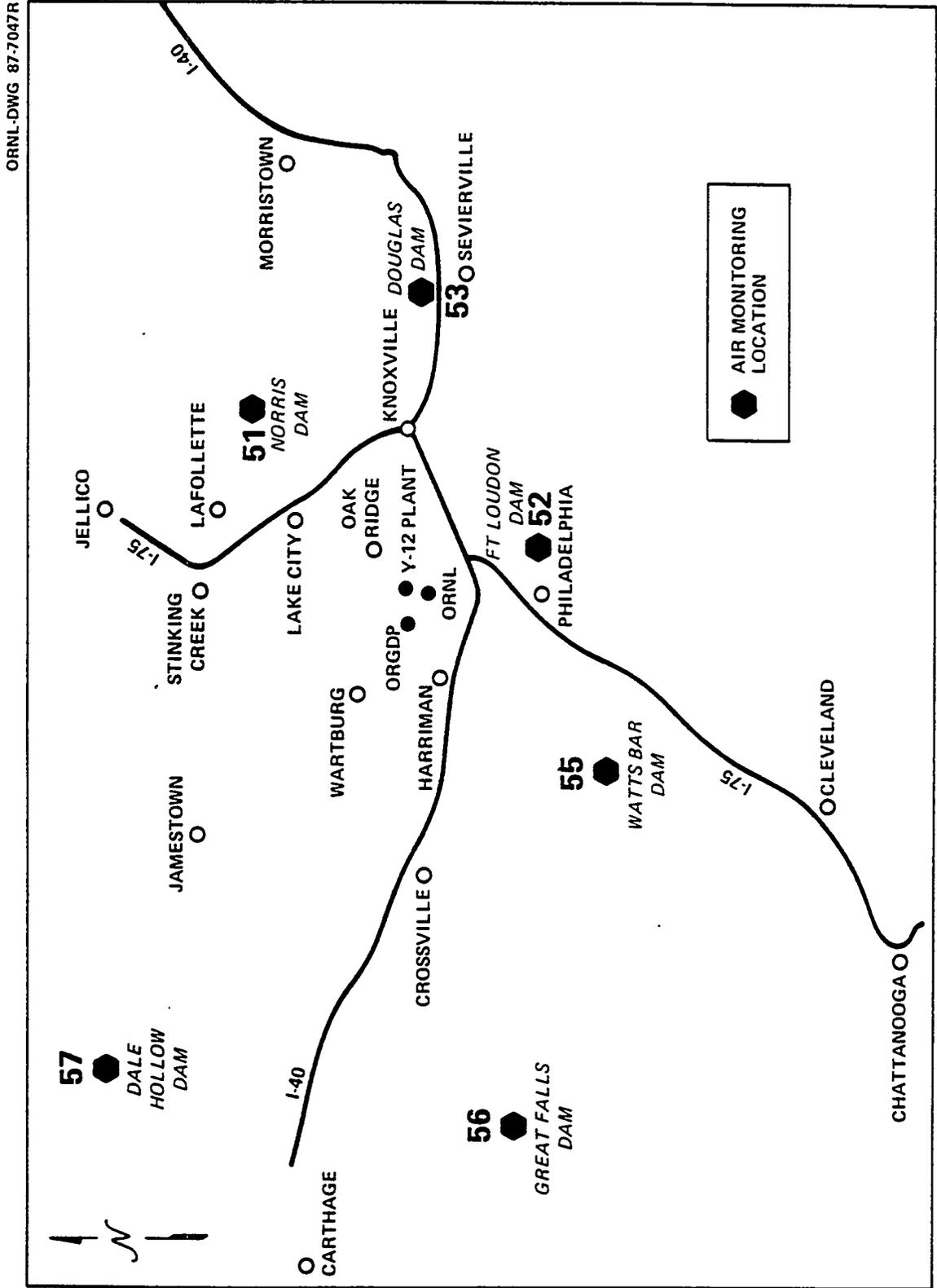


Fig. 2.1.15. ORR and ORNL perimeter monitoring locations.



ORNL-DWG 87-7047R

Fig. 2.1.1.16. Remote air monitoring locations.

Table 2.1.14. Summary of collection and analysis frequencies of air monitoring stations

Station <sup>a</sup>	Parameter	Collection frequency	Type	Analysis frequency
3, 7, 8, 9, 22, 23, 31, 33, 34, 36, 40, 41, 42	<sup>131</sup> I, gross alpha, gross beta	Weekly	Flow proportional	Weekly
3, 8	Tritium	Monthly	Flow proportional	Monthly
Local, <sup>b</sup> perimeter, <sup>c</sup> remote, <sup>d</sup> 34, 36, 40, 41, 45, 46	<sup>7</sup> Be, <sup>60</sup> Co, <sup>137</sup> Cs, <sup>238</sup> Pu, <sup>239</sup> Pu, <sup>228</sup> Th, <sup>230</sup> Th, <sup>232</sup> Th, total Sr, <sup>e</sup> <sup>234</sup> U, <sup>235</sup> U, <sup>238</sup> U	Weekly	Flow proportional	Quarterly

<sup>a</sup>See Figs. 2.1.15 and 2.1.16.

<sup>b</sup>Composite of 3, 7, 9, and 22.

<sup>c</sup>Composite of 8, 23, 31, 33, 42, 43, and 44.

<sup>d</sup>Composite of 51-53 and 55-57.

<sup>e</sup>Total radioactive Sr (<sup>89</sup>Sr + <sup>90</sup>Sr).

and at the remote stations have been replaced with round paper filters. The new filter is easier to handle and gives 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 papers are analyzed 3-4 d after collection. The airborne <sup>131</sup>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 off, and flow rates are recorded when a sampler is mounted or removed. The total volume of air that flowed through the sampler at each station is calculated using this information. The concentration of radionuclides in air is calculated by dividing the total activity per sample by the total volume of air. New stations have flow totalizers.

During 1987, monthly samples for atmospheric tritium were collected from ORNL perimeter station 3 and Reservation perimeter station 8. Samples have not been collected at ORNL perimeter station 7 since January because the station is being upgraded and has not been operational. 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, 7, 9, and 22), Reservation perimeter stations (excluding 34, 36, 40, 41, 45, and 46), remote stations (51-53 and 55-57), and individual stations (34, 36, 40, 41, 45, and 46) and are analyzed for specific radionuclides.

### Summary

Annual concentrations of gross alpha, gross beta, atmospheric <sup>131</sup>I, and tritium at the ORNL and Reservation perimeter and remote stations are summarized in Table 2.1.15. Air concentrations of gross alpha, gross beta, <sup>131</sup>I, and tritium at individual stations in each of the air monitoring networks are shown in Tables 2.1.6-2.1.9 of Vol. 2. Instrument background concentrations of each of these were subtracted from the measured concentrations. All data in the tables have been reported to two significant figures.

There appears to have been little or no alpha activity at any of the ORNL sampling stations during 1987 (see Vol. 2, Table 2.1.6). Average gross alpha concentrations at the ORNL and Reservation perimeter stations were near zero.

Table 2.1.15. 1987 radionuclide concentrations in air

Area <sup>a</sup>	Determination	Number of samples	Concentration ( $1 \times 10^{-15}$ Ci/m <sup>3</sup> )				
			Max	Min	Av	95% cc <sup>b</sup>	%DCG <sup>c</sup>
ORNL perimeter stations	Gross alpha	184	7.6	-3.5	-0.90	0.27	
	Gross beta	184	42	0	16	1.2	
	<sup>131</sup> I	184	9.6	-3.8	0.67	0.24	0.01
	<sup>3</sup> H	25	0.1	0.00058	0.0019	0.0087	0.1
	<sup>60</sup> Co	4	0.18	<0.063	<0.10	0.054	0.01
	<sup>137</sup> Cs	4	0.13	<0.052	<0.085	0.038	0.01
	<sup>238</sup> Pu	4	0.0011	-0.00076	0.00020	0.00085	0.01
	<sup>239</sup> Pu	4	0.00041	-0.0022	-0.00059	0.0012	0.01
	<sup>228</sup> Th	4	0.069	0.00076	0.022	0.031	0.26
	<sup>230</sup> Th	4	0.019	0.0015	0.0099	0.0074	0.073
	<sup>232</sup> Th	4	0.021	0.00076	0.0010	0.0086	0.26
	Total Sr <sup>d</sup>	4	0.042	-0.12	-0.028	0.078	0.01
	<sup>234</sup> U	4	0.50	0.030	0.20	0.20	0.62
	<sup>235</sup> U	4	0.050	0.0030	0.029	0.023	0.047
<sup>238</sup> U	4	0.084	0.017	0.052	0.029	0.078	
Reservation perimeter stations	Gross alpha	665	25	-6.1	-0.64	0.19	
	Gross beta	665	53	1.2	22	0.71	
	<sup>131</sup> I	665	6.6	-4.9	0.54	0.11	<0.01
	<sup>60</sup> Co	4	<0.063	<0.043	<0.049	0.0096	<0.01
	<sup>137</sup> Cs	4	0.086	<0.022	<0.047	0.027	<0.01
	<sup>238</sup> Pu	4	0.0049	-0.0000	0.0013	0.0023	0.012
	<sup>239</sup> Pu	4	-0.00045	-0.0044	-0.0015	0.0019	<0.01
	<sup>228</sup> Th	4	0.059	0.0009	0.022	0.025	0.22
	<sup>230</sup> Th	4	0.027	0.0004	0.012	0.011	0.10
	<sup>232</sup> Th	4	0.030	0.0004	0.014	0.012	0.37
	Total Sr <sup>d</sup>	4	0.027	-0.035	0.0093	0.030	0.01
	<sup>234</sup> U	4	0.92	0.056	0.39	0.37	1.1
	<sup>235</sup> U	4	0.12	0.0028	0.063	0.058	0.11
	<sup>238</sup> U	4	0.11	0.023	0.079	0.041	0.11
Remote stations	Gross alpha	280	11	-5.0	1.1	0.24	
	Gross beta	280	70	-7.9	15	2.1	
	<sup>60</sup> Co	4	<0.050	<0.030	<0.042	0.0082	<0.01
	<sup>137</sup> Cs	4	<0.092	<0.030	<0.057	0.026	<0.01
	<sup>238</sup> Pu	4	-0.00020	-0.0010	-0.00052	0.00035	<0.01
	<sup>239</sup> Pu	4	-0.00014	-0.0065	-0.0024	0.0029	<0.01
	<sup>228</sup> Th	4	0.037	0.00066	0.017	0.018	0.14
	<sup>230</sup> Th	4	0.025	0.00033	0.011	0.011	0.093
	<sup>232</sup> Th	4	0.029	0.00033	0.011	0.013	0.36
	Total Sr <sup>d</sup>	4	0.070	0.0066	0.030	0.028	0.01
	<sup>234</sup> U	4	0.090	0.033	0.052	0.025	0.11
	<sup>235</sup> U	4	0.0034	0.0014	0.0022	0.00088	0.01
	<sup>238</sup> U	4	0.036	0.022	0.031	0.0064	0.034

<sup>a</sup> See Figs. 2.1.15 and 2.1.16.

<sup>b</sup>95% cc = 95% confidence coefficient about the average.

<sup>c</sup>Percent DCG = maximum  $\times$  100/derived concentration guide (DCG).

<sup>d</sup>Total radioactive Sr (<sup>89</sup>Sr + <sup>90</sup>Sr).

There were statistically significant differences among the average concentrations of the ORNL perimeter and remote stations and among the Reservation perimeter and remote stations. These concentrations are low and close to zero and are probably due to differences in natural background levels of gross alpha. The highest concentration of gross alpha was measured at Reservation perimeter station 23 in Walker Branch watershed. This concentration was probably the result of a uranium release at the Y-12 Plant. During the release, the predominant wind direction was toward this station. These data are supported by the measurement of uranium isotopes on filter papers following the release. (Also see the tables in Vol. 2 for specific isotopic concentrations.)

There was very little gross beta activity measured during 1987 at any of the ORNL sampling stations (see Table 2.1.7 of Vol. 2). Statistically significant differences were observed between the Reservation perimeter stations and the ORNL perimeter and remote stations. While the remote stations had the highest maximum gross beta values observed during the year, the Reservation perimeter stations had the highest average concentrations.

Table 2.1.8 in Vol. 2 gives the  $^{131}\text{I}$  concentrations at the ORNL and Reservation perimeter stations. Iodine-131 is not sampled at the remote stations because the concentrations are below minimum levels of detectability. There were no statistically significant differences in the  $^{131}\text{I}$  concentrations between the two ORNL networks (ORNL and Reservation perimeter stations). The last column in Table 2.1.8 of Vol. 2 compares the maximum values measured at each of these stations with the derived concentration guide (DCG) for  $^{131}\text{I}$  in air. In all cases, the maximum concentration was less than 0.04% of the DCG.

Annual tritium concentration summaries are given in Table 2.1.9 of Vol. 2. There were no significant differences in the average concentrations between ORNL stations 3 and 8. Concentrations at station 3 were highly variable, ranging from 3.8 to 100 pCi/m<sup>3</sup>. The maximum tritium concentration was compared with the DCG for tritium in air; all maximum

concentrations were less than 0.1% of the DCG.

Results of the quarterly analysis of composited air filters are given for each isotope and for total radioactive strontium ( $^{89}\text{Sr} + ^{90}\text{Sr}$ ) in Tables 2.1.10–2.1.20 of Vol. 2. When there is a release of uranium from the Y-12 Plant, filters from the Reservation perimeter stations are submitted for specific isotopic analysis of uranium so that a dose to the public can be estimated. These results are weighted for the period of release with the other results for the quarter to estimate the quarterly concentration. The last column of these tables gives the maximum concentration observed during the year as a ratio of the DCG. Of the ten radionuclides and total radioactive strontium analyzed, all maximum levels except for  $^{234}\text{U}$  were less than 1% of the DCG for inhaled air. No ratio of the maximum value to the DCG exceeds 5%. The highest concentrations of  $^{234}\text{U}$  (see Table 2.1.18 in Vol. 2) were observed near the Y-12 Plant at stations 45 (west Y-12), 46 (Scarboro community), and 40 (east Y-12) during releases. An elevated level of  $^{234}\text{U}$  was observed on the filter from perimeter station 23 during one of these events. This contributed significantly to the Reservation perimeter station maximum.

### 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. 2.1.17. These monitors sample ambient air for 24 h every sixth day to be consistent with the TDHE TSP sampling schedule. The analysis parameters for the 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.

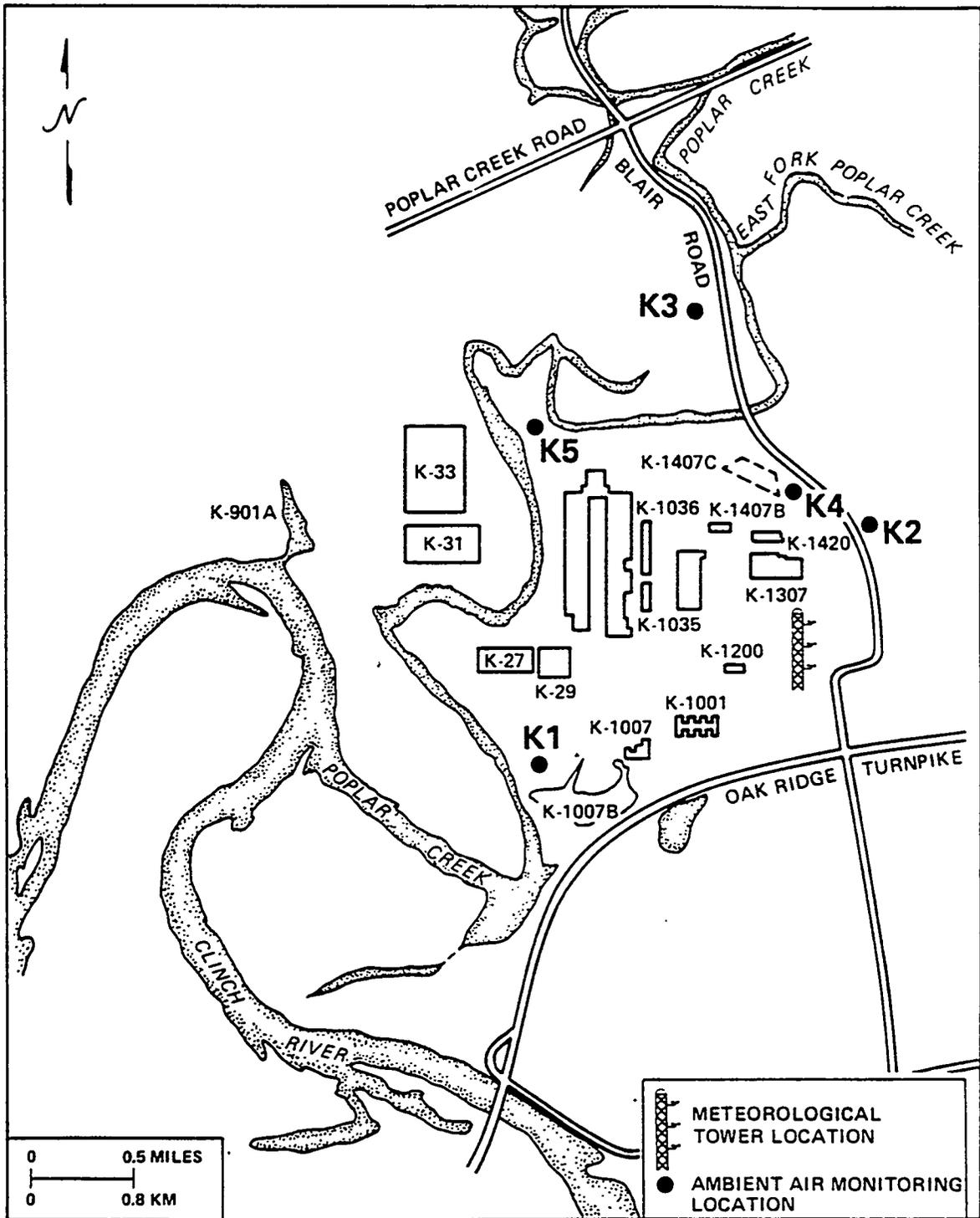


Fig. 2.1.17. Location of ORGDP ambient air monitors and meteorological tower.

Fluoride sampling was not conducted at ORGDP in 1987 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 of results

Table 2.1.16 summarizes data for each parameter monitored by the ORGDP ambient air monitoring system. Each monitor, K1 through K5, was sampled for each parameter 24 h every sixth day through the year. The number of samples per location ranged from 56 to 61. The number of samples taken by each monitor varied primarily because of mechanical equipment failures.

As can be seen from the data summary tables, no standards were exceeded. In fact, for total suspended particulates, no maximum reading reached 50% of the secondary standard. For lead, the percentage of standard never exceeded 3%.

### 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. 2.1.18, consists of one 60-m tower at ORGDP (MT1); one 100-m tower (MT2) and two 30-m towers (MT3 and MT4) at ORNL; and one 100-m tower (MT5) and one 60-m tower (MT6) at the Y-12 Plant. The other

towers (MT7 and MT8) shown in Fig. 2.1.18 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 and at the top of the tower. At the 100-m towers, data are collected at intermediate (30- or 60-m) 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 data are polled, checked for validity against a predetermined set of parameters, summarized, and filed on disk. Fifteen-minute and hourly values are stored at each site for a running 24-h period. Only hourly data are routinely stored beyond 24 h. Data archiving on magnetic tape occurs every month. The meteorological monitoring data from all towers are checked quarterly, with summaries of data and wind roses, such as the data from MT2 presented in Fig. 2.1.19. 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. In the event of releases in excess of a few hours, hourly data are input to dispersion models. These data are extracted from the archival computer file. Annual releases are analyzed 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).

Table 2.1.16. 1987 ORGDP environmental air sampling

Sample point <sup>a</sup>	No. of samples	Concentration ( $\mu\text{g}/\text{m}^3$ )			Percentage of standard (based on maximum concentration)	
		Max	Min	Geometric average	Primary standard	Secondary standard
<i>TSP<sup>b</sup></i>						
K1	58	67.30	5.58	20.46 $\pm$ 4.03	26	45
K2	61	61.17	3.64	20.30 $\pm$ 3.56	26	41
K3	61	63.04	4.91	20.38 $\pm$ 3.50	24	42
K4	59	66.19	5.69	24.32 $\pm$ 4.46	25	44
K5	56	64.97	5.24	21.13 $\pm$ 3.98	25	43
<i>Lead<sup>c</sup></i>						
K1	58	0.0390	<0.0049	<0.0134 $\pm$ 0.0020	3	NA <sup>d</sup>
K2	61	0.0415	<0.0052	<0.0147 $\pm$ 0.0022	3	NA
K3	61	0.0375	<0.0049	<0.0151 $\pm$ 0.0020	2	NA
K4	59	0.0511	<0.0053	<0.0183 $\pm$ 0.0027	3	NA
K5	56	0.0357	<0.0046	<0.0135 $\pm$ 0.0021	2	NA
<i>Chromium<sup>e</sup></i>						
K1	58	0.0050	<0.0024	<0.0027 $\pm$ 0.0001	NA	NA
K2	61	0.0049	<0.0024	<0.0027 $\pm$ 0.0001	NA	NA
K3	61	0.0052	<0.0003	<0.0024 $\pm$ 0.0001	NA	NA
K4	59	0.0071	<0.0021	<0.0029 $\pm$ 0.0002	NA	NA
K5	56	0.0045	<0.0023	<0.0025 $\pm$ 0.0001	NA	NA
<i>Nickel<sup>f</sup></i>						
K1	58	0.0139	<0.0024	<0.0038 $\pm$ 0.0006	NA	NA
K2	61	0.0125	<0.0024	<0.0037 $\pm$ 0.0005	NA	NA
K3	61	0.0122	<0.0014	<0.0034 $\pm$ 0.0006	NA	NA
K4	59	0.0133	<0.0022	<0.0042 $\pm$ 0.0007	NA	NA
K5	56	0.0136	<0.0023	<0.0034 $\pm$ 0.0007	NA	NA
<i>Uranium<sup>g</sup></i>						
K1	58	0.0006	<0.0001	<0.0002 $\pm$ 0.0000	0.4	NA
K2	61	0.0018	<0.0001	<0.0002 $\pm$ 0.0001	1.15	NA
K3	61	0.0017	<0.0001	<0.0002 $\pm$ 0.0001	1.15	NA
K4	59	0.0017	<0.0001	<0.0003 $\pm$ 0.0002	1.15	NA
K5	56	0.0016	<0.0001	<0.0002 $\pm$ 0.0001	1.15	NA

<sup>a</sup>See Fig. 2.1.17.

<sup>b</sup>Primary standard for TSP for the state of Tennessee is 260  $\mu\text{g}/\text{m}^3/24$  h. Secondary standard for TSP for the state of Tennessee is 150  $\mu\text{g}/\text{m}^3/24$  h.

<sup>c</sup>The primary standard for lead is 1.5  $\mu\text{g}/\text{m}^3$ .

<sup>d</sup>Not applicable.

<sup>e</sup>There are no standards for chromium.

<sup>f</sup>There are no ambient air standards for nickel.

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

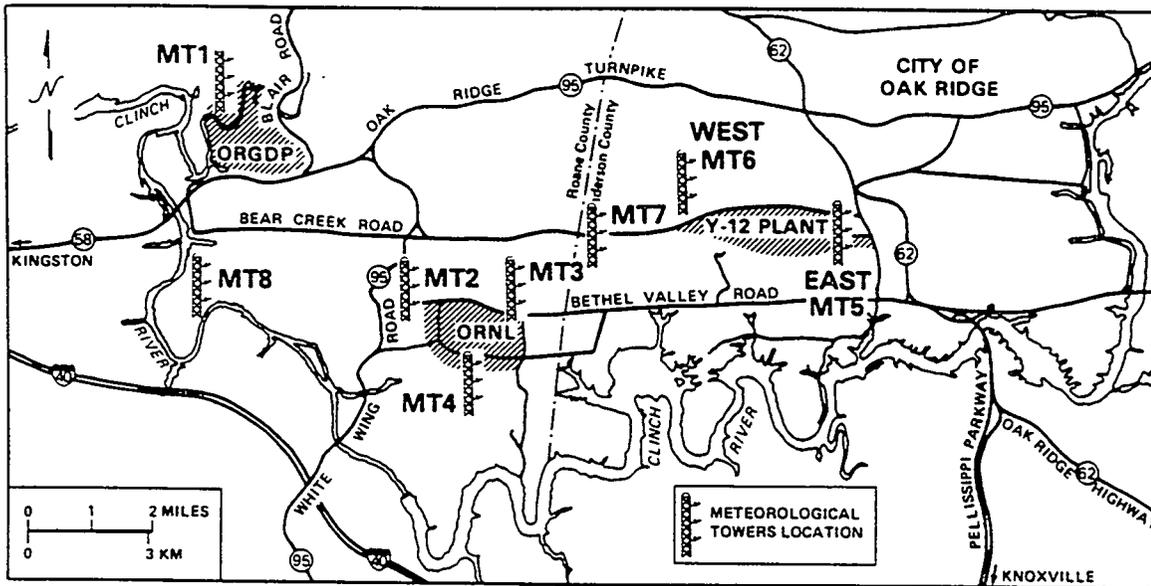


Fig. 2.1.18. ORR meteorological monitoring network.

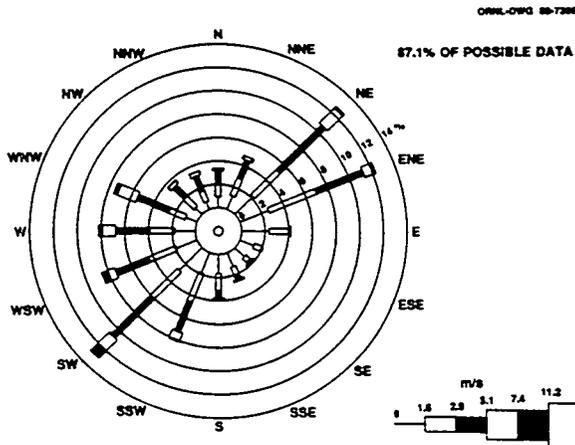


Fig. 2.1.19. Wind rose for ORNL tower MT2 (100-m level).

2.1.3.2 Summary

The data presented in Fig. 2.1.19 are from the 100-m tower located west of ORNL. Wind roses from other tower locations are presented in Figs. 2.1.1–2.1.12 of Vol. 2. The information contained in Fig. 2.1.19 is useful in describing the meteorological conditions of the Reservation. Prevailing winds are generally up-valley from the southwest and west-southwest, or down-valley

from the northeast and east-northeast. This pattern is the result of the channeling effect of the ridges flanking the site. Winds in the valleys tend to follow the ridges, with limited cross-ridge flow. Any material released in these valley winds would tend to stay within the valley. These conditions are dominant over the entire Reservation, with the exception of the ORGDP site, which is located in a relatively open area that has more varied flows. However, somewhat weaker valley flows are noted in the ORGDP area, particularly in locations near the Clinch River.

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

The atmosphere over the Reservation is dominated by stable conditions on most nights and in early morning hours. These conditions, coupled with the low wind speeds and channeling effects of 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 the towers 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. 2.1.20). The data from the ORNL tower location reflect a generally similar trend.

## 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 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 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 not attributed to geologic variation but to different contaminant loadings. 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 ORR activities, by contamination introduced upstream from the ORR, 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

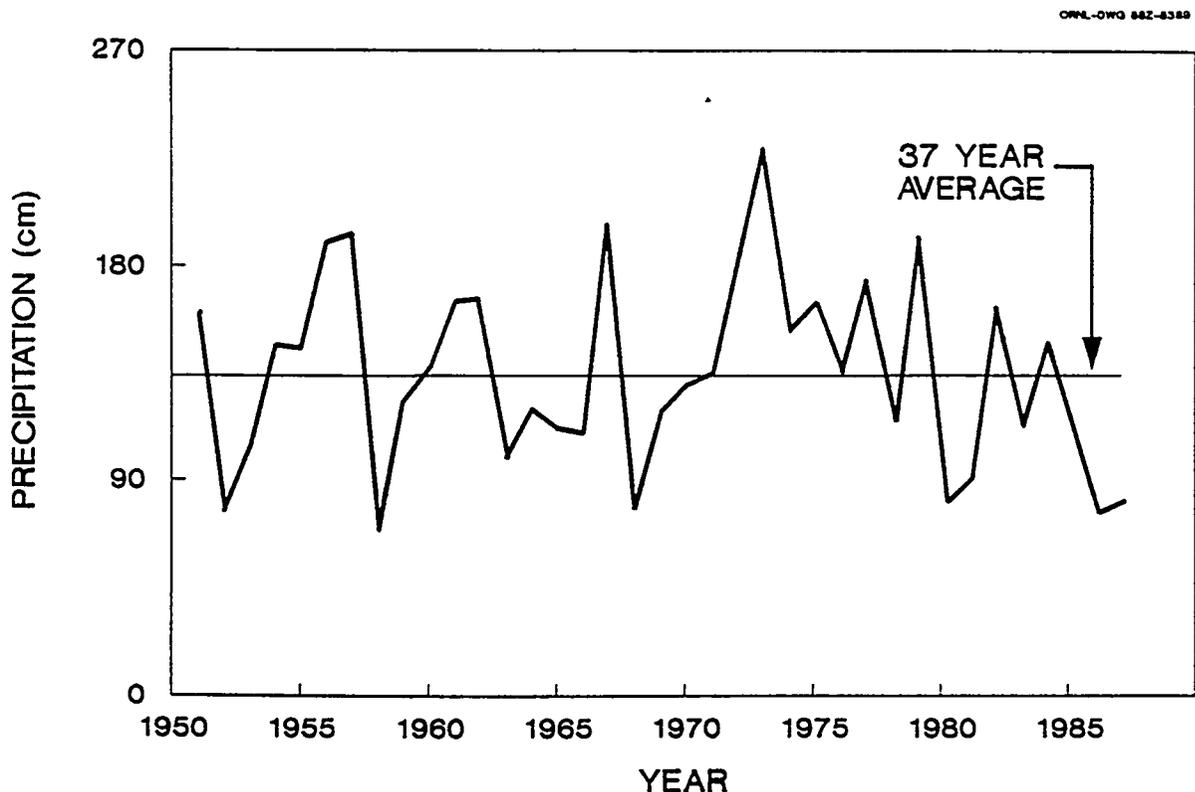


Fig. 2.1.20. Precipitation summary for the Oak Ridge area.

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, 3.2 km 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 content.

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

Water samples are collected for analyses of nonradioactive substances at many locations both on and off the ORR. Concentrations of chemicals in streams and creeks on or around the ORR are then compared with Tennessee's in-stream allowable concentrations, which are based on the long-term protection of domestic water supply, fish and aquatic life, and recreation classifications and recommendations made by TDHE to DOE-Oak Ridge Operations (ORO). Concentrations of chemicals in the outlet for the ORGDP sanitary water plant are 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

Surveillance of the water environment consists of the collection of surface water samples and samples required under the National Pollutant Discharge Elimination System (NPDES) permit. Samples are analyzed for radionuclides and nonradioactive chemicals.

### 2.2.1.1 Oak Ridge Y-12 Plant

At the Y-12 Plant, surface water is monitored routinely at two locations that are not required by NPDES permit No. TN0002968. At each of these locations, samples are collected for both radiological and nonradiological parameters.

The first location is at kilometer 12.4 on upper Bear Creek near the S-3 ponds area. 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 these data is presented in Table 2.2.1.) Comparison of data collected at kilometer 12.4 on upper Bear Creek during 1987 with data collected in 1986 shows a continuation of the improvements in water quality noted since the S-3 ponds were emptied of wastewater in 1986.

Monitoring is also conducted at the influent to New Hope Pond. 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 of purposes. Samples at the influent to New Hope Pond are collected at the same time as samples from the effluent of the pond to help determine the effectiveness of the pond in improving the quality of water in East Fork Poplar Creek as well as monitoring the effectiveness of Y-12 Plant's area source control activities. Data from these locations indicate that New Hope Pond does act as a sink for contaminants, thus reducing the quantities of contaminants leaving the site. The data are also used to determine the most effective manner in which to close New Hope Pond under the Resource Conservation and Recovery Act (RCRA). (Summaries of the

Table 2.2.1. 1987 annual summary for Upper Bear Creek

Parameter	Concentration <sup>a</sup>		
	Max	Min	Av
Hg	0.0020	<0.0002	<0.0004
Alpha (pCi/L)	1000.0	6.7	496.5
<sup>241</sup> Am (pCi/L)	<6.80	<0.10	<1.53
Beta (pCi/L)	2000.0	9.3	776.1
<sup>237</sup> Np (pCi/L)	18.00	0.23	<2.43
<sup>238</sup> Pu (pCi/L)	<2.70	<0.03	<0.70
<sup>239/240</sup> Pu (pCi/L)	<1.80	<0.03	<0.30
<sup>99</sup> Tc (pCi/mL)	<40.00	<0.03	<1.50
<sup>235</sup> U (pCi/L)	40.00	<0.58	<11.17
<sup>235</sup> U (%)	5.44	0.21	0.50
U	1.690	0.019	0.969
CN	0.120	<0.002	<0.013
F	1.1	0.5	0.8
Nitrate-nitrogen	600.0	6.6	198.0
Dissolved oxygen	12.0	2.8	6.8
pH (units)	7.5	6.8	7.2
Phenols	0.140	<0.001	<0.004
TDS	4100	290	2003
TSS	100	0.5	<10
Chloroform (µg/L)	80	<10	<10
Methylene chloride (µg/L)	48	<10	<10
Perchloroethylene (µg/L)	<10	<10	<10
Trichloroethane (µg/L)	<10	<10	<10
Trichloroethylene (µg/L)	<10	<10	<10
PCB	0.0006	<0.0005	<0.0005
Aluminum	20.60	<0.01	<1.01
Arsenic	<0.04	<0.04	<0.04
Barium	0.1950	0.0275	0.0764
Beryllium	0.0010	<0.0001	<0.0002
Boron	0.1700	0.0350	0.1088
Cadmium	0.017	<0.003	<0.006
Calcium	680.0	59.8	352.4
Cerium	0.03	<0.02	<0.02
Chromium	0.014	<0.006	<0.006
Cobalt	0.008	<0.002	<0.002
Copper	0.025	<0.002	<0.004
Gallium	0.02	<0.01	<0.01
Iron	11.70	<0.02	<0.57
Lanthanum	0.003	<0.003	<0.003
Lead	0.02	<0.02	<0.02
Lithium	0.060	0.011	0.021
Magnesium	130.0	8.2	60.8
Manganese	5.400	0.139	1.918
Molybdenum	<0.006	<0.006	<0.006
Nickel	0.029	<0.007	<0.008
Niobium	<0.06	<0.01	<0.01
Phosphorus	0.30	<0.06	<0.07
Potassium	21.2	3.6	9.2

Table 2.2.1. (continued)

Parameter	Concentration <sup>a</sup>		
	Max	Min	Av
Scandium	0.0033	<0.0004	<0.0005
Silver	0.006	<0.004	<0.004
Sodium	179.0	29.2	82.5
Strontium	1.570	0.148	0.886
Thorium	<0.01	<0.01	<0.01
Titanium	0.119	<0.002	<0.009
Vanadium	0.018	<0.004	<0.004
Zinc	0.097	<0.001	<0.009
Zirconium	0.006	<0.002	<0.002

<sup>a</sup>Units are in mg/L unless noted otherwise.

influent data are presented in Tables 2.2.2 and 2.2.3.)

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 in final form on December 16, 1987. Before issuance of this permit, monitoring was conducted in accordance with a draft permit issued in February 1986. These data are summarized in Tables 2.2.4 and 2.2.5.

#### 2.2.1.2 Oak Ridge National Laboratory

The ORNL site is drained by two main streams, White Oak Creek (WOC) and Melton Branch. With the exception of two small discharges from the 7600 area to Melton Hill Lake, all ORNL effluents discharge to these two main streams or their tributaries. WOC flows through Bethel Valley, where Fifth Creek, First Creek, and Northwest Tributary enter it. WOC continues through a gap in Haw Ridge into Melton Valley, and is joined there by Melton Branch, which drains Melton Valley. WOC then continues to White Oak Lake, which is controlled by White Oak Dam (WOD) and is the last monitoring/sampling point before effluents leave the ORNL site. Below WOD, WOC is affected by water levels in the Clinch River that are controlled by Melton Hill Dam (see Fig. 2.2.1).

The Clinch River flows southwest from Virginia to its mouth near Kingston, Tennessee, where it joins the Tennessee River. Major discharges to WOC include (1) treated domestic (sanitary) waste from the sewage treatment plant (STP); (2) cooling tower blowdown; (3) cooling water from various sources; (4) surface drainage from the main ORNL area, including drainage from solid waste storage areas (SWSAs) 3, 4, 6, and 7 and the pits and trenches process; (5) discharges from waste collection (190 pond area) and the process waste treatment plant (PWTP) (3544); and (6) discharges from process building areas. Major discharges to Melton Branch include those from SWSA 5, blowdown from the recirculating cooling water system at the High Flux Isotope Reactor (HFIR), and discharges from the 7900 waste pond system.

#### Radiological description

ORNL does not perform any nonradiological sampling of surface waters other than that specified in the NPDES permit (see Sect. 2.2.2). This section is limited to a discussion of radiological sampling performed by ORNL.

**Off-site streams/discharges.** Treated water samples are collected weekly at the Kingston and ORGDP (Gallaher) potable water treatment plants and are analyzed quarterly for radionuclides (see Fig. 2.2.2). For comparison, samples were collected daily from the ORNL potable water system (tap water) in Building

Table 2.2.2. 1987 annual summary for New Hope Pond influent radiological data

Parameter	Concentration <sup>a</sup>		
	Max	Min	Av
<sup>241</sup> Am	4.3	<0.27	<1.01
<sup>137</sup> Cs	<23	<5.4	<11
<sup>60</sup> Co	<21	<5.6	<12
<sup>237</sup> Np	<1.6	<0.4	<0.8
<sup>95</sup> Nb	<24	<6.8	<11
<sup>238</sup> Pu	<0.97	<0.04	<0.38
<sup>239/240</sup> Pu	<0.22	<0.04	<0.12
<sup>226</sup> Ra	6.1	<0.4	<1.6
<sup>106</sup> Ru	<135	<39	<87
<sup>90</sup> Sr	<9.1	<6.0	<7.0
<sup>99</sup> Tc (pCi/mL)	<40	<0.02	<3.6
<sup>228</sup> Th	4.1	0.15	0.97
<sup>230</sup> Th	<1.6	<0.3	<0.73
<sup>232</sup> Th	<1.6	<0.09	<0.4
Thorium, total (mg/L)	0.189	<0.003	<0.024
Tritium	<1300	<10	<763.6
<sup>234</sup> U	19	<0.85	<10
<sup>235</sup> U activity	19	<0.34	<2.3
<sup>235</sup> U (%)	1.22	<0.52	<0.83
<sup>238</sup> U	10	0.3	<5.5
Uranium, total (mg/L)	0.029	0.007	0.017
<sup>95</sup> Zr	<53	<14	<22

<sup>a</sup>Units are in pCi/L unless noted otherwise.

4500S and analyzed quarterly for radionuclides. 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 for radionuclides (see Table 2.2.6). 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. Sampling and analysis frequencies at these locations are given in Table 2.2.6.

**On-site streams/discharges.** To determine discharges of radionuclides from ORNL processes, flow and concentration data from ORNL streams were recorded. Water samples were collected regularly from the following stations (see Table 2.2.6): 1500 area, 190 ponds, First Creek, 2000 area, acid neutralization facility (3518), PWTP (3544), Fifth Creek, 7500 bridge, Melton Branch 1 (MB1), Melton Branch

2 (MB2), Melton Hill Dam, Northwest Tributary (NWT), Raccoon Creek, STP, transuranic waste (TPP) ponds, HFIR, WOC, WOC headwaters, and WOD (see Figs. 2.2.1 and 2.2.3). Real-time monitoring of pH, dissolved oxygen, turbidity, conductivity, temperature, flow, and beta and gamma activity (in cpm) was performed at Melton Branch, WOC, and WOD; a gamma spectrum was also monitored at WOD. The samples collected and analyzed daily at the 7500 bridge were used as an early warning of radioactive discharges from ORNL processes (see Fig. 2.2.1). Radiological monitoring at stations in the 1500 area, 190 ponds, 3518, and 3544 was initiated in February 1987 to comply with the requirements of the NPDES Radiological Monitoring Plan.

#### Radiological summary

The annual radionuclide summaries for the off-site stream monitoring locations are given in

Table 2.2.3. 1987 annual summary for New Hope Pond  
influent nonradiological data

Parameter	Concentration (mg/L)		
	Max	Min	Av
Mercury	0.22	0.0005	0.0082
Selenium	<0.002	<0.002	0.002
Ammonia	2.1	<0.4	<0.5
BOD	9	<5	<5
COD	35	4.6	<11
Chloride	300	<2	<23
Cyanide	0.113	<0.002	<0.025
Fluoride	11	0.7	1.0
Nitrate	8	1.8	3.1
TOC	250	<2	<6
TDS	670	120	250
TSS	170	<5	<9
Sulfate	110	21	55
Aluminum	4.64	0.09	0.59
Arsenic	<0.04	<0.04	<0.04
Barium	0.468	0.039	0.053
Beryllium	0.0002	<0.0001	<0.0001
Boron	0.067	<0.015	<0.022
Cadmium	<0.003	<0.003	<0.003
Calcium	64.1	38.9	48.0
Cerium	<0.02	<0.02	<0.02
Chromium	0.026	<0.006	<0.007
Cobalt	0.004	<0.002	<0.002
Copper	0.029	0.005	0.012
Gallium	<0.01	<0.01	<0.01
Iron	8.18	0.07	0.77
Lanthanum	<0.003	<0.003	<0.003
Lead	0.02	<0.02	<0.02
Lithium	0.392	0.007	0.025
Magnesium	15.1	9.02	11.6
Manganese	0.229	0.032	0.080
Molybdenum	0.338	0.055	0.162
Nickel	0.36	<0.007	<0.009
Niobium	<0.01	<0.01	<0.01
Phosphorus	0.74	0.2	0.41
Potassium	3.4	1.4	2.1
Scandium	0.0011	<0.0004	<0.0004
Silver	<0.004	<0.004	<0.004
Sodium	148	7	17
Strontium	0.259	0.107	0.131
Thorium	<0.01	<0.01	<0.01
Titanium	0.058	<0.002	<0.006
Vanadium	0.011	<0.004	<0.005
Zinc	0.246	0.043	0.094
Zirconium	0.004	<0.002	<0.002

Table 2.2.4. 1987 annual summary for West end sanitary sewer<sup>a</sup>

Parameter	Concentration <sup>b</sup>		
	Max	Min	Av
Mercury	0.0250	0.0003	0.0054
Alpha (pCi/L)	65.0	<1.0	<30.2
Beta (pCi/L)	126.0	<4.0	<32.1
<sup>238</sup> Pu (pCi/L)	<0.91	<0.10	<0.42
<sup>235</sup> U (pCi/L)	9.20	0.36	<1.93
<sup>235</sup> U (%)	3.22	0.63	1.55
Uranium	0.026	0.002	0.011
CN	0.010	0.002	0.017
NO <sub>3</sub> -N	11	0.1	<2.5
pH (units)	7.9	7.4	NA <sup>c</sup>
Kjeldahl nitrogen	28	0.5	17
TSS	220	<5	<51
PCB	0.0020	<0.0005	<0.0007
BOD	58	<5	<29
Aluminum	4.51	0.02	0.73
Arsenic	<0.04	<0.04	<0.04
Barium	0.1480	0.0387	0.0809
Beryllium	0.0005	<0.0001	<0.0002
Boron	0.0690	0.0140	0.0330
Cadmium	0.010	<0.003	<0.004
Calcium	58.8	36.9	47.7
Cerium	<0.02	<0.02	<0.02
Chromium	0.007	<0.006	<0.006
Cobalt	0.004	<0.002	<0.002
Copper	0.077	<0.002	<0.024
Gallium	<0.01	<0.01	<0.01
Iron	4.22	0.07	1.07
Lanthanum	<0.003	<0.003	<0.003
Lead	<0.02	<0.02	<0.02
Lithium	0.015	0.001	0.007
Magnesium	13.6	6.54	10.64
Manganese	0.370	0.034	0.166
Molybdenum	0.026	<0.006	<0.008
Nickel	0.027	<0.007	<0.011
Niobium	<0.01	<0.01	<0.01
Phosphorus	7.64	0.12	2.97
Potassium	14.4	2.3	7.3
Scandium	<0.0004	<0.0004	<0.0004
Silver	<0.004	<0.004	<0.004
Sodium	42.2	12.5	21.2
Strontium	0.168	0.083	0.129
Thorium	<0.01	<0.01	<0.01
Titanium	0.062	<0.002	<0.012
Vanadium	<0.004	<0.004	<0.004
Zinc	0.567	0.015	0.190
Zirconium	<0.002	<0.002	<0.002

<sup>a</sup>All samples collected in accordance with the Oak Ridge Sewer Use Ordinance were within the limits set in the permit with the exception of one cyanide result. The single cyanide value above the limit specified in the permit was investigated, but the cause has not been determined. Follow-up sampling indicated the cyanide excursion was of short duration and that samples have returned to normal values.

<sup>b</sup>Units are in mg/L unless noted otherwise.

<sup>c</sup>Not applicable.

Table 2.2.5. 1987 annual summary for East end sanitary sewer

Parameter	Concentration <sup>a</sup>		
	Max	Min	Av
Mercury	0.0080	0.0003	0.0024
Alpha (pCi/L)	150.0	<1.0	<36.6
Beta (pCi/L)	85.0	<4.0	<27.9
<sup>238</sup> Pu (pCi/L)	<2.30	<0.17	<0.53
<sup>235</sup> U (pCi/L)	12.00	<0.12	<1.71
<sup>235</sup> U (%)	2.08	0.31	1.16
Uranium	0.190	0.002	0.024
CN	0.011	<0.002	<0.005
NO <sub>3</sub> -N	4.5	0.2	1.1
pH (units)	8.1	7.6	NA <sup>b</sup>
Kjeldahl nitrogen	22	6.0	13
TSS	210	<5.0	<35
PCB	<0.0005	<0.0005	<0.0005
BOD	86	<5	<29
Aluminum	0.92	0.05	0.23
Arsenic	<0.04	<0.04	<0.04
Barium	0.0750	0.0346	0.0472
Beryllium	<0.0001	<0.0001	<0.0001
Boron	0.0600	0.0160	0.0260
Cadmium	<0.003	<0.003	<0.003
Calcium	53.2	37.9	42.7
Cerium	<0.02	<0.02	<0.02
Chromium	<0.006	<0.006	<0.006
Cobalt	<0.002	<0.002	<0.002
Copper	0.024	0.005	0.014
Gallium	<0.01	<0.01	<0.01
Iron	0.91	0.16	0.36
Lanthanum	<0.003	<0.003	<0.003
Lead	<0.02	<0.02	<0.02
Lithium	0.064	0.004	0.018
Magnesium	12.2	0.05	9.57
Manganese	0.167	0.043	0.084
Molybdenum	0.154	0.010	0.043
Nickel	0.010	<0.007	<0.007
Niobium	<0.01	<0.01	<0.01
Phosphorus	3.60	0.89	2.14
Potassium	10.3	3.6	5.8
Scandium	<0.0004	<0.0004	<0.0004
Silver	0.046	<0.004	<0.012
Sodium	17.7	8.4	13.6
Strontium	0.144	0.102	0.118
Thorium	<0.01	<0.01	<0.01
Titanium	0.007	<0.002	<0.003
Vanadium	0.005	<0.004	<0.004
Zinc	0.222	0.059	0.122
Zirconium	<0.002	<0.002	<0.002

<sup>a</sup>All units are in mg/L unless noted otherwise.

<sup>b</sup>Not applicable.

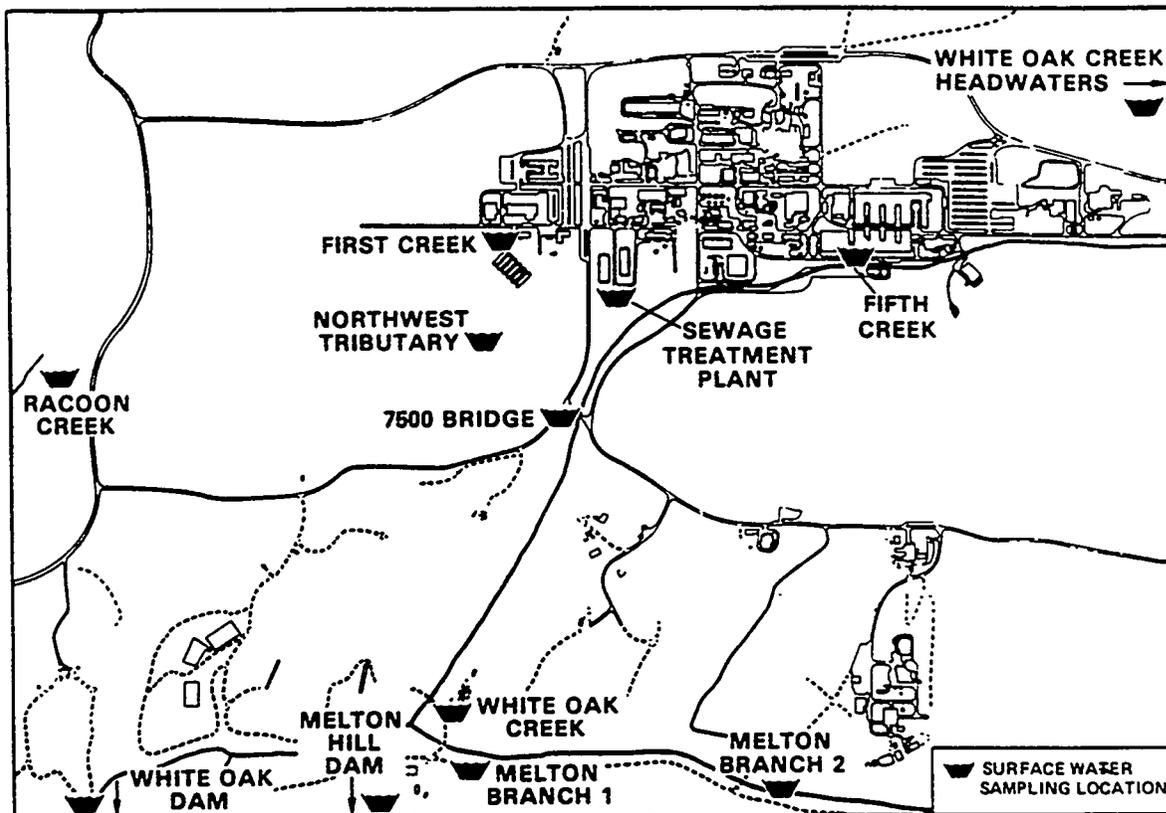


Fig. 2.2.1. ORNL water sampling locations.

Table 2.2.7. The maximum concentration is given as a percentage of the derived concentration guide (DCG) in the last column of this table. None of the percentages was above 0.1%. No  $^{60}\text{Co}$  or  $^{137}\text{Cs}$  was detected at any location except Melton Hill Dam, where one quarterly measurement revealed a 2.5-pCi/L level (detection limit) of  $^{137}\text{Cs}$ . There were no significant differences in the total radioactive strontium, total plutonium, or  $^{235}\text{U}$  measured at any of the four locations. ORNL tap water concentrations of uranium isotopes were at least as low as in the off-site streams. Differences in the stream concentrations of uranium isotopes may be the result of natural background levels.

Because facilities located near these creeks may discharge to the creeks, sampling and analysis of the processes and their discharges are discussed here.

In some cases, the software used for estimating concentrations of radionuclides in water subtracts the instrument background, which may result in negative numbers being reported. Before the software was upgraded for some analyzers, a lower limit of detection was reported. Not all analytical laboratories currently have the capability to report values below the lower limits of detection. To compare radionuclide concentrations in surface water for all Oak Ridge facilities, the results have been adjusted to the lowest reporting limit established by a multiplant analytical committee. Summary statistics for each radionuclide at each surface water sampling location are given in Table 2.2.1 in Vol. 2. The last column in this table shows the maximum value for each radionuclide as a percent of the DCG for water. All results have been reported to two significant figures.

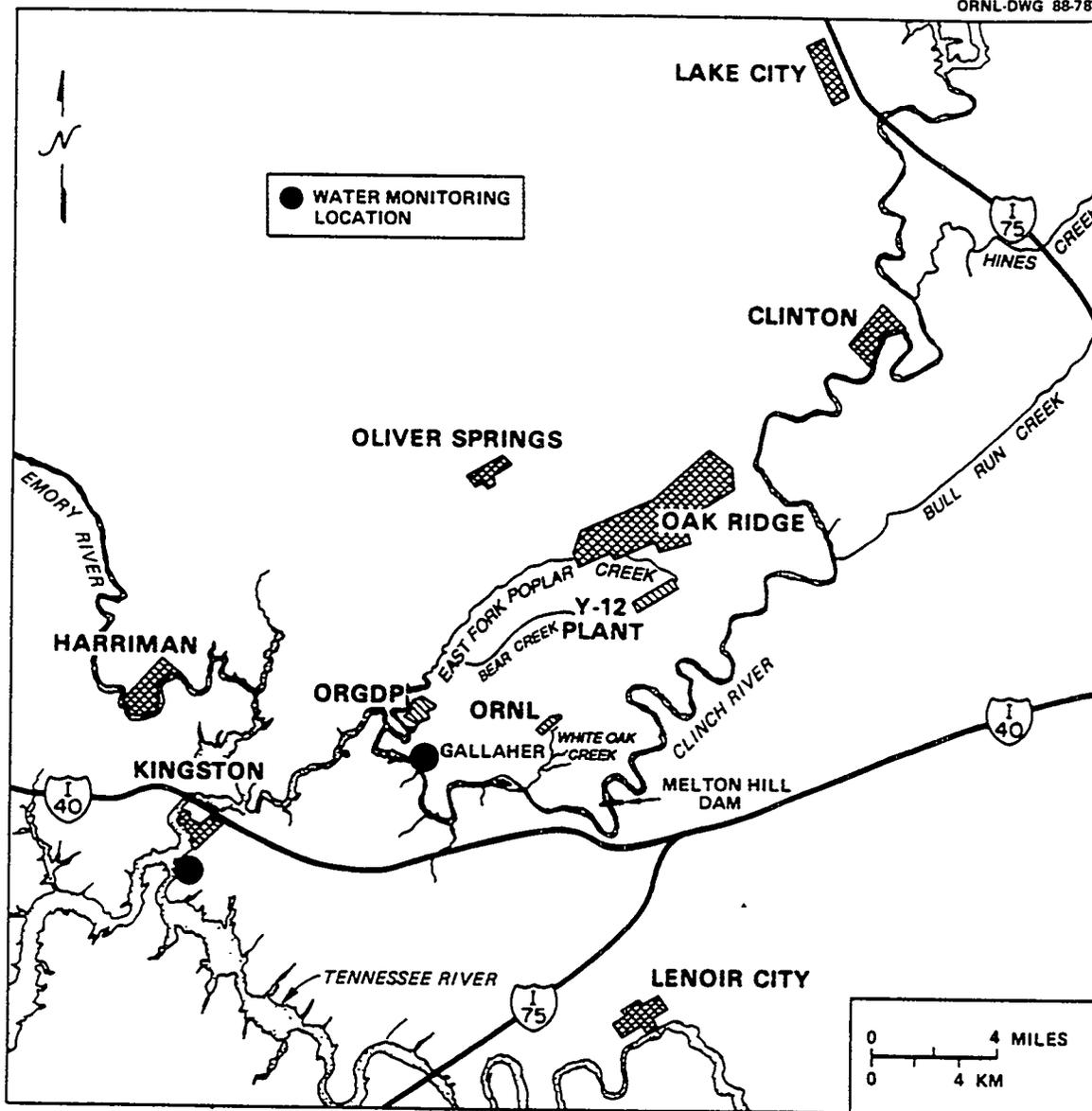


Fig. 2.2.2. Kingston and Gallaher water sampling locations.

The maximum concentrations of  $^{241}\text{Am}$ ,  $^{244}\text{Cm}$ ,  $^{238}\text{Pu}$ ,  $^{239}\text{Pu}$ ,  $^{228}\text{Th}$ ,  $^{230}\text{Th}$ ,  $^{232}\text{Th}$ ,  $^{234}\text{U}$ ,  $^{235}\text{U}$ ,  $^{238}\text{U}$ , and  $^{152}\text{Eu}$  were less than 1% of the DCG at all surface water stations measured.

At 5 of the 17 surface water monitoring stations where  $^{60}\text{Co}$  was measured, the maximum concentration was greater than 1% of the DCG. All of these releases are primarily attributable to process discharges. The highest percentage (295%) of the DCG was measured at the discharge from the HFIR ponds. Below this

discharge point at MB2 (0.61 km), the maximum  $^{60}\text{Co}$  concentration was 19% of the DCG. Further downstream at MB1 (0.91 km), the maximum percentage of the DCG was only 1.6%. Other locations where the maximum  $^{60}\text{Co}$  exceeded 1% of the DCG include the discharges from the 3544 PWTP (5%) and the 190 ponds (1.8%), which receive process waste from the 4500 area.

The maximum  $^{137}\text{Cs}$  concentrations exceeded 1% of the DCG at 6 of 17 stations. Cesium-137 releases to the creeks appear to be primarily the

Table 2.2.6. Summary of collection and analysis frequencies of surface 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 <sup>d</sup>	Weekly	Flow proportional	Monthly
3544	Gross alpha, gross beta, gamma scan, Total Sr <sup>d</sup>	Weekly	Flow proportional	Monthly
7500 Bridge	Gamma scan, Total Sr <sup>d</sup>	Daily	Time proportional	Daily
7500 Bridge, MB1, WOC, MB2	Gamma scan, Total Sr <sup>d</sup> , <sup>3</sup> H	Weekly	Flow proportional	Monthly
First Creek, Fifth Creek, Raccoon Creek	Gamma scan, Total Sr <sup>d</sup>	Weekly	Grab	Monthly
Gallaher, Kingston	<sup>3</sup> H, <sup>60</sup> Co, <sup>137</sup> Cs, gamma scan, gross alpha, gross beta, Pu, Total Sr <sup>d</sup> , U	Weekly	Grab	Quarterly
HFIR Ponds	Gamma scan, gross alpha, gross beta	After discharge	Flow proportional	Monthly
Melton Hill Dam	<sup>241</sup> Am, <sup>244</sup> Cm, <sup>60</sup> Co, <sup>137</sup> Cs, gross alpha, Pu, Th, U, Total Sr <sup>d</sup> , <sup>3</sup> H	Weekly	Flow proportional	Quarterly
NWT	Gamma scan, Total Sr <sup>d</sup>	Weekly	Flow proportional	Monthly
ORNL Tap	<sup>60</sup> Co, <sup>137</sup> Cs, gross alpha, gross beta, Pu, Total Sr <sup>d</sup> , U	Daily	Grab	Quarterly
ORR	<sup>60</sup> Co, <sup>137</sup> Cs, gross alpha, gross beta	After discharge	Flow proportional	Monthly
WOC Headwaters	<sup>241</sup> Am, <sup>244</sup> Cm, <sup>60</sup> Co, <sup>137</sup> Cs, gross alpha, Total Sr <sup>d</sup> , <sup>3</sup> H, Pu, Th, U	Weekly	Grab	Monthly
WOD	<sup>241</sup> Am, <sup>244</sup> Cm, <sup>60</sup> Co, <sup>137</sup> Cs, gross beta, Pu, Total Sr <sup>d</sup> , <sup>3</sup> H	Weekly	Flow proportional	Weekly
TPP Ponds	Gross beta	After discharge	Flow proportional	Monthly

<sup>d</sup>Total radioactive Sr (<sup>89</sup>Sr + <sup>90</sup>Sr).

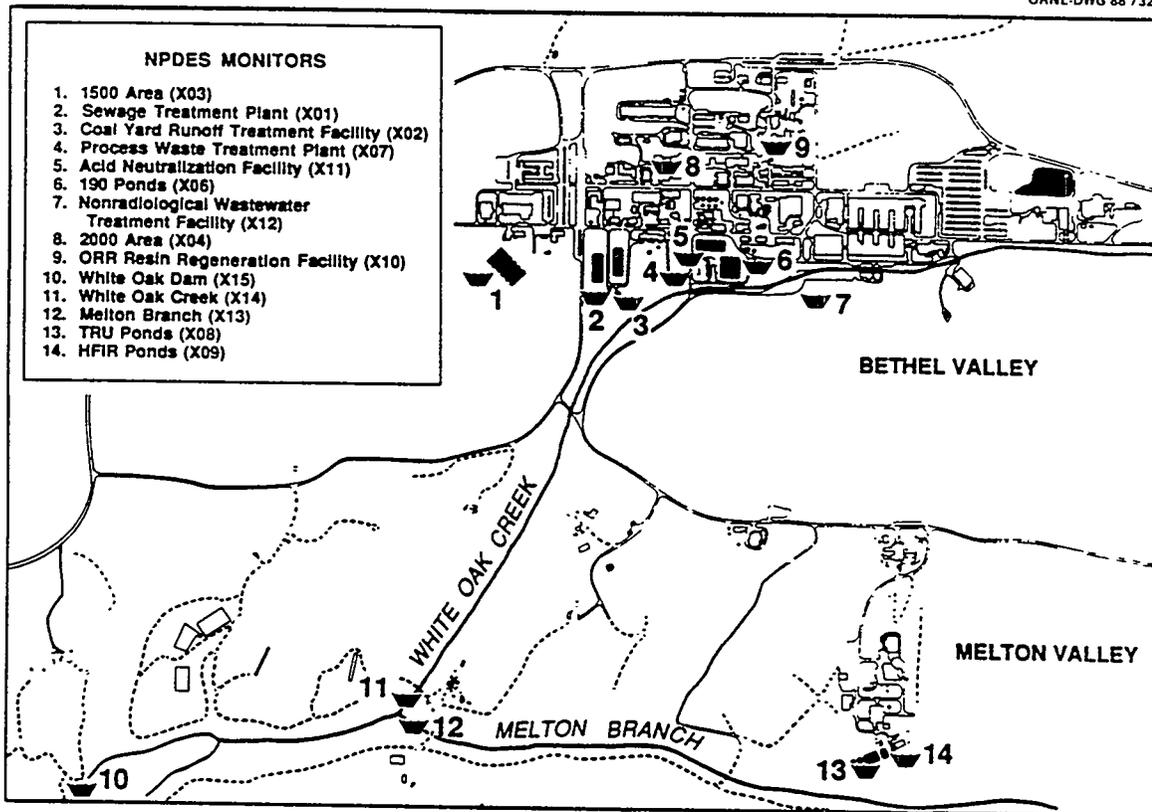


Fig. 2.2.3. ORNL NPDES monitoring locations.

result of process discharges. The highest percentage of the DCG for  $^{137}\text{Cs}$  was in the discharge from the 3544 PWTP (97%) and from the 190 ponds (64%). Other stations where the percentage of the DCG for  $^{137}\text{Cs}$  exceeded 1% include WOD (11%), WOC (7.1%), 7500 bridge (3.2%), and the discharge from the HFIR ponds (2.3%). Concentrations of  $^{137}\text{Cs}$  at WOC and WOD appear to be coming from SWSAs 4 and 5 and the pits and trenches area of the burial grounds (SWSA 6).

At all 11 stations where total radioactive strontium was measured, the maximum concentration, as a percentage of the DCG, was greater than 1%. The highest percentages occurred in First Creek (75%), MB1 (55%), WOD (38%), and the STP (35%). 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 3000 area. Unlike the  $^{60}\text{Co}$  and  $^{137}\text{Cs}$  discharges, which are primarily process related, the total radioactive strontium releases are more diffuse and are probably the result of surface runoff and subsurface input rather than discharges from process facilities.

Maximum tritium ( $^3\text{H}$ ) concentrations exceeded 1% of the DCG at five of seven stations. The two stations where the percentage was less than 1 are background or reference stations (WOC headwaters and Melton Hill Dam). The highest percentages were measured at MB1 station (163%), followed by the WOD station (88%), WOC station (63%), and MB2 station (35%). 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

Table 2.2.7. 1987 radionuclide concentrations in water around ORNL

Radionuclide	Number of samples	Concentration (pCi/L)				Percent of DCG <sup>b</sup>
		Max	Min	Av	95% cc <sup>a</sup>	
<i>Gallaher<sup>c</sup></i>						
<sup>60</sup> Co	4	<2.5	<2.5	<2.5	0.0	<0.046
<sup>137</sup> Cs	4	<2.5	<2.5	<2.5	0.0	<0.093
Gross Alpha	4	3.5	1.1	2.6	1.1	NA
Gross Beta	4	7.0	4.6	5.6	1.1	NA
Total Pu	4	0.050	0.050	0.050	0.0	0.0019
Total Sr	4	4.6	2.0	3.3	1.2	0.43
Tritium	4	2500	1500	1700	480	0.11
<sup>234</sup> U	4	0.10	0.050	0.079	0.026	0.019
<sup>235</sup> U	4	0.050	0.050	0.050	0.0	0.0093
<sup>236</sup> U	4	0.00035	<0.000032	<0.00014	0.00015	0.0010
<sup>238</sup> U	4	0.068	0.050	0.056	0.0084	0.013
<i>Kingston<sup>c</sup></i>						
<sup>60</sup> Co	4	<2.5	<2.5	<2.5	0.0	<0.046
<sup>137</sup> Cs	4	<2.5	<2.5	<2.5	0.0	<0.093
Gross Alpha	4	1.8	1.0	1.3	0.37	NA
Gross Beta	4	4.0	4.0	4.0	0.0	NA
Total Pu	4	0.050	0.050	0.050	0.0	0.0019
Total Sr	4	4.3	2.0	3.0	1.2	0.40
Tritium	4	1500	1500	1500	0.0	0.069
<sup>234</sup> U	4	0.10	0.062	0.079	0.021	0.019
<sup>235</sup> U	4	0.050	0.050	0.050	0.0	0.0093
<sup>236</sup> U	4	0.00059	<0.000099	<0.00029	0.00021	0.0010
<sup>238</sup> U	4	0.061	0.050	0.053	0.0054	0.011
<i>Melton Hill<sup>c</sup></i>						
<sup>60</sup> Co	4	<2.5	<2.5	<2.5	0.0	<0.046
<sup>137</sup> Cs	4	2.5	<2.5	<2.5	0.0	0.093
Gross Alpha	4	2.2	<1.0	<1.3	0.57	NA
Gross Beta	4	7.0	4.3	5.7	1.2	NA
Total Pu	4	0.050	0.050	0.050	0.0	0.0019
Total Sr <sup>e</sup>	4	3.8	2.0	2.5	0.85	0.35
<sup>234</sup> U	4	0.14	0.091	0.12	0.025	0.026
<sup>235</sup> U	4	0.050	0.050	0.050	0.0	0.0093
<sup>236</sup> U	4	0.00017	<0.000037	<0.00012	0.000066	0.0010
<sup>238</sup> U	4	0.090	0.055	0.074	0.017	0.017
<i>ORNL Tap Water</i>						
<sup>60</sup> Co	4	<2.5	<2.5	<2.5	0.0	<0.046
<sup>137</sup> Cs	4	<2.5	<2.5	<2.5	0.0	<0.093
Gross Alpha	4	2.2	1.0	1.4	0.51	NA <sup>d</sup>
Gross Beta	4	6.8	<4.0	<4.7	1.4	NA <sup>d</sup>
Total Pu	4	0.050	0.050	0.050	0.0	0.0019
Total Sr <sup>e</sup>	4	5.1	2.0	3.0	1.5	0.48
<sup>234</sup> U	4	0.087	0.050	0.059	0.018	0.016
<sup>235</sup> U	4	0.050	0.050	0.050	0.0	0.0093
<sup>236</sup> U	4	0.000040	<0.000013	<0.000023	0.000012	0.0010
<sup>238</sup> U	4	0.052	0.050	0.050	0.00075	0.0095

<sup>a</sup>95% confidence coefficient about the average.

<sup>b</sup>Percent of DCG = maximum × 100/derived concentration guide (DCG).

<sup>c</sup>See Fig. 2.2.2.

<sup>d</sup>Not applicable.

<sup>e</sup>Total Sr = total radioactive strontium (<sup>89</sup>Sr + <sup>90</sup>Sr).

characterization, which began in August 1987, is needed to comply with the RCRA requirements and to determine the measures that will reduce most effectively the flow of  $^3\text{H}$  and/or other contaminants from SWSA 5.

Radioactive discharges into the on-site creeks and later into the Clinch River are affected not only by the concentrations in the streams, but also by rainfall, surface runoff, subsurface inflow to streams, and stream flows. Modeling efforts are under way by staff members of the Environmental Sciences Division (ESD) in conjunction with the Environmental Compliance and Health Protection Division at ORNL to predict radioactivity released and dispersed to the Clinch River under various stream, weather, and process conditions.

Flows in the Clinch River (as measured at Melton Hill Dam) and in WOC (as measured at WOD) are summarized in Table 2.2.8. Water over Melton Hill Dam is closely controlled by TVA. The flow in the Clinch River ranged from  $91 \times 10^9$  L (December) to  $530 \times 10^9$  L (January). Flow in WOC ranged from  $0.41 \times 10^9$  L (August) to  $1.4 \times 10^9$  L (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 2.2.9. These discharges are calculated by multiplying the concentration for the period (month or week) by the flow. At both WOC and MBI, 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 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 2.2.9. 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.

#### 2.2.1.3 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. 2.2.4. Table 2.2.10 lists sampling locations, sample type, the agency requiring the sample, and the NPDES identification number where applicable.

**Table 2.2.8. Flow for Clinch River and White Oak Creek (January–December 1987)**

Month	Flow ( $\text{L} \times 10^9$ )		Average ratio <sup>a</sup>
	Clinch River	White Oak Creek	
January	530	1.4	590
February	470	1.3	440
March	430	0.84	510
April	210	0.87	270
May	470	0.61	780
June	210	0.46	480
July	520	0.56	1000
August	420	0.41	1100
September	230	0.43	550
October	320	0.50	650
November	105	0.44	230
December	91	0.50	190

<sup>a</sup>Ratio of Clinch River to White Oak Creek flow is calculated weekly and averaged for the month.

Table 2.2.9. 1987 ORNL liquid releases and radionuclide concentrations

Radionuclide	Emission source release (Ci)	Derived concentration guide (DCG) (pCi/L)	Average flow-weighted concentration (pCi/L)	Percent of DCG <sup>a</sup>
<i>White Oak Creek</i>				
<sup>60</sup> Co	0.046	5400	<6.8	<0.13
<sup>137</sup> Cs	0.47	2700	68	2.5
Total Sr	0.71	1100	100	9.7
Tritium	380	2,200,000	56,000	2.6
<i>White Oak Dam</i>				
<sup>241</sup> Am	0.0012	110	<0.14	<0.13
<sup>244</sup> Cm	0.0028	1600	<0.34	<0.021
<sup>60</sup> Co	0.12	5400	<15	<0.27
<sup>137</sup> Cs	0.57	2700	69	2.5
Gross Beta	3.3	NA	390	NA
<sup>238</sup> Pu	0.00049	2700	<0.058	<0.0022
<sup>239</sup> Pu	0.0014	2700	<0.16	<0.0060
Total Sr	1.2	1100	140	13
Tritium	2500	2,200,000	300,000	14
<i>Melton Branch 1</i>				
<sup>60</sup> Co	0.075	5400	49	0.90
<sup>137</sup> Cs	0.0073	2700	<4.8	<0.18
Total Sr	0.44	1100	280	26
Tritium	3200	2,200,000	2,100,000	95

<sup>a</sup>Percent of DCG = average flow-weighted concentration × 100/DCG.

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 1987 grab samples were collected once a week at all locations, with the exception of K-1513, and composited into monthly samples. At K-1513, 24-h composite samples were collected each week and composited into a monthly sample. All monthly samples were analyzed for radiological and nonradiological parameters.

In 1988, the sampling frequency will be reduced to once a month, but each sample will be a 24-h composite. Field preservation will also be incorporated during 1988.

Mitchell Branch, located on the northeast side of the plant site, is shown in Fig. 2.2.4. The branch is sampled for both radiological and

nonradiological parameters at three locations: near the headwaters, upstream, and downstream of a spring flowing into the branch.

#### Radiological summary

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.

Only uranium was above the detection limit in Poplar Creek and the Clinch River. 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 no

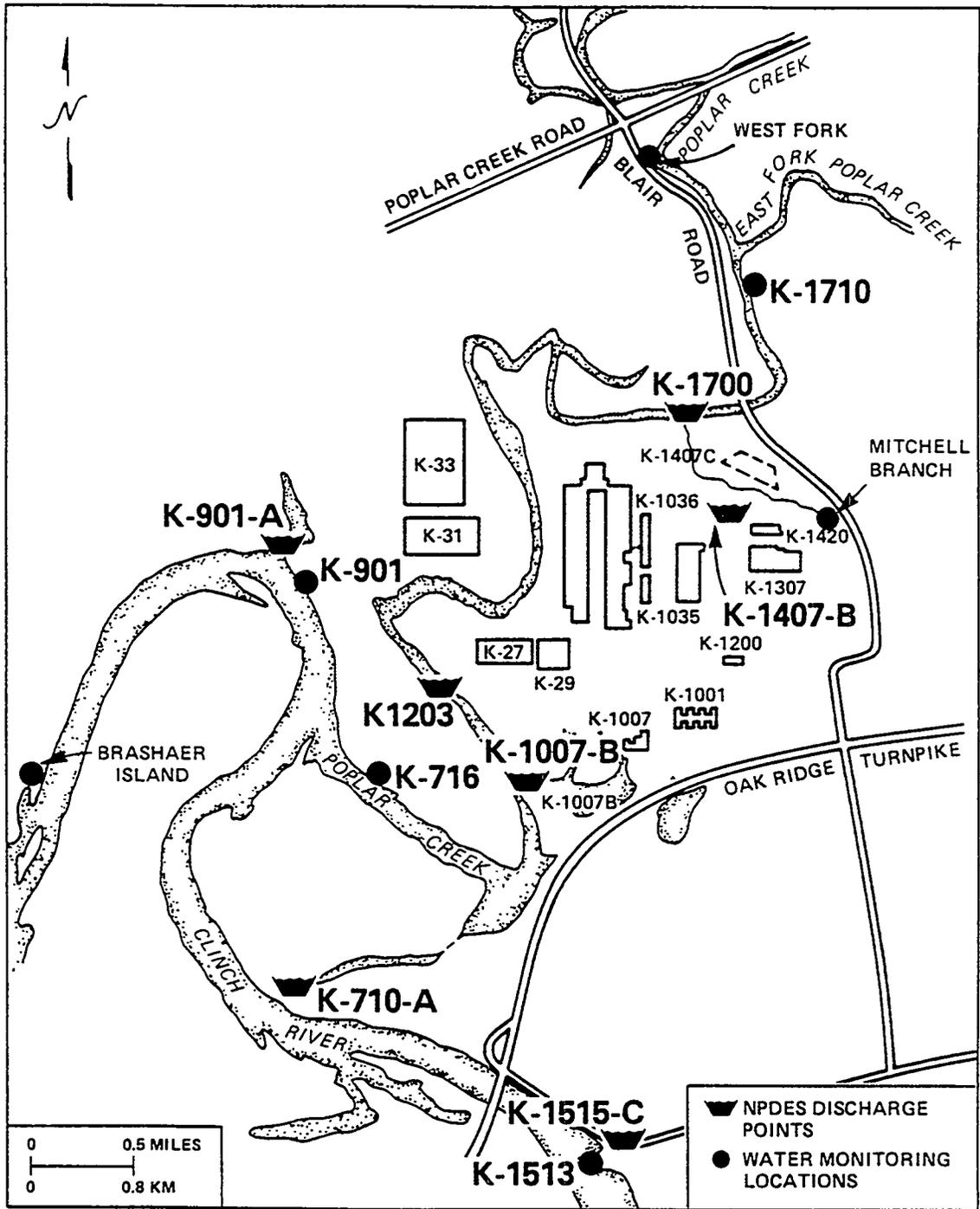


Fig. 2.2.4. ORGDP NPDES and perimeter monitoring locations.

Table 2.2.10. 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 <sup>a</sup>	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-1513	DOE	Perimeter	
K-1515-C	TDHE	NPDES	009
K-1700	TDHE	NPDES	001
K-1710	DOE	Perimeter	

<sup>a</sup>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.

indication of elevated uranium values in the Clinch River samples above or below ORGDP.

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

#### Nonradiological summary

Tables 2.2.7 to 2.2.13 in Vol. 2 give the water quality parameter data for the ambient surface water surrounding ORGDP. Figure 2.2.4 depicts the sampling locations.

When compared to the primary and secondary national drinking water standards, two parameters show exceedences: manganese and nitrate nitrogen.

The source of the manganese is upstream of the ORGDP because average values exceed drinking water standards upstream of the plant. On the Clinch River, only maximum values periodically exceed drinking water standards. ORGDP is not suspected as the source of the manganese.

The average nitrate nitrogen concentration

increases from 20% of the primary drinking water standard to 30% of the standard from K-1710 (upstream) to K-716 (downstream). In West Fork Poplar Creek, the average value is only 3% of the drinking water standard. At K-901 @ 892 and Clinch River, the average values are 18% and 4% of the standard, respectively. It appears that ORGDP slightly elevates the nitrate nitrogen in the waters of Poplar Creek.

No additional drinking water parameters are impacted when upstream and downstream data are compared.

At K-1700, locally known as Mitchell Branch, elevated chemical oxygen demand (COD) values were recorded. A potential source is naturally occurring decomposition products. No drinking water standard exists for COD.

#### 2.2.2 NPDES Monitoring

Under the requirements of the CWA, an NPDES permit has been issued to each of the three Oak Ridge facilities. Tables 2.2.12, 2.2.14, and 2.2.19 detail the permit requirements and compliance records at each outfall during 1987. 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 biomonitoring by regulatory agencies reflects a shift from a strictly water-quality-based approach to wastewater treatment to a biomonitoring-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 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 (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.

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.

The status of the biomonitoring studies at the three Oak Ridge facilities is discussed in more detail later in this section.

#### **2.2.2.1 Oak Ridge Y-12 Plant**

Over the past few years, significant changes in the interpretation of existing environmental

legislation have impacted the environmental management programs at the Y-12 Plant. Until 1977, EPA had total responsibility for enforcing the CWA at federal facilities such as the Y-12 Plant. Under the EPA, the Y-12 Plant had one NPDES permit with four Y-12 perimeter outfalls: one at the outlet of New Hope Pond, one west of the main plant site on Bear Creek (at Highway 95), one at the outlet of Rogers Quarry, and one at the outlet of Kerr Hollow Quarry. While operating under the EPA NPDES permit, the Y-12 Plant regularly achieved compliance with the effluent discharge criteria.

In 1977, amendments to the Federal Water Pollution Control Act (FWPCA) allowed the states to establish their own water quality criteria. By law, these criteria took precedence over any EPA-issued NPDES permits. The NPDES permit issued May 25, 1985, is a reflection of the 1977 amendments to the FWPCA and the Y-12 Federal Facilities Compliance Agreement signed by EPA and DOE on April 17, 1985. This current NPDES permit combines water quality and industrial BAT effluent limitations for the metal finishing and steam electric power generation industries with emphasis on biological and toxicological monitoring. The Y-12 Plant is committed to achieving effluent characteristics that are better than those specified by BAT. The effluent limitations for each treatment facility may be adjusted if the treated effluent results in in-stream toxicity as determined by 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. 6.

#### **Outfalls**

A variety of liquid wastes (uranium-contaminated as well as noncontaminated) results from Y-12 Plant activities associated with metal finishing, plating, uranium recovery, and facility cleaning operations. Numerous waste streams of conventional liquid wastes also exist, such as domestic sewage, steam plant wastewaters, and coal-pile runoff. Aqueous process waste streams may be divided into two categories: high nitrate

wastewater and low-nitrate wastewaters. With the exception of nitrate wastewaters, the waste streams are amenable to physical/chemical types of treatment including pH control and solids removal. Wastewater treatment facilities are planned, or are already in place, that can handle specific waste streams (plating rinse waters, domestic sewage, high-nitrate streams, etc.).

Until the Y-12 Plant wastewater treatment complex is completed, wastewaters will be handled by one of the following methods:

1. Nitrate-contaminated wastewaters generated throughout the plant are neutralized, biodenitrified, stored, polished, and discharged at the Central Pollution Control Facility II/West End Treatment Facility (CPCF-II/WETF).
2. Wastewaters low in nitrates are collected and transported to the CPCF.

3. Domestic waste compatible with the Oak Ridge wastewater treatment facility is discharged to the sanitary sewer and treated at that facility.
4. Coal-pile runoff, boiler blowdown, and wastewaters from the ORNL Biology Division complex at the Y-12 Plant will be discharged to East Fork Poplar Creek until the treatment facility is completed.
5. Untreated waste streams such as cooling tower blowdown and noncontact cooling waters are monitored to ensure compliance with the NPDES permit.

All of these waters discharge to upper East Fork Poplar Creek. The Y-12 Plant NPDES-permitted outfalls are identified in Table 2.2.11.

#### Radiological description

In addition to standard compliance monitoring, various monitoring program

**Table 2.2.11. Y-12 Plant NPDES-permitted outfalls**

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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
Central Pollution Control Facility, Phase II—Outfall 502
West End Treatment Facility—Outfall 502
Steam Plant Wastewater Treatment Facility—Outfall 503
Plating Rinsewater Treatment Facility—Outfall 504
Biology Wastewater Treatment Facility—Outfall 505
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)

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requirements are imposed by the NPDES permit. A radiological monitoring plan for the Y-12 Plant, an additional monitoring requirement, has been developed and submitted to TDHE for approval. Monitoring activities for 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 will be monitored. Treatment facilities to be monitored include CPCF, CPCF-II/WETF, Steam Plant Wastewater Treatment Facility (SPWTF), Plating Rinsewater Treatment Facility (PRWTF), and Biology Wastewater Treatment Facility. Other point and area source discharges to be monitored include outfall 109—Y-12 Plant area drainage; outfall 135—Y-12 Plant area drainage; outfall 147—isotope separation process; outfall 305—oil pond 1; and outfall 306—oil pond 2. The in-stream locations include outfall 303—New Hope Pond discharge; outfall 304—Bear Creek; and a point 5 m upstream of outfall 135 in East Fork Poplar Creek.

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.

#### Nonradiological description

Other nonradiological NPDES monitoring requirements include a polychlorinated biphenyl (PCB) monitoring plan for the Y-12 Plant and groundwater monitoring plans for Kerr Hollow and Rogers quarries.

The PCB monitoring plan proposes a routine sampling program for PCBs designed to identify PCB sources and address remedial and environmental permitting requirements. The PCB monitoring plan has the following components:

- surface water monitoring,
- biological monitoring, and
- sediment monitoring.

The surface water monitoring component of the PCB plan will be used to demonstrate compliance with the Y-12 Plant NPDES permit and to identify any sources of PCB contamination. The routine surface water monitoring sites include (1) Kerr Hollow Quarry, (2) Rogers Quarry, (3) New Hope Pond outlet, (4) New Hope Pond inlet, (5) headwaters of East Fork Poplar Creek, and (6) Bear Creek.

The NPDES-required groundwater monitoring proposals for Kerr Hollow and Rogers quarries are discussed in Sect. 2.3.

Samples for water quality parameters are collected along with radiological samples using the same frequency and method described in Sect. 2.2.1.

#### Nonradiological summary

The Y-12 Plant NPDES permit (No. TN0002968) was issued effective May 24, 1985. This permit greatly increased the monitoring requirements for surface waters. The permit requires sampling and analysis at 16 serially numbered outfalls, approximately 195 categorized outfalls, and approximately 30 miscellaneous discharges. Tables 2.2.14–2.2.34 in Vol. 2 detail concentrations for Y-12 Plant discharge points for 1987. Tables 2.2.35–2.2.38 in Vol. 2 depict compliance results at the four NPDES categories for outfalls.

During 1987, the Y-12 Plant was 99% in compliance with NPDES standards as compared with 98.3% compliance during 1986. Progress was made on several projects during 1987 in an effort to minimize the release of pollutants to surface waters at the Y-12 Plant. Among those were CPCF-II, WETF, SPWTF, and PRWTF. With the completion of CPCF-II in late 1987 and the projected completion of WETF in early 1988, all nitrate wastewaters produced at the Y-12 Plant will be treated there and will no longer be transported to ORGDP for partial treatment and then back to the Y-12 Plant for final treatment. With the completion of

the PRWTF in 1987, an estimated 8 million gal of untreated plating rinsewaters per year have been eliminated from East Fork Poplar Creek. During 1987, the construction at the SPWTF was on schedule, and in early 1988 approximately 47 million gal per year of untreated acidic and caustic discharges from the Y-12 Plant coal yard and steam plant operations will receive treatment before release to East Fork Poplar Creek.

Discharges from the Y-12 Plant area 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 liquid wastes discharged to East Fork Poplar Creek. Until all of the new wastewater treatment facilities are constructed and ready for operation, some untreated waste streams will continue discharging to East Fork Poplar Creek. Discharges allowed under the permit include storm drainage, cooling water, cooling tower blowdown, and process wastewaters including effluents from pollution control treatment facilities. Sumps that collect groundwater in building basements also discharge to the stream. Major point discharges and treatment facility discharges are categorized according to their NPDES outfalls.

A network of storm drains covers the entire area of the Y-12 Plant that discharges into East Fork Poplar Creek. The system gathers rainfall from the adjacent hillsides, the parking areas north of the developed portion of the plant, 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 process 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. The NPDES permit has been established using BAT as a basis for discharge. Storm sewer and stream monitoring stations are planned to characterize area source contamination.

There are 21 major cooling tower systems and 6 small air-conditioning towers in operation at the Y-12 Plant. Approximately 1380 million L/year are required as makeup for the 21 major cooling tower systems. About 550 million L/year are discharged as blowdown into East Fork Poplar Creek, and 830 million L are lost as evaporation. The blowdown consists of water containing nontoxic chemical treatment (a corrosion inhibitor and a microbiocide). During 1987, the NPDES compliance for the cooling tower blowdown showed a significant change in two parameters. An improved compliance percentage of 100% for temperature and an increase from 45 to 81% for pH reflect an aggressive cooling tower improvement program undertaken by the Y-12 Plant in 1987. The cooling tower system is being upgraded by replacement of towers and modified chemical treatment to meet NPDES permit requirements. These changes are helping to reduce the total amount of water consumption and to promote compliance with the NPDES permit.

The Y-12 Plant's NPDES discharges from Kerr Hollow Quarry (discharge point 301) in 1987 were in compliance 100% of the time, as they were in 1986.

The percentage of compliance for discharges to Rogers Quarry (discharge point 302) decreased for two effluent parameters. NPDES compliance of settleable solids fell from 100% in 1986 to 98% in 1987, and pH dropped from 100% in 1986 to 62% compliance in 1987. However, the oil and grease parameter improved from 71% in 1986 to 100% of compliance in 1987.

NPDES compliance for discharges to New Hope Pond (discharge point 303) (East Fork Poplar Creek) showed some improvement in the mercury and nitrogen parameters. Mercury compliance improved from 90% in 1986 to 94% in 1987. Nitrogen (as N) compliance improved from 97% in 1986 to 100% in 1987. All other parameters showed no significant change.

NPDES compliance for discharges to Bear Creek (discharge point 304) showed no significant change from 1986 to 1987. Effluent

parameters oil and grease and pH remained at 100% of compliance.

NPDES compliance for miscellaneous discharges (cooling tower blowdown) showed a significant change in two parameters. Temperature improved from 96% to 100% of compliance for 1987, and pH compliance improved from 45% for 1986 to 81% for 1987.

NPDES compliances for category I, II, III, and IV outfalls, outfall 623, and the wastewater treatment facilities are included in Table 2.2.12.

### Toxicity Studies

The Y-12 Plant's NPDES permit stipulates, in Sect. III, the development and implementation of a TCMP. Under the TCMP, wastewaters from the cooling towers, CPCF, PRWTF, the S-3 ponds Liquid Treatment Facility (S-3 LTF), the category IV discharges, and the Biology Wastewater Treatment Facility (BWTF) are routinely evaluated for acute and chronic toxicity to a representative species of fish (the fathead minnow, *Pimephales promelas*) and a microcrustacean (*Ceriodaphnia dubia*). Effluents from new wastewater treatment facilities are also evaluated for toxicity before going on line. The biotests with the two species use procedures detailed in EPA/600/4-85/014. Results of the tests are used to determine whether or not a given wastewater is likely to be detrimental to biota in EFPC to which the wastewaters are ultimately discharged. If a test shows evidence of toxicity, additional tests are initiated to (a) confirm the presence of the toxic material(s), (b) to identify the substance(s) causing toxicity, and (c) to provide guidance to wastewater operation engineers on the effectiveness of changes in wastewater treatment operations that are made to reduce toxicity.

The results of many such biotests have shown that, in general, *Ceriodaphnia* is more sensitive to diverse effluents than fish. Tests with *C. dubia* are therefore typically used to identify toxicants and to provide guidance regarding changes in wastewater treatment operations when toxicity has been confirmed.

Table 2.2.13 gives the results of toxicity tests on *Ceriodaphnia* and fathead minnows using effluent water from nine of Y-12's outfalls. This table gives, for each discharge, the dates the tests were conducted and the no observed effect concentration (NOEC) values obtained. The NOEC designates the highest tested concentration (in percentage of full strength) of the effluent causing no significant reduction in survival or growth of fathead minnow larvae or in survival or reproduction of *Ceriodaphnia*.

For the Building 9202 catch basin discharge, the toxicity was evaluated only with *Ceriodaphnia*. The NOEC concentration of <10% indicates that the effluent is at least acutely toxic at low concentrations periodically. The toxicity of this waste stream will be evaluated in the next series of tests using both species.

The NOEC's for the cooling tower 9409-10 discharge was 60% or greater in all tests indicating that the discharge will probably not affect the biotic environment. In several tests in the past, blowdown from cooling tower operations has been found to be problematic to both species; in these tests, however, the primary toxicant appears to be the chlorine, which is used to prevent the growth of microbiota that can damage, by bio-oxidative and reductive chemical reactions, the interior surfaces of heat exchangers. Chlorine has a relatively short half-life, and degrades (in the presence of sunlight, oxygen, and oxidizable organic matter) to chloride ions.

The toxicity tests for the Dye Penetrant/Emulsifier (DP/E) wastewater discharge indicate that the NOEC for the fathead minnow larvae and the *Ceriodaphnia* was 0.05% and 0.1% respectively of full strength. Toxicity identification tests with DP/E wastewater showed that an organic fluorescent dye was the most likely toxicant. Toxicity of this wastewater, when treated with activated carbon to remove the dye, declined markedly. Biotests to ensure that toxicity associated with this wastewater has been eliminated will be conducted as soon as the carbon columns purchased for DP/E toxicity control have been installed.

Table 2.2.12. 1987 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	8
	pH (units)		>6.5		<8.5	100	8
	Total suspended solids		30.0		50.0	100	8
	Temperature (°C)				30.5	100	8
	Zirconium				3.0	100	8
	Oil and grease		10.0		15.0	100	52
	pH (units)		>6.5		<8.5	62	53
	Settleable solids (mL/L)				0.5	98	52
302 (Rogers Quarry)	Total suspended solids		30.0		50.0 <sup>a</sup>	100	52
	Temperature (°C)				30.5	100	53
	Ammonia (as N)				1.6	99	199
	Cadmium, total		0.0025		0.0035	96	201
	Chromium, total		0.05		0.08	100	201
	Copper, total		0.015		0.022	99	201
	Dissolved oxygen		5.0 <sup>b</sup>			99	253
	Dissolved solids				2000	100	198
303 (New Hope Pond)	Fluoride		1.5		2.0	99	198
	Lead, total		0.012		0.17	100	201
	Lithium, total				5.0	100	201
	Mercury, total		0.0035		0.0080	94	199
	Nitrogen, total (as N)				20.0	100	53
	Oil and grease		10.0		15.0	100	65
	pH (units)		>6.5		<10.0	100	255
	Settleable solids (mL/L)		5.0		8.0	100	13
	Surfactants (as MBAS)				20.0 <sup>c</sup>	99	54
	Total suspended solids				30.5	100	198
	Temperature (°C)				30.5	100	69
	Zinc, total		0.20		0.30	100	201
	304 (Bear Creek)	Oil and grease		10.0		15.0	100
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	11
	pH (units)		>6.5		<8.5	100	11
	Total suspended solids		30.0		50.0	95	11

Table 2.2.12. (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)		
306 (seepage from burial pit and surface water runoff—Oil Pond #2)	Oil and grease			10.0	15.0	100	8
	pH (units)			>6.5	<8.5	100	8
501 Central Pollution Control Facility (CPCF-I)	Total suspended solids			30.0	50.0	97	8
	Cadmium, total	0.07	0.19	0.26	0.69	100	31
	Chromium, total	0.5	0.75	1.71	2.77	100	31
	Copper, total	0.6	0.92	2.07	3.38	100	31
	Cyanide, total	0.2	0.33	0.65	1.20	100	31
	Lead, total	0.12	0.19	0.043	0.69	100	31
	Nickel, total	0.65	1.1	2.38	3.98	100	31
	Oil and grease	7.1	14.2	26.0	52.0	100	31
	pH (units)			>6.0	<9.0	100	31
	Silver, total	0.07	0.12	0.24	0.43	100	31
	Temperature (°C)			31.0	60.0	100	31
	Total suspended solids	8.5	16.4		2.13	100	31
	Total toxic organics			1.48	2.61	97	30
Zinc, total	0.4	0.7			100	31	
502 Central Pollution Control Facility (CPCF-II) and West End Treatment Facility (WETF)	Cadmium, total	0.07	0.019	0.26	0.69	100	22
	Chromium, total	0.50	0.75	1.7	2.77	100	22
	Copper, total	0.60	0.9	2.07	3.38	100	22
	Cyanide, total	0.2	0.33	0.65	1.20	100	22
	Lead, total	0.12	0.19	0.43	0.69	100	22
	Nickel, total	0.65	1.10	2.38	3.98	100	22
	Oil and grease	7.1	14.2	26.0	52.0	100	22
	pH (units)			>0.6	<9.0	100	18
	Silver, total	0.07	0.12	0.24	0.43	100	22
	Temperature (°C)			31.0	60.0	100	18
	Total suspended solids	8.5	16.4		2.13	100	22
	Total toxic organics			1.48	2.61	100	5
	Zinc, total	0.4	0.7			100	22
Category I Outfalls (precipitation runoff and small amounts of groundwater)	pH (units)			>6.5	<8.5	100	33

Table 2.2.12. (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)		
Category II Outfalls (cooling waters, condensate, precipitation runoff, and building, roof, and foundation drains)	pH (units)			>6.5	<8.5	100	107
	Temperature <sup>d</sup> (°C)					100	107
Category III Outfalls (process wastewaters)	pH (units)			>6.5	<8.5	96	50
Category IV Outfalls (untreated process wastewaters)	pH (units)			>6.5	<8.5	99	648
504 Plating Rinse Water Treatment Facility	Cadmium, total	0.07	0.019	0.26	0.69	100	13
	Chromium, total	0.50	0.75	1.7	2.77	100	13
	Copper, total	0.60	0.9	2.07	3.38	100	13
	Cyanide, total	0.2	0.33	0.65	1.20	98	13
	Lead, total	0.12	0.19	0.43	0.69	100	13
	Nickel, total	0.65	1.10	2.38	3.98	100	13
	Oil and grease	7.1	14.2	26.0	52.0	100	13
	pH (units)			>0.6	<9.0	100	13
	Silver, total	0.07	0.12	0.24	0.43	100	13
	Temperature (°C)				30.5	100	13
	Total suspended solids	8.5	16.4	31.0	60.0	100	13
	Total toxic organics		0.6		2.13	100	13
Zinc, total	0.4	0.7	1.48	2.61	100	13	
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	15
	Chromium, total	0.50	0.75	1.7	2.77	100	15
	Copper, total	0.60	0.9	2.07	3.38	100	15
	Cyanide, total	0.2	0.33	0.65	1.20	100	15
	Lead, total	0.12	0.19	0.43	0.69	100	15
						100	15

Table 2.2.12. (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)			
623 (Steam Plant Fly Ash Sluice Water)	Nickel, total	0.65	1.10	2.38	3.98	100	15	
	Oil and grease	7.1	14.2	26.0	52.0	100	15	
	pH (units)			>0.6	<9.0	100	15	
	Silver, total	0.07	0.12	0.24	0.43	100	15	
	Temperature (°C)				30.5	100	15	
	Total suspended solids	8.5	16.4	31.0	60.0	100	15	
	Total toxic organics		0.6		2.13	100	14	
	Zinc, total	0.4	0.7	1.48	2.61	100	15	
	pH (units)			>6.5	<8.5	100	52	
	507 (S-3 Ponds Liquid Treatment Facility)	Cadmium, total	0.14	0.38	0.26	0.69	ND <sup>e</sup>	NA <sup>f</sup>
		Chromium, total	0.93	1.5	1.7	2.77	ND	
		Copper, total	1.13	1.84	2.07	3.38	ND	
		Cyanide, total	0.35	0.65	0.65	1.20	ND	
		Lead, total	0.23	0.38	0.43	0.69	ND	
Nickel, total		1.30	2.17	2.38	3.98	ND		
Oil and grease		14.2	28.4	26.0	52.0	ND		
pH (units)				>6.0	<9.0	ND		
Silver, total		0.13	0.23	0.24	0.43	ND		
Temperature (°C)					30.5	ND		
Total suspended solids		16.9	32.7	31.0	60.0	ND		
Total toxic organics			1.16		2.13	ND		
Zinc, total		0.81	1.42	1.48	2.61	ND		
508 (Experimental Mobile Wastewater Treatment Facility)		Mercury, total			0.002	0.004	ND	
	pH (units)			>6.5	<9.0	ND		
	Total suspended solids			30.0	45.0	ND		
510 (Waste Coolant Processing Facility)	Biochemical oxygen demand	1.33	2.65			ND		
	Oil and grease			15.0	20.0	ND		
	pH (units)			>6.5	<9.0	ND		
	Temperature (°C)				30.5	ND		
Total suspended solids			30	50	ND			

Table 2.2.12. (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)		
Miscellaneous discharges (cooling tower blowdown)	Chromium, total				1.0	100	56
	Copper, total			0.5	1.0	100	56
	Free available chlorine			0.2	0.5	88	56
	pH (units)			>6.5	<8.5	81	56
	Temperature (°C)			35	38	100	56
	Zinc, total			0.5	1.0	100	56
Miscellaneous discharges (deminerallizers)	pH units			>6.5	<8.5	ND	
	Total suspended solids			30	50	ND	

<sup>a</sup>Limit not applicable during periods of increased surface runoff resulting from precipitation.

<sup>b</sup>Daily minimum.

<sup>c</sup>If discharge volume exceeds  $8.0 \times 10^6$  gal/d as a result of precipitation, daily maximum is 100 mg/L.

<sup>d</sup>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.

<sup>e</sup>ND—no discharge.

<sup>f</sup>NA—not applicable.

Table 2.2.13. 1987 toxicity test results on *Ceriodaphnia* and fathead minnows using Y-12 effluent water

Discharge facility	Test date (1987)	<i>Ceriodaphnia</i> NOEC <sup>a</sup> (%)	Fathead minnow NOEC <sup>a</sup> (%)
Catch basin (category IV)	Apr. 30–May 7	10	NA
Cooling tower 9409-10	Oct. 1–8	60	80
CPCF	Jan. 22–29	20	20
	Oct. 23–30	5.0	1.0
Dye penetrant (category IV)	Apr. 9–16	0.1	0.05
Overhead still (category IV)	Apr. 30–May 7	5.0	10
Photographic rinsewaters (category IV)	Apr. 9–16	0.28	0.07
Plasma torch cooling water (category IV)	Jan. 9–16	20	80
Plating rinsewater treatment facility (category IV)	June 11–18	20	20
S-3 LTF/DTF	May 7–14	1.0	3.0
	May 21–28	3.0	3.0

<sup>a</sup>NOEC—No observed effect concentration.

The overhead still wastewater had a NOEC of 5%. This value is not toxic. The photographic rinsewater wastewater discharge was collected from Building 9981. The NOEC values for *Ceriodaphnia* (0.28%) and fathead minnows (0.07%) indicate that this discharge may adversely affect biotic communities in EFPC. Tests to identify the toxicant(s) present in the photographic wastewaters have not yet been conducted, but the appropriate chemical fractionation schemes for studying this effluent have been developed. The biotests to complete this investigation are expected to start in May 1988.

The plasma torch cooling water discharge was not toxic to fathead minnows at concentrations of 80%; however, the

*Ceriodaphnia* NOEC was 20% of full concentration. The projected instream waste concentration for the plating rinsewater treatment facility is just under 1%. Because the NOEC (20%) of the wastewater greatly exceeds 1%, it is unlikely to be toxic to the creek. Discharges from the CPCF were found not to be harmful to either the fathead minnow larvae or the *Ceriodaphnia*. The instream waste concentration (IWC) for the CPCF is 1.14%; therefore, the water will pass toxicity tests at a NOEC of >1.14%. Effluents from the S-3 LTF and the WETF proved to be toxic to *Ceriodaphnia*. The NOEC values from the S-3 LTF/DTF discharge were <3.0%. Additional biotests were used to identify conditions leading to effluent toxicity in the S-3 LTF; the results of 35 such tests showed that

chemicals commonly used to treat wastewaters to remove problematic contaminants (e.g., lime) and salts remaining in the wastewaters from which the contaminants have been removed (e.g., sodium sulfate, sodium bicarbonate, etc.) can in themselves contribute to toxicity. Studies to identify conditions contributing to toxicity of effluent from the WETF are presently under way.

#### **2.2.2.2 Oak Ridge National Laboratory**

Under the requirements of the CWA, a new NPDES permit issued to ORNL became effective on April 1, 1986. The current permit requires the monitoring of 10 point source outfalls, 3 ambient monitoring stations (Melton Branch, WOC, and WOD), 35 category I outfalls (storm drains uncontaminated by any known activity), 61 category II outfalls (roof drains, parking lot drains, storage area drains, spill area drains, once-through cooling water, blowdowns, and condensate), 32 category III outfalls (untreated process or laboratory drains), and 13 miscellaneous source discharges. One of the point source outfalls, the ORR resin regeneration facility, was decommissioned in December 1986. An additional outfall, the nonradiological wastewater treatment plant, will not be operational until March 1990.

In addition, the new permit requires that a number of other plans and programs be implemented: the mercury assessment plan, radiological monitoring plan, monitoring plan for PCBs in the aquatic environment, BMAP, best management practices (BMP) plan, and TCMP.

The mercury, PCB, and radiological monitoring plans are designed to characterize and minimize or eliminate discharges of these contaminants from ORNL. The plans have been submitted to TDHE for approval; implementation will be scheduled pending approval.

A BMP plan is developed to ensure that a facility employs BMPs as part of normal operations. In the context of the NPDES permit, BMPs are procedures that eliminate or minimize the potential for release of significant amounts of toxic or hazardous pollutants to surface water.

The new permit required the development of a BMAP and a TCMP to determine if effluent

limitations are providing adequate protection of the environment. The BMAP will result in complete ecological characterization of area streams and will address the effects of both effluent and area source discharges. It will also allow determination of the ecological health of area streams before, during, and after treatment facilities are installed. The TCMP accompanies the BMAP and identifies sources of toxicity from ORNL effluent discharges so that the discharges can be controlled and later monitored to confirm that their toxicity has been reduced to an acceptable level.

The BMAP is a long-range program that is intended to satisfy the data needs of the CWA and the RCRA/Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

The point source and ambient stations are shown in Fig. 2.2.3. Sampling and analysis frequencies at these locations are varied. Limits have been placed on the sewage treatment plant and the coal yard runoff facility; category I, II, and III outfalls; and the miscellaneous source discharges.

#### **ORNL nonradiological results**

A summary of the NPDES compliance at ORNL is given in Table 2.2.14, 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 1987. 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 90% for all parameters measured. Fecal coliform concentrations resulting from the low chlorine concentrations required by the permit continue to be a problem; however, an engineering review of the STP chlorination system is expected to result in a permanent solution to chlorine/fecal coliform problems.

Category I and II outfalls include storm drains and parking lot and roof drains and are not contaminated by any known activity, nor do

Table 2.2.14. 1987 NPDES compliance at ORNL

Discharge point	Effluent parameters	Discharge limitations				Number of noncompliances	Percent in 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	99.4
	Biological oxygen demand (winter)	17.4	26.2	20	30	2	98.7
	Total suspended solids	26.2	39.2	30	45	10	93.6
	Ammonia (N) (summer)	3.5	5.2	4	6	0	100
	Ammonia (N) (winter)	7.8	11.8	9	13.5	0	100
	Oil and grease	8.7	13.1	10	15	4	97.5
	Dissolved oxygen			6.0 <sup>d</sup>		0	100
	Downstream pH (units)					0	100
	Residual chlorine				0.5	1	99.4
	Fecal coliform, geometric mean			200 <sup>b</sup>	400 <sup>b</sup>	6	96.2
X02 (Coal Yard Runoff Treatment Facility)	Temperature (°C)				30.5	0	100
	Total suspended solids				50	0	100
	Oil and grease			15.0	20.0	0	100
	Chromium, total			0.2	0.2	0	100
	Copper, total			1.0	1.0	0	100
	Iron, total			1.0	1.0	0	100
X03 (1500 Area)	pH (units)			1.0	1.0	3	93.8
	Zinc			1.0	1.0	0	100
	Downstream pH (units)					0	100
X11 (Acid Neutralization Facility)	pH (units)					1	98.1
	Downstream pH (units)					0	100
						3	94.2

Table 2.2.14. (continued)

Discharge point	Effluent parameters	Discharge limitations				Number of noncompliances	Percent in compliance
		Monthly Av (kg/d)	Daily Max (kg/d)	Monthly Av (mg/L)	Daily Max (mg/L)		
Category I	Oil and grease			10	15	0	100
	pH (units)					1	91.7
	Temperature (°C)				30.5	1	91.7
Category II	Total suspended solids			30	50	1	91.7
	Oil and grease			10	15	0	100
	pH (units)					0	100
Category III	Total suspended solids			30	50	19	76.8
	pH (units)					0	100
	Temperature (°C)			35	38	4	0
Steam Plant (SP2519)	Biological oxygen demand			30	45	0	100
	Downstream pH (units)					2	80
	Fecal coliform			200 <sup>a</sup>		0	100
Vehicle Cleaning (VC7002)	Oil and grease			10	15	3	70
	pH (units)					1	90
	Phenols			1.0	2.0	0	100
Equipment Maintenance Facility (EF7007)	Total suspended solids			25	40	1	90
	Oil and grease					1	90
	Downstream pH (units)					0	100
Paint Facility (PF7007)	Oil and grease			10	15	0	100
	pH (units)					0	100
	Phenols			1.0	2.0	0	100
Paint Facility (PF7007)	Total suspended solids			25	40	0	100
	Oil and grease					6	37.5
	Downstream pH (units)					0	100

Table 2.2.14. (continued)

Discharge point	Effluent parameters	Discharge limitations				Number of noncompliances	Percent in compliance
		Monthly Av (kg/d)	Daily Max (kg/d)	Monthly Av (mg/L)	Daily Max (mg/L)		
Cooling Systems (3086, 3103, 4509, 7902)	Chlorine				0.2	0	100
	Chromium				1.0	0	100
	Copper			0.5	1.0	0	100
	Temperature (°C)			35	38	0	100
	Zinc			0.5	1.0	2	75

<sup>a</sup>Minimum.

<sup>b</sup>Colonies per 100 mL.

Note: The pH and downstream pH shall not be less than 6.0 standard units or greater than 9.0 standard units. It shall be monitored by: a weekly grab sample taken at the effluent for discharge points X01, X02, X03, X06, X07 and X11; a per discharge grab sample taken at the effluent for discharge points X08, X09, X10; a monthly grab sample taken at the effluent for discharge points X13, X14, X15; once per year by a grab sample taken at the effluent for pH at each of the category I Outfalls; once per quarter by a grab sample taken at the effluent for pH at each of the category II Outfalls; and once per quarter by a grab sample taken at the effluent for pH at each of the category III Outfalls. The percentage of pH measurements in compliance at X03 and X11 was 93.8 and 94.2, respectively. At all other locations 100% of the measurements were in compliance. At all locations, 100% of the downstream pH measurements were in compliance.

they discharge through any oil/water separator or other treatment facility or equipment. During rain events, water from the parking lots and surrounding areas washes into these outfalls, carrying with it oil and grease and other residue. This activity frequently results in noncompliances for oil and grease and total suspended solids at a number of these outfalls.

The low compliance percentage for the paint facility for total suspended solids is based on the small number of samples collected during the year. The effluent from this facility is discharged to a parking lot drain that routes runoff to a storm drain discharge pipe. This pipe carries the combined runoff from much of the 7000 area at ORNL to WOC, a distance of 400 m. This discharge is believed to be caused not only by the paint facility but also by the other area sources discharging to the same drain. To address this issue, samples will be taken at the point of discharge and only when there is a discharge.

Several of the noncompliances at the vehicle cleaning facility were the result of problems in collecting samples (i.e., when no sample is collected, an automatic noncompliance results). This issue is being addressed through improvements in the ORNL environmental sampling program.

More than 300 permit violations occurred at ORNL because of administrative failures either in collecting or analyzing required samples. Where appropriate, corrective actions or investigations are under way to address these types of noncompliances.

All data collected for the NPDES permit are also summarized monthly for reporting to DOE-ORO and to the state of Tennessee. These summaries are submitted to DOE in monthly DMRs. Monthly summaries of sampling for the NPDES permit are found in Tables 2.2.39-2.2.62 in Vol. 2.

### Toxicity studies

**Description.** As part of the ORNL NPDES permit, a TCMP has been developed and approved for evaluating the toxicity of effluents from the three ORNL treatment systems and two streams. The three treatment systems are the sewage treatment plant (X01), the coal yard runoff treatment system (X02), and the process waste treatment facility (X07). The streams are WOC and Melton Branch. Results obtained from the tests are used to determine, for each location,

if effluent at the anticipated IWC is likely to contribute to instream toxicity.

Toxicity of effluent from each treatment system and the streams is determined using two standard bioassays: (1) the 7-d fathead minnow (*Pimephales promelas*) larval survival and growth test and (2) the 7-d daphnid (*Ceriodaphnia*) life-cycle test.

In toxicity tests involving treatment facilities, groups of organisms are exposed to 100% contaminant-free dilution water and to effluent concentrations greater than and less than the anticipated IWC for effluent from each system. In these tests, survival and growth of fathead minnow larvae and survival and reproduction of *Ceriodaphnia* relative to controls are used as indices of toxicity. The NOEC and the lowest observed effect concentration (LOEC) of effluent from each system are determined for each test using analysis of variance. In each test, the NOEC value is compared with the anticipated IWC to determine whether the effluent is likely to be considered safe to discharge. Computations of stream and treatment system effluents differ because the streams have no dilution factor. Hence, water from stream locations is considered toxic by EPA if survival and growth of the fathead minnow larvae and survival or fecundity of the *Ceriodaphnia* is less than 50% of that in water collected from a reference background location.

After initial tests, regular tests for each location were done every two months during 1987.

**Results.** Results of toxicity tests using effluent water from three of ORNL's outfalls on fathead minnows and *Ceriodaphnia* are given in Table 2.2.15. This table gives, for each effluent water test, the date that the test was conducted and the NOEC. The NOEC designates the highest tested concentration (in percentage of full strength) of the effluent causing no significant reduction in survival or growth of fathead minnow larvae or in survival or reproduction of *Ceriodaphnia*. The NOEC reported in Table 2.2.15 is based on the most sensitive test for each species. At the process waste treatment plant (X07), the NOEC was equal to or greater than 80% for both species tested. At the coal yard runoff facility (X02), the NOEC for the fathead minnow was 60% or greater in all tests; however, the NOEC for the *Ceriodaphnia* ranged from 3

Table 2.2.15. 1987 toxicity test results on fathead minnows and *Ceriodaphnia* using ORNL effluent water

ORNL outfall <sup>a</sup>	Test date (1987)	Fathead minnow NOEC <sup>b</sup> (%)	<i>Ceriodaphnia</i> NOEC <sup>b</sup> (%)
PWTP (X07)	Jan.	100	80
PWTP (X07)	Mar.	80	80
PWTP (X07)	May	80	80
PWTP (X07)	July	80	80
PWTP (X07)	Sept.	100	80
Average		88	80
CYRF (X02)	Jan.	60	3
CYRF (X02)	Mar.	60	10
CYRF (X02)	June	>80	10
CYRF (X02)	Aug.	>80	25
Average		70	12
STP (X01)	Feb.	100	75
STP (X01)	Mar.	100	50
STP (X01)	June	100	75
STP (X01)	Aug.	100	50
Average		100	63

<sup>a</sup>See Fig. 2.2.3.

<sup>b</sup>NOEC = No observed effect concentration.

to 25%. These low values (high dilution of the effluent needed to cause no effect) are believed to result from the high hardness concentration of the effluent. Table 2.2.16 gives the average concentrations of four water quality parameters in each of the effluents. Effluent waters from the coal yard runoff facility (X02) had an average hardness of 1434 mg/L during 1987. Future toxicity tests will attempt to determine the exact cause of the low NOECs for *Ceriodaphnia* in the coal yard runoff facility effluent water. Although these results are low, there is no accompanying information to suggest that the effluent is having an adverse effect on the receiving stream. This is probably because the flow from the coal yard runoff facility is very low compared with that in the receiving stream. At the sewage treatment plant (X01), the NOEC for fathead minnows was 100% in all tests. For *Ceriodaphnia*, the NOEC was between 50% and 75%. These NOECs apparently result from high chlorine levels in the effluent water, although the chlorine concentrations were within the limits prescribed by the NPDES permit.

### 2.2.2.3 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. 2.2.4. Table 2.2.10 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 will

Table 2.2.16. 1987 average water quality parameters at ORNL outfalls

ORNL outfall <sup>a</sup>	Number of tests	Conductivity ( $\mu\text{mho/cm}$ )	Alkalinity (mg/L)	Hardness (mg/L)	pH (units)
PWTP (X07)	5	688	54	18	7.6
CYRF (X02)	4	2064	10	1434	7.1
STP (X01)	4	415	94	164	7.7

<sup>a</sup>See Fig. 2.2.3.

continue into 1988. During 1987, the sample station platforms were replaced and flow monitoring systems were installed. During 1988, refrigerated composite samplers will be installed and linked to the flow monitoring systems to allow flow proportional sampling.

#### Outfalls

The NPDES permit for ORGDP has seven authorized discharge points (Fig. 2.2.4). Samples are collected at six of the seven outfalls and at three internal wastewater discharges. The seventh 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 2.2.17. Each ORGDP location is listed in Table 2.2.18 along with sampling frequency and sample type. Sample preservation during 1987 was conducted after samples were taken to the laboratory. Henceforth, sample preservation will be 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 and a

current use of approximately 1.1 million L/d. Improvements have been made to the collection lines to reduce inflow and infiltration. During periods of heavy rain, raw sewage is partially diverted into a 1-million-L tank to reduce the heavy loading on the treatment facility. 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 0.076 million L/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 will be used in the NPDES permit renewal to be initiated in July 1988.

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

Only the K-1407-B NPDES discharge location is expected to experience changes 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

Table 2.2.17. ORGDP NPDES permit discharges<sup>a</sup>

Serial discharges	Effluent discharges	Average Flow (L × 10 <sup>6</sup> /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 Y-12 Plant treated wastewaters Surface runoff TSCA incinerator	0.54	Mitchell Branch
K-901-A	Treated blowdown from plant cooling tower basins Lime softening sludges from fire water makeup treatment Surface runoff	0.33	Clinch River
K-1203	Sanitary wastewaters Y-12 Plant treated wastewaters Organic industrial wastewaters Surface runoff	1.53	Poplar Creek
K-1007-B	Potable water from once-through cooling systems Fire water from once-through systems Surface runoff	4.31	Poplar Creek
K-1515-C	Water from sludge and back-wash systems associated with the potable water plant Surface runoff	0.45	Clinch

<sup>a</sup>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 2.2.18. ORGDP NPDES sampling frequency

Location	Sampling type	Sample frequency	Analysis <sup>a</sup> frequency	Parameter analyzed
K-1700	Grab	Daily		pH
K-1700	NA <sup>b</sup>	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 <sup>c</sup>
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 2.2.18. (continued)

Location	Sampling type	Sample frequency	Analysis <sup>a</sup> 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 <sup>c</sup>
K-1407-B	Grab	1/week		Phenols
K-1407-B	Grab	5/week		GC/MS <sup>d</sup> 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 2.2.18. (continued)

Location	Sampling type	Sample frequency	Analysis <sup>a</sup> 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	NA <sup>b</sup>	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 <sup>c</sup>
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	NA <sup>b</sup>	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 <sup>c</sup>
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	NA <sup>b</sup>	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 2.2.18. (continued)

Location	Sampling type	Sample frequency	Analysis <sup>d</sup> 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 <sup>c</sup>
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	NA <sup>b</sup>	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

<sup>a</sup>Analysis frequency—identical to sample frequency unless otherwise noted.

<sup>b</sup>NA—Not applicable.

<sup>c</sup>An isotopic analysis is conducted on uranium if any week is above 0.02 mg/L.

<sup>d</sup>Gas chromatograph/mass spectrometer.

been used primarily for flow equalization and settling of solids from neutralization activities.

The outfall of K-1407-B was permitted during the September 1986 NPDES permit modifications. When the K-1407-B pond is removed from service, the permitted NPDES point will be split to accommodate the two effluent streams from the central neutralization facility. One stream will contain small quantities of uranium contamination; the other will contain only coal pile and steam plant effluents.

#### Radiological description

Sample collection for radiological constituents is performed along with NPDES samples. Each ORGDP location is listed in Table 2.2.18 along with the sampling frequency and sampling method.

ORGDP's original mission was uranium enrichment. Until the 1950s, activities were very specific and uranium was the principal radiochemical 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 Tc, Cs, Np, and Pu. 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 has the greatest potential for radioactive emissions because of the facilities operating nearby. K-1407-B has recently been added to the NPDES permit. 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 Tc, Cs, Np, and Pu analyses on the monthly composite samples. K-1203 receives Tc analysis on the monthly composites, and K-901-A and K-1007-B receive Tc, Cs, Np, and Pu on the quarterly composite samples. These data are transmitted quarterly to the state with the DMRs.

#### **Radiological summary**

The data indicate that radiological effluents are well within limits at all effluent locations (see Tables 2.2.3-2.2.6 in Vol. 2). Neptunium, plutonium, technetium, and cesium were always below detection limits. Uranium, determined by wet chemistry analysis, is reduced and presented by isotope in Tables 2.2.3-2.2.6 in Vol. 2. One value is 11% of the DCG value. All other values are at 6% of the DCG or well below. These low values are supported by the fact that ambient surface water radiological samples do not indicate contamination from ORGDP.

#### **Nonradiological summary**

Table 2.2.19 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 1987. Individual parameters are listed by monthly values in Tables 2.2.63-2.2.68 of Vol. 2 for all ORGDP NPDES locations. 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 only two

noncompliances during 1987. One noncompliance occurred when the plant was overloaded because of heavy rains and snow melt. The other noncompliance was silver and is of unknown origin. No Y-12 Plant wastewaters were being processed at ORGDP at that time. The dechlorination system has eliminated residual chlorine noncompliances at this discharge.

At the K-901-A discharge point, chromium had one noncompliance. This condition was repeatedly experienced during 1986 and is now believed to be under control. Dissolved oxygen was out of compliance once 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.

Of the total noncompliances, 25% were the result of trace PCB contamination at the K-1407-B NPDES point. The source was a discharge pipe from Building K-1420 that contained some oil deposits with PCB content. It is believed that the origin of the deposits was related to equipment cleaning activities and small discharges of oil reaching the discharge line. Contaminated oil did not reach the NPDES point itself. Since the source was discovered and cleaned, no further noncompliances of this nature have occurred.

Studies are being conducted of several recurring noncompliances that represent 42.5% of the total 1987 noncompliances. 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, to occur before February 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.

#### **Toxicity studies at ORGDP**

**Description.** The September 1986 permit modifications required the implementation of a BMAP addressing whether the stream use

Table 2.2.19. 1987 NPDES compliance at ORGDP

Discharge point	Effluent parameters	Effluent limits				Number of noncompliances	Percentage of measurements in 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 <sup>a</sup>	30	50	470	780		100	
	Oil and grease	10 <sup>b</sup>	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	1	99	
	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	
	Visible solids					1	99	
	003 K1407-B <sup>c</sup>	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			1	99	
PCB, µg/L			0.014			10	88	
Visible solids						3	99	

Table 2.2.19. (continued)

Discharge point	Effluent parameters	Effluent limits				Number of noncompliances	Percentage of measurements in compliance
		Monthly av (mg/L)	Daily max (mg/L)	Monthly av (kg/d)	Daily max (kg/d)		
005 (K-1203 Sanitary Treatment Facility) <sup>d</sup>	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 <sup>b</sup>					100
	Fecal coliform, No./100 mL	200	400				100
	pH, units		6.09-0				100
	Suspended solids	30	45	74	110	1	99
	Settleable solids, mL/L		0.50				100
	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	1	98
	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	7	93
	Chromium (total)		0.050		0.30		100
	Dissolved oxygen	5.0 <sup>b</sup>					100
	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 <sup>a</sup>	30	50	182	304		100	

Table 2.2.19. (continued)

Discharge point	Effluent parameters	Effluent limits				Number of noncompliances	Percentage of measurements in compliance
		Monthly av (mg/L)	Daily max (mg/L)	Monthly av (kg/d)	Daily max (kg/d)		
007 (K-901-A Holding Pond)	Chromium (total)		0.05		0.68	1	98
	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 <sup>a</sup>	30	50	125	210		100
	Dissolved oxygen <sup>b</sup>				>5	1	99
009 (Sanitary Water Plant)	Suspended solids <sup>a</sup>	30	50	34	51		100
	Aluminum	5.0	10	5.7	11		100
	Sulphate		1400		1600		100
	pH, units		6.0-9.0				100
Storm drain	Diesel fuel		ND <sup>c</sup>			2	NA <sup>d</sup>
	Sewage		ND			1	NA

<sup>a</sup>Limit applicable only during normal operations. Not applicable during periods of increased discharge due to surface run-off resulting from precipitation.

<sup>b</sup>Daily minimum.

<sup>c</sup>During the characterization of this effluent point more data are obtained and reported but are not subject to limits at this time.

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

<sup>e</sup>ND-No discharge.

<sup>f</sup>NA-Not applicable.

classification of Mitchell Branch is being maintained. Mitchell Branch is designated for fish and aquatic life. As part of the BMAP, toxicity testing is required of the K-1407-B (003) NPDES discharge point. A unique aspect of the toxicity testing at K-1407-B is the requirement to pass in 100% of full-strength effluent. This condition was imposed because of zero flow conditions in the stream during drought periods. It has been determined that high concentrations of water treatment chemicals, such as lime, used for neutralization may adversely affect *Ceriodaphnia*. This finding is substantiated in studies conducted for the Y-12 Plant. Although fathead minnows are not affected by the same concentrations of treatment chemicals as *Ceriodaphnia*, evidence suggests that the sodium chloride levels produced by the Toxic Substances Control Act (TSCA) incinerator may be toxic to fathead minnows. Further studies addressing this concern are in progress.

**Results.** The results of the K-1407-B toxicity tests for 1987 are summarized in Table 2.2.20. The NOECs listed in this table are the highest concentrations of the effluent at which there were no toxic effects on the organism being studied. According to the NPDES permit for the K-1407-B effluent, the effluent's NOEC should be 100%.

The effluent's NOEC for fathead minnows was <100% for several of the toxicity tests. This means that all the organisms failed the test at a concentration of 100% of the effluent. No other

concentrations were tested. These effects appear to be due to more transient trace contaminants rather than to a chronic presence of a trace contaminant. During June, in-depth studies could not identify the cause of toxicity. During August the toxicity was related to elevated sodium chloride concentrations.

The effluent's effects on *Ceriodaphnia* appear to be of a more chronic nature. Results of toxicity tests and concurrent chemical analyses indicate that concentrations of calcium in the effluent may be high enough to adversely impact *Ceriodaphnia*. Toxicity tests conducted for ORGDP and the Y-12 Plant indicate that calcium concentrations above 110 ppm may be toxic to *Ceriodaphnia*. Lime, which contains calcium, is utilized extensively for neutralizing effluent streams, of which coal pile runoff is the main contributor. Coal pile runoff is a large component of the K-1407-B effluent. The increased calcium concentrations in the K-1407-B effluent have been detected during the wet winter months and following heavy rains. During the dry summer months, less coal pile runoff was treated at this facility and, therefore, calcium concentrations in the K-1407-B effluent were reduced. During this same period, the K-1407-B effluent was not toxic to *Ceriodaphnia*, and chemical analyses indicated that calcium concentrations were low.

Studies conducted on Mitchell Branch indicate that discharges from ORGDP are having a negative impact. Continued monitoring is

Table 2.2.20. K-1407-B Pond toxicity test end points

Date (1987)	Fathead minnows		<i>Ceriodaphnia</i>	
	Survival NOEC <sup>a</sup> (%)	Growth NOEC (%)	Survival NOEC (%)	Reproduction NOEC (%)
February	100	60	<20	<20
March			<50	<50
April	100	100	<100	<100
June	<100	<100	100	100
July			100	100
August	50	<50	50	100
October	100	100	<50	<50
December	100	100	<100	<100

<sup>a</sup>NOEC = No observed effect concentration.

anticipated and warranted through mid-1990 to determine both short- and long-term effects on the branch due to remedial action projects scheduled for the entire watershed.

A more detailed discussion of the results from toxicity testing of the K-1407-B effluent and of Mitchell Branch are presented in an annual report issued by ORNL.

### 2.2.3 Special Activities

Design work was completed in 1987 for a new station on the WOC headwaters. This station will be located north of the 7000 area and will provide background data for surface waters before they are influenced by the plant. Construction is scheduled to start in January 1988.

A dye study was performed in the Clinch River beginning at the mouth of WOC. The plume was followed downstream past ORGDP and almost to the Kingston water plant. This Environmental Monitoring and Compliance (EMC) funded project was a cooperative effort among the TVA, ESD, EMC, and ORGDP personnel. Results are incorporated into flow and dispersion models developed by TVA and adapted by ORNL.

ESD and EMC personnel performed a second, smaller dye study from the WOC weir, through White Oak Lake, to WOD. The results of this study will be used in the WOC watershed models for flow and dispersion modeling.

During 1987, DOE and Energy Systems Engineering took several steps to address issues of hazards associated with WOD. A hazard rating has been obtained by ORNL in accordance with TDHE and the Army Corps of Engineers standard. A hazard analysis was also performed. Additional efforts to evaluate and ensure integrity of the dam will include seismic testing and core sampling during early 1988.

## 2.3 GROUNDWATER

The quality of our nation's water resources is seen as a serious and pressing issue, and public awareness of the need to protect these resources has increased dramatically in this decade. Public

sentiment is reflected in legislation enacted by Congress mandating that actions be taken to preserve water resources from contamination. These statutes have been codified into regulations by the 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.

### 2.3.1 Description

*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)] 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)] 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 must be made by November 8, 1988. At the time of issuance of the permit, a facility will shift 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 at the Oak Ridge Reservation (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 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 of these programs are similar in nature:

- Collect piezometric head measurements to determine the direction of groundwater flow;
- Obtain representative water samples from the geologic strata;
- Determine the background 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 constituents 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 Geology

The Oak Ridge Reservation is located in the Valley and Ridge Physiographic Province of the Appalachian Highlands Physiographic Division (Fig. 2.3.3). The Valley and Ridge is bounded by the Blue Ridge Province on the east and the bold escarpment of the Cumberland Plateau on the west. The Valley and Ridge Province is characterized by narrow, subparallel ridges and intervening valleys elongated northeast-southwest in conformity with the trend of the Appalachian region. Mountain-building processes in the

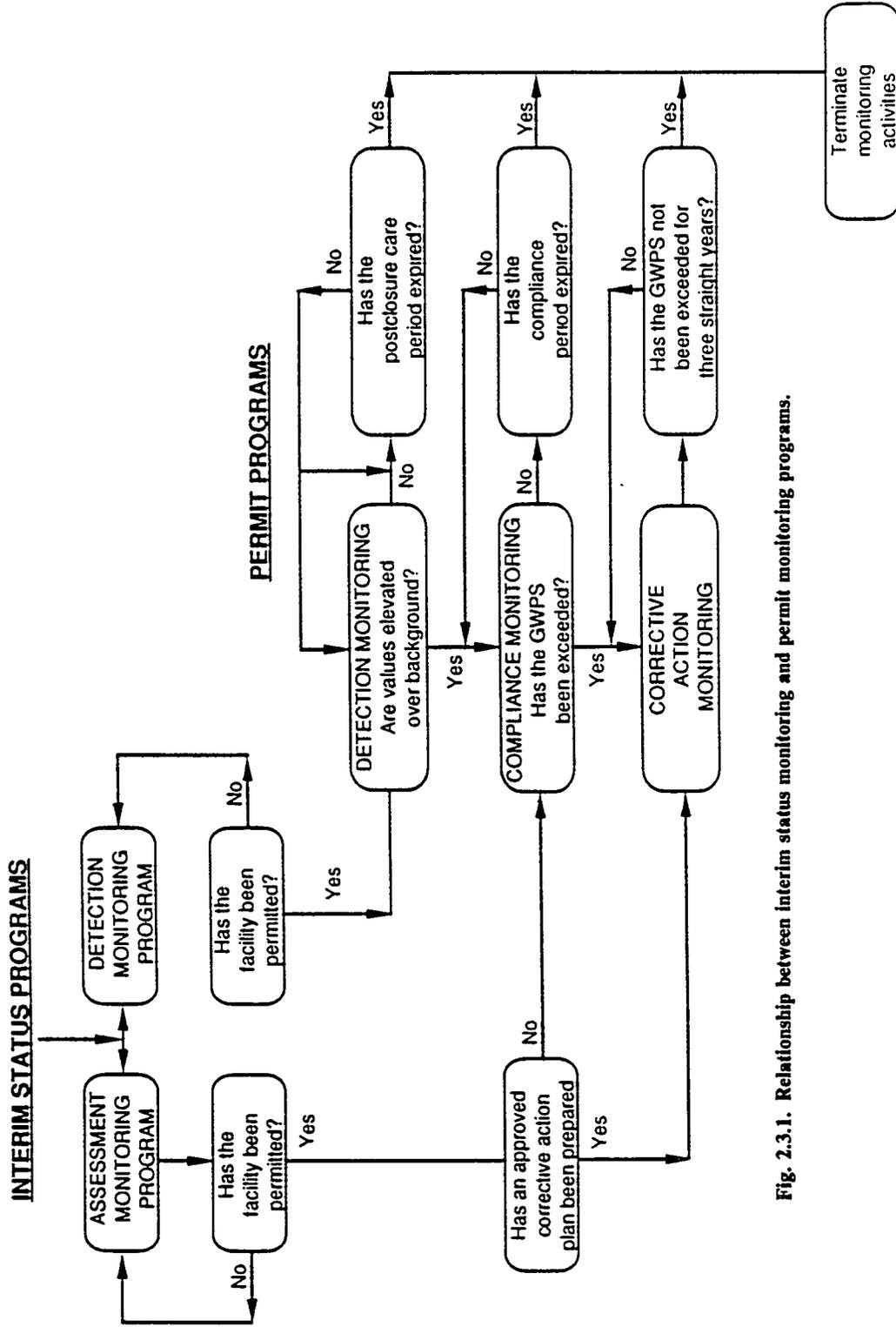


Fig. 2.3.1. Relationship between interim status monitoring and permit monitoring programs.

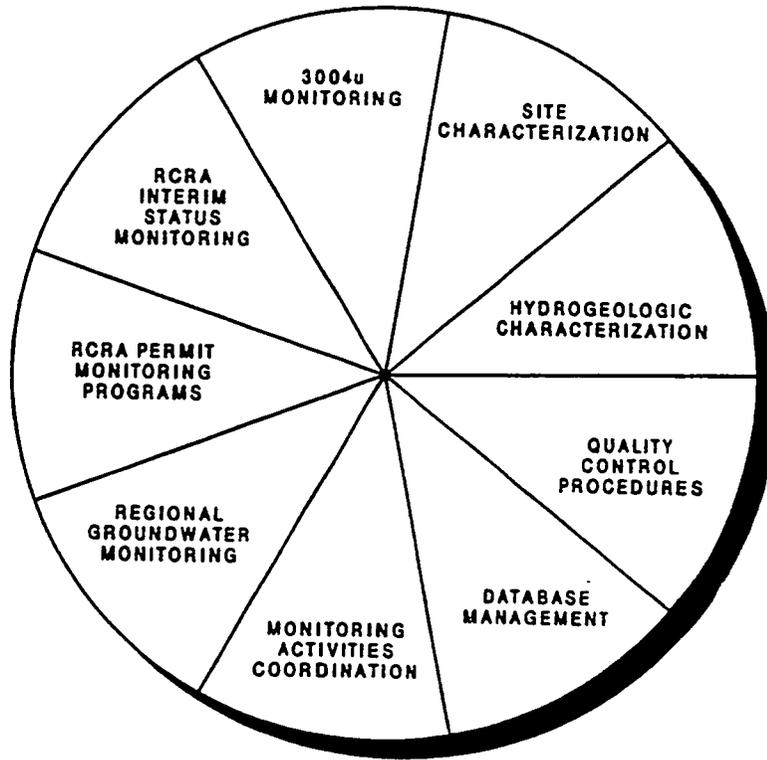


Fig. 2.3.2. Components of Oak Ridge Reservation groundwater surveillance program.

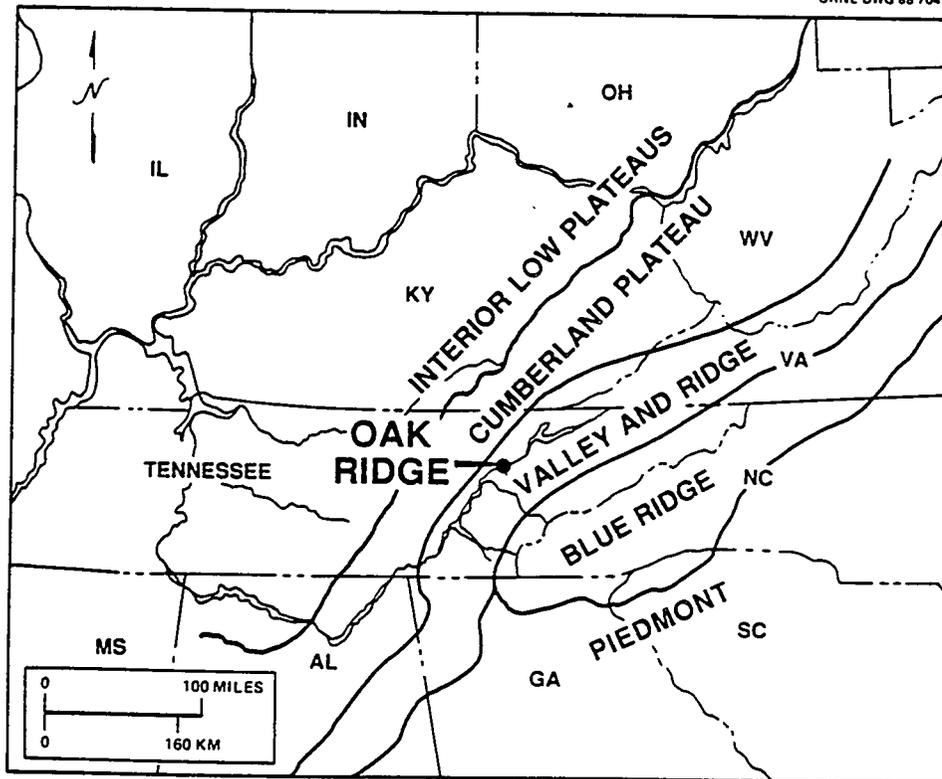


Fig. 2.3.3. Regional physiographic map of the Oak Ridge Reservation.

geologic past have folded, faulted, and otherwise deformed the rocks of the Valley and Ridge Province. It is this history of deformation that produced the belted patterns of rock formations characteristic of the Valley and Ridge (Fig. 2.3.4). The ridges are generally underlain by resistant sandstones, siltstones, and siliceous limestones and dolostones. Valleys are generally underlain by shales and more soluble carbonate formations. Some of these relationships are illustrated by the cross section of Fig. 2.3.5.

**2.3.2.1 Stratigraphy**

The ORR is underlain by ten different geologic formations or groups of formations ranging in age from early Cambrian to early Mississippian. These rocks are of sedimentary origin, both chemical and clastic. From the oldest to the youngest they include the Shady Dolomite, Rome Formation, the Conasauga Group, the Knox Group, the Chickamauga Group, the

Sequatchie Formation, the Rockwood Formation, the Chattanooga Shale, and the Fort Payne Formation (Fig. 2.3.6). From the standpoint of outcrop area, the most important are the Rome Formation, the Conasauga Group, the Knox Group, and the Chickamauga Group. The others are of limited areal extent.

**Shady Dolomite**

The Shady Dolomite is the oldest formation exposed in the Valley and Ridge Province of Tennessee. The outcrop area is generally restricted to the eastern side of the province. However, exposures have been found along the hanging wall of the Whiteoak Mountain Thrust Fault near the western border of the ORR in the vicinity of ORGDP (D'appolonia 1981; Ketelle 1988 personal communication). The Shady Dolomite consists of white to blue-gray dolostone and magnesian limestones. Silica as chalcedonic chert and brown to gray jasperoid in a yellow to

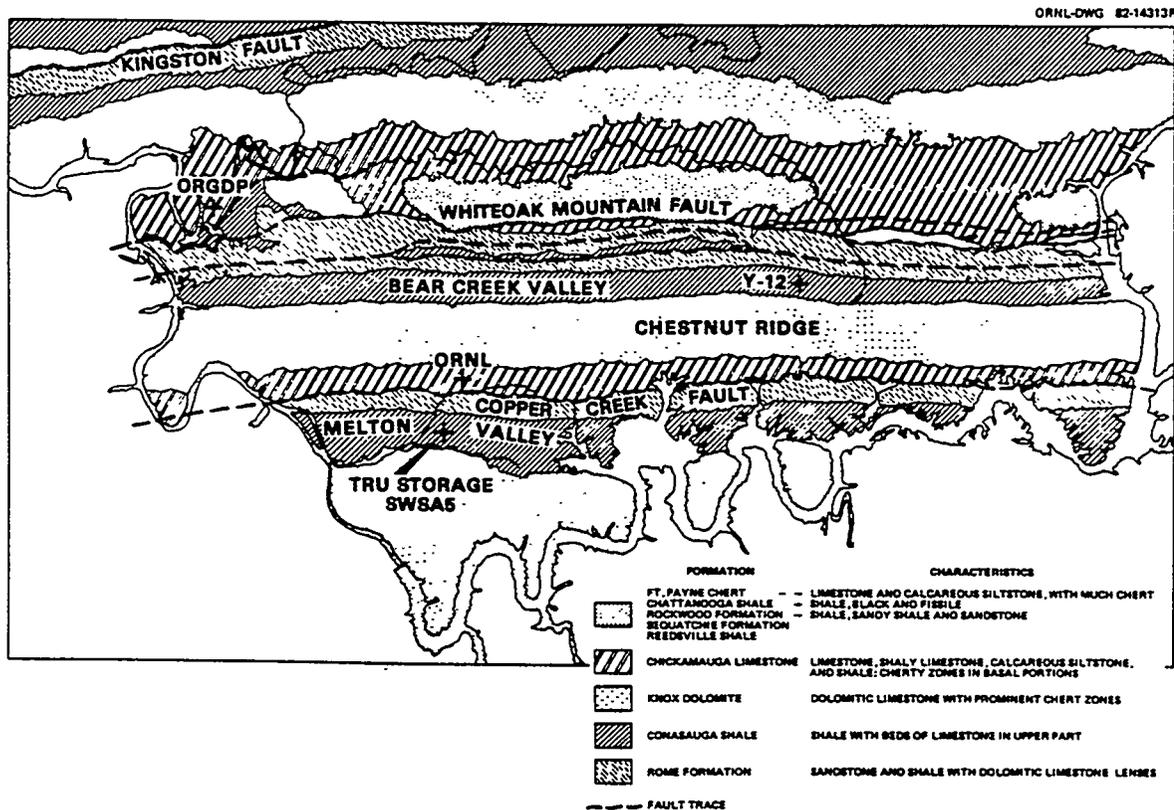


Fig. 2.3.4. Generalized geologic map of the Oak Ridge Reservation.

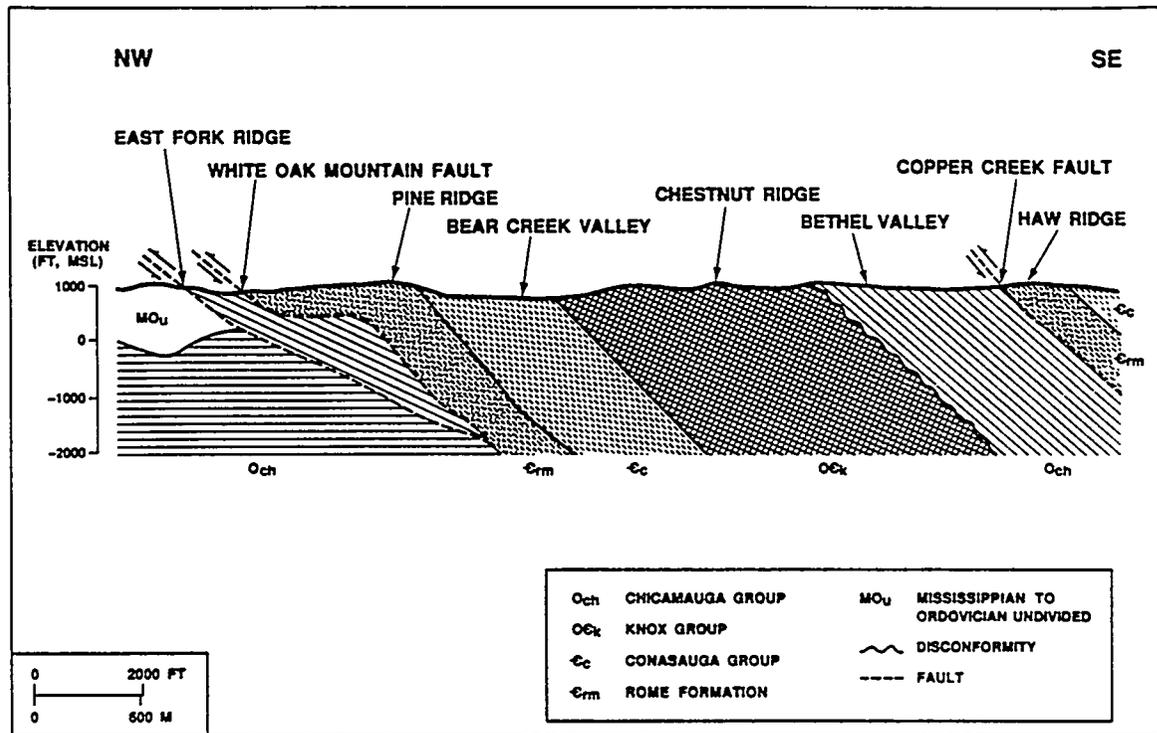


Fig. 2.3.5. Geologic cross section of the Oak Ridge Reservation.

red clay identify the weathered Shady Dolomite areas. The complete thickness of the Shady Dolomite is not preserved on the ORR because of faulting; where it is found, the Shady exhibits a large degree of fracturing and dissolution.

#### Rome Formation

The Rome Formation underlies Pine Ridge and Haw Ridge on the ORR. Lithologically the Rome is predominantly a siltstone and shale with fine-grained sandstones and zones of impure dark-colored dolostone and magnesian-limestone. The clastic rocks are variegated; maroon to gray-green colors are common. Glauconite and mica are typical accessory minerals. Where entirely preserved, the Rome is at least 1,200 ft (360 m) thick. Internal deformation and faulting make accurate measurement difficult.

#### Conasauga Group

Rocks of the Conasauga Group underlie Bear Creek Valley and Melton Valley of the

ORR. The Conasauga Group consists primarily of calcareous shales interbedded with limestones and siltstones. The total thickness of the group varies from 1500 to 1900 ft (450 to 580 m). Six formations can be recognized within the group. They are, in ascending order, the Pumpkin Valley Shale, the Rutledge Limestone, the Rogersville Shale, the Maryville Limestone, the Nolichucky Shale, and the Maynardville Limestone. Thicknesses of each formation vary throughout the area.

The Pumpkin Valley Shale ranges from 260 to 320 ft (80 to 98 m) in thickness throughout the valley and 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 richer in shale and mudstone than the lower one. The lower member contains abundant zones of mottled, bioturbated shaley siltstones interbedded with thinly bedded shales and siltstones (Law Engineering 1975; Hasse et al. 1987).

PERIOD	GROUP	FORMATION	THICKNESS	CHARACTERISTICS OF ROCKS
MISSISSIPPIAN		FT. PAYNE	80 FT	IMPURE LIMESTONE AND CALCAREOUS SILTSTONE, WITH ABUNDANT CHERT
	?	CHATTANOOGA SHALE	25 FT	SHALE, BLACK, FISSILE
SILURIAN		ROCKWOOD	700 FT	SILTSTONE, SANDSTONE, AND SHALE; YELLOW TO TAN AND BROWN
		SEQUATCHIE	300 FT	SHALE, SHALY LIMESTONE, SANDY SHALE, CALCAREOUS; MAROON TO GRAY OLIVE
ORDOVICIAN	CHICKAMAUGA		2000 FT	LIMESTONE, SHALY LIMESTONE, CALCAREOUS SILTSTONE, AND SHALE; MOSTLY GRAY, PARTLY MAROON; WITH CHERTY ZONES IN BASAL PORTIONS
	KNOX		3000 FT	DOLOSTONE AND DOLOMITIC LIMESTONE; LIGHT TO DARK GRAY; WITH PROMINENT CHERT ZONES
	CONASAUGA	MAYNARDVILLE LIMESTONE NOLICHUCKY SHALE MARYVILLE LIMESTONE ROGERSVILLE SHALE RUTLEDGE LIMESTONE PUMPKIN VALLEY SHALE	1800 FT	LIMESTONE, SILTSTONE, AND SHALE; GRAY, OLIVE, BROWN
CAMBRIAN		ROME	800 + FT	SANDSTONE AND SHALE; VARIEGATED WITH BRILLIANT YELLOW, BROWN, RED, MAROON, OLIVE-GREEN; WITH DOLOMITIC LIMESTONE LENSES

Fig. 2.3.6. Generalized geologic section of the Oak Ridge Reservation.

The Rutledge Limestone is 90 to 120 ft (28 to 37 m) thick and 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, 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 (Law Engineering 1975; Haase et al. 1987).

The Rogersville Shale is composed predominantly 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. The Rogersville Shale varies from 90 to 120 ft (28 to 37 m) in thickness (Law Engineering 1975; Haase et al. 1987).

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. Zones of limestone-pebble conglomerates and oolite-rich beds are locally abundant in the upper portion (Haase et al. 1987). The lower portion consists of medium to thinly bedded calcareous shales and siltstones with subordinate amounts of crystalline limestones. Thicknesses of the Maryville Limestone vary from 346 to 445 ft (105 to 135 m).

The Nolichucky Shale ranges in thickness from 442 to 550 ft (135 to 168 m). The formation consists of maroon-brown to 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 and serves to differentiate shales of this formation from those of the underlying Maryville Limestone (Haase et al. 1987). The interbedded limestones typically contain limestone-pebble conglomerates and oolite-rich beds similar to those occurring in the underlying Maryville Limestone.

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 contains subordinate amounts of interbedded dolostone, and the lower Low Hollow member is locally dolomitic and contains abundant oolite-rich horizons. Both members are locally stylolitic. Within the study area, the Maynardville Formation varies from 418 to 450 ft (127 to 137 m) in thickness.

### **Knox Group**

The Knox Group underlies the areas of Chestnut Ridge, Copper Ridge, and McKinney Ridge on the ORR. Rocks of the Knox Group have an aggregate thickness of 3000 to 3500 ft (915 to 1065 m) and constitute the most extensive outcrops in the Valley and Ridge Province. The group is divided into as many as five formations by various stratigraphers; however, there are variations of interpretation among them.

The Lower Ordovician to Upper Cambrian Knox consists of gray to blue-gray, thin- to thick-bedded dolostone with interbeds of limestone, weathering to a reddish-orange to yellow-orange clayey soil commonly containing an abundance of chert.

Solution features such as sinkholes and caverns are common in the Knox Group, and the Lower Ordovician contact with the Conasauga Group and the Upper Cambrian contact with the Chickamauga Group are zones of discharge for springs in many places (DeBuchananne 1956). This upper contact marks a major disconformity throughout the Valley and Ridge Province, and evidence of erosion of this surface is common.

### **Chickamauga Group**

Rocks of the Chickamauga Group occur in Bethel Valley and East Fork Valley on the ORR. This group is lithologically quite variable both vertically and areally, and its components are variously named from place to place by different stratigraphers. The correlation from one exposure belt to other belts of outcrop is difficult.

The Chickamauga ranges from 1800 to 2200 ft (550 to 670 m) in thickness in the ORR area and is composed of interbedded limestones, argillaceous limestones, calcareous shales, and calcareous siltstones with abundant chert in the lower portion. The rocks are commonly colored maroon or gray.

#### **Sequatchie Formation**

The Sequatchie Formation occupies an area at the base of the East Fork Ridge and consists of maroon to gray, silty to shaley limestone with calcareous, maroon siltstone. This formation is approximately 360 ft (110 m) thick (McMaster 1962).

#### **Rockwood Formation**

The Silurian-age Rockwood underlies the higher topographic areas of East Fork Ridge. On the ORR, the Rockwood consists of brown, tan, and yellow siltstone, shale, sandstone, and minor hematitic limestone totaling about 700 ft (213 m) in thickness (McMaster 1962).

#### **Chattanooga Shale**

McMaster (1962) has mapped the Chattanooga and Maury formations as one unit on the southern side of East Fork Ridge on the ORR. Here the two formations have a collective thickness of only 25 ft (8 m) and consist primarily of black, fissile shale.

#### **Fort Payne Formation**

Rocks of the Fort Payne overlie the Chattanooga Shale in the area of East Fork Ridge. McMaster (1962) states that less than 80 ft (24 m) of the formation is present and that it consists of extremely siliceous limestone.

#### **2.3.2.2 Structure**

The ORR is transected by two major thrust faults: the White Oak Mountain Fault and the Copper Creek Fault. These faults trend northeast-southwest and represent displacements of about 5–15 km during the Alleghenian Orogeny.

The White Oak Mountain Fault originates about 18 miles northeast of the ORNL site near Clinton, Tennessee, by the convergence of the Hunter Valley and Wallen Valley faults. It extends about 130 km to the southwest and merges with the Copper Creek Fault near Cleveland, Tennessee. In the Oak Ridge area, the White Oak Mountain Fault is a complexly branching thrust fault along which siltstones and shales of the lower Rome Formation have been thrust over middle Cambrian and younger rocks. One result of the fault is the development of synclinal structures (East Fork Ridge) northwest of the main fault. The main White Oak Mountain Fault crosses the ORGDP site northwest of Pine Ridge and southeast of McKinney Ridge.

In contrast with the White Oak Mountain Fault, the Copper Creek Fault is, with a few exceptions, a single fault along which the Rome Formation is thrust onto Chickamauga rocks. The Copper Creek Fault extends southeast from Virginia and merges with the White Oak Mountain Fault near Cleveland, Tennessee. This fault emerges along the northwestern flank of Haw Ridge. The fault has an average strike of N 55°E in the Oak Ridge area.

The average strike and dip of bedding in the ORR is approximately N 55°E, and 45°SE, respectively. Locally, small-scale folding is common and contributes to the wide range of bedding orientations that can be observed in the area. The folds generally have axes parallel to the strike of the bedding.

The presence of joints in the rocks is one of the most important factors controlling the movement of groundwater through the subsurface. Joints provide pathways that may become enlarged by solution. This process is important in the carbonate rocks. Studies of joints in the ORR (Law 1975; Sledz and Huff 1981; Rothschild et al. 1984) indicate that joint orientations and spacing are quite variable. The studies generally agree that there is at least one major joint set that roughly parallels the geologic strike.

A second steeply dipping joint set that strikes approximately N 12°W has been documented (Law 1975; Rothschild et al. 1984). Other

documented joint orientations in Bear Creek Valley include N 35°W with a dip of 35°NE; N 46°W, dipping 57°NE; and N 50° with a dip of 72°SW. The joint spacing may vary from fractions of inches to several feet. The greatest concentration of joints is observed in siltstones and sandstones, and the least in shales and limestones. The joint density was found to be inversely proportional to bed thickness in both shales and siltstones.

Faults, joints, and bedding planes in carbonate rock provide avenues along which solution can occur. Cavities commonly occur in the upper part of the rock. These cavities may be above or below the current water table and may be partly to completely filled with clay or other detritus. Cavities are more common in the Knox Group than in the Chickamauga Group, the Conasauga Group, and the Rome Formation.

#### 2.3.2.3 Groundwater occurrence

The groundwater system on the ORR consists of two components: an upper regolith zone composed of unconsolidated materials and a lower bedrock zone. Because the unconsolidated zone is in hydraulic connection with the bedrock, these two zones are considered to be a single groundwater system over much of the Reservation. However, locally this interconnection is poor. In addition, artesian conditions exist in the deeper bedrock zones underlying some of the valley areas.

Water table conditions generally prevail throughout the ORR. The configuration of the water table is generally a subdued replica of the surface topography. Shallow groundwater flow is generally predictable; that is, flow is from topographically high to lower areas. Local recharge from precipitation moves along relatively short flow paths to seeps and springs or to the banks or bottom of the nearest surface water body.

Depth to the water table varies both spatially and temporally. At a given location, depth to water is generally greatest during the October–December quarter and least during the March–May quarter.

The occurrence and movement of groundwater in the bedrock are closely related to the presence of bedding planes, fractures, and cavities. This results in anisotropic flow conditions. Preferred flow paths occur along strike following bedding planes, joints, and cavities, whereas flow perpendicular to bedding is largely limited to joints or fractures that cut across bedding.

Recharge to the groundwater system is derived through precipitation, and groundwater discharge occurs through streams, springs, and evapotranspiration.

Groundwater discharge constitutes the base flow of the surface water systems draining the ORR. The surface streams ultimately augment the water supply of the Clinch River, which is the hydraulic sink for the Reservation.

### 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 2.3.1–2.3.11 in Vol. 2 outline the applicable standards. The analytical data presented in Table 2.3.12 of Vol. 2 depict levels of parameters found in groundwater which are above the applicable standards.

#### 2.3.3.1 Oak Ridge Y-12 Plant

The principal consideration in siting boreholes is to locate them so that maximum geological and hydrological data can be obtained. Borehole locations are chosen based on site topography, available geologic and hydrologic data, and knowledge gained from previous investigations at geohydrologically similar sites. At each site, major features of subsurface geology are identified; boreholes and groundwater investigation wells are then installed to study the hydrogeologic significance of such features and to provide data on subsurface geology, hydrostatic heads, and water quality for shallow-flow regimes in soils and upper weathered-bedrock zones and for deeper-flow regimes in unweathered bedrock.

Each waste disposal facility operated by the Oak Ridge Y-12 Plant has a network of groundwater monitoring wells that consists of at least one well hydraulically upgradient and three 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 1987 groundwater surveillance program is summarized in Table 2.3.1. During 1987, 151 wells were routinely sampled. Figure 2.3.7 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 1987: S-3 ponds, Chestnut Ridge Security Pits (CRSP), New Hope Pond, Chestnut Ridge Sediment Disposal Basin (CRSDB), Kerr Hollow Quarry, Bear Creek Burial Grounds area (includes the Oil Retention Ponds), and Oil Landfarm area. Three of these sites (S-3 ponds, Oil Landfarm, and Bear Creek Burial Grounds) were in assessment monitoring during all of 1987. 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 postclosure 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 400 ft × 400 ft (122 × 122 m). The original pond excavations penetrated residual soil and fill materials but did not extend down to bedrock. The ponds are approximately 17 ft (5 m) deep and contain sludge ranging from 2 to 5 ft (0.6 to 1.5 m) 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 2.5 million gal. Hazardous waste disposal at the S-3 ponds was terminated in 1984. The GWQAP for the S-3 ponds includes both quarterly and annual assessment-well networks. Data regarding the depth, screened interval, and the aquifer zone monitored for each assessment well are summarized in Table 2.3.2.

Results of water-quality analyses for water samples collected from the assessment wells during the four quarters of 1987 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 (150 m) to the northeast, south, and southwest of the ponds. 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 (48 m) in the Nolichucky and the Maynardville.

Review of the VOC data indicated that at least two sources of VOC constituents were present in groundwater at the S-3 Ponds. The S-3 Ponds are most likely a source of tetrachloroethene as indicated by the high concentrations in water samples from the wells adjacent to the ponds. However, high concentrations of carbon tetrachloride and low concentrations of tetrachloroethene in wells located east-southeast of the ponds suggest the presence of another source.

Concentrations of uranium and levels of gross alpha and gross beta activity above applicable standards also were detected in groundwater at the S-3 Ponds. 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 groundwater sampled from the unconsolidated zone or the upper 150 ft (46 m) of the Nolichucky. Elevated concentrations of uranium were not present in samples with high pH values collected from the deep wells in the Nolichucky. The highest uranium concentrations were detected in samples

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 <sup>a</sup> monitored	Monitor wells	Sampling frequency	Comments
		Interim status		Permit		Corrective action	3004(u)				
		Detection	Assessment	Detection	Compliance						
Bear Creek Burial Grounds	RCRA	1985	1986	NA <sup>b</sup>		NA	NA	1, 2, 3, 4, 5, 6, 7, 10	27	Quarterly	
Beta-4 Security Pits	3004(u)	NA	NA	NA	NA	1985	NA	3	6	Semiannually	c
Chestnut Ridge Security Pits	RCRA	1985	1988	NA		NA	NA	1, 2, 3, 4, 5, 6, 7, 10, 11	6	Quarterly	
Chestnut Ridge Sediment Disposal Basin	RCRA	1985				NA	NA	1, 2, 3, 4, 5, 6, 7, 10, 11	8	Quarterly	
Kerr Hollow Quarry	RCRA	1985				NA	NA	1, 2, 3, 4, 6, 7, 9, 10, 11	7	Semiannually	
New Hope Pond	RCRA <sup>d</sup>	1985	1988	NA		NA	NA	1, 2, 3, 4, 5, 6, 7, 10, 11	11	Quarterly	
Oil Landfarm area	RCRA	1985	1986	NA		NA	NA	1, 2, 3, 4, 5, 6, 7, 10, 11	18	Quarterly	
Ravine Disposal site	3004(u)	NA	NA	NA	NA	1985	NA	2, 3, 6, 11	5	Semiannually	c
Rogers Quarry	3004(u)	NA	NA	NA	NA	1985	NA	3	6	Semiannually	c
S-2 site	3004(u)	NA	NA	NA	NA	1986	NA	1, 2, 3, 4, 5, 6, 7, 9, 10, 11	9	Quarterly	
S-3 Ponds	RCRA	1985	1986	NA		NA	NA	1, 2, 3, 4, 5, 6, 7, 9, 10, 11	27	Quarterly	
Salvage Yard area	RCRA/3004(u)	NA	NA	NA	NA	1985	NA	1, 2, 3, 4, 5, 6, 7, 9, 10, 11	16	Quarterly	c
United Nuclear landfill	3004(u)	NA	NA	NA	NA	1985	NA	3	5	Quarterly	

<sup>a</sup>See the following tables for parameters monitored.

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

<sup>b</sup>Not applicable.

<sup>c</sup>Wells installed for plant site characterization program; authority transferred to 3004(u) in 1986

<sup>d</sup>Site is treated like a RCRA site

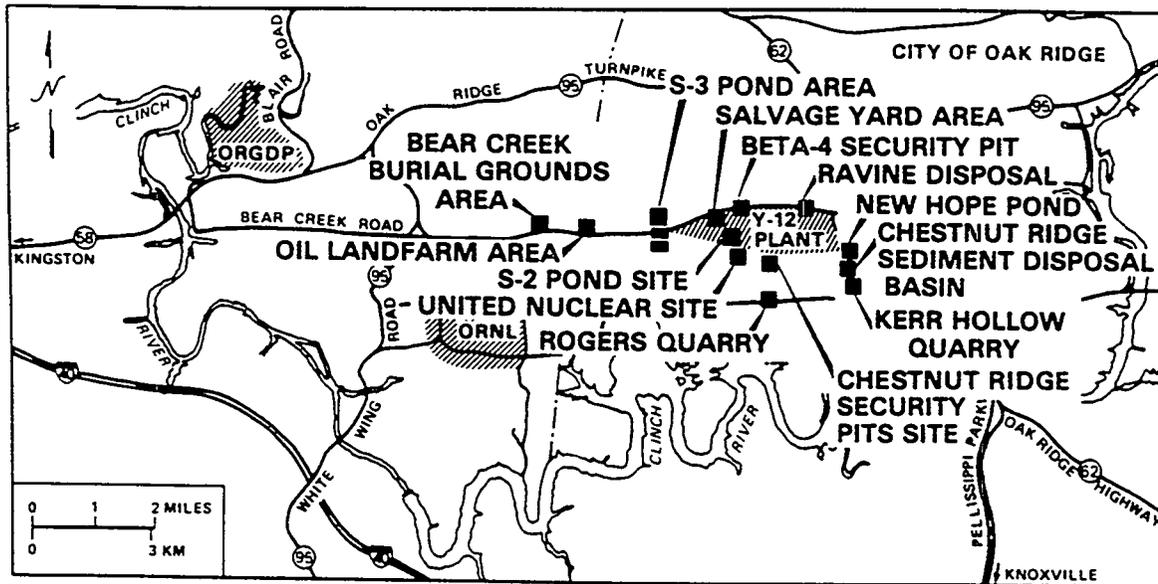


Fig. 2.3.7. Index map of Y-12 Plant comprehensive groundwater characterization program by sites.

Table 2.3.2. Aquifer zones monitored by the S-3 ponds assessment wells

Well number	Total depth (ft)	Screened/open interval (ft)	Aquifer zone
GW-100	20.7	10.2-14.2	UNC <sup>a</sup>
GW-105	17.0	12.1-16.1	UNC
GW-106	75.0	61.9-70.9	BDR <sup>b</sup>
GW-107	14.2	8.5-12.5	UNC
GW-108	58.6	46.7-55.7	BDR
GW-109	128.5	102.9-121.9	BDR
GW-115	57.0	42.0-52.0	BDR
GW-122	142.0	142.0-192.0	BDR
GW-123	572.0	522.0-572.0	BDR
GW-124	150.0	100.0-150.0	BDR
GW-125	552.0	502.0-552.0	BDR
GW-127	24.0	18.8-22.8	UNC
GW-236	18.5	13.0-18.0	UNC
GW-243	77.0	45.1-72.9	BDR
GW-244	77.0	47.3-75.4	BDR
GW-245	76.0	46.6-71.6	BDR
GW-246	76.0	46.9-74.6	BDR
GW-247	78.0	46.9-74.9	BDR
GW-270	18.5	13.0-18.4	UNC
GW-271	56.3	45.9-56.3	BDR
GW-272	16.2	10.9-16.2	UNC
GW-274	35.0	28.5-33.9	UNC
GW-275	65.5	54.8-62.5	BDR
GW-276	18.5	13.0-18.5	UNC
GW-277	77.4	67.0-76.4	BDR
GW-278 <sup>c</sup>	21.1	15.9-21.1	UNC
GW-279 <sup>c</sup>	76.4	66.0-76.4	BDR
GW-280 <sup>c</sup>	154.0	131.4-154.0	BDR

<sup>a</sup>Unconsolidated zone.

<sup>b</sup>Bedrock.

<sup>c</sup>Well removed in third quarter of 1987.

from wells located in the immediate vicinity of the S-3 Ponds.

At this stage of the assessment monitoring program at the S-3 Pond site, it is not possible to accurately determine a quantitative rate of contaminant migration. No significant changes in contaminant plume geometry have been observed, and no consistent trends in contaminant concentrations in individual wells have been identified.

**Chestnut Ridge Security Pits.** The Chestnut Ridge Security Pits are located on the crest of Chestnut Ridge, southeast of the central portion of the Y-12 Plant. Operated since 1973, the Chestnut Ridge Security Pits 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; however, operation of the facility for disposal of nonhazardous wastes will continue until a new classified waste storage facility becomes available.

Nine wells have been installed in conjunction with geologic and hydrologic investigations at the Chestnut Ridge Security Pits. Wells GW-173, 174, 176, 177, and 179 were installed in 1985 in accordance with a monitoring plan designed to meet RCRA requirements (Geraghty & Miller, Inc., 1985a). Wells GW-178, 180, and 322 were installed in 1987. Well 1080, which was installed in 1983, was not constructed in accordance with RCRA standards and will not be used for site assessment. These well locations are shown in Fig. 2.3.8.

**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. The CRSDB is scheduled to be closed in place in 1988 in a manner equivalent to a RCRA facility closure. In 1982, the site was partially characterized by Geotek Engineering with the installation of groundwater wells 1095 and 1096. Additional wells, GW-155, 156, 157, 158, 159, and 241, were installed in 1985 (see Haase et al.). One characterization well, GW-

308, was installed in 1987 to better demonstrate the hydrologic relationships on the north slope of Chestnut Ridge. The groundwater wells located at the CRSDB are shown in Fig. 2.3.9. Currently, mercury-contaminated soil from construction projects is being disposed of in this facility with approval from TDHE.

**Kerr Hollow Quarry.** Kerr Hollow Quarry 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 has been used for the disposal of reactive materials from the Y-12 Plant and ORNL.

Seven groundwater investigation wells (GW-142, GW-143, GW-144, GW-145, GW-146, GW-147, and GW-231) were installed around the Kerr Hollow Quarry site in 1985. An eighth boring at the site (CH-143) is an exploratory core hole for subsurface characterization. The core hole was not finished as a well and was plugged during casing-grouting operations at adjacent groundwater investigation wells.

While an analysis of the groundwater data does not indicate that contamination is moving into the groundwater at Kerr Hollow Quarry, it does serve to accent the complexity of the site. With a few exceptions, the data do not exceed regulatory limits and when limits are exceeded there is no pattern of recurrence.

**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

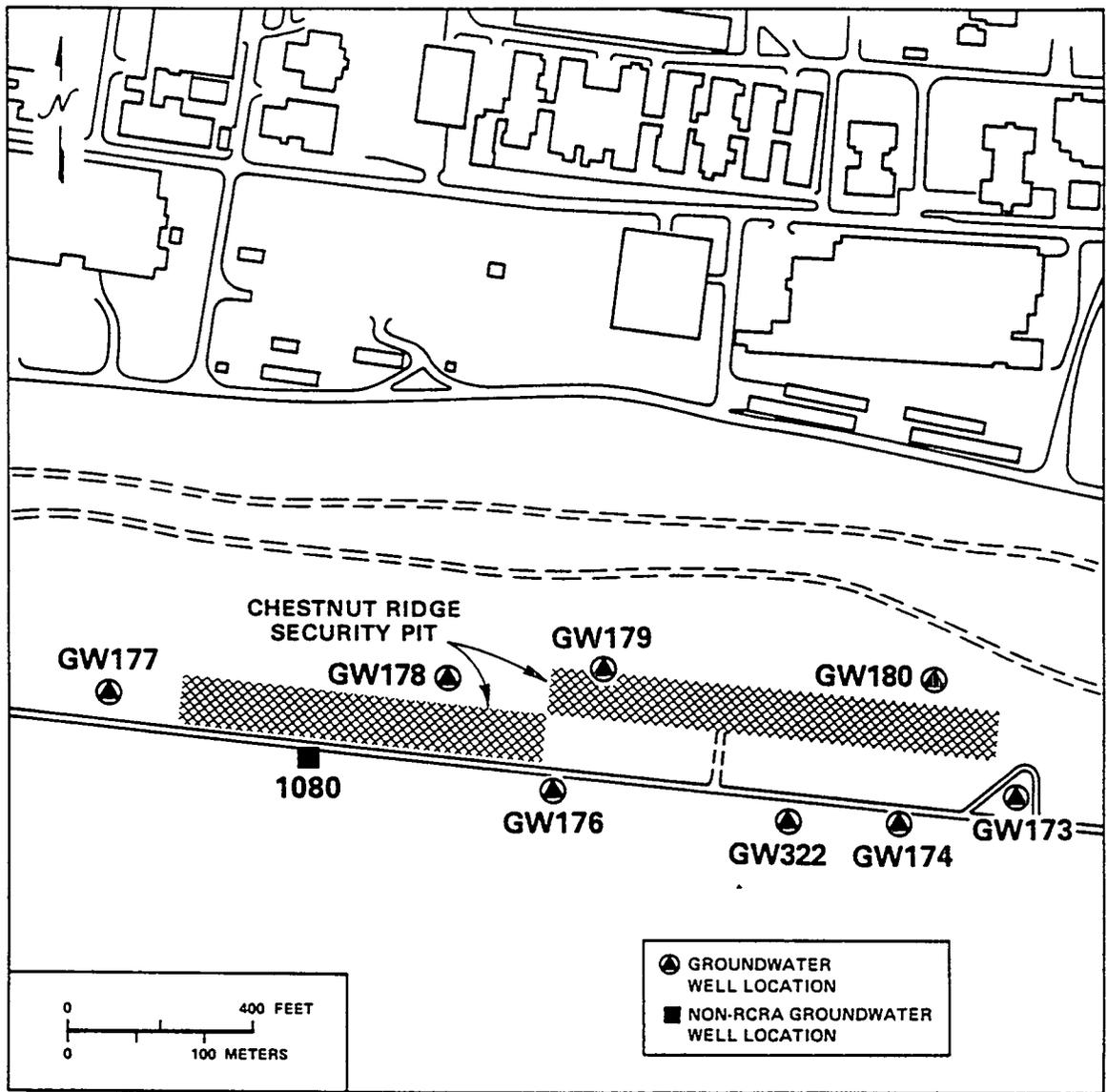


Fig. 2.3.8. Monitor well network at the Chestnut Ridge security pits south of the Y-12 Plant.

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.

The 1987 GWQAP for the Oil Landfarm includes both quarterly and annual assessment well networks (Fig. 2.3.10). Table 2.3.3 provides assessment well information in regard to depth, screened interval, and the aquifer zone monitored. The sample results for 1987 are presented in Table 2.3.12 of Vol. 2.

**Bear Creek Burial Grounds.** The Bear Creek

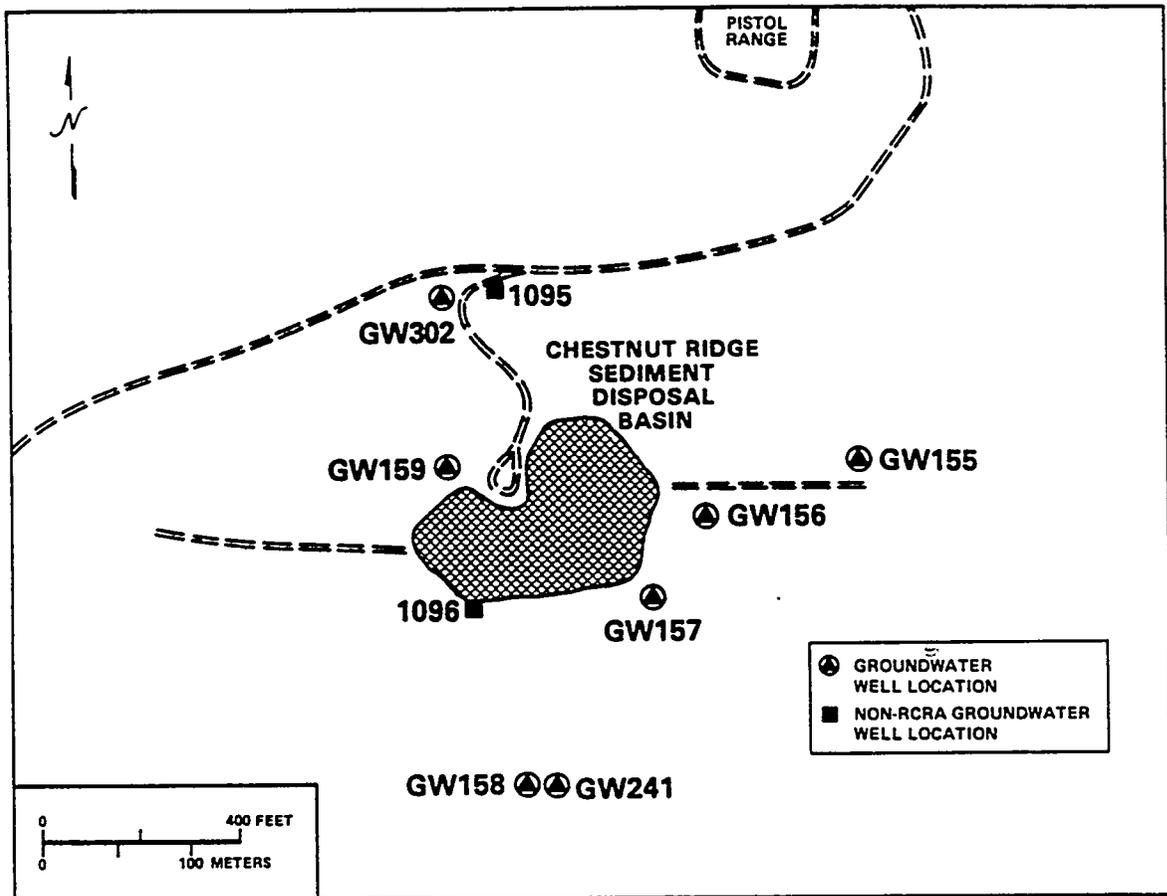


Fig. 2.3.9. Groundwater wells at the Chestnut Ridge sediment disposal basin.

Burial Grounds 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 14 and 25 ft (4.3 and 7.6 m) 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.

The 1987 GWQAP for the burial grounds includes both quarterly (Fig. 2.3.11) and annual assessment well networks. Table 2.3.4 provides assessment well information in regard to depth,

screened interval, and the aquifer zone monitored. The sample results for 1987 are presented in Table 2.3.12 of Vol. 2.

#### Non-RCRA groundwater wells

Quarterly groundwater sampling of the Y-12 Plant historical monitoring wells was continued through 1987. These wells are located at the S-3 Ponds, United Nuclear Corporation (UNC) site, Bear Creek Valley Waste Disposal area, and the Centralized Sanitary Landfill II (see Fig. 2.3.12). Table 2.3.5 identifies the wells that were sampled at the particular waste sites. In 1987, GWQAPs were submitted to the TDHE. The sites addressed by these plans are the S-3 Ponds, Oil Landfarm, and the Bear Creek Burial Grounds. The assessment plans were approved by TDHE; this RCRA program replaces the monitoring at the

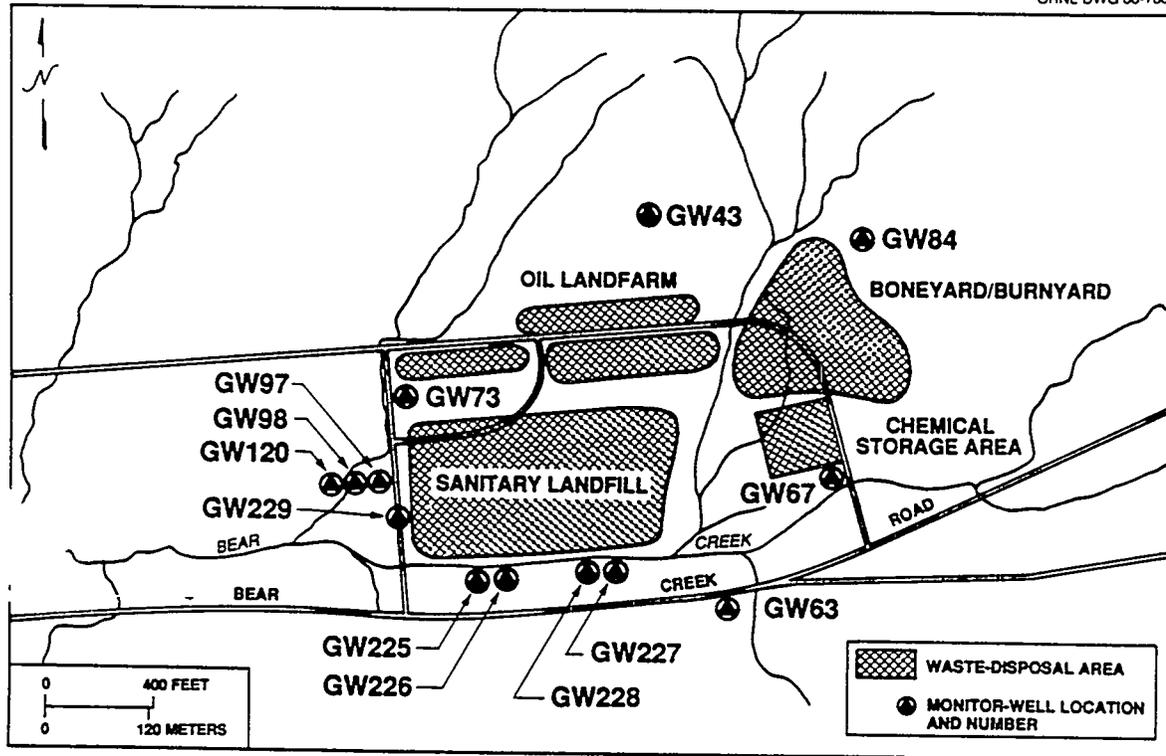


Fig. 2.3.10. Monitor well network for quarterly assessment at the oil landfarm near the Y-12 Plant..

Table 2.3.3. Aquifer zones monitored by the Y-12 Plant oil landfarm assessment wells

Well number	Total depth <sup>a</sup>	Screened/open interval <sup>c</sup>	Aquifer zone
GW-3	35.2	18.0–28.0	BDR <sup>b</sup>
GW-7	16.5	12.3–14.3	UNC <sup>c</sup>
GW-10	15.0	7.7–12.7	UNC
GW-43	40.0	22.8–32.8	UNC
GW-63	35.0	27.7–32.7	BDR
GW-64	57.0	46.8–52.7	BDR
GW-67	16.5	11.2–16.2	UNC
GW-73	81.0	69.8–79.8	BDR
GW-84	34.0	22.8–27.8	UNC
GW-85	62.0	48.4–58.8	BDR
GW-87	19.0	9.0–19.0	UNC
GW-97	19.2	11.8–16.8	UNC
GW-98	104.0	82.4–103.4	BDR
GW-120	180.0	130.0–180.0	BDR
GW-225	200.0	150.0–200.0	BDR
GW-226	55.0	45.0–55.0	BDR
GW-227	40.0	30.0–40.0	BDR
GW-228	100.0	80.0–100.0	BDR
GW-229	55.0	40.0–55.0	BDR

<sup>a</sup>All measurements in feet below ground surface.

<sup>b</sup>BDR—bedrock.

<sup>c</sup>UNC—unconsolidated zone.

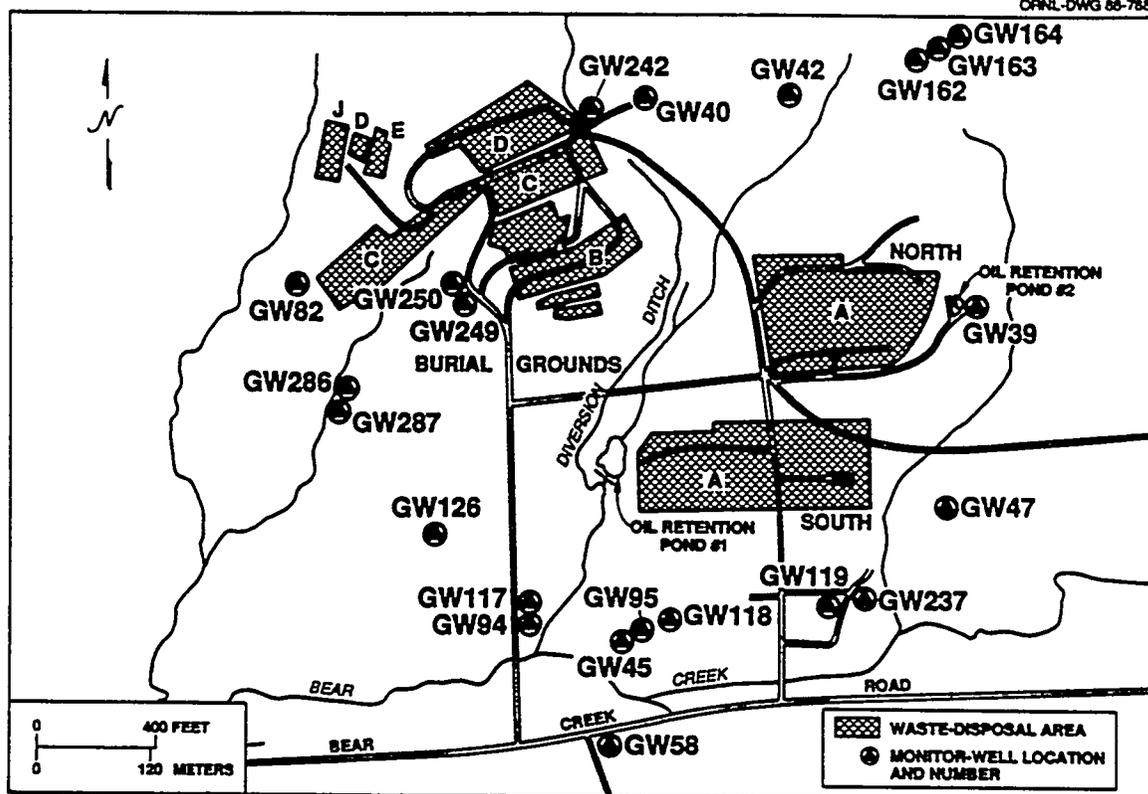


Fig. 2.3.11. Monitor well network for quarterly assessment at the Bear Creek burial grounds.

sites. The historical wells report was discontinued after the third quarter of 1987. The removal of the historical wells identified in Table 2.3.5 will begin after a state-approved plugging and abandonment program is in place (see Sect. 2.3.4). Analytical data for three quarters of 1987 are available for the 24 wells sampled.

#### Subsurface mercury characterization wells

In late 1983 and early 1984, wells were installed at the Y-12 Plant to characterize subsurface mercury. The wells were installed in areas thought to be contaminated with mercury and in line with the general direction of groundwater flow (see Fig. 2.3.13). The mercury-contaminated areas include Building 9204-4, Building 9201-5, Building 9201-4, 9201-2 area, 9202 area, 81-10 area, the old deflasking area near 9103, and the old mercury storage area near Guard Portal 33. The initial groundwater sampling data are included in *Investigation of*

*Subsurface Mercury at the Oak Ridge Y-12 Plant* (ORNL/TM-9092), which was issued in November 1984. In 1987, 38 groundwater samples were taken from the wells. The analytical results from these samples are presented in Table 2.3.12 of Vol. 2.

#### Other site-specific groundwater monitoring

Groundwater monitoring has been ongoing in 1987 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. 2.3.7): Beta-4 Security Pit, Ravine Disposal area, UNC site, Rogers Quarry, S-2 Pond, and the Salvage Yard area (includes 5 SWMUs). RCRA facility investigation (RFI) plans were submitted to the EPA and the state in 1987 for the S-2 Pond and the Salvage Yard area. Reports summarizing the preliminary analysis of groundwater data for the Beta-4 Security Pit,

Table 2.3.4. Aquifer zones monitored by the Bear Creek burial grounds assessment wells

Well number	Total depth <sup>a</sup>	Screened/open interval <sup>a</sup>	Aquifer zone
GW-14	13.2	5.0-13.2	UNC <sup>b</sup>
GW-21	15.0	5.5-14.2	UNC
GW-27	30.0	18.5-30.5	UNC
GW-39	22.5	6.0-21.1	UNC
GW-40	35.0	21.0-29.0	BDR <sup>c</sup>
GW-42	30.0	13.4-28.7	UNC
GW-45	15.2	1.8-15.2	UNC
GW-46	20.5	5.0-20.3	UNC
GW-47	25.5	12.5-25.5	UNC
GW-58	45.2	38.8-45.0	BDR
GW-68	85.0	70.0-83.6	BDR
GW-71	220.6	195.1-219.0	BDR
GW-72	101.4	84.5-98.4	BDR
GW-82	35.0	19.9-29.5	BDR
GW-94	115.3	86.4-115.3	BDR
GW-95	156.0	130.2-156.0	BDR
GW-117	530.0	480.0-530.0	BDR
GW-118	575.0	525.0-575.0	BDR
GW-119	510.0	460.0-510.0	BDR
GW-126	155.0	105.0-155.0	BDR
GW-162	125.0	92.0-125.0	BDR
GW-163	225.0	208.0-225.0	BDR
GW-164	405.0	370.0-405.0	BDR
GW-237	13.7	6.5-13.7	UNC
GW-242	17.0	9.0-17.0	UNC
GW-249	35.1	28.5-35.1	UNC
GW-250	61.7	49.5-61.7	BDR
GW-286	32.3	19.5-32.3	BDR
GW-287	12.3	5.6-12.3	UNC

<sup>a</sup>All measurements in feet below ground surface.

<sup>b</sup>UNC—unconsolidated zone.

<sup>c</sup>BDR—bedrock.

Ravine Disposal area, UNC site, and Rogers Quarry were prepared in 1987. The following commentary summarizes the findings from the 1986 data and an update on the 1987 sampling effort.

**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 locality 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 for the first monitoring year (1986) is not, with one exception, suggestive of contamination at the Beta-4 Security Pit site. One well has shown a trace amount of *trans*-1,2-dichloroethene in all four samples;

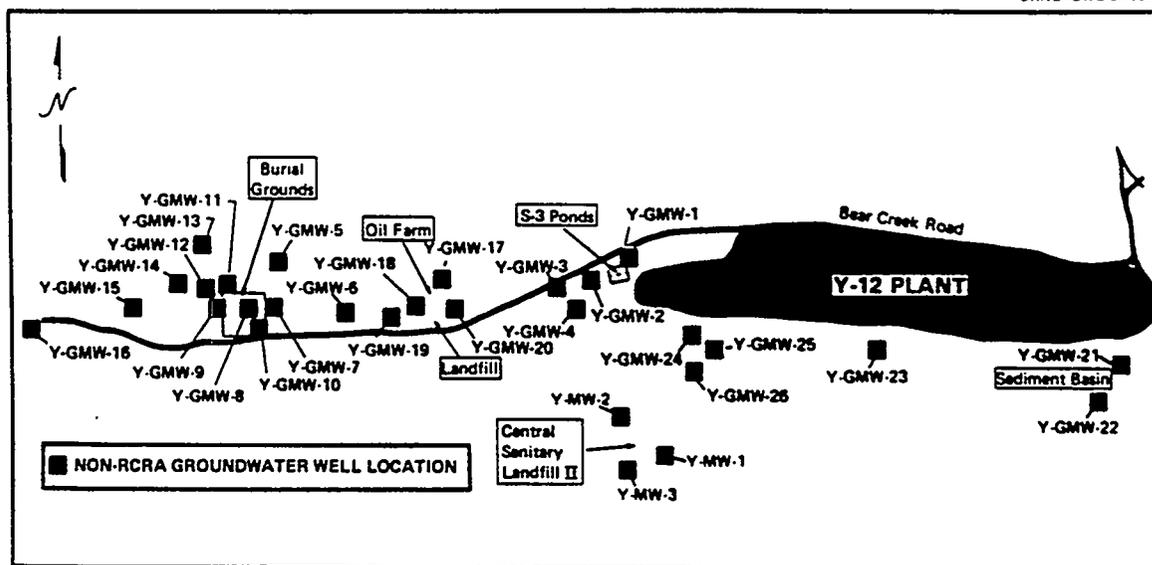


Fig. 2.3.12. Non-RCRA groundwater wells at the Y-12 Plant.

Table 2.3.5. Historical, non-RCRA groundwater wells

Current name	Other name(s)	Location	Status	Data available by quarter CY 1987			
				1	2	3	4
1002	Y-GMW-01	S-3 Ponds	Destroyed				
1003	Y-GMW-02;Y-MW-10	S-3 Ponds	<i>a</i>	x	x		x
1004	Y-GMW-03;Y-MW-09	S-3 Ponds	Destroyed	x	x		x
1005	Y-GMW-04;Y-MW-08	S-3 Ponds	<i>a</i>	x	x		x
1027	Y-GMW-05	Bear Creek Valley	<i>a</i>	x	x		x
1028	Y-GMW-06;Y-MW-11	Bear Creek Valley	<i>a</i>	x	x		x
1029	Y-GMW-07	Bear Creek Valley	<i>a</i>	x	x		x
1030	Y-GMW-08;Y-MW-02	Bear Creek Valley	<i>a</i>	x	x		x
1031	Y-GMW-09;Y-MW-04	Bear Creek Valley	<i>a</i>	x	x		x
1032	Y-GMW-10;Y-MW-01	Bear Creek Valley	<i>a</i>	x	x		x
1033	Y-GMW-11	Bear Creek Valley	<i>a</i>	x	x		
1034	Y-GMW-12;Y-MW-03	Bear Creek Valley	<i>a</i>	x	x		x
1035	Y-GMW-13	Bear Creek Valley	<i>a</i>	x	x		x
1036	Y-GMW-14	Bear Creek Valley	<i>a</i>	x	x		x
1037	Y-GMW-15;Y-MW-07	Bear Creek Valley	<i>a</i>	x	x		x
1047	Y-GMW-16	Bear Creek Valley	<i>a</i>	x	x		
1048	Y-GMW-17	Bear Creek Valley	<i>a</i>	x	x		x
1049	Y-GMW-18;Y-MW-05	Bear Creek Valley	<i>a</i>	x	x		x
1050	Y-GMW-19	Bear Creek Valley	<i>a</i>	x	x		x
1073	Y-GMW-20;Y-MW-06	Bear Creek Valley	<i>a</i>	x	x		x
1080	Y-GMW-23;Y-MW-15			x	x		x
1085	Y-MW-1;Y-MW-12	Landfill II		x	x		x
1086	Y-MW-2;Y-MW-13	Landfill II		x	x		x
1087	Y-MW-3;Y-MW-14			x	x		x
1090	Y-GMW-24	UNC		x	x		x
1091	Y-GMW-25	UNC		x	x		x
1092	Y-GMW-26	UNC	Destroyed				
1095	Y-GMW-21						
1096	Y-GMW-22						

<sup>a</sup>Identified for future plugging and abandonment.

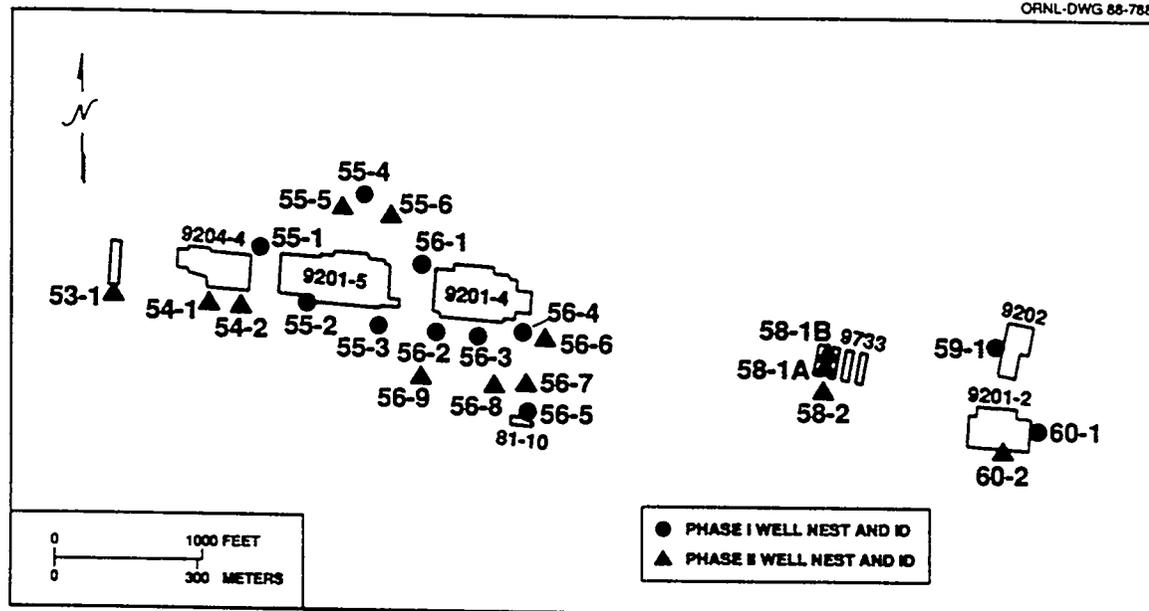


Fig. 2.3.13. Location of monitoring wells at mercury-contaminated areas at the Y-12 Plant.

the source of this material has not been determined and may not be from this site. Data collected during 1987 for surface water and groundwater do not indicate leakage from wastes disposed of at the site.

**Ravine Disposal area.** The Ravine Disposal site 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 be comprised 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 site locality in late 1985. The site is hydrologically similar to the Beta-4 Security Pit. Review of four quarters of 1986 data for all five wells at the ravine disposal site suggests that it is free of groundwater contamination. The site disposal history is consistent with this analysis. Monitoring was continued in 1987 to confirm this preliminary interpretation of the data; the 1987 data are not indicative of contamination emanating from this site.

**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 55-gal (208-L) 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 locality 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 1986 were consistent with the conclusion that the UNC site is not contributing contamination to the groundwater. The water from the upgradient well is of slightly different quality, being higher in sodium, iron, chloride, nitrate, and specific conductivity than the downgradient wells. The wells were sampled during 1987. Based on the 1986 and 1987 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 Kerr Hollow Quarry and 8 km east of ORNL. The quarry is approximately 910 m 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 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. (1987). Well 1081 was installed south of the quarry during a previous drilling program (Haase et al. 1987). Two additional coreholes, CH-185 and CH-189, were drilled at the site to determine subsurface geology and to identify drilling targets for groundwater investigation wells. Well locations are shown in Fig. 2.3.14.

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. Surface water in the quarry has levels of sulfate, arsenic, and boron higher than those expected in natural surface waters in the area; these are characteristic constituents in coal ashes. The levels of sulfate in the groundwater also appear to be elevated.

**S-2 Pond.** 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.

The S-2 site is underlain by soils and residuum developed on the upper Maynardville

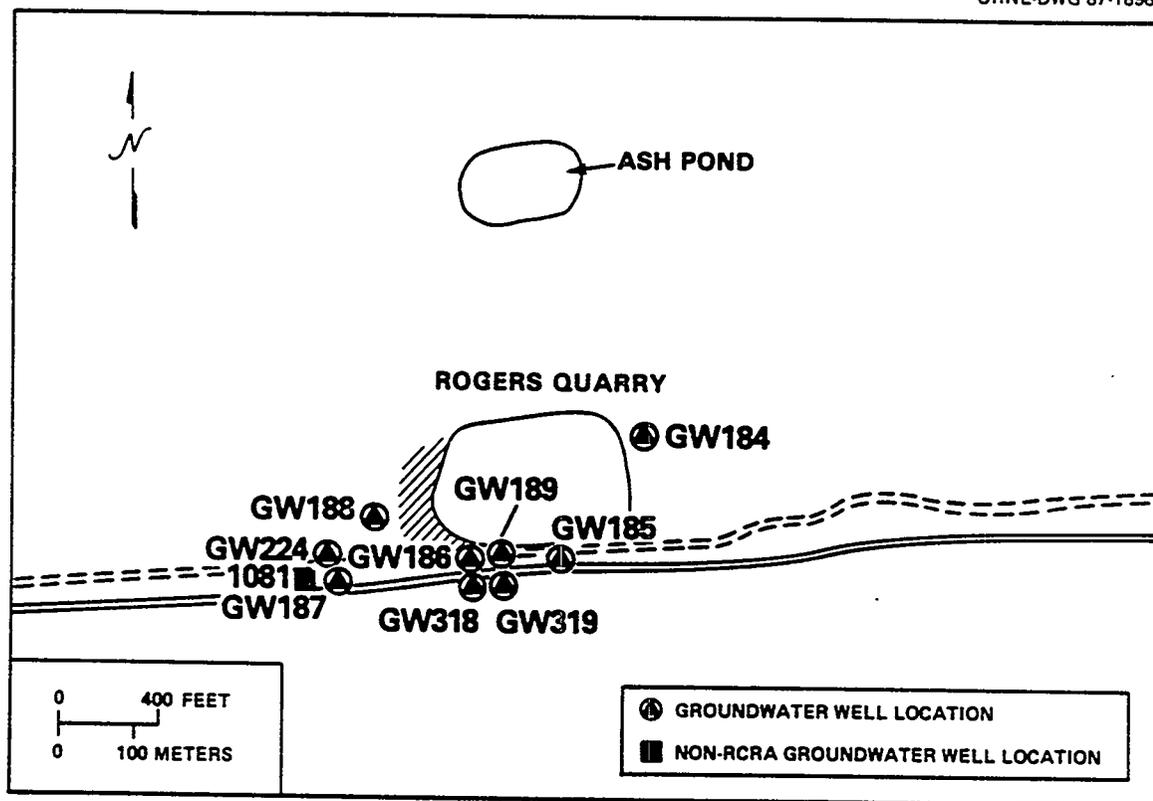


Fig. 2.3.14. Groundwater well locations surrounding Rogers Quarry.

Limestone of the Conasauga Group. The contact between the Maynardville Limestone and the overlying Copper Ridge Dolomite of the Knox Group lies immediately to the south of the site (King and Haase 1987). Depth to bedrock at the site varies from 15 to 30 ft (4.5 to 9 m). Nine groundwater investigation wells were installed at the S-2 site in the spring of 1986 (Fig. 2.3.15). Wells GW-251, 252, 253, 256, and 278 are shallow water table wells finished at the approximate top of weathered bedrock. Wells GW-254, 255, and 279 are finished in weathered bedrock, and well GW-280 is finished in unweathered bedrock. Wells GW-254 and 256 are paired to form a piezometer cluster to investigate the vertical component of groundwater flow at the northeastern corner of the site. Well GW-255 is paired with well GW-252 to form a piezometer cluster at the southern end of the site. Wells GW-278, 279, and 280 are grouped to form a piezometer cluster at the northwestern corner of the site.

**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 uses 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 is currently in progress. The new location is 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-018), 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 6-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

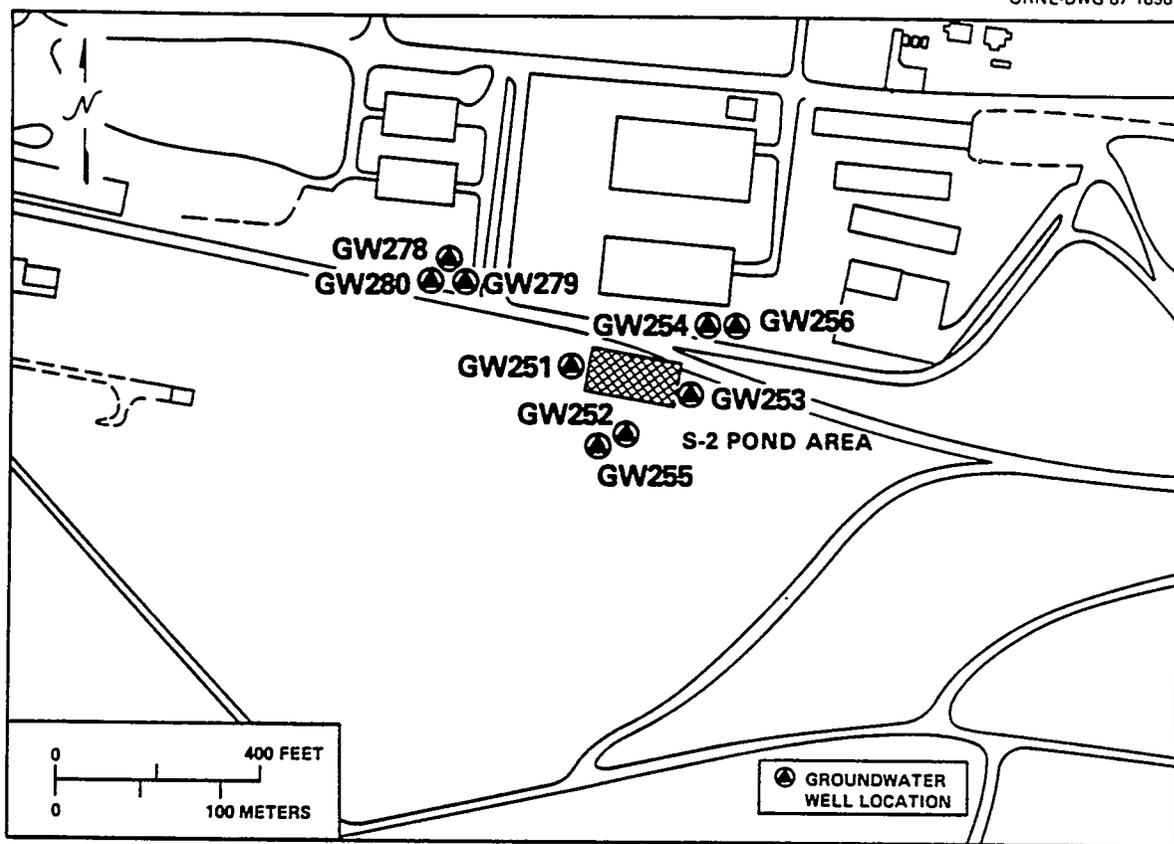


Fig. 2.3.15. Groundwater investigation wells at the Y-12 Plant S-2 site.

flushed out, plugged, and abandoned in 1983. Releases from the acid line will be assessed either in conjunction with the S-3 ponds RCRA closure or 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. In November 1986, the western portion of the Salvage Yard oil/solvent drum storage area was certified closed in accordance with RCRA regulations. Groundwater monitoring wells were installed during 1986 and sampled on a quarterly basis through 1987. Information obtained from these groundwater samples will be used in planning future sampling and analysis in the area.

The existing nine monitoring wells within the Salvage Yard will be used in the RFI study.

#### Monitoring wells installed in FY 1987

In FY 1987, 64 groundwater wells were installed as a result of the drilling program at the Y-12 Plant. Table 2.3.6 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.

Table 2.3.6. Y-12 Plant 1987 well installation program

Site	Category	Wells installed
Rust spoil area	III	7
Spoil area I	III	6
Waste Coolant Processing Facility	III	2
Waste Machine Coolant Biodegradation Facility	III	6
Building 9418-3 uranium vault	III	2
Industrial landfill III	I	7
Industrial landfill IV	I	5
Chestnut Ridge waste pile	I	5
Packaging demonstration (BCBG)	I	4
D-38 site (BCBG)	I	8
Sediment disposal basin	II	1
Rogers Quarry	II	2
Fly ash disposal site	II	2
Chestnut Ridge security pits	II	3
S-3 ponds plume confirmation site	II	2
Gum Hollow area (LLWDDD)	II	2
Total		64

- 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.

A brief discussion is included for other new sites not previously mentioned.

#### Category I sites

Wells were installed at five sites during 1987. Groundwater monitoring will begin in early 1988. Four quarters of data will be gathered.

- *Industrial Landfill III.* Industrial Landfill III will be located on the east end of Chestnut Ridge. It is being designed for the placement of construction debris and soils from mercury-contaminated areas in and around the Y-12 Plant. Landfill III will incorporate the existing East Chestnut Ridge mercury-contaminated soil pile, a former borrow area, which received material relocated from around the City of Oak Ridge Civic Center. Seven groundwater wells were installed in 1987.
- *Industrial Landfill IV.* Industrial Landfill IV will be located on the west end of Chestnut Ridge, southeast of the S-3 Ponds. It will be the replacement for the Chestnut Ridge Security Pits, which are scheduled for closure in 1988. Five groundwater wells were installed in 1987 in preparation for this waste disposal facility.
- *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 satisfy the applicable regulatory requirements.
- *Above-grade packaging demonstration—Bear Creek Burial Grounds.* A low-level waste disposal development demonstration (LLWDDD) project is planned for this site in Bear Creek Burial Grounds, approximately 2.5 km 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 before waste

emplacement. This is important because potential impacts from previous disposals can be evaluated before an experimental technology is evaluated at the site.

- *D-38 site—Bear Creek Burial Grounds.* The D-38 site is in close proximity to the above-grade packaging demonstration. Eight groundwater wells were installed at this site in preparation for a chip-disposal demonstration project. This demonstration will evaluate an alternate/backup method of chip disposal involving open-pit burning. Funding for this project is questionable at this time.

#### Category II sites

The following are category II sites where wells were installed during 1987.

- *Chestnut Ridge Sediment Disposal Basin.* One characterization well was installed at this site in 1987 to further understanding of the hydrologic relationships on the north slope of Chestnut Ridge.
- *Rogers Quarry.* Two additional wells were installed at this site in 1987 to complement the existing well network.
- *Ash Disposal site.* The Ash Disposal site is located on the south side of Chestnut Ridge above Rogers Quarry. Fly ash is slurried at a filled ash pond. The slurried material enters McCoy Branch, which conveys it to Rogers Quarry. To assess potential impacts on groundwater per RCRA 3004(u), wells were installed around Rogers Quarry and in the fly ash behind the dam in 1985. Two groundwater wells were installed in the area between the dam and the quarry in 1987.
- *Chestnut Ridge Security Pits.* Three wells were installed at this site in 1987. To date, nine wells have been installed at the Chestnut Ridge Security Pits in conjunction with geologic and hydrologic investigations.
- *S-3 Ponds Plume confirmation site.* As part of the continued S-3 ponds groundwater assessment, two wells were installed west of the S-3 site north of Bear Creek Road.

- *Gum Hollow area.* Two wells were installed in Gum Hollow, a tributary that feeds into Bear Creek from the north about 3.2 km west of Bear Creek burial grounds. These wells provide additional background groundwater data for the Bear Creek Valley in support of the LLWDDD effort.

#### 2.3.3.2 Oak Ridge National Laboratory

The groundwater monitoring program at ORNL consists of a network of wells of three basic types and functions: (1) water quality monitoring wells built to RCRA specifications and used for site characterization and compliance purposes, (2) piezometer wells used to characterize groundwater flow conditions, and (3) older wells that were not built to RCRA specifications but that are useful for determination of water table elevations and general water quality parameters, including radionuclides. Tables 2.3.13–2.3.15 in Vol. 2 present monitoring data for those parameters at specific sites that measured above regulatory limits or greater than background levels at least once during 1987.

#### RCRA water quality well program

Twenty-two RCRA water quality monitoring wells were installed at ORNL surface impoundments 3524, 3539-40, and 7905-08 in 1985 (see Figs. 2.3.16 and 2.3.17). Surface impoundments 3524 and 3539-40 receive process waste streams (water) from the majority of the ORNL Bethel Valley facility, and on occasion, the 3524 impoundment receives waste from the Melton Valley facilities. The process waste streams are primarily effluents that contain traces of metals and organics and little or no radioactivity under normal operating conditions. Process waste consists of steam condensate from heating coils in vessels containing radioactive solutions, process cooling water, condensate from the low-level waste evaporator facility, and discharges from miscellaneous building sinks and floor drains. Activities that generate process waste include reactor operations, radioisotope processing, hot cell operations, and general

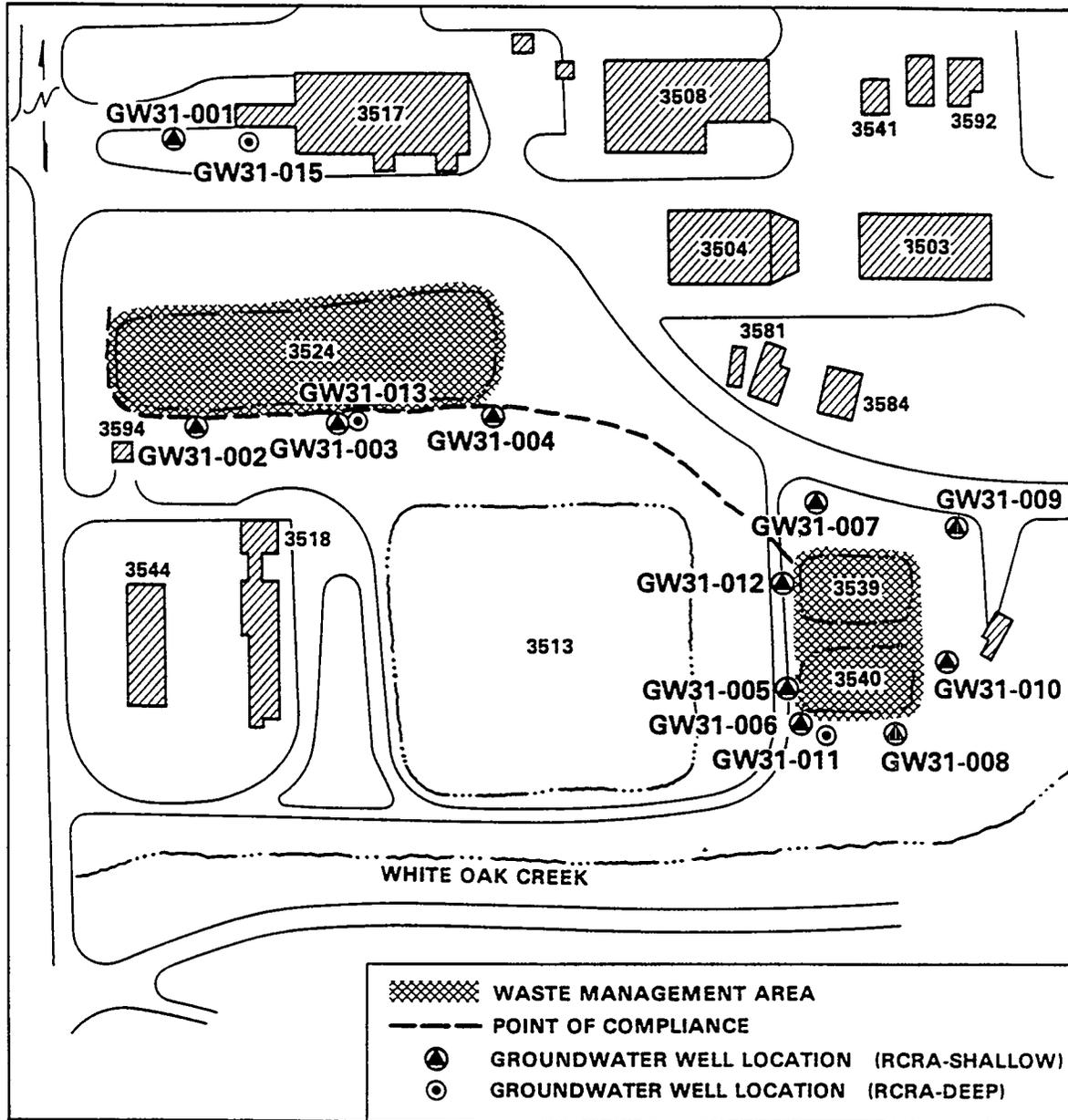


Fig. 2.3.16. Locations of groundwater wells around ponds 3524, 3539, and 3540 (ORNL).

research and development. The 3524 area consists of wells 31-001, 31-002, 31-003, 31-004, 31-013, and 31-015. The 3539-40 area contains wells 31-005, 31-006, 31-007, 31-008, 31-009, 31-010, 31-011, and 31-012.

Surface impoundment 7900 receives process waste streams from the High Flux Isotope Reactor (HFIR), the Thorium-Uranium Facility (TURF), and the Transuranic Processing Facility

(TPP) at ORNL. The process waste streams are primarily effluents that contain traces of metals and solvents and little or no radioactivity under normal operating conditions; rarely they could contain higher levels of radioactivity due to equipment failure or human error. Process waste consists of process cooling water, laboratory discharges, water from cell shields, and discharges from miscellaneous building sinks,

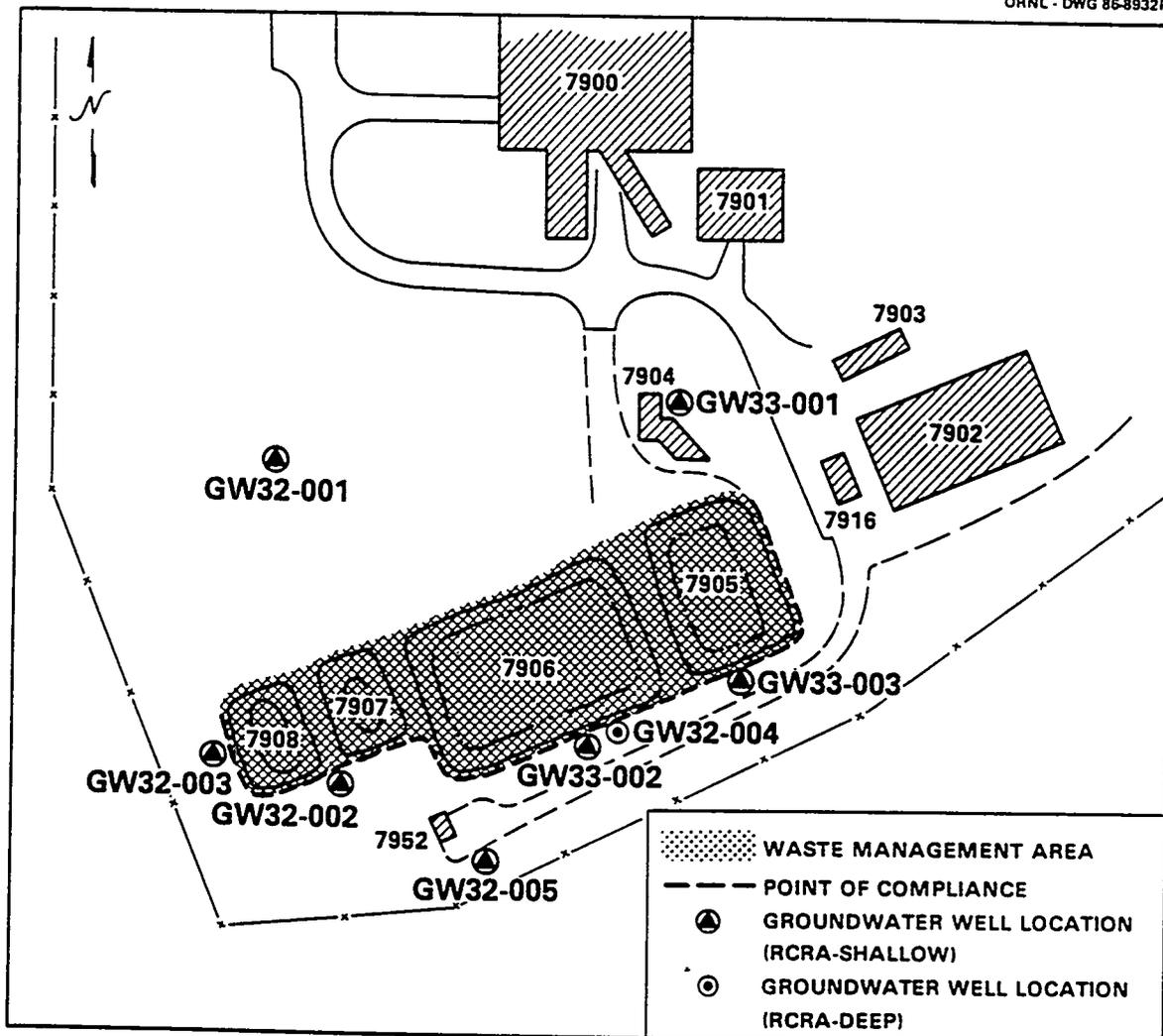


Fig. 2.3.17. Well locations for the 7900 surface impoundment site.

hoods, and floor drains. The activities generating process waste include reactor operations, radioisotope processing, hot cell operations, and general research and development. The network for this area consists of wells 32-001, 32-002, 32-003, 32-004, 32-005, 33-001, 33-002, and 33-003.

#### Piezometer well program

In addition to these RCRA water quality wells, approximately 250 piezometer wells have been installed to characterize groundwater flow conditions around 20 waste area groupings at ORNL and to provide the basis for location of the RCRA water quality monitoring wells.

#### Older non-RCRA water quality wells

Most of the older existing wells at ORNL were constructed with materials and methods that limit their use and preclude the collection of valid samples for compliance purposes. Most are located at SWSAs 4, 5, and 6; waste pits 1, 2, 3, and 4; and waste trenches 5, 6, and 7. Use of these wells will be phased out as the newer RCRA water quality wells are developed.

#### 2.3.3.3 Oak Ridge Gaseous Diffusion Plant

At the end of 1987, there were 77 active monitoring wells at 12 waste treatment, disposal, or storage sites at the ORGDP, an increase of 66 wells since the end of 1986. The additional wells

were installed at SWMUs to aid in the RCRA facility investigations and also at CERCLA sites. Only two units are RCRA interim status units, K-1407-B and K-1407-C surface impoundments. Table 2.3.7 indicates the status of each of the 12 units and the regulations that mandate monitoring of those sites.

Most site monitoring wells are 4-in.-diam stainless steel casing and screen. Typically, there is sand packing in the annular space outside of the screen, a bentonite plug above the sand packing, a bentonite/grout mixture above the plug to several feet below the frostline, and a cement collar at the top of the well. Wells are protected by a cement pad and guardposts.

Groundwater samples are typically obtained by first purging the monitoring well of stagnant water. Samples that will be analyzed for volatile organics and those that are oxidizable are obtained first. Appropriate standard EPA protocols are used in preservation, storage, and chain-of-custody documentation. The laboratory follows the standard analytical methods specified by EPA in the analyses of the samples.

The objectives of the sampling program are to (1) maintain consistency in the application of sampling methods, sample handling, and sample analysis to improve the ability to identify and minimize systematic bias; and (2) apply principles of quality assurance and quality control to identify and minimize sources of inaccuracy.

To obtain background data, typically four groups of parameters are measured or analyzed quarterly: indicator parameters, water quality parameters, drinking water parameters, and radioactivity. Groundwater elevations are also measured before each sampling event.

The indicator parameters include gross indicators of the presence of contaminants and major changes in the groundwater chemistry. The indicator parameters are total organic halides (TOX), total organic carbon (TOC), pH, and specific conductance. Each is measured by four replicates per sampling event.

The water quality parameters include iron, chloride, manganese, phenols, sodium, and sulfate. These parameters provide information on water quality and on gross changes in the groundwater chemistry.

Drinking water parameters include arsenic; barium; cadmium; lead; mercury; selenium; silver; fluoride; nitrate; endrin; lindane; methoxychlor; toxaphene; 2,4-D; 2,4,5-TP silvex; radium; gross alpha; gross beta; and coliform bacteria. The drinking water parameters establish the water's suitability for drinking.

The presence of radioactivity is determined by analyzing samples of uranium, gross alpha, gross beta, and total radium at ORGDP.

Data reported above the applicable standards for the water quality and drinking water parameters are presented in Table 2.3.16 of Vol. 2; the applicable standards for each parameter are given in Tables 2.3.1–2.3.11 of Vol. 2.

## 2.3.4 Investigations and Characterizations

### 2.3.4.1 Y-12 Plant

#### RCRA facility investigations

In November 1984, Congress passed the Hazardous and Solid Waste Amendments (HSWA) to the 1976 RCRA. Section 3004(u) of these amendments specifically addresses the requirement that sites be characterized to determine contamination of groundwater. Within the confines of the Y-12 Plant are 42 sites that have been identified for additional investigation and evaluation under 3004(u) and (v) corrective actions of HSWA. Information pertaining to the 3004(u) and (v) corrective actions effort at the Y-12 Plant is provided in Sects. 4.2.1 and 4.3.1 of this report. In 1987, nine site-specific RFI plans were submitted to TDHE and EPA. These nine sites are listed in Table 2.3.8 along with their site designation numbers. Each RFI plan includes site-specific geographical, historical, operational, and, where available, geological and hydrological data. Each plan addresses the strategy for determining the nature and extent, if any, of hazardous and/or radioactive contaminants through soils, groundwater, surface water, and air pathways.

#### Rust Spoil Area

Rust Engineering, a DOE prime contractor, conducts various renovation, maintenance, and construction operations at the Y-12 Plant. Solid

Table 2.3.7. Oak Ridge Gaseous Diffusion Plant groundwater protection program site information

Unit name	Current groundwater monitoring program							Annual sampling frequency
	Regulatory status	Interim status	Permit	RCRA 3004(u)		Date program was begun	Monitored parameters	
				Detection	Assessment			
K-1407-B surface impoundment	Interim	X				Nov. 1985	a	Semiannually
K-1407-C holding pond	Interim	X				Nov. 1985	a	Semiannually
K-1070-B classified burial ground	3004(u)				X	Apr. 1987	b	Quarterly
K-1407-A neutralization pit	RCRA	X				Apr. 1987	b	Quarterly
K-1413 treatment facility	RCRA	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	RCRA	X				Apr. 1987	b	Quarterly

<sup>a</sup>Parameters establishing groundwater quality (Table 2.3.2 in Vol. 2) and indicator parameters (Table 2.3.2 in Vol. 2).

<sup>b</sup>Primary drinking water parameters (Table 2.3.1 in Vol. 2); parameters establishing groundwater quality (Table 2.3.2 in Vol. 2); indicator parameters (Table 2.3.2 in Vol. 2); metals analyzed by inductively coupled argon plasma (Table 2.3.4 in Vol. 2); metals analyzed by atomic absorption spectroscopy (Table 2.3.5 in Vol. 2); anions (Table 2.3.6 in Vol. 2); volatile organics (Table 2.3.7 in Vol. 2); pesticides and PCBs (Table 2.3.8 in Vol. 2); acid base/neutral extractable organics (Table 2.3.9 in Vol. 2); radionuclides and radioactive metals (Table 2.3.10 in Vol. 2); other parameters (Table 2.3.11 in Vol. 2).

Table 2.3.8. Sites submitted for RFI plans in 1987 at the Y-12 Plant

Solid waste management units	Site designation	Groundwater monitoring
East Fork Poplar Creek (EFPC)	NA	<i>a</i>
Salvage yard area (includes 5 SWMUs)	S-018, S-020, T-109, S-111, and S-204	Yes
S-2 site	D-103	Yes
Rust spoil area	D-106	Yes (1987)
Spoil area I	D-107	Yes (1987)
Waste Z-oil tank	S-121	No
Waste Coolant Processing Facility	T-038	Yes (1987)
Building 9418-3 uranium vault	D-115	Yes (1987)
Tank 2064-U	S-205	No

<sup>a</sup>Groundwater monitoring to be performed by sampling the existing Y-12 Plant well network. This includes the sampling of wells installed near EFPC by the United States Geological Survey (USGS). Additional monitoring wells will be installed as necessary.

waste (spoil material) generated during these operations has been disposed of in an area on the ORR known as the Rust Spoil Area, operated from 1975 to 1983. It is estimated that less than 75,000 m<sup>3</sup> of non-uranium-contaminated construction debris and spoil were disposed of at the site. The 5.4-acre (2.16 ha) site measures approximately 300 × 900 × 10 ft (90 × 275 × 3 m).

This site was closed under a plan approved by TDHE. Site closure activities began in the fall of 1983 with the preparation of the site's closure plan. The plan called for grading and shaping the existing fill, capping the entire fill area with at least 2 ft (0.6 m) of soil, and establishing vegetative growth over the disturbed areas. The specifics of the capping plan called for a minimum of 1.5 ft (0.45 m) of compacted clay and 0.5 ft (0.15 m) of topsoil to be placed over the site. The clay layer would be compacted in maximum 8-in. (20-cm) lifts. Closure began in late 1983 and was completed in mid-1984.

In 1987, seven wells were installed. The wells were sampled for RCRA Appendix IX constituents in late 1987; the data are not yet available. Quarterly monitoring will begin during the first quarter of 1988.

#### Waste Coolant Processing Facility

In 1985, a new treatment facility, the Waste Coolant Processing Facility (WCPF), began operation. It is the replacement facility for the Waste Machine Coolant Biodegradation Facility (WMCBF) constructed in 1977. The WMCBF included an unloading/storage area and a treatment basin/effluent drain field. The new WCPF retained the use of the unloading/storage area for its operations; however, the rest of the old WMCBF treatment/disposal system is being closed under a RCRA closure plan approved by TDHE.

Eight monitoring wells were installed during 1987, and monitoring will begin in 1988.

#### Building 9418-3 Uranium Vault

Building 9418-3 was constructed as part of the Z-oil coolant system when the Y-12 Plant was built by the Army Corps of Engineers in 1943. Z-oil is a mineral oil that was the coolant for the approximately 1200 calutron electromagnetic separators used to produce the fissionable isotope of uranium. Included in the system were storage tanks for clean Z-oil used to maintain the system at its full capacity. Since the electromagnetic

process was discontinued for uranium processing after World War II, large portions of the system have been dismantled as the buildings were refurbished for different uses.

The Building 9418-3 Uranium Vault was originally constructed as a containment structure for a 14,000-gal (53,060-L) Z-oil storage tank. When the Z-oil system was no longer used, Building 9418-3 was demolished, the tank was removed, and the below-grade concrete containment structure was all that remained. An 8-in.-thick (20.3-cm) concrete cap was constructed over the structure with two 2-ft-diam (0.6-m-diam) manholes. This formed what has been referred to as a vault. During 1960, nonenriched uranium oxide dross was disposed of by pouring it from the drums in which it was stored into the vault. From 1960 to 1964, the material was considered to be in storage, but in 1964 it was reclassified as disposal by burial. At a later time, during normal plant operations, the area where the vault is located was paved over with asphalt.

The Building 9418-3 Uranium Vault is located at the base of the north slope of Chestnut Ridge within 20 ft (6 m) of the normal stream channel of upper East Fork Poplar Creek. The base of Chestnut Ridge is near the contact of the Knox and Conasauga groups. A borehole that has been installed at the site indicates that the vault is located in fill material to a depth of at least 11.3 ft (3.4 m). The fill material is underlain by the Maynardville Limestone member of the Nolichucky Shale. Two groundwater wells were installed at this site in 1987.

**Salvage Yard Area.** Site and groundwater information is discussed in Sect. 2.3.3.1.

**S-2 Pond.** Site and groundwater information is discussed in Sect. 2.3.3.1.

### **Spoil Area I**

Spoil Area I is located west of the Y-12 Plant on Old Bear Creek Road near the junction with West Patrol Road. Bear Creek approaches within 200 ft (60 m) of the northern edge of Spoil Area I, which has been in operation since about 1980 as a nonhazardous, nonradioactive

construction spoil disposal area. The site covers about 5 acres (2 ha). Since 1985, Spoil Area I has had a permit from the TDHE as a landfill for rubble and noncombustible, nonputrescible solid waste. An estimated 75,000 m<sup>3</sup> of non-uranium-contaminated construction debris has been disposed of at the site. Although no detailed disposal records are available, 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. Past and existing administrative and other established in-plant controls, including extensive sampling before startup of construction projects, prevent the disposal of significant amounts of chemically or radioactively contaminated waste at Spoil Area I.

Six monitoring wells were installed at spoil area I during September and October 1987. Development of the wells and subsequent sampling and analysis of groundwater will take place in early 1988.

### **2.3.4.2. Oak Ridge National Laboratory**

The groundwater quality wells are classified as upgradient (reference) or downgradient depending on their location relative to the general direction of groundwater flow. The upgradient wells for the surface impoundments (31-001, 31-007, 31-009, 32-001, and 33-001) were located so as to provide groundwater samples that would not be affected significantly by possible leakage from the impoundment. The downgradient wells (those not listed as upgradient) were located immediately adjacent to the waste management facility. These were originally installed as RCRA compliance wells. However, based on analytical data submitted to TDHE, it has been determined that the surface impoundments do not contain RCRA hazardous waste. ORNL will continue to sample the wells to provide additional site characterization data in support of future closure activities.

During 1987, water samples were collected semiannually from the deep and shallow wells. Only pH, temperature, and specific conductance

were measured during the first sampling period at well 31-011; the quantity of water sampled was not sufficient for chemical analyses.

The data required by EPA and TDHE fall into three categories: (1) drinking water parameters (As, Ba, Cd, Cr, F, Pb, Hg, NO<sub>3</sub>, Se, Ag, endrin, lindane, methoxychlor, toxaphene, 2,4-D, 2,4,5-TP silvex, Ra, gross alpha, gross beta, <sup>60</sup>Co, <sup>137</sup>Cs, and fecal coliform; (2) water quality parameters (Cl, Fe, Mn, phenols, Na, and SO<sub>4</sub>); and (3) groundwater contamination parameters (pH, specific conductance, TOC, and TOX).

In accordance with the EPA regulations in 40 CFR Pt. 265, Subpart F, at least four measurements per well were recorded for pH, specific conductance, and temperature. Four analyses were also done for TOC and TOX. All other parameters were measured once.

Because these wells are no longer considered RCRA wells, analysis of samples during the second sampling period was greatly reduced. Only groundwater contamination indicator parameters were measured during this period.

Installation and development of 30 RCRA water quality monitoring wells at solid waste storage area (SWSA) 6 have been completed. A quarterly sampling program will begin in the first quarter of 1988.

Additional RCRA water quality monitoring wells are being installed by the ORNL Remedial Action Program (RAP) as part of ORNL's compliance with the requirements of RCRA Section 3004(u). ORNL has established an 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 site SWMUs that must be evaluated as potential sources of releases to the environment, ORNL has combined the sites into 20 waste area groupings (WAGs). Each WAG contains sites (SWMUs) within geographically contiguous and/or hydrologically defined units and allows the subdivision of remedial action sites into more manageable units. Water quality monitoring wells (approximately 250) will be established around

the perimeter of those WAGs determined to have a potential for the release of contaminants. During 1987, 95 piezometer wells, 89 water quality wells, and 1 hydrostatic pressure well were installed. Sampling will begin in 1988.

#### **2.3.4.3 Oak Ridge Gaseous Diffusion Plant**

The ORGDP Groundwater Protection Program consists of 35 sites. Two of the sites are in the assessment phase to determine the rate and extent of possible contamination. Ten sites have a groundwater monitoring network in place and are in the first year of detection monitoring. Twenty-three of the sites are being characterized, and a monitoring well network is being designed to monitor the groundwater chemistry of each site. Table 2.3.7 indicates the sites monitored during 1987, their status in the program, and the samples being obtained.

##### **Assessment monitoring**

K-1407-B and K-1407-C surface impoundments, which are under RCRA interim status, are undergoing assessment monitoring. Background data were obtained on the sites in 1986. The first semiannual sampling indicated a statistically significant increase in the indicator parameters. An assessment monitoring plan was prepared and submitted to the state. The units are now undergoing assessment sampling to determine whether the results were (1) false positives or (2) indicative of groundwater contamination at the site. Results are expected early in 1988.

##### **Detection monitoring**

Ten sites not under interim status are in the detection monitoring phase: the K-1407-A neutralization pit, K-1070-B old classified burial ground, K-1070-C/D classified burial ground, K-1085 old firehouse burn area, K-1232 treatment facility, K-1070-A contaminated burial ground, K-770 scrap metal yard, K-1064 peninsula burn area, K-1413 treatment facility, and K-1070-F contractors' burial ground. Figure 2.3.18 shows the locations of these waste management units at



ORGDP. Wells are being installed around these units, which are undergoing a program identical to that used in detection monitoring for RCRA interim status sites. The information gained will be used for site characterization under the 3004(u) program.

### Characterization

Twenty-three sites are being characterized by placement of piezometers to determine groundwater flows and contours. A monitoring well network will be installed during 1988, and the water will be analyzed for possible contamination.

### 2.3.5 Summary

#### 2.3.5.1 Oak Ridge Y-12 Plant

At the Y-12 Plant during 1987, seven sites were under interim status monitoring; of these, three were under assessment for releases to the groundwater. The S-3 Ponds have released nitrate, heavy metals, radioactivity, and small amounts of volatile organics. Both the Oil Landfarm and Bear Creek Burial Grounds have contributed mainly volatile organics. Of the other four sites, Kerr Hollow Quarry and the Chestnut Ridge Sediment Disposal Basin continued in detection monitoring; the Chestnut Ridge Security Pits are entering assessment for releases of volatile organics, and upgradient wells at New Hope Pond also show traces of volatile organics. The source of the New Hope Pond contamination will be assessed during 1988.

Under site characterization and the 3004-u program, monitoring is under way for the Beta-4 Security Pit, Ravine Disposal area, UNC site, Rogers Quarry, S-2 Pond, and the Salvage Yard area. Of these sites, the first three show no contribution of contamination to groundwater. Rogers Quarry may have elevated sulfate levels from fly ash. The S-2 Pond and the Salvage Yard show nitrate, heavy metals, and organics in the groundwater; these sites and associated plant areas are the probable sources. The entire area is under study.

During 1987, 64 additional wells were installed. These wells augment site-specific networks already in place, surround new sites, or will allow monitoring of new waste projects.

#### 2.3.5.2 Oak Ridge National Laboratory

Table 2.3.13 in Vol. 2 provides a summary of the constituents in groundwater and the wells at the ORNL site where concentrations exceeded the regulatory standards listed in Tables 2.3.1–2.3.3 in Vol. 2. The values for a few wells exceeded the standards for gross alpha, total radium, chromium, and nitrate as nitrogen. The values for gross beta in most wells exceed the calculated standard. The EPA Interim Primary Drinking Water Standard for gross beta is an annual dose equivalent of 4 mrem. A concentration was calculated from this dose based on ingestion of 2.2 L of water per day. All gross beta was assumed to be <sup>90</sup>Sr, which is a worst-case analysis. A dose conversion factor of 1.438 rem/ $\mu$ Ci was used to calculate the concentration. Table 2.3.14 in Vol. 2 summarizes the pH data for wells where pH was outside the applicable standard of 6.5–8.5. Table 2.3.15 in Vol. 2 provides a summary of constituents in groundwater wells at ORNL that were greater than background. Background has been defined here as greater than the analytical detection limit. Sodium, selenium, and total recoverable phenolics exceeded the background levels in most wells.

#### 2.3.5.3 Oak Ridge Gaseous Diffusion Plant

Groundwater monitoring data obtained during 1987 consisted of one quarter of data from the 12 units and the assessment data from the 2 RCRA interim status surface impoundments. A compilation of these data is shown in Table 2.3.16 of Vol. 2.

One quarter of RCRA data was obtained from each of the 12 units. No statistical comparison can be made based on these data. After the required one year of background data is obtained, calculations can be performed to determine if any statistical increases are a result of chemical constituents leaching from the units.

The results from all the units indicate that some metals, volatile organics, extractable organics, and radiological constituents are present in the groundwater. In 1988, sufficient information will be gathered to perform the statistics to determine if the units are contaminating the groundwater.

The K-1407-B and K-1407-C surface impoundments are currently in assessment monitoring. During the semiannual sampling event, it was discovered that the conductivity and TOX parameters were significant in a number of the wells. An assessment is being conducted to determine if on-site hazardous constituents are causing the increases or if the increases are a result of off-site contamination. Statistical results are to be completed in April 1988.

## 2.4 BIOLOGICAL SAMPLING

Air and water are the principal dispersal media for the Oak Ridge DOE facility releases. However, the environmental surveillance programs also include biotic and abiotic environments 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.

### 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-to-cow-to-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 and one commercial dairy within a radius of 80 km of

Oak Ridge is analyzed for  $^{131}\text{I}$  and total radioactive strontium ( $^{89}\text{Sr}$  and  $^{90}\text{Sr}$ ) by 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 (see Fig. 2.4.1). The cow at station 6 was sold during the second quarter of 1987. At station 7, the cow calved during the second quarter and no further samples were collected. Samples were analyzed for  $^{131}\text{I}$  by gamma spectroscopy and for total radioactive strontium by chemical separation and low-level beta counting.

#### 2.4.1.2 Results

Concentrations of  $^{131}\text{I}$  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 40% of the guideline for both sampling networks. There were no statistically significant differences in the concentrations of either parameter between the two sampling networks. Iodine-131 was not detected in any of the milk samples analyzed during 1987. Total radioactive strontium routinely detected in milk in 1987 was within ranges observed (for  $^{90}\text{Sr}$ ) during the last several years. Sampling results for specific locations are given in Tables 2.4.1 and 2.4.2 of Vol. 2.

During the last quarter of 1987, the software program on the nuclear data analyzer for computing the lower limits of detection for the analysis of  $^{131}\text{I}$  in milk was updated. The previous system used a value of about 2 pCi/L for the detection limit, and the new system uses about 3 pCi/L. This lower limit of detection depends on immediate analysis of the samples upon receipt at the laboratory. Because  $^{131}\text{I}$  has such a short half-life (8.04 d), it quickly decays and the precision of the analysis decreases. Therefore, detection limits of about 5.5 pCi/L may be observed in the annual summary tables. For

Table 2.4.1. Summary of collection and analysis frequencies of biological samples in 1987

Station	Parameter	Collection frequency	Sample type	Analysis frequency
<i>Milk</i>				
2,3,4,6,7,8	$^{131}\text{I}$ , total Sr <sup>b</sup>	Biweekly	Grab	Biweekly
51,53,56 <sup>a</sup>	$^{131}\text{I}$ , total Sr <sup>b</sup>	Semiannually	Grab	Semiannually
<i>Fish</i>				
CRK 8.0, CRK 33.0, CRK 40.0 <sup>c</sup>	Gamma scan, total Sr <sup>b</sup> , Hg, PCBs	Semiannually	Grab	Semiannually
<i>Grass</i>				
3,7,9, 8,23,31,33 34,36, 40-46 <sup>d</sup>	Gamma scan, total Sr <sup>b</sup> , $^{238}\text{Pu}$ , $^{239}\text{Pu}$ , $^{234}\text{U}$ , $^{235}\text{U}$ , $^{238}\text{U}$	Annually	Grab	Annually
V1-V13 <sup>e</sup>	Fluoride, uranium, technetium	Semiannually	Grab	Semiannually
<i>Pine needles</i>				
PN1-PN6 <sup>f</sup>	Fluoride, uranium, technetium	Semiannually	Grab	Semiannually

<sup>a</sup>See Fig. 2.4.1.

<sup>b</sup>Total radioactive strontium ( $^{89}\text{Sr} + ^{90}\text{Sr}$ ).

<sup>c</sup>See Fig. 2.4.2.

<sup>d</sup>See Fig. 2.4.4.

<sup>e</sup>See Fig. 2.4.6.

remote station 53, one of the samples was inadvertently left for 1 week before analysis, which resulted in a reduced sensitivity and a detection limit of about 14 pCi/L.

#### 2.4.2 Fish

Ingestion of fish is a pathway for contaminant uptake in man. During 1987, bluegill were collected for tissue analysis to estimate concentrations for dose assessment models. Bluegill were selected for analysis because of the relatively high concentrations of radionuclides, PCBs, and mercury that have been measured in their tissue as compared with several other types of fish. 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 2.4.1) by ORNL. Sampling locations include the following Clinch River kilometers (CRK): (1) 40.0, which is above Melton Hill Dam and serves as a background location for the DOE facilities. It is above all the Oak Ridge DOE facilities' outfalls; (2) 33.3, which is ORNL's discharge point from White Oak Creek to the Clinch River; and (3) 8.0,

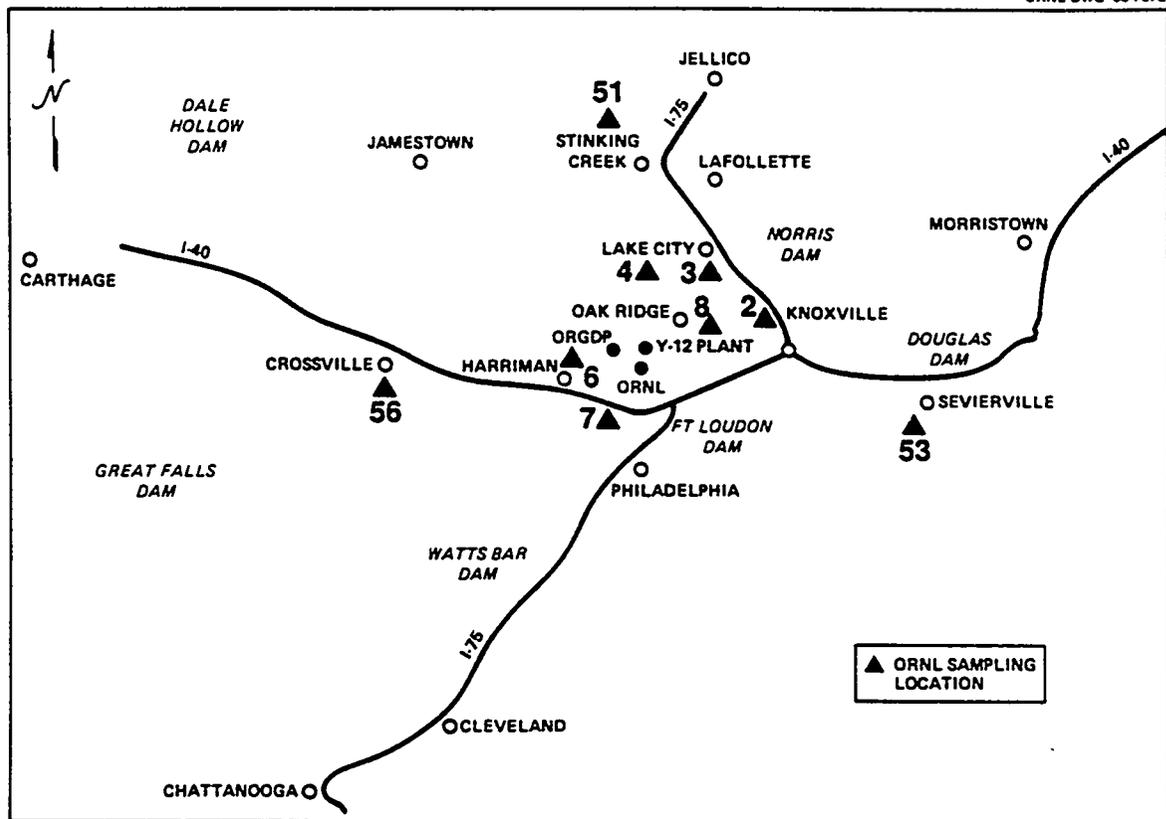


Fig. 2.4.1. Map showing milk sampling stations.

Table 2.4.2. 1987 radionuclide concentrations in milk<sup>a</sup>

Location <sup>b</sup>	Determination	No. of samples	Concentration (pCi/L)				Percent of guidelines <sup>d</sup>
			Max	Min	Av	95% cc <sup>c</sup>	
←→							
Immediate environs	<sup>131</sup> I	89	<5.4	<2.2	<2.3	0.10	23
	Total Sr <sup>e</sup>	93	25	1.6	6.1	0.79	31
Remote environs	<sup>131</sup> I	9	<14	<2.2	<3.8	2.5	38
	Total Sr <sup>e</sup>	9	16	2.1	6.4	3.9	32

<sup>a</sup>Raw milk samples, except for one dairy.<sup>b</sup>See Fig. 2.4.1.<sup>c</sup>95% confidence coefficient about the average.<sup>d</sup>Percent of applicable FRC standard assuming 1 L/d intake: Range I for <sup>131</sup>I, 0–10 pCi/L, Range I for total Sr, 0–20 pCi/L; adequate surveillance required to confirm calculated intakes.<sup>e</sup>Total radioactive strontium (<sup>89</sup>Sr + <sup>90</sup>Sr).

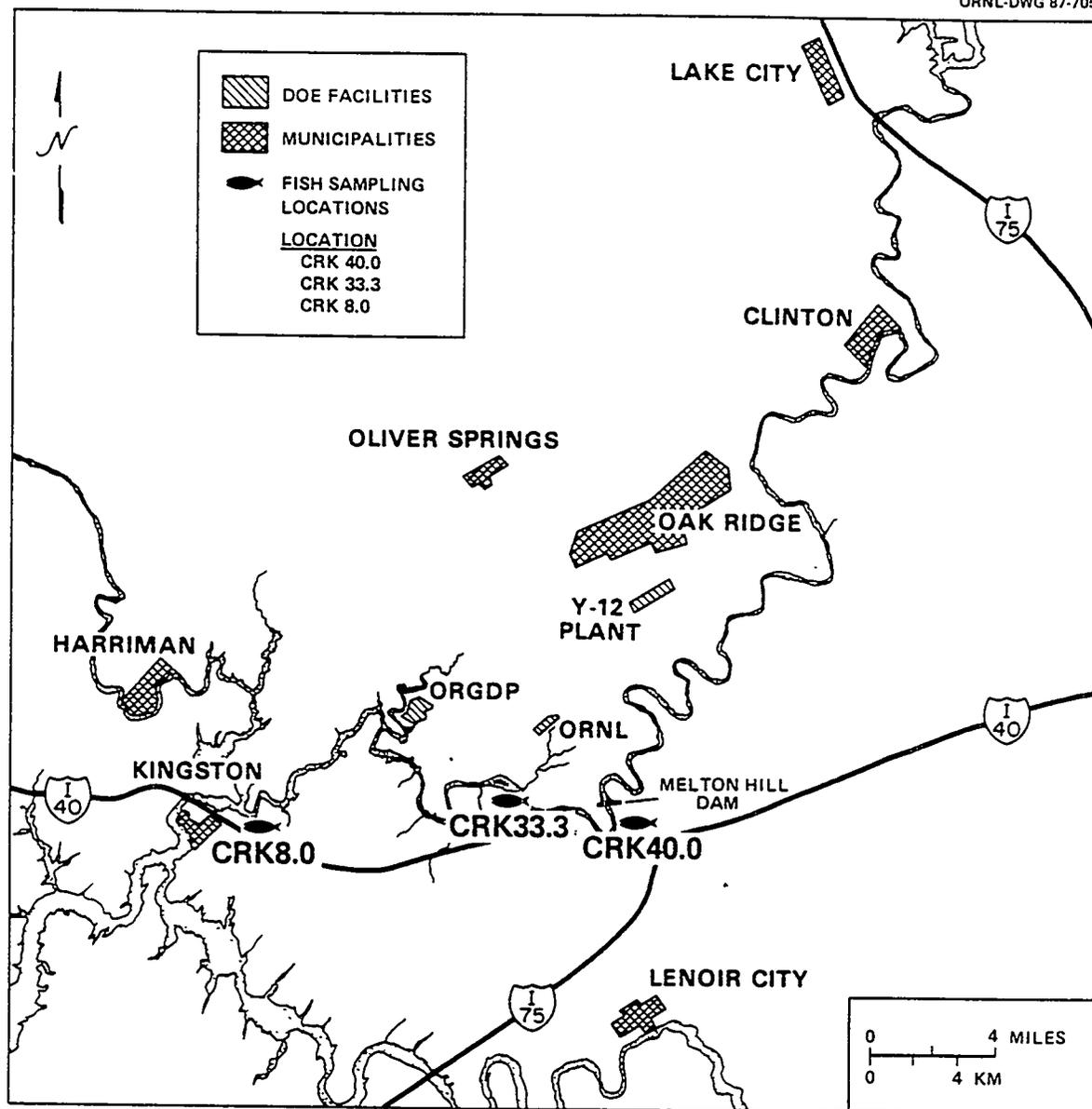


Fig. 2.4.2. Fish sampling locations along Clinch River.

which is downstream from both ORNL and ORGDP.

The primary radionuclides of concern at ORNL regarding fish consumption are total radioactive strontium and  $^{137}\text{Cs}$ . These two result in the highest dose to man from ingestion of fish. Radionuclide concentrations were determined on at least one composite of six to ten fish per sampling period. Mercury and PCB

concentrations were measured in six individual fish from each sampling location during each period. Scales, head, and entrails were removed from each fish before 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.

### 2.4.2.2 Results

Concentrations of mercury, PCBs,  $^{60}\text{Co}$ ,  $^{137}\text{Cs}$ , 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 9.4% of the FDA guideline. For the PCBs, the percentage of the guideline was 2.0% for PCB-1254 and 1.5% for PCB-1260 (or 3.5% 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. There were no statistically significant differences in the average mercury concentrations in fish collected at any of the locations. The highest concentration of mercury was measured at CRK 8.0 (0.34  $\mu\text{g/g}$  wet weight). The average concentration at each station was compared with the FDA action level for mercury in fish (1.0  $\mu\text{g/g}$  wet weight). The

average values at all stations were 9.4% of this limit. None of the individual fish concentrations of mercury exceeded the FDA action level (see Vol. 2, Table 2.4.3).

PCB concentration summaries for bluegill for 1987 are given in Table 2.4.4 of Vol. 2. There were no statistically significant differences in the concentrations of PCB-1254 in fish among the locations sampled. The highest concentration of PCB-1254 was measured in fish collected at CRK 8.0, near Kingston. There was a statistically lower average PCB-1260 concentration in fish collected above Melton Hill Dam (CRK 40.0) than in those collected at the other two Clinch River locations. The maximum concentration of PCB-1260 was observed in fish collected at ORNL's discharge point (CRK 33.3). The average concentration of each type of PCB at each CRK was compared with the FDA's tolerance limit for PCBs in fish (2  $\mu\text{g/g}$  wet weight). All average concentrations were less than 3% of the tolerance limit. None of the individual fish concentrations of PCBs exceeded the FDA tolerance limit (see Vol. 2, Table 2.4.4).

Annual summaries of radionuclide concentrations in Clinch River fish are given in Vol. 2, Table 2.4.5. No statistically significant differences in  $^{60}\text{Co}$  were detected in fish collected at the three locations. Total strontium was highly variable at all locations, making comparisons among the averages meaningless. The highest

Table 2.4.3. 1987 tissue concentrations of Clinch River bluegill

Location <sup>a</sup>	Determination	No. of samples	Concentration <sup>b</sup>				Percent of guidelines <sup>d</sup>
			Max	Min	Av	95% cc <sup>c</sup>	
Clinch River	Hg	36	0.34	0.03	0.09	0.03	9.4
	PCB-1254	36	0.17	0.01	0.04	0.01	2.0
	PCB-1260	36	0.14	<0.01	<0.03	0.01	1.5
	$^{60}\text{Co}$	18	<4.7	<0.96	<3.6	0.42	NA <sup>e</sup>
	$^{137}\text{Cs}$	18	290	<1.7	<70	35	NA <sup>e</sup>
	Total Sr <sup>f</sup>	18	120	<0.61	<19	14	NA <sup>e</sup>

<sup>a</sup>See Fig. 2.4.2.

<sup>b</sup>Mercury and PCB units are  $\mu\text{g/g}$  wet weight. All radionuclides are in pCi/kg wet weight.

<sup>c</sup>95% confidence coefficient about the average.

<sup>d</sup>Percent of Food and Drug Administration action level of mercury in fish (1.0  $\mu\text{g/g}$  wet weight) and tolerance for PCBs in fish (2.0  $\mu\text{g/g}$  wet weight) for the average concentration.

<sup>e</sup>Not applicable.

<sup>f</sup>Total radioactive strontium ( $^{89}\text{Sr}$  and  $^{90}\text{Sr}$ ).

concentration of total radioactive strontium was measured at CRK 8.0, near Kingston (120 pCi/kg wet weight). There were significantly higher concentrations of  $^{137}\text{Cs}$  in fish collected at ORNL's discharge point, CRK 33.3, than at the other two locations. Cesium-137 concentrations were the lowest in fish collected at the reference location above Melton Hill Dam (CRK 40.0). A maximum  $^{137}\text{Cs}$  concentration of 290 pCi/kg wet weight was measured in fish collected at CRK 33.3.

### 2.4.3 Wildlife

Annual hunts are conducted on the Oak Ridge Reservation (ORR) to control the deer population and to reduce the number of deer-vehicle collisions. There were four separate weekend hunts, with the first two restricted to archers (Oct. 17–18 and 24–25). The archery hunts had 1300 permits for each weekend. The permits were issued in two groups; one group of 300 limited to the Tower Shielding and Park City Road areas and a second group of 1000 for the other archery areas on the ORR. The first hunt yielded a total harvest of 89 deer, and the second hunt yielded 59. The remaining two hunts were held on the weekends of November 14–15 and December 12–13. The latter hunts were for shotgun or muzzle-loader hunters, and 900 hunter permits were issued for each one. The gun hunts yielded harvests of 252 and 130 deer for the two respective dates. The total harvest for the 1987 season was 530 deer, of which 58% were bucks. There was a slight increase in the proportion of bucks in the 1987 harvest compared with that in 1986 (58 vs 56.4%).

The age distribution of the harvested deer was similar to that of the 1985 hunts. Deer of 2½ years of age and older had a similar percentage distribution irrespective of sex. Bucks 1½ years old exceeded does by about 2 to 1, whereas ½-year-old does were harvested about 2 to 1 over the bucks.

#### 2.4.3.1 Sample collection

All animals were monitored for radioactivity with portable NaI detectors before they were

released to the hunters for consumption. This radiological survey for the 1987 DOE-Tennessee Wildlife Resources Association (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 Analytical Procedures and Results

Soft-tissue radionuclide concentrations continued to be low and acceptable for the entire harvest. Cesium-137 concentrations were determined in all 530 animals by analysis of a liver or muscle sample using a sensitive gamma-ray spectrometer system. Ninety percent of the harvest contained  $^{137}\text{Cs}$  at concentrations less than 0.5 pCi/g, and only 12 animals contained this nuclide at concentrations exceeding 1 pCi/g. (Maximum value of any animal was 2.9 pCi/g.)

With the bone-checking procedure developed for the 1986 hunts, 30 deer were found to contain elevated levels of  $^{90}\text{Sr}$ . These animals were confiscated from the hunters; however, those hunters were allowed to return to that hunt or to a subsequent hunt. The percentage of contamination in the harvest (5.7%) is up slightly from that of 1986 (4.4%). Following the checking station measurements, subsequent quantitative analyses for  $^{90}\text{Sr}$  were performed on bone samples from all of the confiscated animals. Results of the specific radiochemical analyses of bone samples from the confiscated animals along with the kill location are presented in Table 2.4.4. (Concentrations are calculated on fresh-weight basis.) Note that 50% of the confiscated animals were taken from a 2-mile<sup>2</sup>-area southwest of ORNL (within grids 06F and 06G of the locations indicated in Table 2.4.4).

Data were collected on deer thyroids from the confiscated animals as well as from other selected animals killed during 1987. The 1987 collection confirmed the presence of concentrations of  $^{129}\text{I}$  in their bones. This trend was noted from previous hunts. Radioiodine concentrations in the thyroids are also given in Table 2.4.4. (Concentrations are calculated on fresh-weight basis.)

Table 2.4.4. Radionuclide concentrations in confiscated deer

Deer No.	S-16 grid <sup>a</sup>	<sup>90</sup> Sr (pCi/g bone)	<sup>129</sup> I <sup>b</sup> (pCi/g thyroid)
3	10G	4	0
11	06G	7	32
14	06G	144	28
23	07H	30	0
52	07G	4	0
58	05F	61	0
68	06G	5	44
71	07I	29	5
108	08E	190	5
140	08E	380	9
159	06F	5	0
182	06F	96	29
203	07E	22	37
229	06F	120	67
236	06G	43	3
294	06G	300	—
320	04E	5	—
347	07E	6	0
357	06F	58	7
410	08B	96	15
413	06F	47	2
419	08E	70	12
432	06G	480	15
434	07E	53	2
457	06G	520	29
486	06F	54	0
501	06E	280	8
505	13F	130	0
525	06G	61	7
529	06F	240	11

<sup>a</sup>Administrative grid coordinates are shown in Fig. 2.4.3.

<sup>b</sup>Note that a zero in this column indicates not detected, while dashes indicate not analyzed.

## 2.4.4 Vegetation

Contamination of growing plants may result from sorption of materials from soil or from materials deposited from the atmosphere. Grass was analyzed routinely for radioactivity by ORNL and 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. After initial preparation, the samples were analyzed by gamma spectrometry and radiochemical techniques for a wide variety

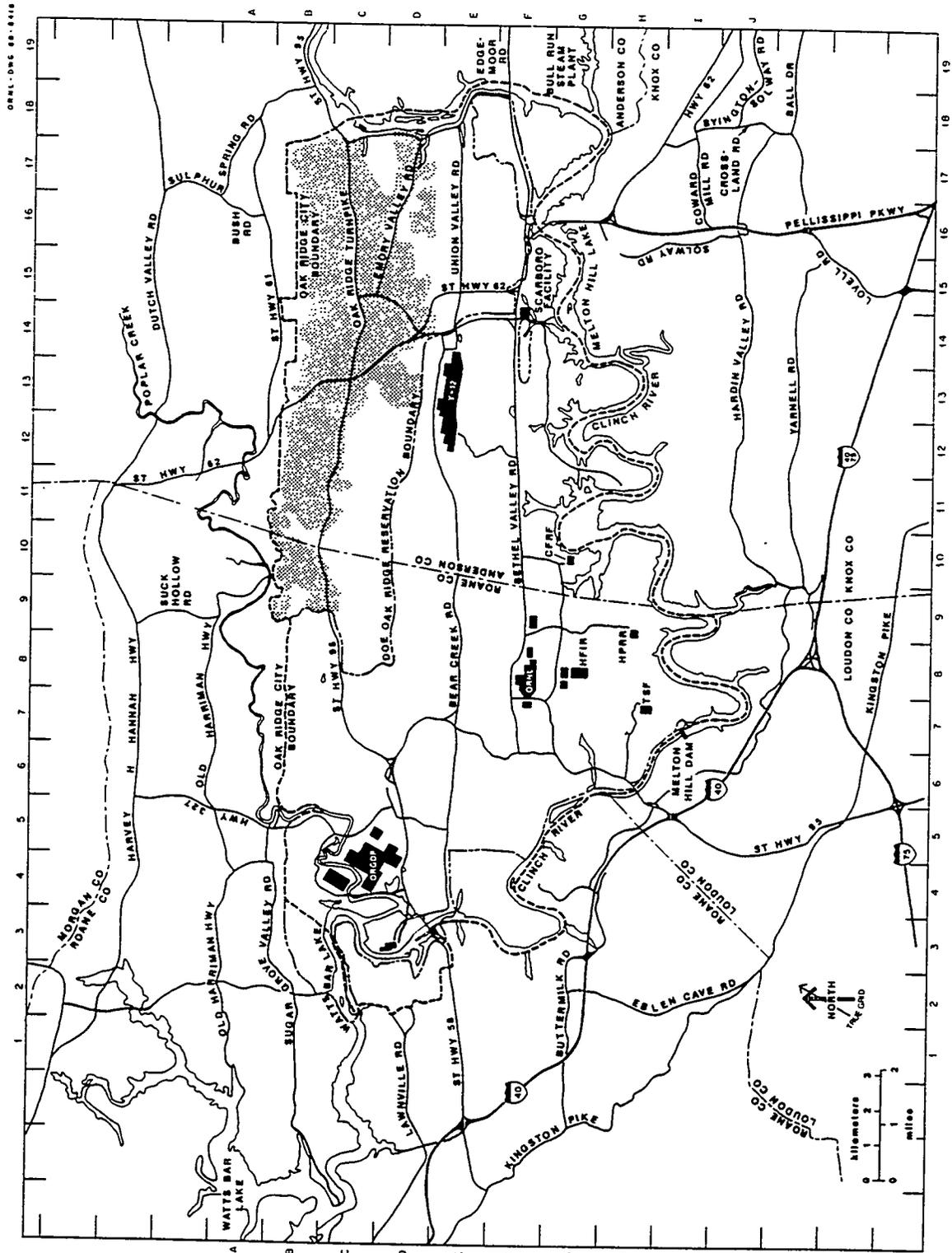


Fig. 2.4.3. Administrative grid coordinates of the ORR.

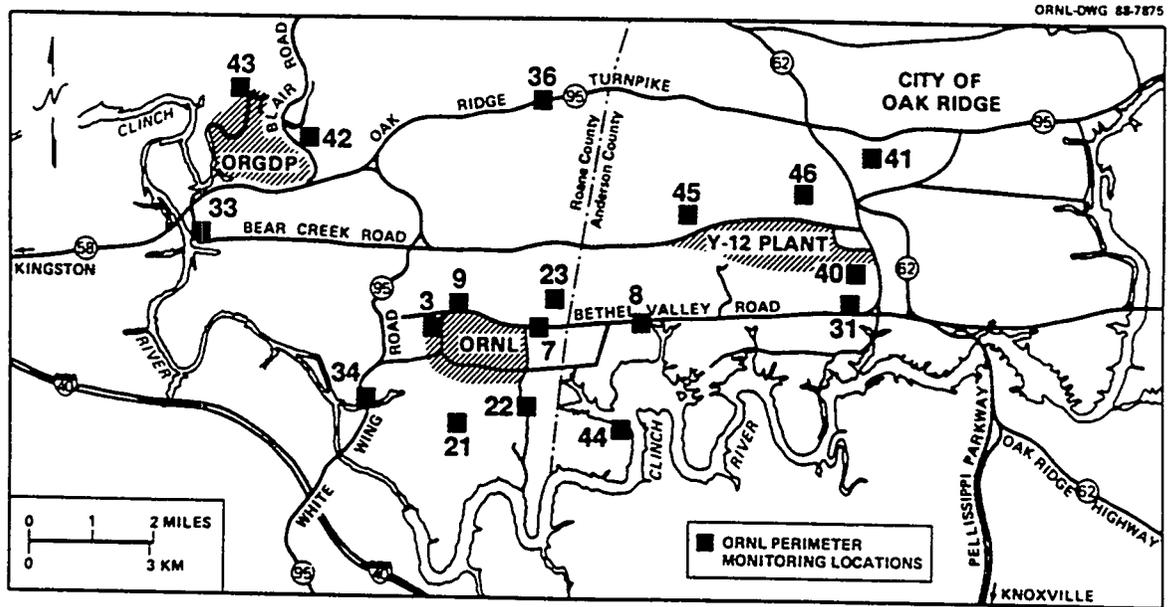


Fig. 2.4.4. ORNL perimeter and ORR grass and soil monitoring locations.

Table 2.4.5. 1987 grass sampling and pine needle data at ORGDP<sup>a</sup>

Station	F <sup>-</sup> concentration ( $\mu\text{g/g}$ dry wt)			U (total) concentration						<sup>99</sup> Tc concentration (pCi/g dry wt)		
	Feb	Oct	Av	( $\mu\text{g/g}$ dry wt)			(pCi/g dry wt)			Feb	Oct	Av
<i>Grass sampling data</i>												
V1	<1.0	<3	<2	0.1	<0.2	<0.15	0.08	<0.15	<0.11	0.4	0.6	0.5
V2	1.2	<3	<2.1	0.1	0.3	0.2	0.08	0.23	0.15	<0.2	<0.3	<0.25
V3	<1.0	3.1	<2.1	0.1	<0.2	<0.15	0.08	<0.15	<0.11	0.3	<0.3	<0.3
V4	<1.0	X <sup>b</sup>	-	0.1	<0.2	<0.15	0.08	<0.15	<0.11	<0.2	0.5	<0.35
V5	<1.0	X	-	0.1	<0.2	<0.15	0.08	<0.15	<0.11	0.1	0.7	0.4
V6	<1.0	<3	<2	0.4	<0.2	<0.3	0.3	<0.15	<0.23	0.6	9.7	5.2
V7	<1.0	X	-	0.1	1.25	0.68	0.08	0.95	0.52	0.2	1.9	1.1
V8	<1.0	X	-	<0.1	0.8	<0.45	<0.08	0.61	<0.34	0.1	0.7	0.4
V9	7.5	X	-	0.1	0.2	0.15	0.08	<0.15	<0.11	0.2	<0.6	<0.4
V10	14.4	X	-	0.1	0.9	0.5	0.08	0.68	0.38	0.8	1.3	1.1
V11	<1.0	X	-	1.4	0.8	1.1	1.1	0.61	0.84	108.7	191.4	150.1
V12	<1.0	<3	<2	0.2	0.7	0.45	<0.15	0.53	<0.34	0.7	15.1	7.9
V13	<1.0	<3	<2	0.2	<0.2	<0.2	0.15	<0.15	<0.15	<0.1	0.4	<0.25
<i>Pine needle sampling data<sup>a</sup></i>												
PN1	7.0	<3	<5	0.2	0.3	0.25	0.15	0.23	0.19	<0.2	0.6	<0.4
PN2	<1.0	<3	<2	3.5	0.2	1.9	2.7	0.15	1.4	1.0	0.5	0.75
PN3	<1.0	<3	<2	0.5	4.5	2.5	0.38	3.4	1.9	0.4	0.3	0.35
PN4	1.1	4.1	2.6	0.2	0.2	0.2	0.15	0.15	0.15	<0.4	0.3	<0.35
PN5	<1.0	<3	<2	0.9	0.3	0.6	0.68	0.23	0.46	1.8	1.9	1.85
PN6	4.7	X	-	0.2	0.2	0.2	0.15	0.15	0.15	<0.5	<0.7	<0.6

<sup>a</sup>See Fig. 2.4.6 (grass and pine needle sampling locations).

<sup>b</sup>Where an "X" appears, the composite sample was too small to complete the analysis.

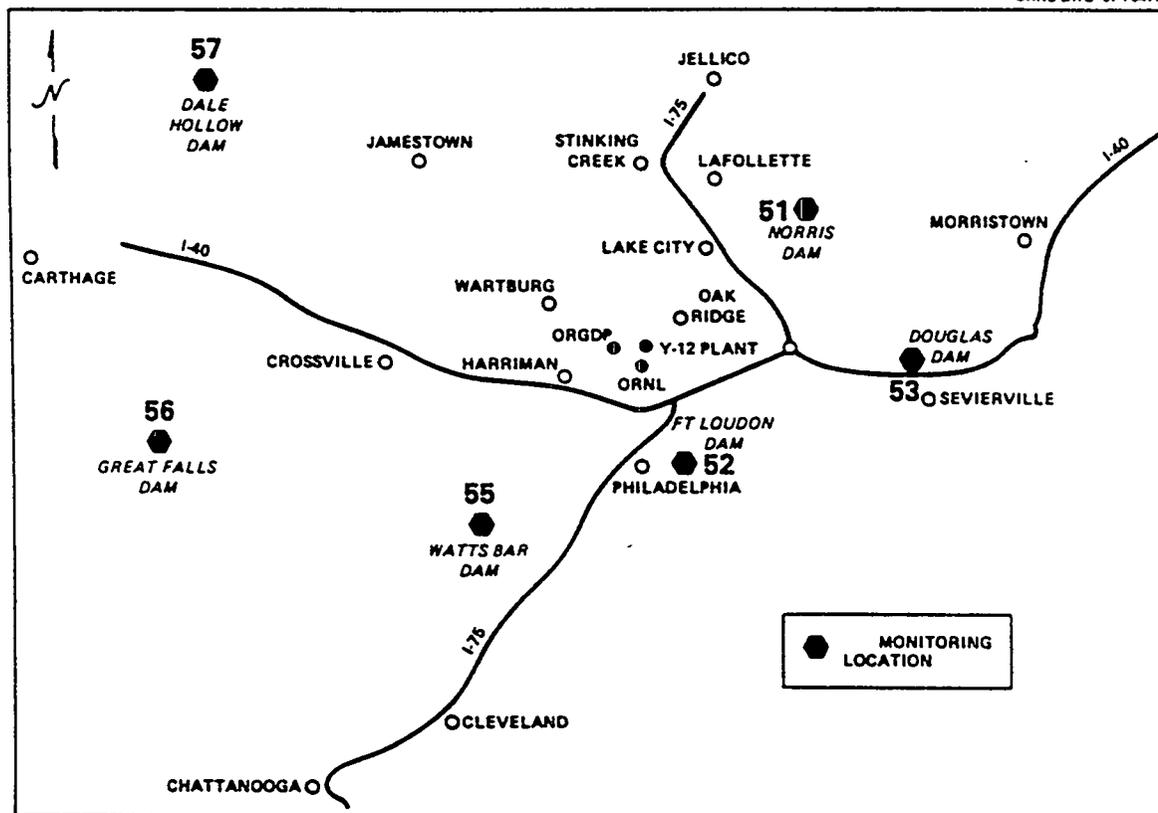


Fig. 2.4.5. ORNL remote grass and soil monitoring locations.

of radionuclides. Station 22 has been upgraded, and samples are being collected at that station.

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 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 grass and pine needle sampling data.

#### 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 2.4.6. There were no statistically

significant differences in the average concentrations of the radionuclides or total radioactive strontium in grass among the three sampling networks, with the exception of  $^{234}\text{U}$  (Table 2.4.6). Uranium-234 concentrations in grass were significantly lower at the ORNL perimeter stations than at the Reservation or remote stations. Average concentrations of  $^{60}\text{Co}$  and  $^{137}\text{Cs}$  were near the analytical detection limits. Average concentrations of the plutonium isotopes for all the networks were less than zero (corrected for instrumental background). At low concentrations, negative values can occur because sampling results are adjusted to subtract out background levels. Concentrations of total radioactive strontium were highly variable at several of the remote stations, which makes it difficult to see significant differences among the sampling networks. Summaries of the grass concentrations of radionuclides and total

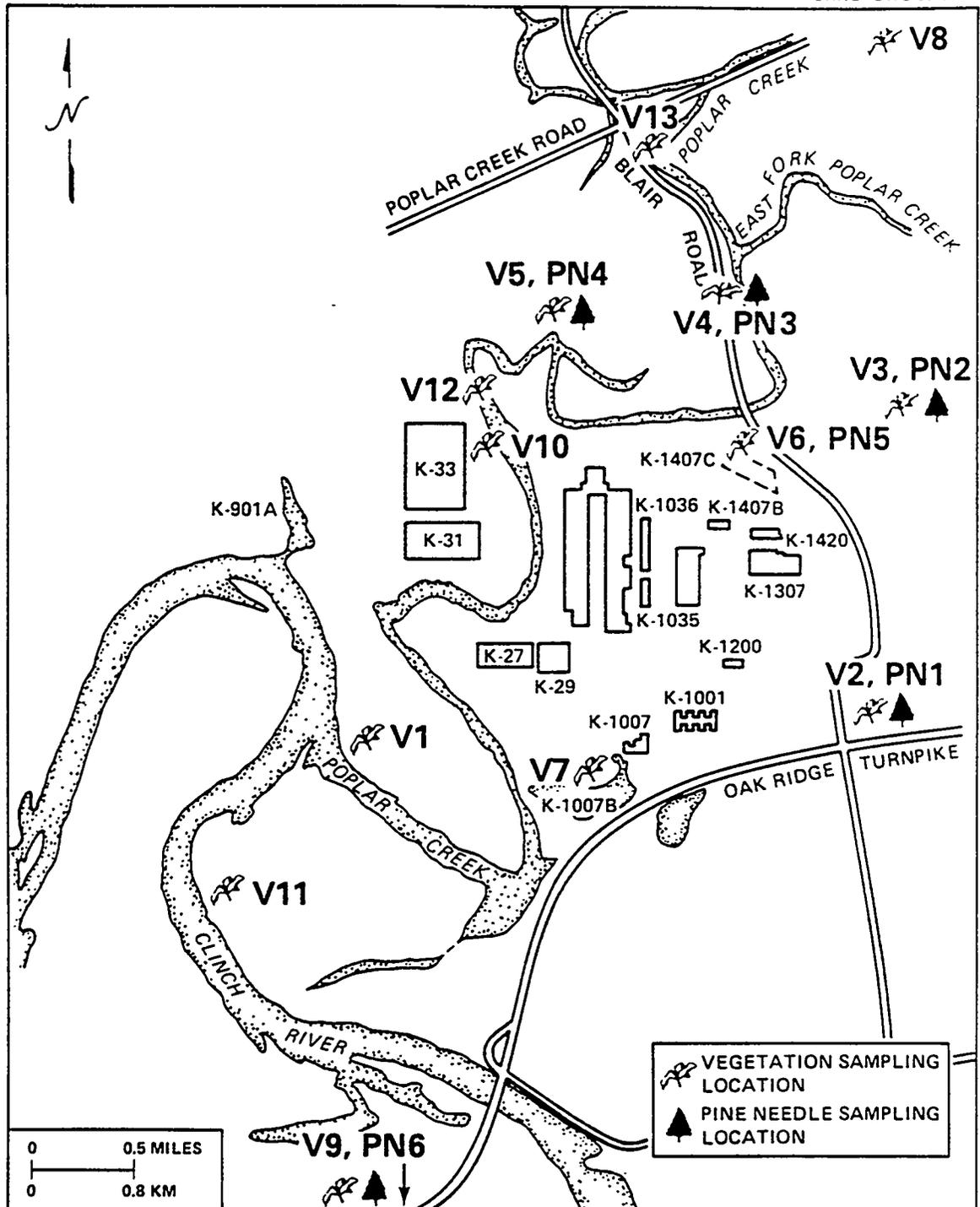


Fig. 2.4.6. Map of ORGDP pine needle and grass sampling locations.

Table 2.4.6. 1987 concentrations of radionuclides in grass

Location <sup>a</sup>	Radionuclides	No. of samples	Concentration (pCi/kg dry wt)			
			Max	Min <sup>b</sup>	Av	95% cc <sup>c</sup>
ORNL perimeter stations	<sup>60</sup> Co	16	<63	<24	<39	5.7
	<sup>137</sup> Cs	16	210	<21	<47	23
	<sup>238</sup> Pu	16	0.97	-2.7	-0.39	0.53
	<sup>239</sup> Pu	16	3.5	-2.7	-0.64	0.85
	Total Sr <sup>d</sup>	16	430	27	170	49
	<sup>234</sup> U	16	84	10	24	9.0
	<sup>235</sup> U	16	7.3	-0.32	1.9	0.99
	<sup>238</sup> U	16	84	2.5	11	9.8
Oak Ridge Reservation stations	<sup>60</sup> Co	52	<54	<22	<34	2.2
	<sup>137</sup> Cs	52	90	<16	<30	3.0
	<sup>238</sup> Pu	52	3.8	-9.2	-0.11	0.63
	<sup>239</sup> Pu	52	3.5	-18	-2.3	1.1
	Total Sr <sup>d</sup>	52	730	-380	150	41
	<sup>234</sup> U	52	260	0.22	54	16
	<sup>235</sup> U	52	20	-1.3	3.1	1.1
	<sup>238</sup> U	52	140	0.092	21	7.1
Remote stations	<sup>60</sup> Co	24	<50	<23	<35	3.6
	<sup>137</sup> Cs	24	52	<23	<34	3.1
	<sup>238</sup> Pu	24	2.7	-97	-4.1	8.1
	<sup>239</sup> Pu	24	1.1	-13	-1.9	1.3
	Total Sr <sup>d</sup>	24	2700	-270	390	290
	<sup>234</sup> U	24	270	10	96	34
	<sup>235</sup> U	24	24	-2.7	4.7	2.2
	<sup>238</sup> U	24	32	4.1	14	3.7

<sup>a</sup>See Figs. 2.4.4 and 2.4.5.

<sup>b</sup>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).

<sup>c</sup>95% confidence coefficient about the average.

<sup>d</sup>Total radioactive strontium (<sup>89</sup>Sr + <sup>90</sup>Sr).

radioactive strontium at each station are given in Vol. 2, Tables 2.4.6–2.4.13. Except for uranium isotopes, concentrations observed were similar to local background not affected by Oak Ridge DOE facilities' operations. Uranium isotopes, when present, are attributable to Y-12 Plant Operations.

#### Oak Ridge Gaseous Diffusion Plant

Because of scheduling conflicts, vegetation samples for ORGDP were collected during February and October 1987 instead of customary February and July.

Because of an insufficient number of samples collected in October, there was not enough grass

from seven locations to complete the fluoride analysis. The data collected in 1987 tend to be lower than in the previous years, except for a few stations (see Table 2.4.5). Stations V2 and V10 had higher fluoride concentrations; V6, V7, V8, V9, V10, and V12 had higher uranium concentrations; <sup>99</sup>Tc concentrations were higher at V6, V11, and V12. Concentrations of technetium and uranium are always higher at V11 than at the other locations because V11 is located in the contaminated scrap yard. The fluoride levels in grass at all sampling points were below the 30- $\mu\text{g/g}$  level, which is considered to produce adverse effects when ingested by cattle with average grazing intakes (AIHA 1969).

## 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 ORNL perimeter stations, the 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 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 cesium or plutonium. In addition, chemical separation in the laboratory of radionuclides such as strontium and plutonium in 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 a number of samples provide a better measure of soil radionuclide concentrations. Because of this, 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<sup>2</sup> plots were sampled. From each plot, five aliquots were taken with an 8-cm setter of the type used on golf

Table 2.5.1. Summary of collection and analysis frequencies of soil and sediment sampling in 1987

Station	Parameter	Collection frequency	Type	Analysis frequency
<i>Soil</i>				
3,7,9,8,23,31,34,36,40-46 <sup>a</sup>	Total Sr, <sup>b</sup> <sup>239</sup> Pu, gamma scan, <sup>238</sup> Pu, <sup>234</sup> U, <sup>235</sup> U, <sup>238</sup> U	Annually	Grab	Annually
S18-S30 <sup>c</sup>	Fluoride, uranium	Semiannually	Grab	Semiannually
<i>Stream sediment</i>				
SS1-SS8 <sup>d</sup>	Hg, Pb, Ni, Cu, Zn, Cr, Mn, Al, Th, Cd, U	Semiannually	Grab	Semiannually

<sup>a</sup>See Fig. 2.4.3.

<sup>b</sup>Total radioactive strontium (<sup>89</sup>Sr + <sup>90</sup>Sr).

<sup>c</sup>See Fig. 2.5.1.

<sup>d</sup>See Fig. 2.5.2.

courses. Aliquots from the two plots were composited for analysis for a total of four samples per location. Only the top 2 cm of soil was analyzed for radionuclides. All samples were dried before analysis. Station 22 has been upgraded, and samples are being collected at this location.

## Results

Summary concentrations of radioactive materials in soils at each of the monitoring networks are given in Table 2.5.2. There were no statistically significant differences in the average concentrations of any of the materials among the three networks, with the exception of  $^{239}\text{Pu}$ . The

average concentration of  $^{239}\text{Pu}$  (15 pCi/kg dry weight) at the remote stations was significantly higher than the average of the Reservation stations (6.8 pCi/kg dry weight).

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. Average concentrations of  $^{60}\text{Co}$  at most of the stations are near the analytical detection limit. However, high concentrations in soil were measured at remote station 53. Concentrations of  $^{60}\text{Co}$  in soil are similar to those measured in grass (Table 2.5.1, Vol. 2). Cesium-137 concentrations in soil are about 20 times higher than those in grass. Plutonium-238 concentrations were not detected

Table 2.5.2. 1987 concentrations of radionuclides in soil

Location <sup>a</sup>	Radionuclides	No. of samples	Concentration (pCi/kg dry wt)			
			Max	Min	Av	95% cc <sup>b</sup>
ORNL perimeter stations	$^{60}\text{Co}$	16	73	<0	<29	10
	$^{137}\text{Cs}$	16	2300	110	790	330
	$^{238}\text{Pu}$	16	4.1	-25	-0.41	3.3
	$^{239}\text{Pu}$	16	35	0.92	11	5.7
	Total Sr <sup>c</sup>	16	760	46	190	87
	$^{234}\text{U}$	16	1100	240	470	110
	$^{235}\text{U}$	16	210	-3.8	53	28
	$^{238}\text{U}$	16	1500	220	450	190
Oak Ridge Reservation stations	$^{60}\text{Co}$	52	54	<22	<33	3.3
	$^{137}\text{Cs}$	52	2400	32	650	140
	$^{238}\text{Pu}$	52	14	-780	-15	30
	$^{239}\text{Pu}$	52	38	-86	6.8	4.7
	Total Sr <sup>c</sup>	52	2400	-110	190	95
	$^{234}\text{U}$	52	19000	230	1100	750
	$^{235}\text{U}$	52	1800	4.6	150	88
	$^{238}\text{U}$	52	6800	140	680	310
Remote stations	$^{60}\text{Co}$	24	410	<16	<42	32
	$^{137}\text{Cs}$	24	1500	120	760	150
	$^{238}\text{Pu}$	24	4.6	-24	-2.5	3.4
	$^{239}\text{Pu}$	24	38	1.4	15	3.4
	Total Sr <sup>c</sup>	24	350	-27	130	41
	$^{234}\text{U}$	24	760	220	460	70
	$^{235}\text{U}$	24	320	-7.8	76	33
	$^{238}\text{U}$	24	780	160	410	66

<sup>a</sup>See Figs. 2.4.4 and 2.4.5.

<sup>b</sup>95% confidence coefficient about the average.

<sup>c</sup>Total radioactive strontium ( $^{89}\text{Sr}$  and  $^{90}\text{Sr}$ ).

in soil. Plutonium-239 concentrations were significantly higher in soil than in grass (see Tables 2.5.4 and 2.4.8, Vol. 2), while those of total radioactive strontium were similar to concentrations in grass. The highest concentrations of  $^{234}\text{U}$  and  $^{238}\text{U}$  were found at stations closest to the Y-12 Plant (numbers 40, 45, and 46). This indicates that the Y-12 Plant is contributing uranium to the natural levels already present in the soil. Uranium-235 was significantly higher at station 40 (just east of Y-12) than at other stations. Uranium concentrations in soil were significantly higher than those in grass.

### 2.5.1.2 Oak Ridge Gaseous Diffusion Plant

#### Sample collection and analytical procedures

Samples were collected from 13 locations in and around ORGDP (see Fig. 2.5.1) semiannually. Approximately 450 g of soil is collected using a stainless steel scoop to remove the top 1 cm 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

Because of an insufficient sample size in October, there was not enough soil to complete the fluoride analysis. The fluoride concentrations ranged from 120  $\mu\text{g/g}$  at S28 to 1050  $\mu\text{g/g}$  at S22 (see Table 2.5.9, Vol. 2). Uranium concentrations in the soil around ORGDP have changed little since 1985. High uranium concentrations at S28 result from contamination of the soil from the contaminated scrapyard at this location rather than from atmospheric releases from ORGDP.

### 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

(see 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 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 2.5.9 in Vol. 2 gives data on the ORGDP samples. Table 2.5.10 in Vol. 2 gives metal concentrations in the stream sediment.

An examination of the ORGDP stream sediment results (see Table 2.5.10 in Vol. 2) shows SS7 and SS8, from the Clinch River, to have the lowest metal concentrations of the sampling stations. For most of the metals the highest concentrations occurred at stations in the creek close to or above ORGDP: SS2, SS4, SS5, and SS6. Concentrations of chromium, copper, lead, mercury, nickel, zinc, and uranium were generally lower in 1987 than in 1986.

## 2.6 EXTERNAL GAMMA RADIATION

External gamma radiation measurements are made to determine if routine radioactive effluents from ORNL are increasing external radiation levels significantly above normal background levels.

### 2.6.1 Sample Collection and Analytical Procedures

Currently, external gamma radiation measurements are made monthly at the ORNL perimeter stations and at ORR perimeter stations 8 and 23 (see Fig. 2.4.4), quarterly at sites along the bank of the Clinch River (see Fig. 2.6.1), and semiannually at the remote stations (see Fig. 2.4.5). A summary of collection and analysis frequencies is given in Table 2.6.1. Measurements along the bank of the Clinch River, from the mouth of White Oak Creek for several hundred yards downstream, are made to evaluate gamma

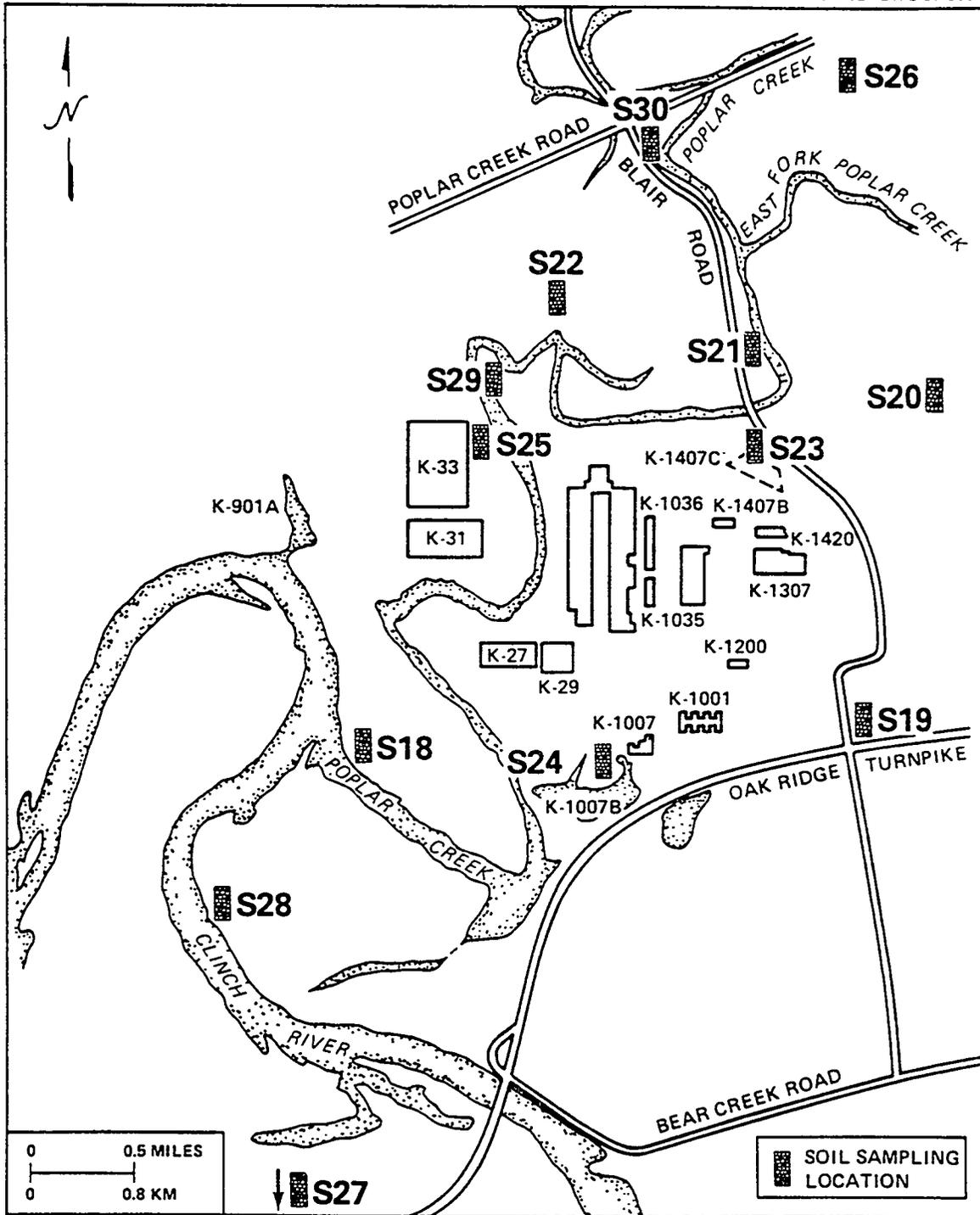


Fig. 2.5.1. Soil sampling locations around ORGDP.

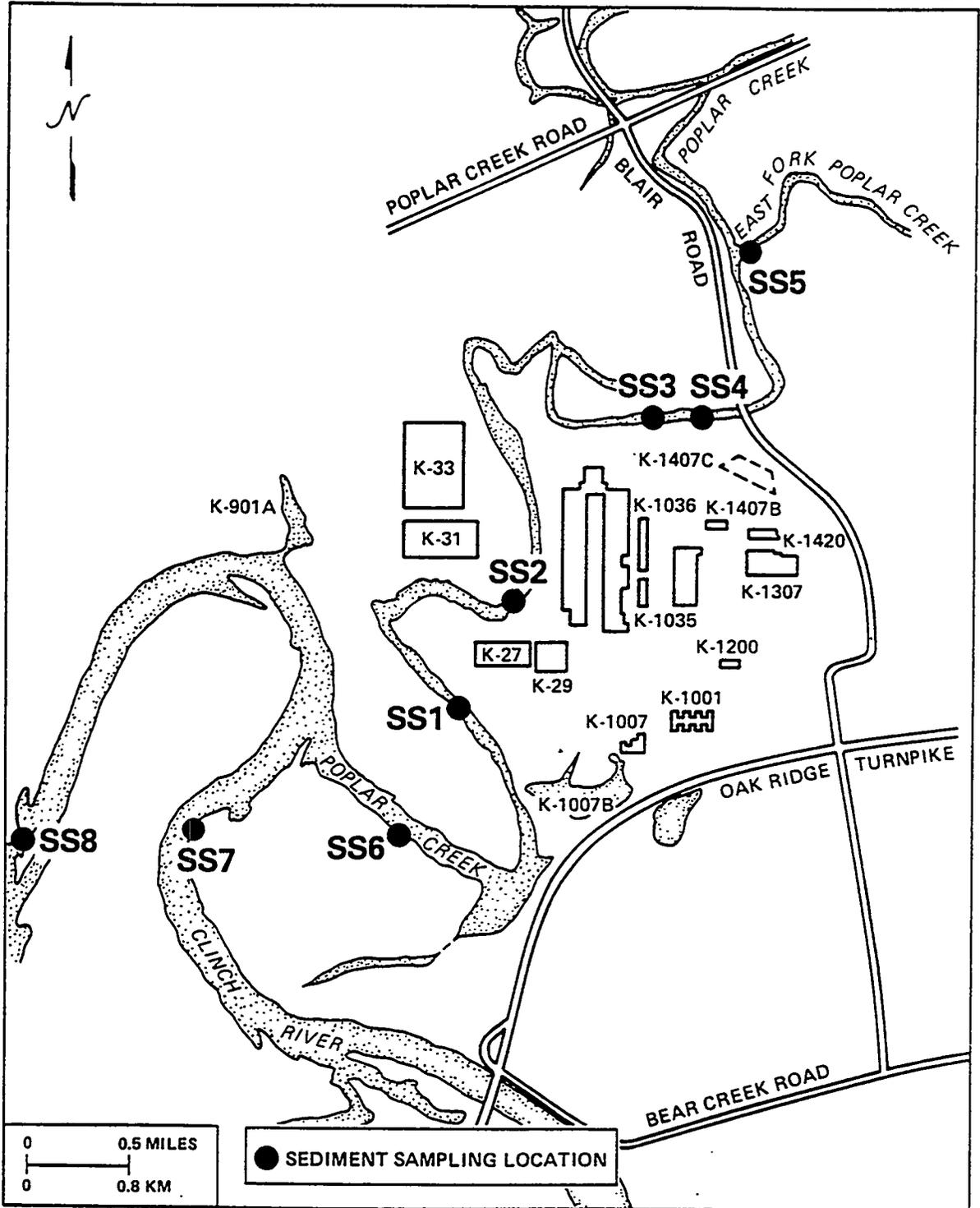


Fig. 2.5.2. Stream sediment sampling locations at ORGDP.

radiation levels resulting from ORNL effluents or releases and air-scattered gamma radiation (sky shine) from an experimental radioactive cesium plot located near the river bank. Measurements at these sites are made using thermoluminescent dosimeters (TLDs). Three dosimeters are placed in each container, and the containers are suspended 1 m above ground. Measurements from each dosimeter are averaged for the monthly, quarterly, or semiannual period. Real-time readings of external gamma radiation are collected at 10-min intervals for all ORR perimeter stations except 8 and 23. The real-time monitoring system provides an alert or alarm message if the reading exceeds background. These continuous monitoring data are not reported here. Only sampling data are provided.

### 2.6.2 Results

Summary statistics of external gamma radiation measurements for the three air monitoring networks and the Clinch River

stations are given in Table 2.6.2. The average external gamma radiation levels near ORNL and on the ORR were 6.4 and 5.1  $\mu\text{R}/\text{h}$ , respectively, which are not significantly different. Average external gamma radiation concentrations were significantly lower at the remote stations than those at the other networks. Although the results and calculations have been verified, there appears to be a problem associated with the analysis of the remote TLDs. The values appear to be too low in relation to those of past years. The natural background should be between 6 and 9  $\mu\text{R}/\text{h}$  for eastern Tennessee. Problems with these analyses will be investigated during the first part of 1988. The average concentrations at the Clinch River stations were significantly higher than those at the other locations because of the  $^{137}\text{Cs}$  used in experiments in this area. Data for the individual stations in each location are provided in Vol. 2, Table 2.6.1.

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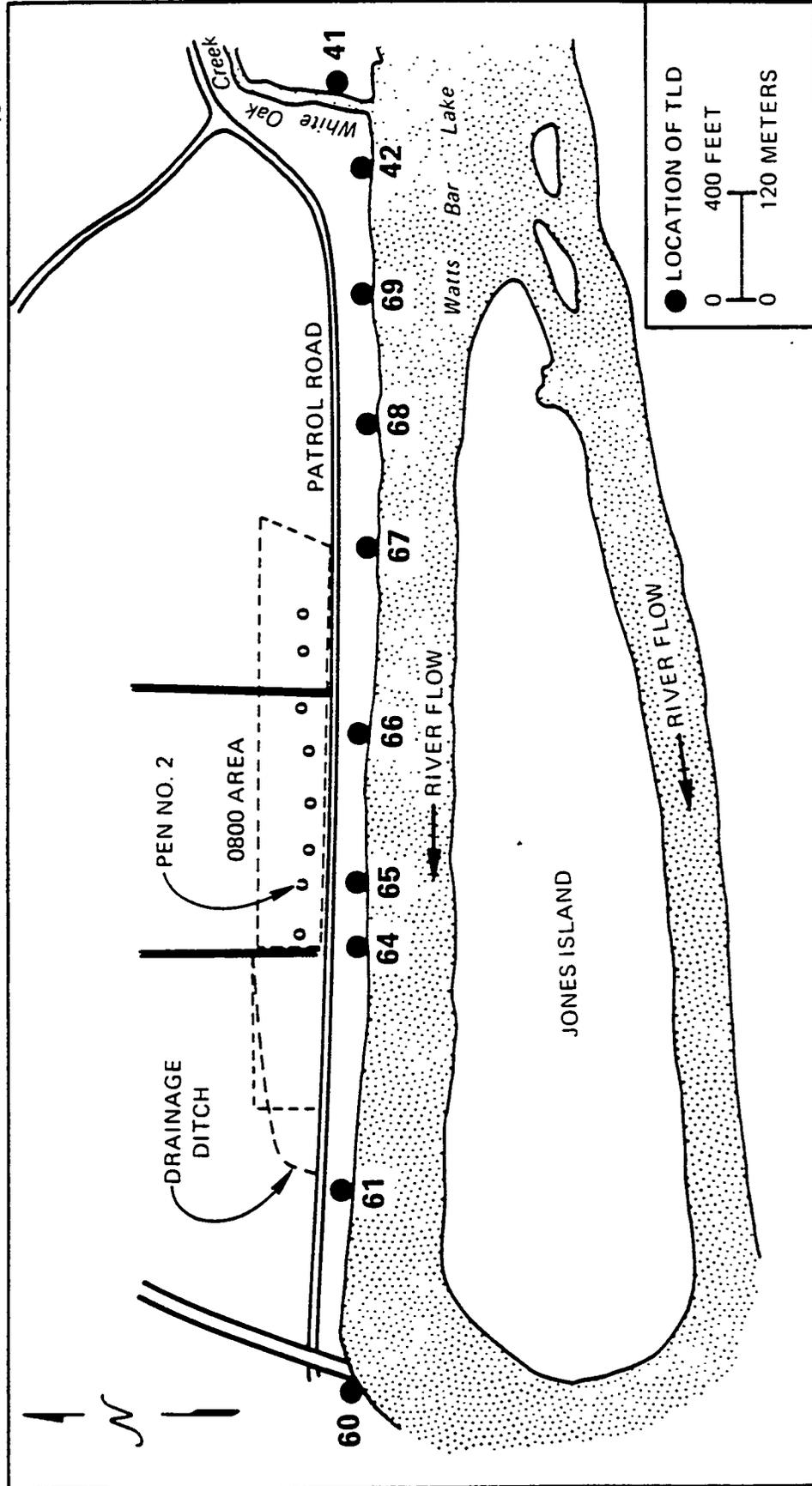


Fig. 2-6.1. TLD locations along Clinch River.

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

Area	Stations	Collection frequency	Type	Analysis frequency
ORNL perimeter <sup>a</sup>	3,7,9,21,22	Monthly	Continuous	Monthly
Oak Ridge Reservation <sup>a</sup>	31,33,34,36 40-45	Real time	Continuous	10-min
Clinch River <sup>b</sup>	8,23	Monthly	Continuous	Monthly
	41,42,60,61, 64-69	Quarterly	Continuous	Quarterly
Remote <sup>c</sup>	51,52,53, 55-57	Semiannually	Continuous	Semiannually

<sup>a</sup>See Fig. 2.4.4.

<sup>b</sup>See Fig. 2.6.1.

<sup>c</sup>See Fig. 2.4.5.

Table 2.6.2. 1987 external gamma radiation measurements

Location	No. of samples	Concentration ( $\mu\text{R}/\text{h}$ )			
		Max	Min	Av	95% CC <sup>a</sup>
ORNL perimeter <sup>b</sup>	50	12	1.3	6.4	0.88
Oak Ridge Reservation <sup>b</sup>	20	9.3	0.67	5.1	1.2
Clinch River <sup>c</sup>	39	32	3.3	13	2.2
Remote <sup>d</sup>	12	5.0	0	2.4	0.74

<sup>a</sup>95% confidence coefficient about the average.

<sup>b</sup>See Fig. 2.4.4.

<sup>c</sup>See Fig. 2.6.1.

<sup>d</sup>See Fig. 2.4.5.

## 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 ORR facilities during 1987. 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 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.

*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  $\mu\text{Ci}$ ) of a radionuclide. The second gives the dose equivalent rate (mrem/year) per unit activity (1.0  $\mu\text{Ci}$ ) of a radionuclide in a unit ( $\text{cm}^3$  or  $\text{cm}^2$ ) 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 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).

### 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 1987 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 (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; Sjoreen and Miller 1984) developed under sponsorship of the EPA for use in demonstrating compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAP)—Radionuclides (CFR 1986). The

Table 3.1.1. Dose equivalent conversion factors (rem/ $\mu\text{Ci}$ ) for inhalation<sup>a</sup>

Radionuclide (solubility)	Effective	Lung	Endosteal bone	Thyroid
<sup>3</sup> H	$1.25 \times 10^{-4}$	$1.25 \times 10^{-4}$	$9.85 \times 10^{-5}$	$1.24 \times 10^{-4}$
<sup>85</sup> Kr	$6.28 \times 10^{-7}$	$2.00 \times 10^{-6}$	$4.90 \times 10^{-7}$	$4.90 \times 10^{-7}$
<sup>90</sup> Sr (D) <sup>b</sup>	$2.22 \times 10^{-1}$	$1.35 \times 10^{-2}$	2.53	$9.43 \times 10^{-3}$
<sup>99</sup> Tc (D)	$1.00 \times 10^{-3}$	$1.32 \times 10^{-3}$	$1.76 \times 10^{-4}$	$4.54 \times 10^{-3}$
<sup>131</sup> I (D)	$3.29 \times 10^{-2}$	$2.50 \times 10^{-3}$	$1.98 \times 10^{-4}$	1.08
<sup>133</sup> Xe	$6.24 \times 10^{-7}$	$1.40 \times 10^{-6}$	$5.00 \times 10^{-7}$	$5.71 \times 10^{-7}$
<sup>234</sup> U (D)	2.67	1.20	$3.97 \times 10^1$	$9.40 \times 10^{-2}$
(Y) <sup>b</sup>	$1.32 \times 10^2$	$1.10 \times 10^3$	4.05	$9.83 \times 10^{-3}$
<sup>235</sup> U (D)	2.54	1.11	$3.84 \times 10^1$	$9.20 \times 10^{-2}$
(Y)	$1.22 \times 10^2$	$1.02 \times 10^3$	3.95	$1.55 \times 10^{-2}$
<sup>236</sup> U (D)	2.53	1.14	$3.94 \times 10^1$	$9.30 \times 10^{-2}$
<sup>238</sup> U (D)	2.40	1.06	$3.44 \times 10^1$	$8.40 \times 10^{-2}$
(Y)	$1.18 \times 10^2$	$9.78 \times 10^2$	3.53	$1.05 \times 10^{-2}$
<sup>231</sup> Th (W) <sup>b</sup>	$9.30 \times 10^{-4}$	$3.92 \times 10^{-3}$	$2.70 \times 10^{-3}$	$8.33 \times 10^{-6}$
<sup>234</sup> Th (W)	$3.00 \times 10^{-2}$	$1.79 \times 10^1$	$2.73 \times 10^{-2}$	$4.04 \times 10^{-3}$
<sup>234m</sup> Pa (W)	$3.76 \times 10^{-6}$	$3.13 \times 10^{-5}$	$4.10 \times 10^{-9}$	$6.66 \times 10^{-9}$

<sup>a</sup>Factors taken from the EPA Clean Air Act data tapes.

<sup>b</sup>D = soluble; W = moderately soluble; Y = insoluble.

Table 3.1.2. Dose equivalent conversion factors (rem/ $\mu$ Ci) for ingestion<sup>a</sup>

Radionuclide (solubility)	Effective	Lung	Endosteal bone	Thyroid
<sup>3</sup> H	$8.93 \times 10^{-5}$	$8.36 \times 10^{-5}$	$6.56 \times 10^{-5}$	$8.28 \times 10^{-5}$
<sup>85</sup> Kr	0	0	0	0
<sup>90</sup> Sr (D) <sup>b</sup>	$1.30 \times 10^{-1}$	$5.33 \times 10^{-3}$	1.44	$5.33 \times 10^{-3}$
<sup>99</sup> Tc (D)	$1.40 \times 10^{-3}$	$2.31 \times 10^{-4}$	$2.31 \times 10^{-4}$	$5.98 \times 10^{-3}$
<sup>131</sup> I (D)	$5.05 \times 10^{-2}$	$3.67 \times 10^{-4}$	$2.88 \times 10^{-4}$	1.67
<sup>133</sup> Xe	0	0	0	0
<sup>234</sup> U (D&W) <sup>b</sup>	$2.74 \times 10^{-1}$	$9.60 \times 10^{-3}$	4.07	$9.60 \times 10^{-3}$
(Y) <sup>b</sup>	$2.50 \times 10^{-2}$	$3.84 \times 10^{-4}$	$1.63 \times 10^{-1}$	$3.84 \times 10^{-4}$
<sup>235</sup> U (D&W)	$2.63 \times 10^{-1}$	$9.40 \times 10^{-3}$	3.94	$9.40 \times 10^{-3}$
(Y)	$2.58 \times 10^{-2}$	$3.87 \times 10^{-4}$	$1.57 \times 10^{-1}$	$3.76 \times 10^{-4}$
<sup>236</sup> U (D&W)	$2.60 \times 10^{-1}$	$9.10 \times 10^{-3}$	3.84	$9.10 \times 10^{-3}$
<sup>236</sup> U (Y)	$2.38 \times 10^{-2}$	$3.64 \times 10^{-4}$	$1.54 \times 10^{-1}$	$3.64 \times 10^{-4}$
<sup>238</sup> U (D&W)	$2.47 \times 10^{-1}$	$8.70 \times 10^{-3}$	3.52	$8.70 \times 10^{-3}$
(Y)	$2.30 \times 10^{-2}$	$3.47 \times 10^{-4}$	$1.41 \times 10^{-1}$	$3.46 \times 10^{-4}$
<sup>231</sup> Th (W)	$1.23 \times 10^{-3}$	$5.30 \times 10^{-7}$	$1.20 \times 10^{-5}$	$3.45 \times 10^{-8}$
<sup>234</sup> Th (W)	$1.30 \times 10^{-2}$	$2.45 \times 10^{-6}$	$7.30 \times 10^{-5}$	$1.08 \times 10^{-6}$
<sup>234m</sup> Pa (W)	$5.80 \times 10^{-6}$	$4.18 \times 10^{-9}$	$1.86 \times 10^{-9}$	$4.13 \times 10^{-10}$
<sup>60</sup> Co (W)	$1.13 \times 10^{-2}$	$2.11 \times 10^{-5}$	$1.34 \times 10^{-5}$	$2.38 \times 10^{-5}$
<sup>137</sup> Cs (D)	$4.30 \times 10^{-2}$	$4.44 \times 10^{-2}$	$3.05 \times 10^{-2}$	$5.08 \times 10^{-2}$
<sup>238</sup> Pu (Y)	3.85	$8.42 \times 10^{-2}$	$6.76 \times 10^1$	$8.42 \times 10^{-2}$
<sup>238</sup> Pu (Y)	$4.45 \times 10^{-1}$	$9.45 \times 10^{-3}$	7.59	$9.45 \times 10^{-3}$
<sup>241</sup> Am (W)	4.43	$9.71 \times 10^{-2}$	$7.80 \times 10^1$	$9.70 \times 10^{-2}$
<sup>244</sup> Cm (W)	2.32	$5.0 \times 10^{-2}$	$4.03 \times 10^1$	$5.0 \times 10^{-2}$

<sup>a</sup>Factors taken from the EPA Clean Air Act data tapes.<sup>b</sup>D = soluble; W = moderately soluble; Y = insoluble.Table 3.1.3. Dose equivalent rate conversion factors (mrem/year per  $\mu$ Ci/cm<sup>3</sup>) for immersion in air<sup>a</sup>

Radionuclide	Effective	Lung	Endosteal bone	Thyroid
<sup>3</sup> H	0	0	0	0
<sup>85</sup> Kr	$1.09 \times 10^7$	$9.73 \times 10^6$	$1.14 \times 10^7$	$1.21 \times 10^7$
<sup>90</sup> Sr	0	0	0	0
<sup>99</sup> Tc	$2.50 \times 10^3$	$2.09 \times 10^3$	$3.65 \times 10^3$	$3.07 \times 10^3$
<sup>131</sup> I	$1.86 \times 10^9$	$1.64 \times 10^9$	$2.02 \times 10^9$	$2.07 \times 10^9$
<sup>133</sup> Xe	$1.66 \times 10^8$	$1.30 \times 10^8$	$2.31 \times 10^8$	$2.01 \times 10^8$
<sup>234</sup> U	$7.36 \times 10^5$	$4.11 \times 10^5$	$7.10 \times 10^5$	$6.07 \times 10^5$
<sup>235</sup> U	$7.37 \times 10^8$	$6.32 \times 10^8$	$9.36 \times 10^8$	$8.51 \times 10^8$
<sup>236</sup> U	$5.80 \times 10^5$	$2.99 \times 10^5$	$5.40 \times 10^5$	$4.48 \times 10^5$
<sup>238</sup> U	$5.00 \times 10^5$	$2.50 \times 10^5$	$4.51 \times 10^5$	$3.77 \times 10^5$
<sup>231</sup> Th	$5.52 \times 10^7$	$4.29 \times 10^7$	$7.47 \times 10^7$	$6.40 \times 10^7$
<sup>234</sup> Th	$3.65 \times 10^7$	$3.01 \times 10^7$	$5.29 \times 10^7$	$4.48 \times 10^7$
<sup>234m</sup> Pa	$5.83 \times 10^7$	$5.25 \times 10^7$	$5.58 \times 10^7$	$6.66 \times 10^7$

<sup>a</sup>Factors taken from the EPA Clean Air Act data tapes.

Table 3.1.4. Dose equivalent rate conversion factors (mrem/year per  $\mu\text{Ci}/\text{cm}^2$ ) for ground surface exposure<sup>a</sup>

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

<sup>a</sup>Factors taken from the EPA Clean Air Act data tapes.

Table 3.1.5. Calculated maximally exposed individual 50-year committed dose equivalents from airborne releases in 1987

Release location	Dose equivalents (mrem/year)				
	Whole body	Effective	Lung	Endosteal bone	Thyroid
<i>ORNL<sup>a</sup></i>					
3039 stack	0.40	0.40	0.38	0.30	0.38
7911 stack	0.0093	0.0097	0.0081	0.013	0.013
Total ORNL	0.41	0.41	0.39	0.31	0.39
<i>ORGDP<sup>b</sup></i>					
Bldg. K-1420	0.0000018	0.000099	0.000038	0.0014	0.0000053
<i>Y-12 Plant<sup>c</sup></i>					
Center	0.0021	2.1	17	0.97	0.0044
<i>Entire ORR<sup>d</sup></i>					
ORR	0.41	2.1	17	0.97	0.39

<sup>a</sup>The maximally exposed individual is located 4980 m SW of the 3039 stack and 5270 m WSW of the 7911 stack.

<sup>b</sup>The maximally exposed individual is located 3000 m WSW of Building K-1420.

<sup>c</sup>The maximally exposed individual is located 570 m NNW of the center of the Y-12 Plant.

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

**Table 3.1.6. Calculated collective 50-year committed effective dose equivalents due to airborne releases in 1987**

Release location	Effective dose equivalent (person-rem/year)
<i>ORNL<sup>a</sup></i>	
3039 stack	25.
7911 stack	0.47
Total ORNL	25
<i>ORGDP<sup>b</sup></i>	
Total ORGDP	0.0014
<i>Y-12 Plant<sup>c</sup></i>	
Total Y-12	30
Entire ORR <sup>d</sup>	55

<sup>a</sup>The collective 50-year committed dose equivalents to the 835,766 persons residing within 80 km of the ORNL.

<sup>b</sup>The collective 50-year committed dose equivalents to the 837,129 persons residing within 80 km of the ORGDP.

<sup>c</sup>The collective 50-year committed dose equivalents to the 863,264 persons residing within 80 km of the Y-12 Plant.

<sup>d</sup>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 1987  
per 40CFR61.94**

*ORNL<sup>a</sup>*

*Section I. Air emissions (Ci/year)*

Radionuclide	Quantity
<sup>3</sup> H	$4.41 \times 10^4$
<sup>85</sup> Kr	$4.71 \times 10^3$
<sup>90</sup> Sr	$4.86 \times 10^{-3}$
<sup>131</sup> I	$1.86 \times 10^{-2}$
<sup>133</sup> Xe	$2.26 \times 10^4$

*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	0.41	2
Any organ	≤75	0.56 (LLI Wall)	1

*ORGDP<sup>a</sup>*

*Section I. Air emission (Ci/year)*

Radionuclide	Quantity
<sup>234</sup> U	$1.75 \times 10^{-4}$
<sup>235</sup> U	$8.64 \times 10^{-6}$
<sup>238</sup> U	$1.33 \times 10^{-4}$

Table 3.1.7. (continued)

*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)*

	<u>EPA standard</u>	<u>Facility estimate</u>	<u>Percent of standard</u>
Whole body	≤25	0.0000018	<0.001
Any organ	≤75	0.0014 (Endosteal bone)	0.002

*Y-12 Plant<sup>a</sup>**Section I. Air emissions (Ci/year)*

<u>Radionuclide</u>	<u>Quantity</u>
<sup>234</sup> U	$1.10 \times 10^{-1}$
<sup>235</sup> U	$4.30 \times 10^{-3}$
<sup>238</sup> U	$2.54 \times 10^{-2}$

*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)*

	<u>EPA standard</u>	<u>Facility estimate</u>	<u>Percent of standard</u>
Whole Body	≤25	0.0021	0.008
Any organ	≤75	17	23

<sup>a</sup>Owner: U.S. Department of Energy; Operations Office: Oak Ridge, Tennessee. Site Operator: Martin Marietta Energy Systems, Inc.

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).

Plant-specific meteorological data, population distributions, and source terms were used in all calculations. At ORNL, doses due to airborne releases from the 3039 stack were characterized using meteorological data from the 100-m sensor on ORNL tower MT2; releases from the 7911 stack were characterized using 1987 meteorological data from the 30-m sensor on ORNL tower MT4. (These stacks are by far the dominant sources of radionuclides released to the atmosphere at ORNL.) Releases from ORGDP were characterized using 1987 data from tower MT1 at ORGDP. The 1987 Y-12 data were unacceptable for use in the analysis because of excessive downtime of the tower. Because of the problems associated with the Y-12 Plant meteorological data set, the input data used to estimate doses resulting from releases at the Y-12 Plant in 1986 were used to estimate doses resulting from releases at Y-12 in 1987. Lacking suitable on-site meteorological data, this approach ensures consistency between annual dose estimates. 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 essentially from the 3039 and 7911 stacks. Two modifications were made to the source terms reported in Sect. 2.1. All particulate releases were assumed to be  $^{90}\text{Sr}$ , the fission product likely to deliver the highest doses. The noble gas releases were assumed to be 83%  $^{133}\text{Xe}$  and 17%  $^{85}\text{mKr}$ , a

combination that is representative of 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). Calculated dose equivalents to the maximally exposed resident, who is located 4980 m SW from the 3039 stack and 5270 m WSW from the 7911 stack, are given in Table 3.1.5. Essentially all of the doses (~98%) are from ingestion and inhalation of tritium released from the 3039 stack. The 0.41-mrem/year whole-body and effective doses and the highest organ dose (0.56 mrem/year to the lower large intestinal wall) 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 25 person-rem (Table 3.1.6).

Releases from ORGDP during 1987 came from Building K-1420. The total release was restricted to 403 g of 1% enriched  $^{235}\text{U}$  in a soluble form (class D solubility). Calculated dose equivalents to the maximally exposed resident, who is located 3000 m WSW of building K-1420, 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 0.14 Ci of uranium was released from the Y-12 Plant during 1987 (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 was assumed to be from the center of the plant at a height of 20 m. Calculated dose equivalents to the maximally exposed resident, who is located 570 m NNW of the center of the Y-12 Plant, are given in Table 3.1.5. The dominant exposure pathway is inhalation. The 0.0021-mrem/year whole-body dose is well below the 25-mrem standard. The highest organ dose, 17 mrem/year to the lung, also is well below the NESHAP requirements (Table 3.1.7). The 50-year collective committed effective dose

equivalent to the ~863,000 persons residing within 80 km of the Y-12 Plant was calculated to be 30 person-rem (Table 3.1.6). For the entire ORR, the maximum individual doses depend on the dose of interest. Maximum whole-body and thyroid doses are attributable to releases from ORNL; maximum effective, lung, and endosteal bone doses are attributable to the Y-12 Plant. The total collective dose commitment due to operations at the ORR during 1987 is estimated to be 55 person-rem. This collective dose could produce a fatal cancer risk of ~0.007/year, 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 3.1.8 and the assumption that a person drinks 2 L of water per day (730 L/year). Two nuclides,  $^{90}\text{Sr}$  and  $^{137}\text{Cs}$ , are responsible for most of the doses. Tritium, when present, is also important. The resulting potential dose estimates are given in Table 3.1.8. Doses

estimated for consumption of water at Melton Hill Dam, 0.38 mrem effective and 2.4 mrem to bone, represent upstream (background) doses. No water is drunk at White Oak Dam, but doses were calculated to illustrate the absolute worst possible case, which occurs before dilution by the Clinch River. 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 0.53 mrem effective and 2.8 mrem to endosteal bone, the highest organ. The public water supply closest to the ORR is located about 26 km 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 0.5 mrem effective and 2.6 mrem to endosteal bone. This could result in a collective committed effective dose of about 3.7 person-rem to the estimated 7500 persons who could drink this water. The primary contributors to effective dose are  $^{90}\text{Sr}$ ,  $^{137}\text{Cs}$ , and  $^3\text{H}$ . 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 3.1.9. These doses were calculated using measured concentrations of radionuclides in fish

Table 3.1.8. Potential 50-year committed dose equivalents from drinking water in 1987<sup>a</sup>

Location	Dose equivalent (mrem)		
	Effective	Endosteal bone	Stomach wall
Melton Hill Dam	<0.38	2.4	0.05
White Oak Dam	33.9	124.3	24.8
Gallaher process water	<0.53	2.8	0.19
ORNL tap water	<0.39	2.5	0.05
Kingston water plant	<0.50	2.6	0.26

<sup>a</sup>Assumes ingestion of 730 L of water per year (2 L per day).

**Table 3.1.9. Potential 50-year committed dose equivalents from eating fish in 1987<sup>a</sup>**

Location	Dose equivalents (mrem)	
	Effective	Endosteal bone
CRK 8.0	0.14	0.56
CRK 33.3	0.30	0.60
CRK 40.0	0.03	0.22

<sup>a</sup>Assumes ingestion of 21 kg of fish per year.

harvested at the given locations (see Sect. 2.4.2). The highest doses, 0.3 mrem effective and 0.6 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 0.14-mrem effective dose to an individual from eating 21 kg of fish caught at Kingston could result in a population dose of about 1.0 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 <sup>137</sup>Cs and to the highest organ dose is <sup>90</sup>Sr. To put these doses from waterborne radionuclides further into perspective, the nearest population (Kingston) exposed to these radionuclides would

receive an annual population dose of about 4.8 person-rem from drinking water and eating fish. This represents about 0.2% of the annual dose from background radiation (2250 person-rem) estimated for this population.

### 3.1.2.3 Radionuclides in other environmental media

One of the important pathways for movement of radionuclides from environmental media to man is the atmosphere→pasture→cow→milk food chain. Strontium-90 and <sup>131</sup>I are radionuclides that are especially important in this terrestrial food chain. Table 3.1.10 gives doses to an individual from drinking 365 L of milk per year. Measured, annual-average concentrations of <sup>90</sup>Sr and <sup>131</sup>I in milk taken from sampling stations near the ORR and from stations located away from the ORR (see Sect. 2.4.1) were used to calculate the doses. Effective doses and doses to endosteal bone (from <sup>90</sup>Sr) and the thyroid (from <sup>131</sup>I) are given in Table 3.1.10. Doses at immediate and remote environs stations are similar; for example, effective doses of 0.26 and 0.29, respectively. Concentrations of <sup>90</sup>Sr and <sup>131</sup>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

**Table 3.1.10. Potential 50-year committed dose equivalents from drinking milk in 1987<sup>a</sup>**

Location <sup>b</sup>	Dose equivalents (mrem)		
	Effective	Endosteal bone	Thyroid
Immediate environs (stations 2, 3, 4, 6, 7, 8)	0.26	2.1	1.5
Remote environs (stations 51, 53, 56)	0.29	2.1	2.5

<sup>a</sup>Assumes ingestion of 365 L of milk per year using the average radionuclide concentrations at each location.

<sup>b</sup>See Fig. 2.4.1.

due to natural radioactivity in the ground. Table 3.1.11 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 55.6 mrem/year (Myrick et al. 1981). The dose values given in Table 3.1.11 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  $^{137}\text{Cs}$  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 3.1.12. 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 2.1 mrem from gaseous effluents, also drank milk from the sampled stations (0.26 mrem), ate fish from CRK 33 (0.3 mrem); drank Oak Ridge city water [which is the same as ORNL tap water (0.39 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 9 mrem/year, or about 3% of the annual dose from background radiation.

### 3.1.4 Five-Year Trends

Dose equivalents associated with selected exposure pathways for the years 1983 through

Table 3.1.11. Potential radiation dose equivalents from external exposures at locations on and off the ORR in 1987

Station <sup>a</sup>	Effective dose equivalent (mrem/year) <sup>b</sup>
<i>ORR stations</i>	
8	42.9
22	45.6
<i>ORNL perimeter stations</i>	
3	55.2
7	48.2
9	61.3
21	50.8
22	64.8
<i>Clinch River stations</i>	
41	72.7
42	96.4
47	72.7
60	51.7
61	87.6
64	157.7
65	183.9
66	210.2
67	105.1
68	87.6
69	45.6
<i>Remote stations<sup>c</sup></i>	
Average of 12 locations in Tennessee	55.6

<sup>a</sup>See Figs. 2.4.3 and 2.4.4.

<sup>b</sup>Assumes an exposure of 8760 h/year.

<sup>c</sup>Source: Myrick, T. E., B. A. Bervin, and F. F. Haywood, *State Background Radiation Levels*, ORNL/TM-7343 (1981).

1987 are given in Table 3.1.13. The variation in values over this 5-year period is probably not statistically significant. The slight increases in effective doses from consumption of milk and water during 1987 probably are not real because the calculations are based on "less than" values of radionuclide concentrations, and the "less than" values reported for 1987 are higher than the "less than" values reported for 1986. For the water data, a lower limit of reporting for the three Oak Ridge facilities was used; it is an order of magnitude higher than the detection limit reported. These doses should be considered "less than" values.

Table 3.1.12. Summary of estimated radiation dose equivalents to an adult during 1987 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	2.1	17 (lung)
	ORNL	0.4	0.6 (LLI wall)
	ORGDP	0.0001	0.001 (endosteal bone)
Terrestrial food chain (milk)	Average of sampling stations	<0.26	<2.0 (thyroid) 2.1 (endosteal bone)
Liquid effluents			
Drinking water	ORNL	<0.39	2.5 (endosteal bone)
	Kingston	<0.50	<2.6 (endosteal bone)
Eating fish	CRK 33 (ORNL discharge point)	0.30	0.60 (endosteal bone)
Direct radiation	Clinch River shoreline (33.3 to 30.0 CRK)	5.6 (250 h/year)	

Table 3.1.13. Five-year dose equivalent trends for selected pathways

Pathway	Dose equivalent (mrem)				
	1983	1984	1985	1986	1987
Inhalation:					
Effective	6.3	4.6	2.4	3.6 <sup>a</sup>	2.1
Lung	21	15	15	23 <sup>a</sup>	17
Milk consumption:					
Effective	0.01	0.01	0.01	0.14	<0.26
Thyroid	0.3	0.07	0.2	1.6	<2.0
Fish consumption:					
Effective	1.4	1.1	1.3	0.8	0.3
Endosteal bone	23.0	2.1	3.5	1.2	0.6
Drinking water (Kingston):					
Effective	0.13	0.2	0.12	0.11	<0.5
Stomach wall	3.0	0.5	1.5	0.25	0.26
Direct irradiation:					
Effective	6.8	5.9	5.0	8.8	5.6

<sup>a</sup>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.

### 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 (0.0021 mrem to whole body, 2.1 mrem effective, and 17 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 DOE facilities. For the entire ORR, maximum doses are 0.41 mrem to whole body, 2.1 mrem effective, and 17 mrem lung, well within the federal standards. The estimated collective committed effective dose to the approximately  $8.7 \times 10^5$  persons living within 80 km (50 miles) of the ORR is 55 person-rem for 1987 airborne emissions. This represents about 0.02% of the  $2.59 \times 10^5$  person-rem the surrounding population would receive from all sources of background radiation.

### 3.2 CHEMICAL DOSE

Health criteria for water were set such that chemical intake from consumption of 2 L of water per day would not exceed the acceptable daily intake (ADI). For noncarcinogenic toxic chemicals, the safe level of exposure is the intake of a toxicant (measured in micrograms per day) that is not anticipated to result in any adverse 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).

All acceptable daily intakes were taken from Hoffman et al. (1984), with the exception of arsenic (Munro and Travis 1986). The term ADI represents an allowable daily intake for both carcinogens and noncarcinogens. For example, in establishing water quality criteria for the priority pollutants, EPA used the following relationship:

$$C_w = ADI/I_w$$

where

$C_w$  = water quality criteria level ( $\mu\text{g/L}$ ),

$ADI$  = EPA-established value for an "acceptable daily intake" ( $\mu\text{g/d}$ ), and

$I_w$  = EPA-assumed value for the daily water consumption (2 L/d);

If the calculated daily intake (CDI)/ADI ratio is  $>1$ , then an unacceptable level of risk would result from daily exposure to ORR surface water. The review of water quality criteria documents appears in Sittig, 1980.

Tables 3.2.1–3.2.3 list the CDI of chemicals from surface water on and off the ORR. To obtain the information compiled in the tables, both the NPDES data at each outfall and the surface water data were reviewed. If one NPDES outfall discharged into another NPDES outfall, only the applicable data associated with the second outfall were reviewed for this study. One of the normal assumptions used for these types of calculations is the consumption of 2 L/d of raw water taken from a stream (which is not only unlikely but also virtually impossible because the outfalls are protected by fences). Therefore, the values given in Tables 3.2.1–3.2.3 are overestimates of the intake.

Table 3.2.1. Potential chemical dose comparison for ORR surface waters average values for sampling period indicated—Y-12 Plant

Chemical	Calculated daily intake (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
<i>Discharge point: 301</i>			
<i>Sampling period: 6 months</i>			
Arsenic (As)	<0.08	0.100	<0.80
Cadmium (Cd)	<0.006	0.0574	<0.10
Chromium (Cr)	<0.012	0.100	<0.12
Copper (Cu)	<0.004	2.0	<0.002
Lead (Pb)	<0.04	0.100	<0.40
Mercury (Hg)	<0.0004	0.0235	<0.02
Nickel (Ni)	<0.014	0.294	<0.05
Selenium (Se)	<0.004	0.023	<0.17
Zinc (Zn)	0.012	10.0	0.001
<i>Discharge point: 302</i>			
<i>Sampling period: 12 months</i>			
Arsenic (As)	0.52	0.100	5.20
Cadmium (Cd)	<0.006	0.0574	<0.10
Chromium (Cr)	<0.012	0.100	<0.12
Copper (Cu)	<0.004	2.0	<0.002
Lead (Pb)	<0.04	0.100	<0.40
Mercury (Hg)	<0.0006	0.0235	<0.03
Nickel (Ni)	<0.014	0.294	<0.05
Selenium (Se)	<0.050	0.023	<2.17
Zinc (Zn)	<0.006	10.0	<0.001
<i>Discharge point: 303</i>			
<i>Sampling period: 12 months</i>			
Beryllium (Be)	<0.0002	0.0002	<1.00
Cadmium (Cd)	<0.006	0.0574	<0.10
Chromium (Cr)	<0.012	0.100	<0.12
Copper (Cu)	0.156	2.0	0.08
Lead (Pb)	<0.04	0.100	<0.40
Mercury (Hg)	<0.0056	0.0235	<0.24
Nickel (Ni)	<0.018	0.294	<0.06
Tetrachloroethylene (PCE)	<0.02	0.0081	<2.47
Zinc (Zn)	0.106	10.0	0.01
<i>Discharge point: 305</i>			
<i>Sampling period: 12 months</i>			
Beryllium (Be)	<0.0002	0.0002	<1.00
Cadmium (Cd)	<0.006	0.0574	<0.10
Lead (Pb)	<0.04	0.100	<0.40
Mercury (Hg)	<0.0004	0.0235	<0.02
Silver (Ag)	0.008	0.016	0.50
<i>Discharge point: 306</i>			
<i>Sampling period: 8 months</i>			
Cadmium (Cd)	<0.006	0.0574	<0.10
Lead (Pb)	<0.04	0.100	<0.40
Mercury (Hg)	<0.0004	0.0235	<0.02
Nickel (Ni)	<0.014	0.294	<0.05
Silver (Ag)	<0.008	0.016	<0.50

Table 3.2.1. (continued)

Chemical	Calculated daily intake (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
<i>Discharge point: 504</i>			
<i>Sampling period: 6 months</i>			
Beryllium (Be)	<0.0002	0.0002	<1.00
Cadmium (Cd)	<0.006	0.0574	<0.10
Chromium (Cr)	<0.012	0.100	<0.12
Copper (Cu)	<0.008	2.0	<0.004
Cyanide (HCN)	<0.018	0.410	<0.04
Lead (Pb)	<0.04	0.100	<0.40
Mercury (Hg)	<0.001	0.0235	<0.04
Nickel (Ni)	0.348	0.294	1.18
Silver (Ag)	<0.008	0.016	<0.50
Zinc (Zn)	0.174	10.0	0.02
<i>Discharge point: 501/504</i>			
<i>Sampling period: 6 months</i>			
Beryllium (Be)	<0.0002	0.0002	<1.00
Cadmium (Cd)	<0.008	0.0574	<0.14
Chromium (Cr)	<0.012	0.100	<0.12
Copper (Cu)	<0.010	2.0	<0.01
Cyanide (HCN)	<0.008	0.410	<0.02
Lead (Pb)	<0.04	0.100	<0.40
Mercury (Hg)	<0.0004	0.0235	<0.02
Nickel (Ni)	0.396	0.294	1.35
Silver (Ag)	<0.012	0.016	<0.75
Zinc (Zn)	0.174	10.0	0.02
<i>Discharge point: 501</i>			
<i>Sampling period: 1 year</i>			
Beryllium (Be)	<0.0002	0.0002	<1.00
Cadmium (Cd)	<0.006	0.0574	<0.10
Chromium (Cr)	<0.012	0.100	<0.12
Copper (Cu)	0.014	2.0	0.01
Cyanide (HCN)	<0.006	0.410	<0.01
Lead (Pb)	<0.04	0.100	<0.40
Mercury (Hg)	<0.0004	0.0235	<0.02
Nickel (Ni)	0.274	0.294	0.93
Silver (Ag)	<0.008	0.016	<0.50
Zinc (Zn)	0.236	10.0	0.02
<i>Discharge point: 502</i>			
<i>Sampling period: 1-month</i>			
Arsenic (As)	<0.08	0.100	<0.80
Beryllium (Be)	<0.0002	0.0002	<1.00
Cadmium (Cd)	<0.006	0.0574	<0.10
Chromium (Cr)	<0.014	0.100	<0.14
Copper (Cu)	0.250	2.0	0.13
Cyanide (HCN)	0.34	0.410	0.83
Lead (Pb)	<0.04	0.100	<0.40
Mercury (Hg)	<0.0008	0.0235	<0.03
Nickel (Ni)	2.84	0.294	9.66
Silver (Ag)	<0.008	0.016	<0.50
Zinc (Zn)	0.222	10.0	0.02

Table 3.2.1. (continued)

Chemical	Calculated daily intake (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
<i>Discharge point: 602</i>			
<i>Sampling period: 1 year</i>			
Chromium (Cr)	<0.030	0.100	<0.30
Copper (Cu)	0.080	2.0	0.04
Zinc (Zn)	0.276	10.0	0.03
<i>Discharge point: 604</i>			
<i>Sampling period: 1 year</i>			
Chromium (Cr)	0.028	0.100	0.28
Copper (Cu)	0.040	2.0	0.02
Zinc (Zn)	1.104	10.0	0.11
<i>Discharge point: 606</i>			
<i>Sampling period: 1 year</i>			
Chromium (Cr)	<0.026	0.100	<0.26
Copper (Cu)	0.168	2.0	0.08
Zinc (Zn)	0.412	10.0	0.04
<i>Discharge point: 610</i>			
<i>Sampling period: 1 year</i>			
Chromium (Cr)	0.02	0.100	0.20
Copper (Cu)	0.048	2.0	0.02
Zinc (Zn)	0.392	10.0	0.04
<i>Discharge point: 612</i>			
<i>Sampling period: 1 year</i>			
Chromium (Cr)	<0.012	0.100	<0.12
Copper (Cu)	0.042	2.0	0.02
Zinc (Zn)	0.322	10.0	0.03
<i>Discharge point: 613</i>			
<i>Sampling period: 1 year</i>			
Chromium (Cr)	0.016	0.100	0.16
Copper (Cu)	0.058	2.0	0.03
Zinc (Zn)	0.294	10.0	0.03
<i>Discharge point: 616</i>			
<i>Sampling period: 1 year</i>			
Chromium (Cr)	0.068	0.100	0.68
Copper (Cu)	0.102	2.0	0.05
Zinc (Zn)	0.124	10.0	0.01
<i>Discharge point: 617</i>			
<i>Sampling period: 1 year</i>			
Chromium (Cr)	0.022	0.100	0.22
Copper (Cu)	0.104	2.0	0.05
Zinc (Zn)	0.264	10.0	0.03

Table 3.2.1. (continued)

Chemical	Calculated daily intake (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
<i>Discharge point: 618</i>			
<i>Sampling period: 1 year</i>			
Chromium (Cr)	0.015	0.100	0.15
Copper (Cu)	0.072	2.0	0.04
Zinc (Zn)	1.00	10.0	0.10
<i>Discharge point: 619</i>			
<i>Sampling period: 1 year</i>			
Chromium (Cr)	0.030	0.100	0.30
Copper (Cu)	0.046	2.0	0.02
Zinc (Zn)	0.220	10.0	0.02
<i>Discharge point: 622</i>			
<i>Sampling period: 1 year</i>			
Chromium (Cr)	<0.014	0.100	<0.14
Copper (Cu)	0.12	2.0	0.06
Zinc (Zn)	0.376	10.0	0.04
<i>Discharge point: 624</i>			
<i>Sampling period: 1 year</i>			
Chromium (Cr)	<0.018	0.100	<0.18
Copper (Cu)	0.134	2.0	0.07
Zinc (Zn)	0.320	10.0	0.03
<i>Discharge point: 626</i>			
<i>Sampling period: 1 year</i>			
Chromium (Cr)	0.108	0.100	1.08
Copper (Cu)	0.144	2.0	0.07
Zinc (Zn)	0.320	10.0	0.03
<i>Discharge point: 628</i>			
<i>Sampling period: 1 year</i>			
Chromium (Cr)	0.026	0.100	0.26
Copper (Cu)	0.050	2.0	0.03
Zinc (Zn)	0.116	10.0	0.01

Table 3.2.1. (continued)

Chemical	Calculated daily intake (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
<i>Discharge point: 630</i>			
<i>Sampling period: 1 year</i>			
Chromium (Cr)	0.046	0.100	0.46
Copper (Cu)	0.032	2.0	0.02
Zinc (Zn)	0.244	10.0	0.02
<i>Discharge point: 632</i>			
<i>Sampling period: 1 year</i>			
Chromium (Cr)	0.016	0.100	0.16
Copper (Cu)	0.092	2.0	0.05
Zinc (Zn)	0.288	10.0	0.03
<i>Discharge point: 634</i>			
<i>Sampling period: 1 year</i>			
Chromium (Cr)	0.036	0.100	0.36
Copper (Cu)	0.096	2.0	0.05
Zinc (Zn)	0.116	10.0	0.01

Table 3.2.2. Potential chemical dose comparison for ORR surface waters  
average values for sampling period indicated—ORNL

Chemical	Calculated daily intake (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
<i>Discharge point: 3086</i>			
<i>Sampling period: 1 month</i>			
Chromium (Cr)	0.062	0.100	0.62
Copper (Cu)	<0.024	2.0	<0.01
Zinc (Zn)	0.30	10.0	0.03
<i>Discharge point: 3103</i>			
<i>Sampling period: 1 month</i>			
Chromium (Cr)	0.136	0.100	1.36
Copper (Cu)	0.036	2.0	0.02
Zinc (Zn)	15.4	10.0	1.54
<i>Discharge point: 4509</i>			
<i>Sampling period: 4 months</i>			
Chromium (Cr)	<0.048	0.100	<0.48
Copper (Cu)	0.106	2.0	0.05
Zinc (Zn)	0.28	10.0	0.03
<i>Discharge point: 7902</i>			
<i>Sampling period: 2 months</i>			
Chromium (Cr)	<0.048	0.100	<0.48
Copper (Cu)	0.024	2.0	0.01
Zinc (Zn)	1.02	10.0	0.10
<i>Discharge point: CAT3</i>			
<i>Sampling period: 5 months</i>			
Mercury (Hg)	<0.0026	0.0235	<0.11
<i>Discharge point: X01</i>			
<i>Sampling period: 12 months</i>			
Cyanide (HCN)	<0.009	0.410	<0.02
Copper (Cu)	<0.024	2.0	<0.01
Mercury (Hg)	<0.0004	0.0235	<0.02
Silver (Ag)	<0.06	0.016	<3.75
Trichloroethylene (TCE)	<0.01	0.057	<0.18
Zinc (Zn)	0.13	10.0	0.01
<i>Discharge point: X02</i>			
<i>Sampling period: 12 months</i>			
Arsenic (As)	<0.12	0.100	<1.20
Cadmium (Cd)	<0.0058	0.0574	<0.10
Chromium (Cr)	<0.048	0.100	<0.48
Copper (Cu)	<0.024	2.0	<0.01
Lead (Pb)	<0.22	0.294	<0.75
Nickel (Ni)	<0.07	0.100	<0.70
Selenium (Se)	<0.24	0.023	<10.43
Silver (Ag)	<0.058	0.016	<3.63
Zinc (Zn)	<0.048	10.0	<0.005

Table 3.2.2. (continued)

Chemical	Calculated daily intake (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
<i>Discharge point: X03</i>			
<i>Sampling period: 12 months</i>			
Arsenic (As)	<0.114	0.100	<1.14
Cadmium (Cd)	<0.006	0.0574	<0.10
Chromium (Cr)	<0.046	0.100	<0.46
Copper (Cu)	0.056	2.0	0.03
Lead (Pb)	<0.22	0.100	<2.20
Nickel (Ni)	<0.068	0.294	<0.23
Zinc (Zn)	0.30	10.0	0.03
<i>Discharge point: X04</i>			
<i>Sampling period: 12 months</i>			
Arsenic (As)	<0.114	0.100	<1.14
Cadmium (Cd)	<0.0056	0.0574	<0.10
Chromium (Cr)	<0.046	0.100	<0.46
Copper (Cu)	<0.028	2.0	<0.01
Lead (Pb)	<0.22	0.100	<2.20
Nickel (Ni)	<0.076	0.294	<0.26
Silver (Ag)	<0.058	0.016	<3.63
Zinc (Zn)	0.20	10.0	0.02
<i>Discharge point: X06</i>			
<i>Sampling period: 12 months</i>			
Arsenic (As)	<0.114	0.100	<1.14
Cadmium (Cd)	<0.0056	0.0574	<0.10
Chromium (Cr)	<0.054	0.100	<0.54
Copper (Cu)	0.144	2.0	0.07
Lead (Pb)	<0.22	0.100	<2.20
Nickel (Ni)	<0.068	0.294	<0.23
Selenium (Se)	<0.22	0.023	<9.57
Zinc (Zn)	0.166	10.0	0.02
<i>Discharge point: X07</i>			
<i>Sampling period: 12 months</i>			
Arsenic (As)	<0.114	0.100	<1.14
Cadmium (Cd)	<0.0056	0.0574	<0.10
Chromium (Cr)	<0.082	0.100	<0.82
Copper (Cu)	<0.058	2.0	<0.03
Lead (Pb)	<0.22	0.100	<2.20
Nickel (Ni)	<0.100	0.294	<0.34
Silver (Ag)	<0.056	0.016	<3.50
Zinc (Zn)	<0.022	10.0	<0.002
<i>Discharge point: X08</i>			
<i>Sampling period: 5 months</i>			
Arsenic (As)	<0.12	0.100	<1.20
Cadmium (Cd)	<0.006	0.0574	<0.1
Chromium (Cr)	<0.048	0.100	<0.48
Copper (Cu)	<0.026	2.0	<0.01
Lead (Pb)	<0.24	0.100	<2.40
Nickel (Ni)	<0.084	0.294	<0.29
Zinc (Zn)	<0.124	10.0	<0.01

Table 3.2.2. (continued)

Chemical	Calculated daily intake (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
<i>Discharge point: X09</i>			
<i>Sampling period: 4 months</i>			
Arsenic (As)	<0.12	0.100	<1.20
Cadmium (Cd)	<0.0088	0.0574	<0.15
Chromium (Cr)	<0.058	0.100	<0.58
Copper (Cu)	0.172	2.0	0.09
Lead (Pb)	<0.24	0.100	<2.40
Nickel (Ni)	<0.072	0.294	<0.24
Zinc (Zn)	0.30	10.0	0.03
<i>Discharge point: X10</i>			
<i>Sampling period: 2 months</i>			
Arsenic (As)	<0.12	0.100	<1.20
Cadmium (Cd)	0.015	0.0574	0.26
Chromium (Cr)	0.184	0.100	1.84
Copper (Cu)	0.32	2.0	0.16
Lead (Pb)	0.68	0.100	6.80
Nickel (Ni)	0.072	0.294	0.24
Zinc (Zn)	1.22	10.0	0.12
<i>Discharge point: X11</i>			
<i>Sampling period: 12 months</i>			
Arsenic (As)	<0.118	0.100	<1.18
Cadmium (Cd)	<0.092	0.0584	<1.58
Chromium (Cr)	<0.062	0.100	<0.62
Copper (Cu)	<0.24	2.0	<0.12
Lead (Pb)	<0.22	0.100	<2.20
Nickel (Ni)	<0.072	0.294	<0.24
Zinc (Zn)	1.64	10.0	0.16
<i>Discharge point: X13</i>			
<i>Sampling period: 12 months</i>			
Arsenic (As)	<0.12	0.100	<1.20
Cadmium (Cd)	<0.004	0.0574	<0.07
Chromium (Cr)	<0.048	0.100	<0.48
Copper (Cu)	<0.024	2.0	<0.01
Lead (Pb)	<0.008	0.100	<0.08
Mercury (Hg)	<0.0001	0.0235	<0.004
Nickel (Ni)	<0.072	0.294	<0.24
Silver (Ag)	<0.01	0.016	<0.63
Trichloroethylene (TCE)	<0.01	0.057	<0.18
Zinc (Zn)	<0.06	10.0	<0.01
<i>Discharge point: X14</i>			
<i>Sampling period: 12 months</i>			
Arsenic (As)	<0.12	0.100	<1.20
Cadmium (Cd)	<0.004	0.0574	<0.07
Chromium (Cr)	<0.124	0.100	<1.24
Copper (Cu)	<0.024	2.0	<0.01
Lead (Pb)	<0.0094	0.100	<0.09
Mercury (Hg)	<0.0002	0.0235	<0.01
Nickel (Ni)	<0.094	0.294	<0.32
Silver (Ag)	<0.01	0.016	<0.63
Trichloroethylene (TCE)	<0.01	0.057	<0.18
Zinc (Zn)	0.07	10.0	0.007

Table 3.2.2. (continued)

Chemical	Calculated daily intake (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
<i>Discharge point: X15</i>			
<i>Sampling period: 12 months</i>			
Arsenic (As)	<0.12	0.100	<1.20
Cadmium (Cd)	<0.0046	0.0574	<0.08
Chromium (Cr)	<0.068	0.100	<0.68
Copper (Cu)	<0.03	2.0	<0.02
Lead (Pb)	<0.013	0.100	<0.13
Mercury (Hg)	<0.0002	0.0235	<0.01
Nickel (Ni)	<0.072	0.294	<0.24
Silver (Ag)	<0.0094	0.016	<0.59
Trichloroethylene (TCE)	<0.01	0.057	<0.18
Zinc (Zn)	<0.084	10.0	<0.01

Table 3.2.3. Potential chemical dose comparison for ORR surface waters  
average values for sampling period indicated—ORGDP

Chemical	Calculated daily intake (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
<i>Discharge point: K-1710</i>			
<i>Sampling period: 12 months</i>			
Arsenic (As)	<0.01	0.100	<0.10
Cadmium (Cd)	<0.004	0.0574	<0.07
Chromium (Cr)	0.026	0.100	0.26
Copper (Cu)	0.016	2.0	0.01
Cyanide (HCN)	0.012	0.410	0.03
Lead (Pb)	0.008	0.100	0.08
Mercury (Hg)	0.0004	0.0235	0.02
Nickel (Ni)	<0.10	0.294	<0.34
Zinc (Zn)	0.06	10.0	0.01
<i>Discharge point: K-716</i>			
<i>Sampling period: 12 months</i>			
Arsenic (As)	<0.01	0.100	<0.10
Cadmium (Cd)	<0.004	0.0574	<0.07
Chromium (Cr)	<0.02	0.100	<0.20
Copper (Cu)	0.018	2.0	0.01
Cyanide (HCN)	0.010	0.410	0.02
Lead (Pb)	0.008	0.100	0.08
Mercury (Hg)	<0.0004	0.0235	<0.02
Nickel (Ni)	<0.10	0.294	<0.34
Zinc (Zn)	0.046	10.0	0.005
<i>Discharge point: K-1513</i>			
<i>Sampling period: 12 months</i>			
Arsenic (As)	0.01	0.100	0.10
Cadmium (Cd)	<0.004	0.0574	<0.07
Chromium (Cr)	<0.02	0.100	<0.20
Copper (Cu)	0.26	2.0	0.13
Cyanide (HCN)	0.006	0.410	0.01
Lead (Pb)	0.008	0.100	0.08
Mercury (Hg)	0.0004	0.0235	0.02
Nickel (Ni)	<0.10	0.294	<0.34
Zinc (Zn)	0.06	10.0	0.01
<i>Discharge point: K-901 at 892</i>			
<i>Sampling period: 12 months</i>			
Arsenic (As)	<0.010	0.100	<0.10
Cadmium (Cd)	0.004	0.0574	0.07
Chromium (Cr)	<0.02	0.100	<0.20
Copper (Cu)	0.013	2.0	0.01
Cyanide (HCN)	0.006	0.410	0.01
Lead (Pb)	0.008	0.100	0.08
Mercury (Hg)	0.0004	0.0235	0.02
Nickel (Ni)	<0.10	0.294	<0.34
Zinc (Zn)	0.066	10.0	0.01

Table 3.2.3. (continued)

Chemical	Calculated daily intake (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
<i>Discharge point: Clinch River</i>			
<i>Sampling period: 12 months</i>			
Arsenic (As)	<0.01	0.100	<0.10
Cadmium (Cd)	0.004	0.0574	0.07
Chromium (Cr)	<0.02	0.100	<0.20
Copper (Cu)	<0.008	2.0	<0.004
Cyanide (HCN)	0.004	0.410	0.01
Lead (Pb)	0.014	0.100	0.14
Mercury (Hg)	<0.0002	0.0235	<0.01
Nickel (Ni)	<0.10	0.294	<0.34
Zinc (Zn)	0.04	10.0	0.004
<i>Discharge point: West Fork Poplar Creek</i>			
<i>Sampling period: 12 months</i>			
Arsenic (As)	<0.010	0.100	<0.10
Cadmium (Cd)	<0.004	0.0574	<0.07
Chromium (Cr)	<0.02	0.100	<0.20
Copper (Cu)	<0.008	2.0	<0.004
Cyanide (HCN)	0.006	0.410	0.01
Lead (Pb)	0.010	0.100	0.10
Mercury (Hg)	<0.0004	0.0235	<0.02
Nickel (Ni)	<0.10	0.294	<0.34
Zinc (Zn)	0.046	10.0	0.005
<i>Discharge point: K-1407-B</i>			
<i>Sampling period: 12 months</i>			
Antimony (Sb)	0.104	0.294	0.35
Arsenic (As)	0.011	0.100	0.11
Beryllium (Be)	<0.002	0.0002	<10.0
Cadmium (Cd)	0.012	0.0574	0.21
Chromium (Cr)	<0.02	0.100	<0.20
Copper (Cu)	<0.013	2.0	<0.01
Cyanide (HCN)	0.024	0.410	0.06
Lead (Pb)	0.022	0.100	0.22
Mercury (Hg)	<0.00042	0.0235	<0.02
Methyl Chloroform	0.011	37.5	0.0003
Methylene Chloride (DCM)	0.01	0.004	2.50
Nickel (Ni)	0.28	0.294	0.95
Selenium (Se)	<0.01	0.023	<0.43
Silver (Ag)	<0.02	0.016	<1.25
Tetrachloroethylene (PCE)	0.01	0.0081	1.23
Trichloroethylene (TCE)	0.04	0.057	0.70
Zinc (Zn)	<0.09	10.0	<0.01

Table 3.2.3. (continued)

Chemical	Calculated daily intake (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
<i>Discharge point: K-1700</i>			
<i>Sampling period: 12 months</i>			
Beryllium (Be)	<0.002	0.0002	<10.0
Cadmium (Cd)	<0.0044	0.0574	<0.08
Chromium (Cr)	0.022	0.100	0.22
Lead (Pb)	<0.018	0.100	<0.18
Mercury (Hg)	0.0006	0.0235	0.03
Methyl Chloroform	<0.01	37.5	<0.0003
Methylene Chloride (DCM)	<0.01	0.004	<2.50
Selenium (Se)	<0.01	0.023	<0.43
Silver (Ag)	<0.02	0.016	<1.25
Tetrachloroethylene (PCE)	<0.01	0.0081	<1.23
Trichloroethylene (TCE)	0.12	0.057	2.11
Zinc (Zn)	0.07	10.0	0.01
<i>Discharge point: K-901-A</i>			
<i>Sampling period: 12 months</i>			
Chromium (Cr)	0.05	0.100	0.50
<i>Discharge point: K-1203</i>			
<i>Sampling period: 12 months</i>			
Beryllium (Be)	<0.002	0.0002	<10.0
Cadmium (Cd)	<0.004	0.0574	<0.07
Copper (Cu)	0.014	2.0	0.01
Lead (Pb)	0.016	0.100	0.16
Mercury (Hg)	0.0006	0.0235	0.03
Methyl Chloroform	<0.01	37.5	<0.0003
Methylene Chloride (DCM)	<0.01	0.004	<2.50
Nickel (Ni)	<0.10	0.294	<0.34
Selenium (Se)	<0.018	0.023	<0.78
Silver (Ag)	<0.022	0.016	<1.38
Tetrachloroethylene (PCE)	<0.01	0.0081	<1.23
Trichloroethylene (TCE)	<0.01	0.057	<0.18
Zinc (Zn)	0.136	10.0	0.01
<i>Discharge point: K-1007-B</i>			
<i>Sampling period: 12 months</i>			
Chromium (Cr)	0.02	0.100	0.20



## 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.

#### 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 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. The act required cleanup of releases of hazardous substances from new and abandoned facilities. During 1985, DOE issued DOE Order 5480.14 to define how CERCLA requirements should be implemented at DOE facilities.

#### **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 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. 4.2.1. 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 DOE CERCLA projects.

##### **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

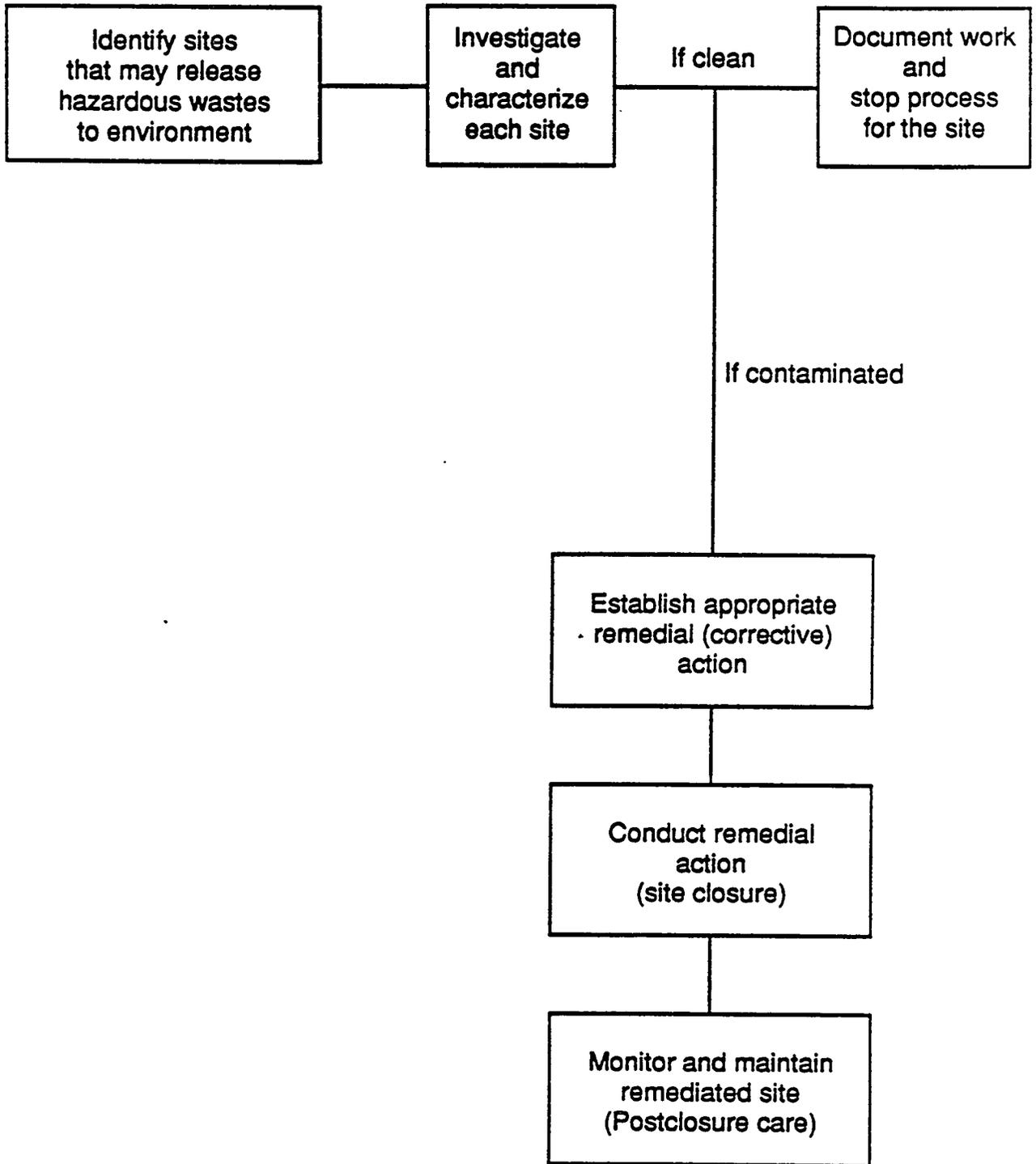


Fig. 4.2.1. Y-12 remedial action process flowchart.

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

Project	Number
<b>Environmental restoration budget category (ERBC)</b>	
<b>RCRA closures</b>	
Incinerator	1
Drum storage areas	4
Treatment facilities	1
Storage tanks	1
Landfills	3
Surface impoundments	4
Land treatment	1
Subtotal: RCRA closures	15
<b>3004(u) and (v) corrective actions</b>	
Drum storage area	5
Storage tanks	22
Landfills	4
Surface impoundments	2
Treatment facilities	1
Creek and floodplain studies	3
Scrap metal and material facilities	5
Subtotal: RFI investigations	42
<b>DOE CERCLA projects</b>	
Material usage areas	4
Drum storage area	1
Subtotal: CERCLA sites	5
Total: ERBC projects	62
<b>Line item project</b>	
Disposal area remedial action project	

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 three 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. Evaluation of the data and information from the RFI to determine the need for and extent of remedial action at each facility. This phase includes the selection and implementation of appropriate remedial action for each facility.

The first phase, RFA, has already been performed for the Y-12 Plant. Initially, 165 sites were included in the assessment phase. Approximately 75% of the sites were determined to be uncontaminated and did not warrant further investigation in the program. The remaining 42 sites, as shown in Table 4.2.1, are to be carried into the RFI phase for additional investigation and evaluation. Examples of facilities and sites to be investigated in this group are the S-2 pond site, sanitary landfills I and II, United Nuclear landfill, upper East Fork Poplar Creek, East 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 DOE CERCLA projects. Investigation of each facility under DOE CERCLA consists of five phases:

- Phase I—Installation Assessment. Evaluate site history and records and locate and identify those inactive hazardous waste disposal sites that may pose a risk to health, safety, and the environment as a result of migration of hazardous substances.
- Phase II—Confirmation. Quantify, by preliminary and comprehensive environmental survey, the presence or absence of hazardous substances that may pose a risk to health, safety, and the environment.

- Phase III—Engineering Assessment. Develop, evaluate, and recommend a plan for controlling the migration of hazardous substances identified in phase II or for effecting remedial actions at the installation.
- Phase IV—Remedial Actions. Implement the recommended site-specific remedial measures identified in phase III. This includes the engineering, design, and actual construction of barriers to restrain migration of identified hazardous substances and/or decontamination operations.
- Phase V—Compliance and Verification. Review monitoring data, perform any monitoring required to determine that remedial action and decontamination have been effective, establish any continuing monitoring requirements, and prepare remedial action documentation.

The DOE CERCLA program contains five sites for investigation: mercury-contaminated areas at the Y-12 Plant, Z-oil-contaminated areas at the Y-12 Plant, 9720-2 drum storage area, beryllium-contaminated area in Building 9766, and the old steam plant. The current status of the DOE 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 grounds (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 described above. 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.

#### 4.2.2 Oak Ridge National Laboratory

In keeping with the DOE policy of controlling the potential hazards associated with operation of the ORNL facilities, site remedial actions will be conducted, where appropriate, to meet these requirements and to ensure adequate protection of on-site workers, the public, and the environment.

Implementation of the RAP at ORNL began with identification of sites requiring corrective actions and will end with final certification of site closure or decommissioning activities. As outlined in Fig. 4.2.2, between these two milestones is a structured path of program planning, site characterizations, alternatives assessments, technology demonstrations, continued maintenance, and necessary interim corrective actions. Some of these activities will be accomplished over relatively short time frames (15 years), while others may extend for many

years. The path that will be chosen for each site is dependent on a number of variables, including site characteristics, regulatory requirements, and resource availability.

Depending on the priority established for a given project after detailed assessment, one of two basic actions will be implemented: (1) remedial actions will be deferred and the facility will be placed into a monitored protective storage mode or (2) site closure or final decommissioning will be carried out to place each facility into a permanently stabilized condition requiring only periodic monitoring to verify site performance. The final long-term closure process will involve comprehensive planning to determine the overall strategy for remedial actions in the White Oak Creek watershed and surrounding areas. As part of each of these actions, a variety of planning documents, characterization activities, technology evaluations, and design studies must be completed to make decisions concerning site disposition. Regulatory interfaces and approvals will be required at several steps within the process. Ultimately, all remedial action sites included in the ORNL inventory will pass through the decommissioning or closure phase to ensure long-term containment and disposal of residual radioactive or hazardous materials. The scheduling of decommissioning or closure, however, will depend on project priorities established through regulatory interaction and approved funding levels.

The ORNL RAP currently includes 164 identified sites in 13 basic categories (Table 4.2.2). These sites range in complexity from abandoned waste storage ponds and tanks to large experimental reactors and waste disposal sites. 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 underground storage tanks, and to large areas of buried solid wastes and environmental contamination. While the scope of hazardous chemical contamination at ORNL appears to be quite limited, a significant number of the sites in the current RAP inventory may be at least partially contaminated with transuranic (TRU) wastes and higher-activity low-level waste

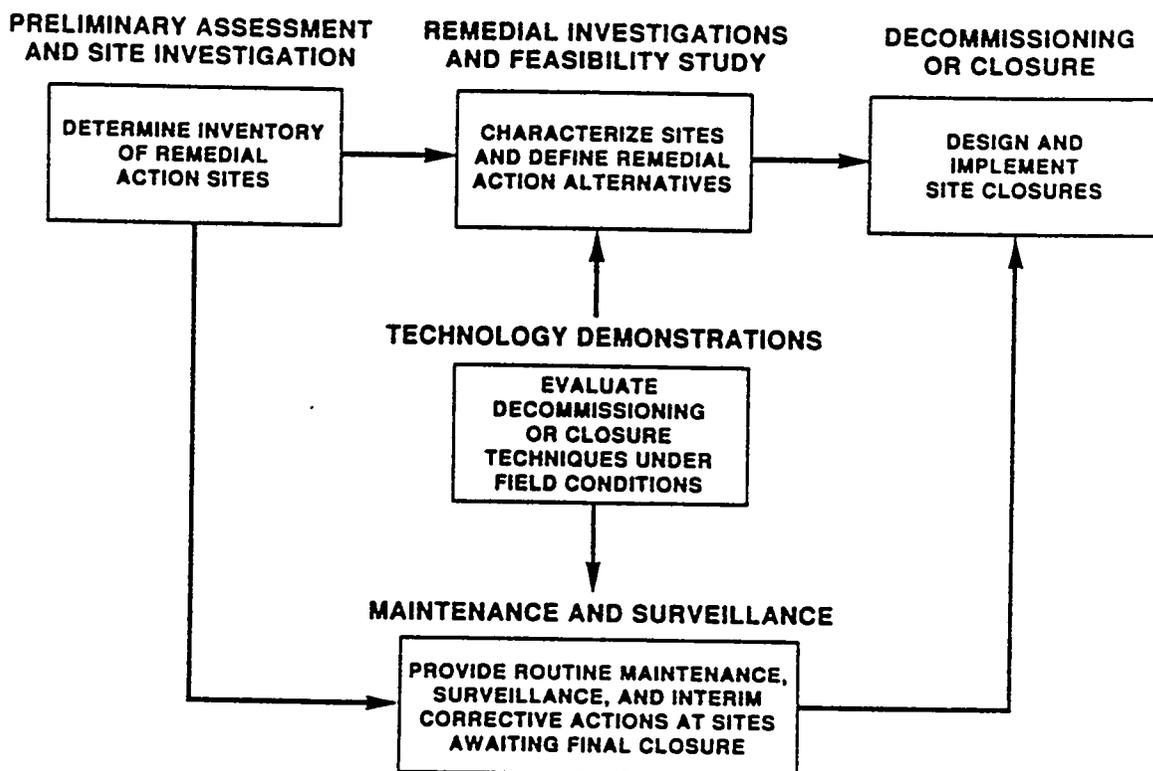


Fig. 4.2.2. ORNL Remedial Action Program implementation flowchart.

Table 4.2.2. ORNL remedial action site summary

Category	Number
1. Solid waste storage areas (SWSAs)	8
2. LLW seepage pits and trenches	8
3. Process ponds	14
4. White Oak Creek watershed	2
5. LLW lines and leak sites	35
6. Environmental research areas	37
7. Hazardous waste sites	5
8. Radioisotope processing facilities	12
9. Experimental reactor facilities	7
10. Radioactive waste facilities	17
11. Research laboratories	7
12. Inactive hydrofracture injection sites	4
13. Other contaminated sites	8
Total	164

(LLW). Most of these fall into only five of the Table 4.2.2 categories: (1) solid waste storage areas (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 (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 (i.e., 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 before ORNL began waste injections into deep geologic formations by hydrofracturing.

Together, these sites contain approximately 70% of the LLW and >99% of the TRU waste inventories, respectively, spilled or disposed of in the external environment at ORNL. (The majority of the remaining LLW is in the old hydrofracture facility grout sheets.)

Because of the large number of RAP sites and the hydrogeologic complexity at ORNL, the strategy developed in response to new 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; 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 the 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 4.2.3 summarizes the corrective 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

Table 4.2.3. ORGDP solid waste management units

	Regulation			Number
	RCRA	3004(u)	CERCLA	
Burial grounds		5		5
Storage facilities	11	9		20
Treatment facilities	4	5		9
Process lines		4	6	10
Underground tanks	2	4	13	19
Surface impoundments	2	3		5
Accumulation areas		18		18
Other		6	2	8
Total	19	54	21	94

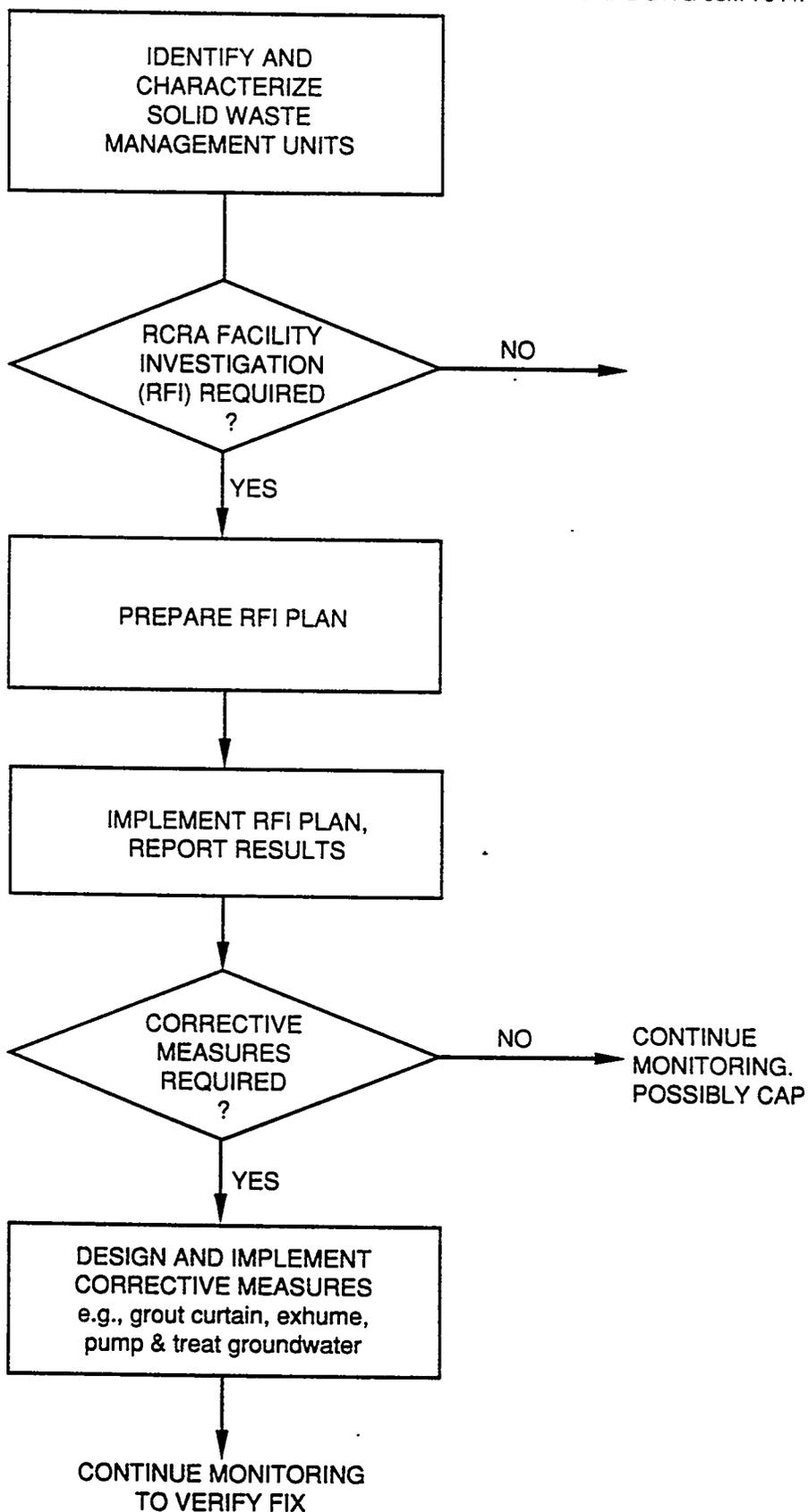


Fig. 4.2.3. ORGDP remedial action flowchart.

**Table 4.2.4. ORGDP RCRA facility investigation (RFI) plan sites**


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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-1414 gasoline tanks
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-1007 gasoline tank
K-1099 Blair Road quarry
K-1095 waste paint accumulation area
K-1407-C holding pond
K-1031 waste paint accumulation area

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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 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 and 1987, considerable progress was made in closure of several hazardous waste treatment, storage, and disposal facilities. Specifically, the following closures have been completed in accordance with TDHE-approved closure plans:

- Partial closure of the oil/solvent drum storage area of the Y-12 Plant Salvage Yard,
- Closure of the hazardous waste storage area in the Old Steam Plant (Building 9401-1),
- Closure of the Prencro Incinerator Facility, and
- Closure of the ACN Drum Yard.

The closures were accepted by the TDHE. In addition, the final closure of the Waste Machine Coolant Biodegradation Facility was initiated during 1987 and is expected to be completed during 1988.

The closure and postclosure activities for the RCRA closure of the following major facilities are currently in the design stage:

- Bear Creek Burial Grounds,
- Chestnut Ridge Security Pits,
- Chestnut Ridge Sediment Disposal Basin,
- Kerr Hollow Quarry,
- New Hope Pond,
- Oil Landfarm,
- Oil Retention Ponds, and
- S-3 Pond site.

Closure for most of these facilities will be initiated during 1988. It is projected that closure of these facilities will be completed by 1992. An overview of the schedule for the RCRA closures is shown in Fig. 4.3.1.

##### 4.3.1.2 3004(u) and (v) corrective actions

As previously stated, the first phase, RFA, of the 3004(u) and (v) corrective actions was performed during 1987. The assessment examined 165 SWMUs at the Y-12 Plant to identify releases or potential releases of hazardous wastes to the environment. The assessment determined that 123 sites were uncontaminated and needed no further investigation. The remaining 42 sites will be addressed in the second phase, RFI, for additional investigation. During 1987, detailed RFI plans were prepared for 9 of the 42 sites. The completed plans were submitted to EPA and TDHE for review and approval. Approval of the proposed plans by the regulatory agencies is needed before the actual field sampling and investigation can be implemented as described in the plans. The information and data obtained from the RFI field work will be used to determine whether or not the sites are contaminated and, if so, the extent of contamination, so that appropriate remedial actions can be selected and implemented.

During 1988, additional RFI plans will be prepared to address nine additional sites. Twenty-four RFI plans to address the remaining sites will be prepared during 1989 and 1990. Implementation of the RFI plans will be dependent on receiving approval of the plans from the regulatory agencies. An overview of the schedule for the 3004(u) and (v) corrective actions is shown in Fig. 4.3.1.

##### 4.3.1.3 DOE CERCLA projects

Fourteen sites were initially addressed in phase I, installation assessment, of the DOE CERCLA program during 1986. During 1987, nine of the sites were transferred to the 3004(u) and (v) corrective actions program. Draft investigation plans for the remaining five sites to be addressed during phase II, confirmation, have been prepared. The purpose of the work in the proposed plans will be to confirm and quantify by site the presence or absence of hazardous substances that may pose a risk to health, safety, and the environment. The draft plans should be finalized during 1988. The survey work in the

**Time (Calendar year)**

**Program Activity** 1987 ■ 1988 ■ 1989 ■ 1990 ■ 1991 ■ 1992 ■ 1993 ■ 1994

1. RCRA Closures  
 ■ Design, Implement, & Complete Remedial Actions ■

■ Postclosure Monitoring and Maintenance

2. 3004(u) & (v) Corrective Actions  
 - Facility Assessments ■  
 - Facility Investigations ■

3. DOE CERCLA Projects  
 - Phase I - Installation Assessment Completed in 1986  
 - Phase II - Confirmation ■

4. Disposal Area Remedial Actions  
 - Design ■  
 - Construction ■

**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.)

plans should be initiated in 1989. An overview of the schedule for the DOE CERCLA investigations is shown in Fig. 4.3.1.

#### 4.3.1.4 Disposal area remedial actions

During 1987, the design criteria for the DARA project was finalized and the engineering design of the project and support facilities was initiated. During 1988, the design of the project should be completed. Also during 1988, construction should be initiated on the groundwater treatment facility and support facilities. An overview of the schedule for this project is shown in Fig. 4.3.1.

#### 4.3.1.5 Special projects

The Y-12 Plant has two special projects for the control of residual mercury at the plant site: (1) reduction of mercury in plant effluents and (2) landlord activities. Detailed discussions of these projects are contained in Sect. 6.

#### 4.3.2 Oak Ridge National Laboratory

Some activity is under way at all of the WAGs either through site characterization and assessment, routine maintenance and surveillance, corrective actions, or facility decommissioning. Project priorities and funding allocations have been established initially to provide continuing protective storage for all sites, to correct deficiencies in regulatory compliance, to reduce or eliminate known sources of environmental contamination, and to decontaminate facilities to allow beneficial reuse.

Site identification efforts have focused on completing a comprehensive inventory of hazardous and radioactive waste sites and a preliminary assessment of current site conditions. The latter (RCRA Facility Assessment) has been submitted to the EPA and TDHE with ORNL's recommendations for further steps necessary to comply with the RCRA Section 3004(u) corrective actions program. This site inventory will be updated as required to include facilities that have reached the end of their active life or additional sites that are identified through characterization activities. Preliminary

characterization efforts are also under way to provide the baseline data necessary for project assessments and prioritization, as well as for future characterization planning. As part of the baseline data collection efforts, a groundwater monitoring network is being developed to allow for routine assessment of that critical environmental pathway and is scheduled for completion by the end of FY 1990.

To determine the need for, extent of, and priority of corrective actions at any of the remedial action sites, a comprehensive remedial investigation/feasibility study (RI/FS) program is being implemented. This RI/FS effort, required under terms imposed by the ORNL RCRA permit [and CERCLA-Superfund Amendments and Reauthorization Act (SARA) requirements], consists of site characterizations, assessments of decommissioning or closure alternatives for each site, and integration of proposed actions into a single feasibility study for the ORNL complex as a whole. Schedules have been developed for the primary WAGs based on a planned seven-year intensive effort through FY 1993-1994. Accomplishment of a project of this magnitude requires the assistance of a major support subcontractor(s), guided by RAP technical staff, and a data base generated by ORNL from historical and preliminary site characterization studies. The subcontractor selection and award process was completed in the fourth quarter of FY 1987. The award was made to a team consisting of Bechtel National, Inc. (lead organization), CH2M Hill, EDGe/MCI, and PEER.

In addition to the need for site-wide assessments of sources of continuing releases, regulatory requirements under RCRA and/or the Solid Waste Disposal Act (SWDA) have led to (1) imminent closure and associated planning for SWSA 6 and (2) assessments and corrective action planning for both underground waste storage tanks and hydrofracture wells. Assessments are currently focusing on the concepts of in situ waste stabilization, on-site waste treatment and disposal, and decontamination of facilities for reuse where practicable. While the RI/FS activity is under way, the remedial action sites continue to be

monitored and assessed through a comprehensive surveillance and maintenance program. Routine facility repairs, improvements, and monitoring are provided through this program to ensure containment of residual contaminants until site decommissioning or closure can be accomplished. Final decommissioning and closure of ORNL facilities will be accomplished according to regulatory agency-approved plans that address the impacts to the environment from the range of remedial action alternatives. The timing for decommissioning/closure activities will be established during the RI/FS sequence. 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.

In support of remedial action planning and implementation, significant efforts will be required in technology evaluations, corrective measures demonstrations, and performance criteria development. There has been only limited experience with performance of permanent site closure and decommissioning, especially on the large scale that will be required at ORNL. Because of this lack of proven technology, performance assessment of proposed corrective actions may be required in many instances prior to widespread application. Examples of such needed technology demonstrations and evaluations are in situ solidification of waste forms (sludges, soil, and solid wastes in trenches); permanent groundwater and surface water diversions; fixation of hazardous wastes for permanent disposal; and development of remotely operable equipment for waste removal and handling. A field demonstration of in situ vitrification was successfully carried out in 1987

on a 3/8-scale model of an ORNL LLW seepage trench. The objective in FY 1988 will be to complete the process performance analysis and verify the leaching characteristics of the vitrified waste form. Performance criteria will need to be established to direct the remedial action efforts, and pathways modeling will be required to allow for verification of long-term site stability. For the humid environment of the ORNL site, the control of surface water and groundwater contact with any residual wastes appears to be the key component of long-term site performance.

#### 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. Ninety-four waste management units have been identified at ORGDP (see Table 4.2.3). Nineteen units are RCRA sites and 54 are RCRA 3004(u) sites. The remaining 21 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 ensure protection of on-site personnel and the public 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 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 requirement for underground storage tanks 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. 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 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 and compliance with the National Pollutant Discharge Elimination System permit, and the Clean Air Act (CAA) requires consideration of air emissions. In addition, DOE facilities comply with DOE Order 5820.2 for radioactive wastes, 5480.2 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 5820.2, currently undergoing revision, 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, transuranic wastes, and wastes

contaminated with naturally occurring radionuclides.

Hazardous waste management at the Oak Ridge facilities is conducted under DOE Orders 5480.1A and 5480.2, as well as the AEA, the RCRA of 1976, and its Tennessee equivalent, the Tennessee Hazardous Waste Management Regulations. DOE Order 5480.1A ensures that hazardous waste generated by DOE-funded activities will be managed in an environmentally acceptable manner. DOE Order 5480.2 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 in 1985. Facilities with interim status had the option of filing for closure and ceasing operations instead of filing for Part B permit applications. Of 34 RCRA sites at the Y-12 Plant, 21 closure plans have been filed, 12 Part B permit applications have been filed, and 1 Part B permit application is under preparation.

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 1987, 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 Prencoc incinerator, the interim drum yard, and the salvage yard oil/solvent drum storage area.

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 and the Y-12 spoil area I. All regulated facilities are inspected quarterly.

#### **5.1.3.2 Oak Ridge National Laboratory**

Waste treatment and disposal activities are regulated by TDHE and EPA through operating permits. ORNL operates hazardous waste treatment, storage, and disposal facilities under an interim RCRA permit except for hazardous waste storage building 7652, which operates according to a full RCRA Part B permit granted in September 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 National Pollutant Discharge Elimination System (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.

#### **5.1.3.3 Oak Ridge Gaseous Diffusion Plant**

To comply with RCRA, ORGDP submitted Part A permit applications in 1984 and Part B

permit applications in 1985. During 1986, ORGDP elected to file for closure and ceased operation of one facility. In September 1987, the regulators issued the Part B permit for the K-1435 TSCA/RCRA hazardous waste incinerator.

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**

##### **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 waste is a candidate 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 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 waste separation effort initiated in September 1986 by the Waste Transportation, Storage, and Disposal Department. To minimize the disposable volume of low-level radioactive solid waste, the department initiated sorting and additional monitoring after the waste had been picked up from the generators in five major production or development buildings. Monitoring was started before disposal. Concurrently, personnel from production areas were enlisted to implement improved segregation procedures through written guidelines, worker training, and administrative controls. In each participating area, designated trash cans were strategically located, and the cans were color coded and/or labeled to identify the appropriate waste category. As a direct result of this initiative, the amount of waste from the participating areas classified as low-level radioactive waste dropped from 38% to 18% of the total monitored waste.

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 initiated the procurement/installation of more effective waste certification equipment: a crated waste assay monitor, a waste curie monitor, and additional detector heads to

improve the capabilities of external radiation monitoring equipment.

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; bionitrification of aqueous nitrate wastes; 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 required activities were completed in preparation for removal and sale of scrap metal from former mercury use areas, such as Building 9201-4, and from the plant in general. Release standards and sale specifications were prepared. A waste management plan for Building 9201-4, including release standards, was prepared and issued. The first sale specification was prepared to initiate contracts for sale of an accumulated quantity of metal from Building 9201-4.

A Low-Level Waste Disposal, Development, and Demonstration (LLWDDD) program has been established to provide for interim storage of waste, improved operation in existing burial grounds, demonstration of candidate disposal technologies for future operations, and a waste minimization program.

Several Y-12 Plant-sponsored technology demonstrations have been completed or scheduled under the LLWDDD program to address disposal issues such as the environmental impact statement strategy for uranium disposal in Bear Creek Valley. Additional demonstrations are under consideration. Demonstrations completed during 1987 include a supercompaction demonstration and two shape-alteration or declassification demonstrations. The supercompaction project successfully

demonstrated that previously compacted waste forms can be further compacted, resulting in volume savings at the disposal site and an improved waste form. The shape-alteration projects demonstrated the difficulties involved in successful declassification of classified objects. However, at least one technology appeared to offer satisfactory results.

In addition, demonstrations that were well into the planning process included the above-grade packaging demonstration, the above-grade disposal demonstration, and the uranium lysimeter demonstration. Plans for the packaging demonstration, which were being reviewed by state regulators during 1987, call for field-scale evaluation of various types of containers with Y-12 waste forms. Design for the disposal demonstration, which will be a tumulus-type facility, was initiated in 1987. Design for the uranium lysimeter demonstration was 90% complete in 1987. The demonstration will provide long-term data from field-size lysimeters on the leachability of depleted uranium and of wastes contaminated with depleted uranium. The data will be used to support design of future disposal facilities.

#### 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 Figs. 5.1.1 and 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.

A procedural change in the Analytical Chemistry Division is an example of process modification. Many chemical analyses are now done on small-volume samples using small volumes of solvents for extractions, thus reducing the volume of waste solvent generated.

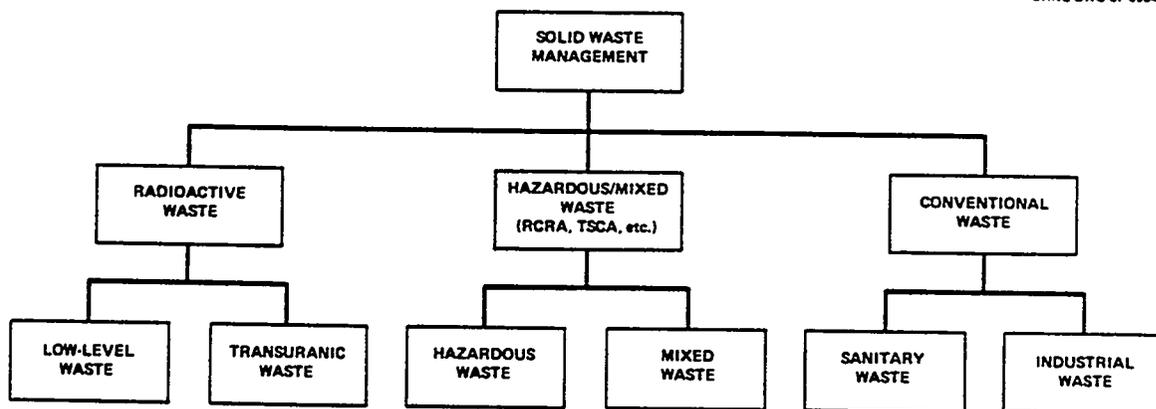


Fig. 5.1.1. Categories of solid waste at ORNL.

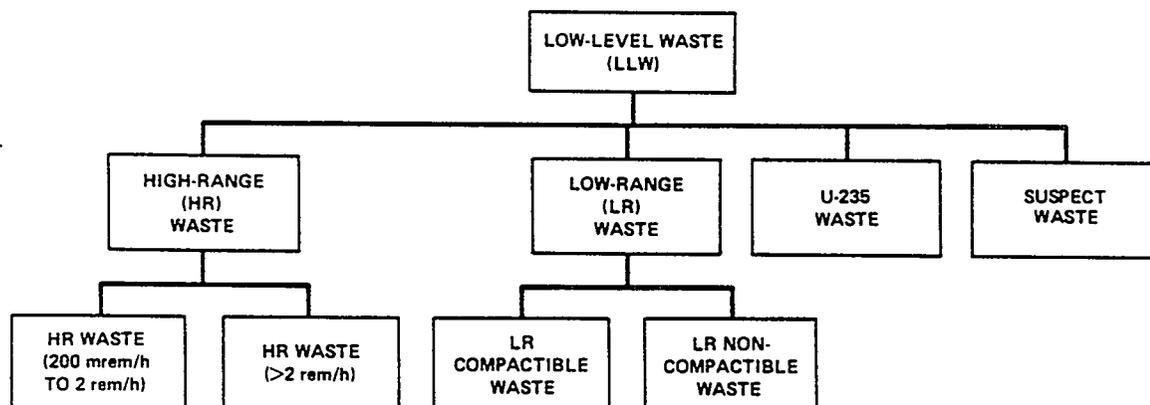


Fig. 5.1.2. Categories of low-level waste at ORNL.

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 implementing these procedures, radioactive and nonradioactive wastes were discarded in the same barrel, thus rendering the nonradioactive portion radioactive.

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 through distillation so that it can be reused; and recovering silver from silver-bearing photographic wastes, thus rendering the waste nonhazardous.

Despite these efforts, some wastes will be produced. Minimizing the impact on public

health and the environment is the goal of the waste management program. To achieve this goal, some wastes, such as sanitary wastes, are treated on-site, while others, such as low-level solid waste, are disposed of on-site. 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 are available. Figures 5.1.3–5.1.5 show the major groups of hazardous chemical wastes and their treatment, recycle, or disposal. Figures 5.1.6–5.1.9 show the disposition of some of the nonhazardous wastes. Thus, management strategies depend on the types of wastes 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

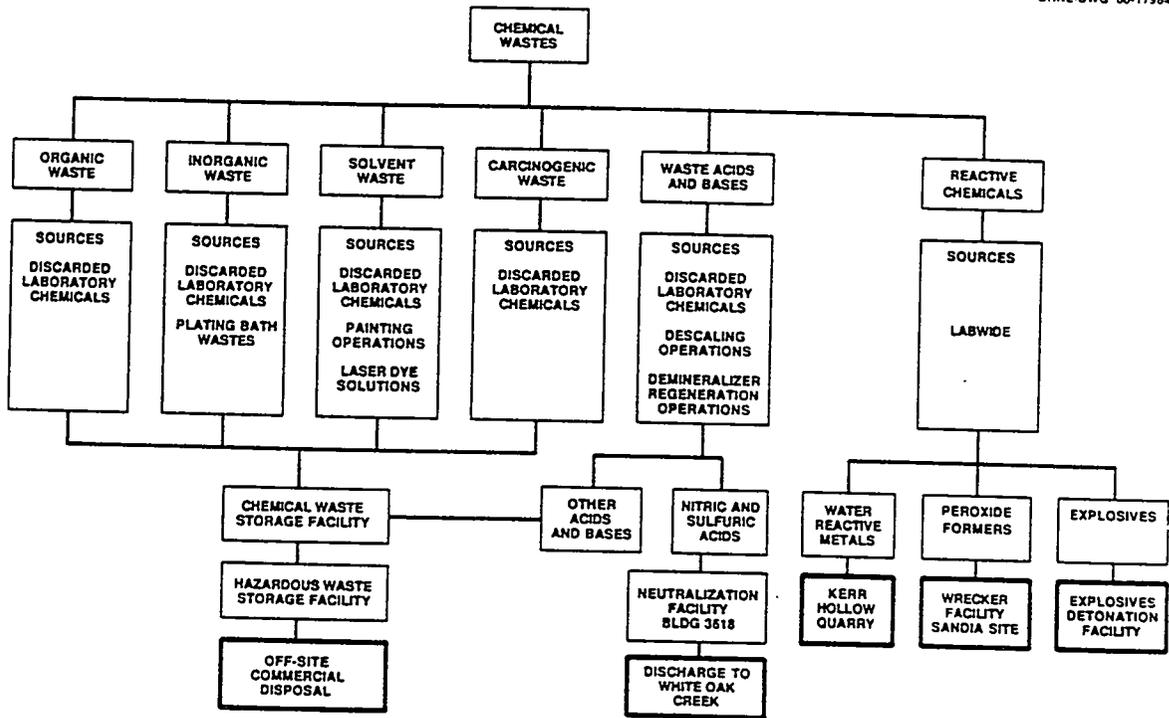


Fig. 5.1.3. Sources and flow of chemical wastes at ORNL.

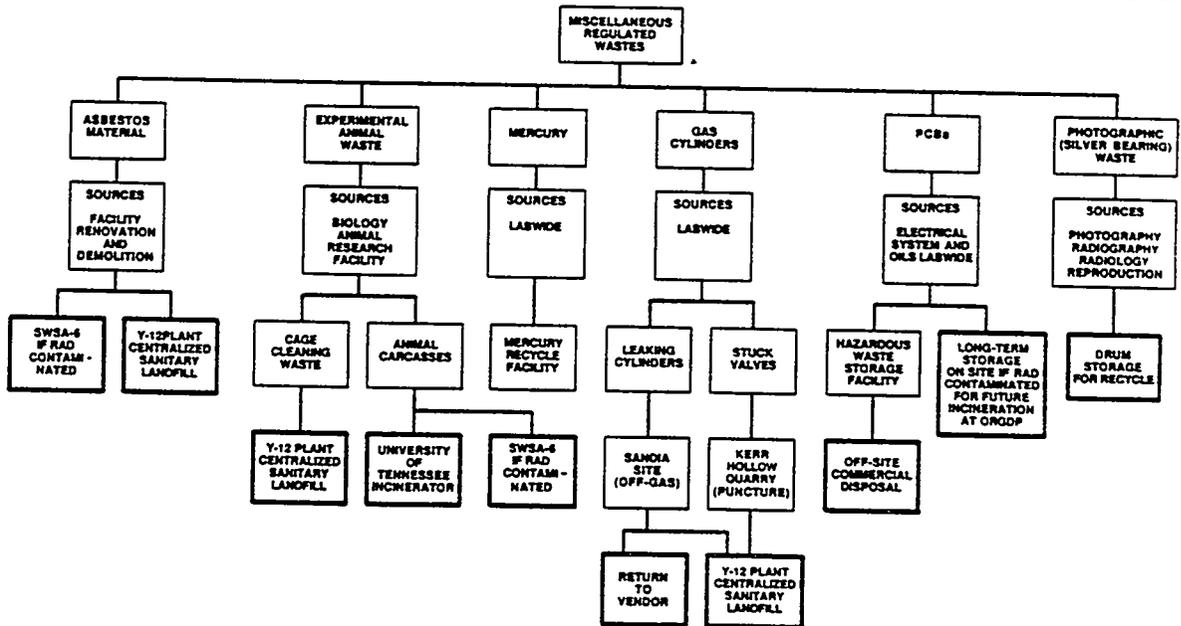


Fig. 5.1.4. Sources and flow of miscellaneous hazardous wastes at ORNL.

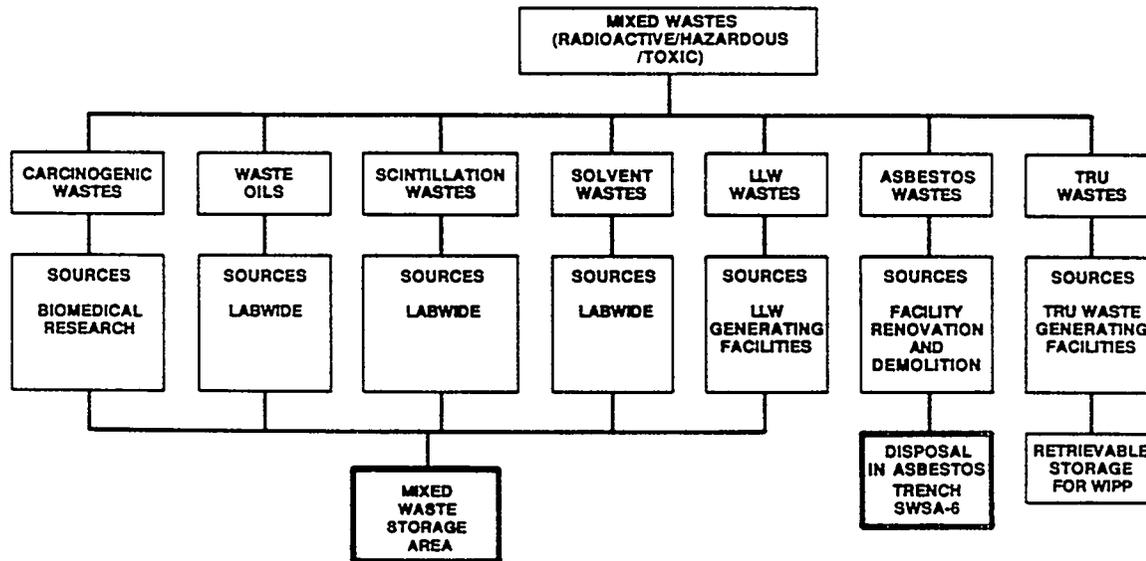


Fig. 5.1.5. Sources and flow of mixed wastes at ORNL.

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. Table 5.1.1 in Vol. 2 depicts the types and quantities of waste recycled in 1987.

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 Waste 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 waste.* 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.

*RCRA hazardous wastes.* Solid wastes (including liquids) that are defined as hazardous by the RCRA regulations by being a listed waste or having a hazardous characteristic.

*Mixed wastes.* RCRA hazardous wastes that are also contaminated with low-level 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.

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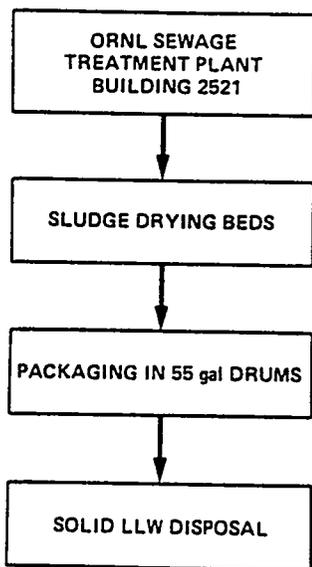


Fig. 5.1.6. Flow path for ORNL Sewage Treatment Plant sludge.

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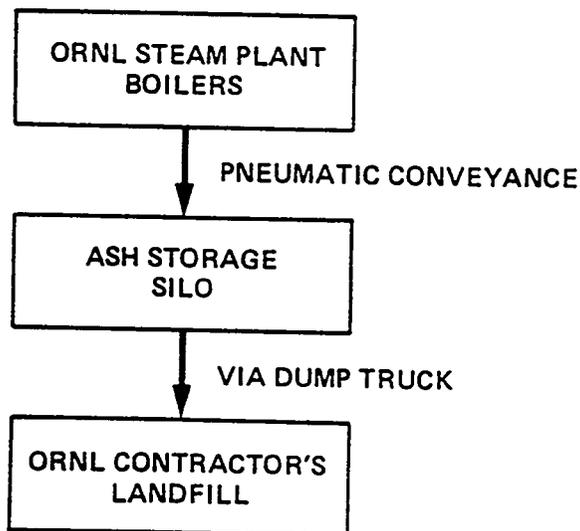


Fig. 5.1.7. ORNL steam plant ash.

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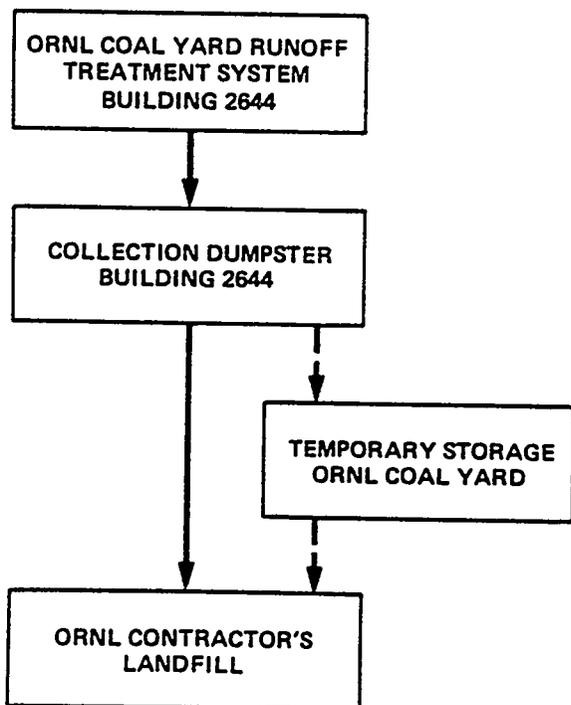


Fig. 5.1.8. ORNL coal yard runoff solids.

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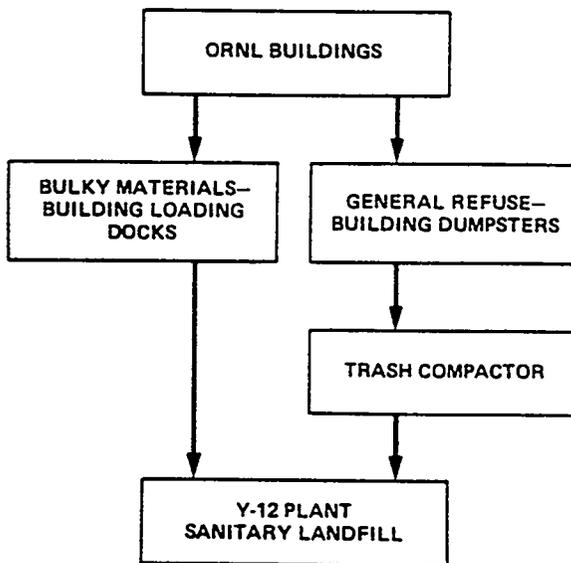


Fig. 5.1.9. ORNL general refuse.

*Low-level 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 non-uranium contaminated or contaminated with low levels of uranium.

*Classified wastes.* Wastes that are classified because of their shape, composition, or both.

*Nonhazardous wastes.* All other types of wastes (including liquids) that are nonhazardous or nonradioactive, or both.

### 5.2.1.2 Oak Ridge National Laboratory

The general types of wastes generated at ORNL include radioactive, hazardous, mixed, and nonhazardous categories. Radioactive wastes include transuranic wastes and low-level solid and liquid wastes (see Figs. 5.1.1 and 5.1.2). Hazardous wastes include chemicals that are characteristically hazardous or listed by RCRA (see Figs. 5.1.3 and 5.1.4). Asbestos and PCB-contaminated materials are "miscellaneous" regulated wastes managed at ORNL (see Fig. 5.1.4). Mixed wastes contain both radioactive and hazardous wastes, and a variety of specific forms are produced at ORNL (see Fig. 5.1.5). 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 (see Figs. 5.1.6–5.1.9 and 5.2.1).

### 5.2.1.3 Oak Ridge Gaseous Diffusion Plant

Six broad categories of waste are generated at ORGDP. These include low-level waste, classified waste, hazardous waste, mixed waste, PCB waste, and sanitary/industrial waste.

*Low-level wastes.* Include solids and liquids that contain radioactive materials. The low-level

radioactively contaminated wastes are managed according to DOE Order 5820.2 and AEA.

*Classified wastes.* 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.* Wastes that are regulated by the EPA RCRA. These wastes are managed in accordance with DOE Orders 5480.1A and 5480.2 and state and federal regulations.

*Mixed wastes.* Wastes regulated as hazardous which are also radioactively contaminated.

*PCB wastes.* 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 waste.* 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 Plant Sanitary Landfill.

## 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 and depleted uranium, to produce significant quantities of machine turnings as a waste product.

The Y-12 steam plant produces steam by burning coal, which produces fly ash as a waste product.

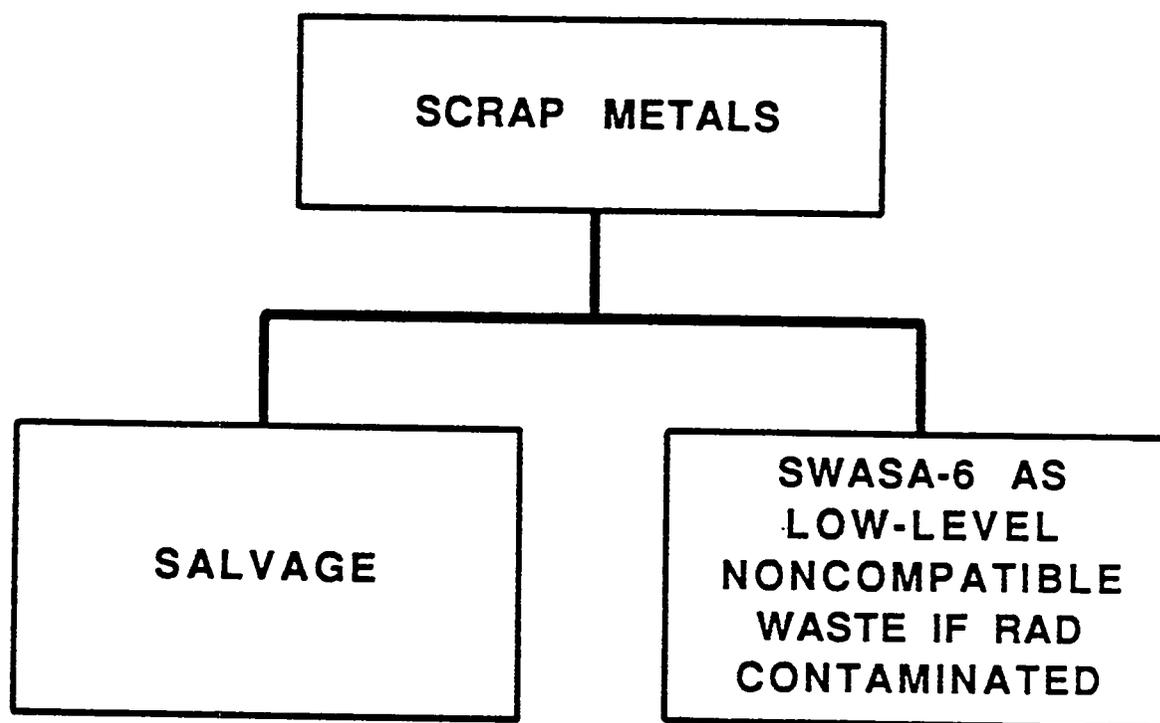


Fig. 5.2.1. Scrap metals and handling at ORNL.

During 1987 the Environmental Improvements-PCB Transformer Replacement Line Item project included the draining, removal, off-site disposal, and subsequent replacement of 43 PCB-filled transformers. (Replacement units are dry or filled with non-PCB fluid.) Eleven of the units were located within plant buildings; the remaining 32 were outside. 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 which are generating waste streams at the site. A summary of waste generation for 1987 is given in Tables 5.2.1 and 5.2.2.

#### 5.2.2.2 Oak Ridge National Laboratory

ORNL is a research facility with many diverse waste-generating activities, each of which may produce only a small quantity of waste.

Table 5.2.1. Y-12 Plant waste generation summary for 1987

Waste	Quantity (kg)
Sanitary/industrial <sup>a</sup>	6,500,000
Construction/demolition spoil	39,300,000
Fly ash	13,000,000
Asbestos/BeO	
Uncontaminated	3,700,000
Uranium contaminated	270,000
Hazardous	4,100,000
Mixed	2,300,000
PCB	306,000
PCB/uranium	47,000
Low-level contaminated waste	1,408,000
Uranium solids	490,000
Scrap metal	
Uncontaminated	740,000
Uranium contaminated	530,000
Classified	175,000
Nonhazardous liquids <sup>b</sup>	1,370,000
Other <sup>c</sup>	29,000

<sup>a</sup>This category consists of wastes disposed at the Y-12 centralized sanitary landfill II.

<sup>b</sup>This category consists of waste oils, mop waters, and other nonhazardous liquids.

<sup>c</sup>This category includes waste characterization pending analytical results.

Table 5.2.2. Y-12 Plant radioactive waste data for 1987<sup>a</sup>

Radionuclide	Concentration (Ci)
<sup>235</sup> U	3.9
<sup>238</sup> U	169
<sup>232</sup> Th	0.2
<sup>99</sup> Tc	1.5
<sup>237</sup> Np	0.05

<sup>a</sup>Does not include airborne emissions or effluent to waterways.

Isotope production, utilities, and support functions such as photography are additional sources of waste. A summary of waste generation for 1987 is given in Table 5.2.3.

Hazardous wastes are generated in laboratory research, electroplating operations, painting operations, descaling, demineralizer regeneration, and photographic processes (see Figs. 5.1.3. and 5.1.4).

Mixed wastes are generated by research projects and some facility operations. Facility renovation and demolition produce asbestos (see Fig. 5.1.4). Although the electrical system has been largely converted to a non-PCB system, PCB-contaminated wastes, including fluorescent light ballasts and capacitors, are still discarded. Additionally, Energy Systems policy requires that

waste materials containing greater than 2 ppm PCBs be managed according to TSCA requirements that legally apply only to wastes exceeding 50 ppm PCBs.

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 also produce nonhazardous industrial wastes.

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 1987, about 134,000 kg of lead-contaminated soil

**Table 5.2.3. 1987 ORNL waste generation summary**

Waste	Volume (m <sup>3</sup> )	Weight (kg)
Hazardous		200,000
Sanitary		
Radiological	9.5	
Nonradiological	30	
Industrial		4,600
Mixed		13,000
PCB		
Radiological		1,300
Nonradiological		15,000
Transuranic		
Contact-handled	26	140
Remote-handled	3.2	500
Low-level wastewater (L)	1,200,000	
Asbestos		
Radiological	2.8	600
Nonradiological		34,000
Scrap metal		
Radiological	460	71,000
Nonradiological		670,000
Miscellaneous nonhazardous	78,000	
Miscellaneous radiological	15	2,700

Table 5.2.4. 1987 ORNL radioactive waste data

Radionuclide	Quantity (Ci)
<sup>241</sup> Am	6.3
<sup>243</sup> Am	0.01
<sup>249</sup> Bk	0.00002
<sup>14</sup> C	0.12
<sup>141</sup> Ce	0.00006
<sup>249</sup> Cf	0.011
<sup>252</sup> Cf	2.9
<sup>36</sup> Cl	0.15
<sup>242</sup> Cm	0.003
<sup>244</sup> Cm	2.9
<sup>248</sup> Cm	0.0002
<sup>60</sup> Co	8,900
<sup>134</sup> Cs	1.9
<sup>137</sup> Cs	27,000
<sup>64</sup> Cu	0.018
<sup>254</sup> Es	0.0001
<sup>152</sup> Eu	250,000
<sup>154</sup> Eu	180,000
<sup>155</sup> Eu	58,000
<sup>156</sup> Eu	310
<sup>55</sup> Fe	0.10
<sup>59</sup> Fe	1.9
<sup>153</sup> Gd	4,200
<sup>68</sup> Ge	0.039
<sup>3</sup> H	45
<sup>203</sup> Hg	0.00018
<sup>125</sup> I	0.06
<sup>131</sup> I	0.07
<sup>192</sup> Ir	26,000
MFP <sup>a</sup>	0.04
<sup>54</sup> Mn	0.00007
<sup>22</sup> Na	0.019
<sup>63</sup> Ni	0.35
<sup>237</sup> Np	0.051
<sup>191</sup> Os	0.065
<sup>210</sup> Pb	0.017
<sup>147</sup> Pm	0.21
<sup>195</sup> Pt	0.0005
<sup>238</sup> Pu	11
<sup>239</sup> Pu	22
<sup>240</sup> Pu	33
<sup>241</sup> Pu	580
<sup>242</sup> Pu	0.0019
<sup>226</sup> Ra	4.90
<sup>106</sup> Ru	0.00019
<sup>35</sup> S	0.00013
<sup>119m</sup> Sn	0.0017
<sup>85</sup> Sr	0.001
<sup>89</sup> Sr	5.10
<sup>90</sup> Sr	1,280
<sup>182</sup> Ta	3.17
<sup>99</sup> Tc	0.14

Table 5.2.4 (continued)

Radionuclide	Quantity (Ci)
<sup>123</sup> Te	0.10
<sup>125</sup> Te	0.20
<sup>228</sup> Th	0.0047
<sup>232</sup> Th	1.49
<sup>232</sup> U	0.011
<sup>233</sup> U	3.92
<sup>234</sup> U	0.00002
<sup>235</sup> U	0.012
<sup>238</sup> U	4.66
<sup>90</sup> Y	1.65
Total	557,550

<sup>a</sup>Mixed fission products.

was 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 as hazardous or PCB wastes.

### 5.2.2.3 Oak Ridge Gaseous Diffusion Plant

Enrichment, maintenance, decontamination, and research/development 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 <sup>235</sup>U isotope. Uranium is the predominant radionuclide found in ORGDP waste streams.

Small quantities of <sup>99</sup>Tc, <sup>237</sup>Np, and <sup>239</sup>Pu have also been released in the waste streams because these radionuclides were present in UF<sub>6</sub> 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.

Historically, these combustible, radioactively contaminated wastes were disposed of at the K-1421 incinerator. However, this facility was

voluntarily shut down in mid-1986 because stack test results indicated that it could not meet Tennessee Air Regulations particulate emission limits.

Currently, low-level solid wastes are either disposed of at Y-12 Bear Creek Burial Ground or stored at K-303-5 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.

The primary generator of radioactively contaminated liquid waste is the uranium decontamination and recovery facility. This waste stream is currently being discharged to K-1407-B pond for settling but will be treated at K-1407-H Central Neutralization Facility to allow for the closure of K-1407-B pond. The K-1407-H facility is scheduled to begin full operation in early 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. ORGDP waste generation totals for 1987 are shown in Table 5.2.5.

## 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 form of documentation and waste tracking for wastes at the Y-12 Plant.

Table 5.2.5. 1987 ORGDP waste generation summary

Waste	Amount of of waste
Hazardous solid (kg)	26,500
Hazardous liquid (L)	146,000
Sanitary	
Radiological (kg)	45,400
Nonradiological (kg)	1,020,000
Industrial solid nonradiological (kg)	736,000
Industrial solid nonradiological (m <sup>3</sup> )	74
Industrial solid radiological (m <sup>3</sup> )	1
Mixed solid (kg)	374,500
Mixed liquid sludge (L)	8,430,000
PCB liquids—radiological (L)	190
PCB solids—radiological (kg)	12,300
Wastewater—nonradiological (L)	65,900,000
Asbestos—nonradiological (m <sup>3</sup> )	31
Scrap metal	
Radiological (kg)	91,000
Nonradiological (kg)	1,640,000
Miscellaneous nonhazardous	
Solids (kg)	22,600
Liquid (L)	26,000
Miscellaneous	
Radiological solids (m <sup>3</sup> )	35
Radiological solids (kg)	250
Radiological liquids (L)	1,130
Nonradiological solids (m <sup>3</sup> )	735

Before the waste is moved, it must be adequately characterized. This is documented on the form.

All off-site shipments of wastes conform to Department of Transportation 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.

### 5.3.2 Waste Management Facilities

#### 5.3.2.1 Y-12 Plant

##### Nonhazardous

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*.

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.

New Hope Pond is a surface impoundment with a surface area of approximately 2 ha. The pond serves as a collection and settling basin for runoff and certain plant process waters.

Chestnut Ridge Sediment Disposal Basin has been used for the disposal of material dredged from New Hope Pond. It is also used for disposal of mercury-contaminated soils.

The garage oil storage tank is a 10,000-gal underground storage tank 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 30,000-gal tank(s) that is used to collect clean oils before sale to the public.

Rogers Quarry was used for the disposal of fly ash from the steam plant.

UNC Landfill is a shallow land burial site for nitrate-contaminated sludges and soils.

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 undergoing decontamination activities and evaluation for reuse.

The Plating Rinsewater Treatment Facility (T-036) provides neutralization, electrochemical reduction, chemical precipitation, carbon adsorption, and filtration to plating rinse waters from plating operations.

##### RCRA hazardous/mixed

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 is used for the disposal of water-reactive and shock-sensitive chemicals.

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 is a diked storage area where drums of oils and solvents are staged pending disposal.

Security Pits are deep trenches for disposal of classified wastes. Hazardous materials have not been disposed of in this facility since 1984.

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 uses 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 is a biodegradation and storage facility for waste coolants.

The West End Treatment Facility uses pH control, metal precipitation, effluent polishing, sludge dewatering, and biodenitrification/biooxidation to treat uranium-contaminated nitrate wastes.

The Central Pollution Control Facility 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.

#### PCBs and PCB/uranium

The garage oil storage tanks are 10,000-gal 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. Approximate building dimensions are 100 × 35 ft. It is west of the Y-12 Plant, on Old Bear Creek Road.

#### Low-level radioactive

Bear Creek Burial Ground, a shallow land burial facility, has been used primarily for the disposal of low-level uranium-contaminated wastes, although it has received RCRA and TSCA wastes. During 1987, only low-level uranium-contaminated material (including asbestos and beryllium oxide), depleted uranium machine turnings, 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*.

Security Pits (D-023) are deep trenches used for disposal of classified wastes, including uranium and uranium-contaminated wastes.

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

M-wing Coolant Storage is composed of four 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 Material Preparation Facility is a compaction/baling facility that compacts solid, uranium-contaminated wastes into bales for disposal in Bear Creek burial ground.

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

The Liquid Organic Waste Storage Facility at the Y-12 Plant is a bulk and drum storage facility that will provide 30,000-gal of bulk storage and storage for about 300 drums of solvents.

The Steam Plant Wastewater Treatment Facility will provide flow equalization, pH adjustment, chemical precipitation, clarification, and sludge dewatering to coal pile runoff, ion-exchange regeneration wastewater, boiler blowdown, and demineralizer waste.

The Waste Oil/Solvent Storage Facility will provide 200,000-gal of bulk storage for uranium-contaminated oils and solvents and PCB-contaminated materials.

### 5.3.2.2 Oak Ridge National Laboratory

RCRA-regulated and PCB wastes are managed in permitted storage facilities and shipped off-site for treatment and/or disposal. Buildings 7507, 7652, and 7653 are permitted for hazardous waste storage. The 7507W storage pad and building 7654 are permitted for mixed waste storage. Radioactively contaminated PCB wastes are also stored at 7507W and 7654. Transuranic wastes are stored at the transuranic retrievable storage facility.

Few hazardous wastes are treated and none are disposed of in on-site facilities. The explosives detonation facility and the wrecker facility process small amounts of wastes that would be dangerous to transport off-site. Explosives such as aged picric acid are detonated in the detonation facility, and chemicals that may form explosive peroxides are disposed of in the wrecker unit.

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 4500N. Photographic wastes that are hazardous only because they contain silver have been recycled for silver recovery in Building 7934. The silver cake is then sold for its silver content. The silver recovery process was not operated during 1987 while a discharge permit was being processed. During this period, photographic wastes were sent off-site for silver recovery.

The contractor's landfill and solid waste storage area 6 (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. The SWSA 6 receives low-level solid radioactive waste including radioactively contaminated asbestos. Asbestos and general refuse are managed in the Y-12 sanitary landfill.

RCRA designates satellite accumulation areas as those near the site of waste generation

on which 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 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<sup>2</sup> 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<sup>2</sup> 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<sup>2</sup> 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-A neutralization facility consists of a 125,070-L reaction pit where sulfuric acid and calcium hydroxide are used to neutralize corrosive wastewater. Effluents from K-1407-A enter the K-1407-B holding pond, which consists of a 0.52-ha impoundment with a storage volume of about  $3.79 \times 10^6$  L. The pond is used for the settling of metal hydroxide precipitates generated during neutralization and precipitation in K-1407-A.

Radioactively contaminated wastewater treated at this location is generated at the K-1420 uranium decontamination facility. Equipment used in the gaseous diffusion and development facilities gradually accumulate uranium-bearing compounds. When this equipment is removed or disposed of, it may require decontamination to meet radiation standards. The primary cleaning method includes mechanical removal in combination with cleaning solutions consisting of water, steam, weak nitric acid, and sodium carbonate. All corrosive solutions from decontamination are piped to the K-1407-A pit for neutralization.

The K-1407-B holding pond contains approximately 7500 m<sup>3</sup> 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 is an unlined surface impoundment containing about  $9.48 \times 10^6$  L. The wastes stored in this facility are 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 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 or 364-L 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 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-1232 treatment facility provides chemical precipitation and pH adjustment for wastewaters generated primarily at the Y-12 Plant. This facility consists of 12 tanks. After the various feed chemicals are added and mixed, the waste is discharged into two lagoons, where the precipitates are allowed to settle out. The settled sludges are collected, dewatered, drummed, and transported to an RCRA-permitted storage facility. The liquid effluent is then discharged to an NPDES point at the K-1203 sewage treatment facility. In September 1987, the Y-12 Plant's central pollution control facility and west end treatment facility began full operation, thus minimizing the need for K-1232.

The K-306-1 vault 23A hazardous waste storage facility provides storage capacity for about 3000 208-L 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 15,200 280-L 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 Best Management Plan (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 280-L 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 113,700-L 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 480 280-L drums, and the tank storage area consists of four 85,275-L tanks in a dike. Wastes stored in this facility include oils, solvents, water, and organics. These are RCRA wastes, contain PCBs, or 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 280-L drums. The tank storage capacity is  $3.48 \times 10^5$  L. 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 1987, the performance test was completed and shakedown testing was begun. The Part B permit was issued in September 1987. The trial burn is scheduled for 1988.

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<sup>3</sup> 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 820-L 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 280-L 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 Waste Coolant Processing Facility. Compaction/baling of solid, low-level, uranium-contaminated wastes is conducted at the waste feed preparation facility, and compaction of used drums is 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 Central Pollution Control Facility, and for nitrate waste sludges at the West End Treatment Facility.

Destruction of water-reactive and shock-sensitive waste is performed at Kerr Hollow

Quarry, where the wastes are reacted with large quantities of water.

Biodenitrification of nitrate wastes is performed at the West End Treatment Facility and the Biodenitrification Facility. Additional treatment for nitrate wastes, including pH control, heavy metal precipitation, and effluent polishing, is performed at the west end treatment facility. Batch treatment for nonnitrate wastes, including filtration, settling, metal precipitation, chemical addition, dewatering, and effluent polishing, is performed at the Central Pollution Control Facility.

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. This facility was inoperative during 1987.

The on-site waste treatment quantities are shown in Table 5.3.1.

#### **5.3.3.2 Oak Ridge National Laboratory**

On-site treatment includes elementary neutralization, detonation, and wrecker facilities and mercury and silver recycle units. Quantities and types of wastes processed during 1987 are shown in Table 5.3.1 of Vol. 2.

#### **5.3.3.3 Oak Ridge Gaseous Diffusion Plant**

On-site treatment facilities at ORGDP include K-1407-A neutralization, K-1419 sludge fixation, K-1232 treatment, and K-900 thermal. See Sect. 5.3.2.3 for description of these treatment units. During 1987 the K-900 unit was not used. Quantities and types of waste treated at these facilities are shown in Table 5.3.2.

### **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 1987 are shown in Table 5.3.2 of Vol. 2.

#### **5.3.4.2 Oak Ridge National Laboratory**

The only on-site disposal units are the contractor's landfill and SWSA 6. Disposal in

these units for 1987 is summarized in Table 5.3.3 of Vol. 2.

#### **5.3.4.3 Oak Ridge Gaseous Diffusion Plant**

The only on-site disposal unit in operation during 1987 was the K-1070-C burial ground for classified, nonhazardous waste. The disposal of this waste is summarized in Table 5.3.4 of Vol. 2.

### **5.3.5 Off-site Waste Disposal**

#### **5.3.5.1 Y-12 Plant**

Incineration is the preferred method for the 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 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 5.3.5 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 U.S. Department of Transportation (DOT) shipping requirements. Packages and vehicles are inspected and inventoried before shipment.

#### **5.3.5.2 Oak Ridge National Laboratory**

It is DOE policy to conduct operations in a safe and environmentally sound manner. Consistent with this policy 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 is another mechanism used to

Table 5.3.1. Y-12 Plant on-site waste treatment data for 1987

Waste	Quantity treated (kg) <sup>a</sup>	Treatment method	Residue type	Residue quantity (kg) <sup>a</sup>
<i>Liquids</i>				
Nonhazardous	1,182,200	<i>b</i>	Sludge	
Hazardous	3,535,000	<i>c</i>	Sludge	
Low-level aqueous	493,400	<i>b, d</i>	Sludge	
Mixed	2,133,100	<i>b</i>	Sludge	
				1,032,000 <sup>e</sup>
<i>Solids</i>				
Low-level solids (ft <sup>3</sup> )	224,600	Compaction	Solid	32,700

<sup>a</sup>Units are kilograms except as noted.

<sup>b</sup>Batch reactors, settling, filtration, chrome reduction, hydrated lime treatment, dewatering, effluent polishing, biodegradation, and biological degradation.

<sup>c</sup>Batch reactors, settling, filtration, chrome reduction, hydrated lime treatment, dewatering, effluent polishing, biodegradation, biological degradation, pH control, and metal precipitation.

<sup>d</sup>Batch reactors, settling, filtration, chrome reduction, hydrated lime treatment, dewatering, effluent polishing, and biodegradation.

<sup>e</sup>Total; cannot be broken down.

Table 5.3.2. ORGDP on-site waste treatment data for 1987

Type	Quantity (kg)	Treatment	Residue type	Quantity
Nonhazardous	$6.6 \times 10^7$	Neutralization	None	
Hazardous	$1.7 \times 10^3$	Neutralization	None	
Mixed	$3.3 \times 10^5$	Metal precipitation	Mixed (kg/year)	$7.1 \times 10^5$
Mixed	$5.2 \times 10^6$	Sludge fixation	Mixed (kg/year)	24,000

ensure safe and environmentally sound operations. 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 5.3.6 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. Scintillation 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, thus, were not 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 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 80 280-L drums. This facility is used for commercially discarded products and chemicals.

The K-1035-A satellite drum storage area has a storage capacity of 16 280-L drums. The wastes stored at this facility are generated from printed circuit board cleaning. Because of decreased demand for circuit board cleaning, the K-1035-A facility will be closed in 1988.

Wastes stored at K-1025-C and K-1035-A are not radioactively contaminated. The wastes are collected at these facilities 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 three years. Quantities and types of wastes disposed of off-site during 1987 are shown in Table 5.3.7 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 5.3.8 and 5.3.9 of Vol. 2.

#### 5.3.6.2 Oak Ridge National Laboratory

Wastes are stored 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 1987 are indicated in Table 5.3.10 of Vol. 2. Wastes remaining in storage at the end of 1987 are shown in Table 5.3.11 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 5.3.12-5.3.14 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 1988.



## 6. SPECIAL STUDIES AND UNUSUAL OCCURRENCES

### ENVIRONMENTAL MONITORING OF THE OAK RIDGE COMMUNITY

**Background.** In 1983, DOE asked Oak Ridge Associated Universities (ORAU) to assist in monitoring the Oak Ridge community after announcement of the mercury contamination of East Fork Poplar Creek (EFPC). For the next 4 years, ORAU made measurements of mercury, uranium, and several other pollutants on the EFPC floodplain, the sewer beltway, and several private properties where floodplain soil may have been placed. This activity, including monitoring during remediation by soil removal at the Oak Ridge Civic Center, took place through 1986.

**Activities during 1987.** ORAU collected and processed over 500 samples from the Oak Ridge

community during 1987. The results were reported monthly to DOE and distributed to federal, state, and local governmental agencies. Each report contained a full description of the sampling location and sample analysis and should be consulted for details not included in this summary report.

gathering to data analysis and preliminary discussion of remediation possibilities, the need for sampling in the Oak Ridge community decreased. In early spring 1987, ORAU, with the concurrence of DOE, made plans to terminate the ORAU environmental monitoring effort in Oak Ridge until remediation plans require additional monitoring. The ORAU program steadily decreased until September, when it was terminated.

**Oak Ridge Water Treatment Plant.** Through the first part of 1987, ORAU continued to monitor the sewage sludge from the Oak Ridge water treatment plant for  $^{60}\text{Co}$  and  $^{137}\text{Cs}$ . The analysis showed that the radioactivity was below guidance levels set by the state and federal governments (Table 6.1).

Table 6.1. Radioactivity in 42 samples of Oak Ridge liquid sewage sludge (pCi/mL)<sup>a</sup>

Radionuclide	Maximum	Regulatory limit	Percent of standard
$^{137}\text{Cs}$	1.2	20	6
$^{60}\text{Co}$	10	50	20

<sup>a</sup> $^{134}\text{Cs}$ ,  $^{125}\text{Sb}$ , and  $^{54}\text{Mn}$  just detectable.

community during 1987. The results were reported monthly to DOE and distributed to federal, state, and local governmental agencies. Each report contained a full description of the sampling location and sample analysis and should be consulted for details not included in this summary report.

As the emphasis of the Oak Ridge Task Force and DOE shifted from information

Quarterly samples of sewage sludge were collected and analyzed for mercury, uranium, and other elements. The mercury concentrations were between 14- and 18-ppm dry weight and the uranium levels between 78 and 170 ppm. The other elements were about as expected for sewage sludge (Table 6.2).

**Salvage Yard vicinity properties.** The state of Tennessee requested DOE's assistance in

**Table 6.2. Elements in three samples of Oak Ridge dry sewage sludge (ppm)**

Element	Maximum	Average
Antimony	4.5	4.2
Arsenic	47	4.5
Barium	950	840
Beryllium	0.9	0.8
Bromine	42	40
Cadmium	8.5	7.8
Chromium	710	500
Copper	570	550
Iodine	83	64
Lead	180	150
Lithium	11	5.7
Mercury	18	17
Nickel	44	39
Selenium	5.7	5.1
Silver	100	97
Thorium	2.5	2.2
Uranium	170	110
Zinc	2100	2000

monitoring several private properties surrounding a salvage yard that had received surplus equipment from DOE-owned facilities. The salvage yard was known to have mercury and uranium contamination. None of the 184 soil samples collected from the vicinity properties exceeded the state interim mercury guideline of 12 ppm. Multielement analysis was also performed on three of the samples and only uranium levels were elevated: 29, 110, and 200 ppm.

**City and privately owned properties.** At the request of the City of Oak Ridge, DOE authorized ORAU to take samples from a proposed mall area. Of the 62 samples, 3 taken at the sewer beltway exceeded the state interim guideline for mercury (Table 6.3). Multielement

**Table 6.3. Study of proposed mall area in Oak Ridge**

Element	No. of samples	Maximum (ppm)	Average (ppm)
Mercury	59	0.83	0.14
Mercury <sup>a</sup>	3	300	250

<sup>a</sup>Samples from sewer beltway.

analysis of 21 samples gave results similar to background levels.

Sampling was also performed on the EFPC floodplain where a storm water drain was to be installed. Of the 53 samples taken, 7 had soil mercury concentrations above the state guideline of 12 ppm (Table 6.4). The mercury was generally located at the old floodplain about 75 cm below the present ground surface.

**Table 6.4. Study of EFPC floodplain construction site**

Element	No. of samples	Maximum (ppm)	Average (ppm)
Mercury	53	270	8.5
Uranium	19	22	3.8

Multielement analysis of 19 of the samples gave results similar to background except for the mercury and slightly elevated uranium levels.

As part of a remediation project during the city's renovation of the Oak Ridge Turnpike, EPA authorized the removal of all soil exceeding 100 ppm of mercury at a location where the sewer beltway crosses South Tulane Avenue. The soil was sampled before removal and each truck was sampled before delivery to the assigned disposal area. ORAU took 91 samples. As expected, about 90% of the samples exceeded the state interim guideline for mercury (12 ppm) (Table 6.5). ORAU had previously identified this area as being above the state guideline levels.

**Table 6.5. Study of remediated Oak Ridge Turnpike area**

Element	No. of samples	Maximum (ppm)	Average (ppm)
Mercury	91	730	315
Uranium	29	35	14

Multielement analysis of 29 samples gave results similar to background except for mercury and uranium.

ORAU collected and processed 16 samples near an apartment complex. Fourteen of the samples exceeded the state interim guideline levels (Table 6.6). The contamination in this area, part of the sewer beltway known to be contaminated with mercury, is now carefully defined.

Table 6.6. Study of apartment complex area

Element	No. of samples	Maximum (ppm)	Average (ppm)
Mercury <sup>a</sup>	16	320	150

<sup>a</sup>State interim guideline is 12 ppm.

Thirty-two samples were collected from a warehouse area previously used by the Atomic Energy Commission but now privately owned. Ten of the samples contained mercury above the state interim guideline. The soil also had high levels of copper, zinc, lead, and nickel (Table 6.7).

Table 6.7. Study of warehouse area

Element	No. of samples	Maximum (ppm)	Average (ppm)
Mercury	32	77	5.3
Copper	17	14,000	3,020
Zinc	17	4,700	1,510
Lead	17	3,400	858
Nickel	17	8,000	1,630

**Groundwater.** During April, ORAU assisted the U.S. Geological Survey in selecting the location for shallow wells designed to provide information about contamination of the groundwater under the EFPC floodplain. ORAU also analyzed 12 of the initial water samples from the wells for mercury (Table 6.8).

**Biological samples.** Vegetables were grown in a greenhouse on highly contaminated soil. Fourteen samples of plant parts were analyzed for mercury. These results, when combined with

Table 6.8. Study of EFPC groundwater wells<sup>a</sup>

Element	No. of samples	Maximum (ppb)	Average (ppb)
Mercury	12	50	12

<sup>a</sup>Results from initial samples only.

earlier results and literature values, suggest that as the mercury concentration in the soil increases, the ratio of mercury concentration in the plant to that in soil decreases.

## Y-12 PLANT

### S-3 Pond Area Air Sampling

As the S-3 Pond waters at the Y-12 Plant were treated and discharged 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: <sup>99</sup>Tc, <sup>90</sup>Sr, <sup>230</sup>Th, <sup>234</sup>Th, and Zr. Also measured were total suspended particulates. Data collection began January 23, 1986; the sampling schedule was set for 24 h every 3 d (average).

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 begins in 1988 to close the S-3 ponds, the sampling frequency will again be increased to adequately monitor the area.

### Y-12 Steam Plant Waste Minimization Project

A study has been made of the feasibility of installing an electro dialysis unit to pretreat feedwater for the Y-12 Steam Plant and the demineralized water system. The electro dialysis

unit would allow estimated reductions of 75% in chemical consumption for water treatment, 95% in boiler blowdown, 5% in fuel consumption, 70% in wastewater requiring treatment, and 80% in chemicals to treat wastewater. The estimated return on investment is 20%.

An electro dialysis unit sized for winter demand will have excess capacity in the summer season. If this excess capacity were used to supply makeup 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.

Several issues must be resolved before installation of an electro dialysis unit will be pursued. (1) The state of Tennessee must give preliminary approval for the direct discharge of electro dialysis blowdown to EFPC. This blowdown passes the current biological toxicity tests for fathead minnow larvae and for *Ceriodaphnia* fecundity, and net water quality in EFPC would be improved by the proposed installation. (2) Resolution of long-term plans for the steam plant and selection of the fuel(s) the plant will use in the future must be made. (3) A cost/benefit analysis incorporating the resolutions of issues 1 and 2 must be completed.

#### **Uranium Lysimeter Demonstration Project**

This study is a joint effort by the Low-Level Waste Disposal Development and Demonstration Program (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  $^{238}\text{U}$ . 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 will be built and filled 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.

#### **Modified Head-End Treatment for the Y-12 West End Treatment Facility**

In an effort to improve treatment of nitrate-containing wastewaters, a modified process was laboratory tested for wastes entering the West End Treatment Facility (WETF). The modified process removes the heavy metals, including uranium, before biologically destroying the nitrate ion. Compared with the current process, several advantages could be realized using the modified process. These include (1) reduction in the amount of radioactive solids, (2) reuse or possible landfill of the calcium carbonate formed, (3) reduction of chemical usage, and (4) probable higher denitrification rates.

#### **Optimizing a Biological Treatment System for Denitrification of Y-12 Waste Streams**

A contract has been made with the Oak Ridge Research Institute (ORRI) to study optimization of biological treatment to denitrify Y-12 Plant waste streams. This study may lead to improvements in the treatment of wastewaters at the Y-12 Plant WETF. The objectives of the ORRI contract were to:

1. determine the effects of pH, DO, temperature, and concentrations of phosphate, nitrogen, acetate carbon, and metals on the denitrification rate;
2. determine the individual toxic concentrations for various metals (specifically Cu, Ni, Pb, Na, Ca, Mg, Cr) and estimate the toxic limit based on total ionic strength (osmotic pressure) for a combination of metal components similar to what was seen in previous tanks;

3. isolate and characterize microorganisms appearing to be most important to the denitrification process;
4. provide a seeding methodology to enhance the denitrification process.

#### 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 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 system is being planned for treating this rinsewater.

An anion exchange resin was very effective at removing silver from the developer rinsewater. 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, is commercially available. Further tests are planned to better evaluate the effectiveness of this treatment technology.

#### Optimization of a Biological/Chemical Wastewater Treatment Process Using Biotoxicity Tests and Chemical Analysis

Nitrate-contaminated wastewater at the Y-12 Plant is biodenitrified in six large ( $1.9 \times 10^6$  L) stirred-tank reactors at the WETF and then aerated to biooxidize organics. After decanting from the settled solids, the water is chemically treated and discharged. The decant treatment facility (DTF) process consists of acidification to remove carbonates; precipitation with ferric chloride, lime, and powdered activated carbon at a pH of 7.5 to 8.0; and filtration. During startup, this facility produced water that met the chemical requirements of its National Pollutant Discharge Elimination System (NPDES) permit; however, biological toxicity tests with the microcrustacean *Ceriodaphnia* showed that the effluent was relatively toxic [lowest observed effect concentration (LOEC) = 0.1%].

Laboratory tests showed that modifications to the treatment process could significantly reduce the uranium concentration and the toxicity of the primary effluent. Parallel experiments examined the toxicity of the primary chemical contaminants that were present in the treated effluent. Sodium sulfate concentration was the controlling influence on the toxicity of the effluent from the improved DTF process. Sodium, chloride, and sulfate were relatively nontoxic (LOEC > 15 mM), and potassium, bicarbonate, and calcium were moderately toxic (LOEC < 10 mM). Lithium and uranium were much more toxic (LOEC < 1 mM). This study shows that chemical and biological tests can be used in concert to optimize wastewater treatment facilities.

#### Toxicity of Common Chemicals to *Ceriodaphnia*

As part of a program to improve wastewater treatment processes used at the Y-12 Plant, the

toxicity of various common chemicals that are either present in or used in the treatment of wastewaters was measured using *Ceriodaphnia*. The results of these tests have been important in understanding the toxicity of several different effluents and in development work to improve the toxicity of other effluents. *Ceriodaphnia* were used to evaluate the toxicity of these chemicals because they have generally been more sensitive to Y-12 Plant effluents than fathead minnows. In this biotoxicity test, both the survival and fecundity (number of offspring) of the test animals are compared with those of control animals. Statistical techniques are used to determine the no-observed-effect concentration (NOEC) and the LOEC for each chemical that was tested. These results are shown in Table 6.9.

Table 6.9. *Ceriodaphnia* biotest results for pure chemicals

Chemical	Concentration (mg/L)			
	Fecundity		Survival	
	NOEC	LOEC	NOEC	LOEC
Na <sub>2</sub> SO <sub>4</sub>	1510	2220	2970	4400
NaCl	1155	1650	1650	3300
NaHCO <sub>3</sub>	555	920	160	960
KCl	160	960	160	960
CaCl <sub>2</sub>	<305	305	<305	305
LiNO <sub>3</sub>	<50	50	50	100

#### Development of a Treatment Process for Pond Waters at the Y-12 Plant

Laboratory and pilot plant tests have been completed for the development of a treatment process for water from ponds located in the Bear Creek burial grounds. This project is related to the closure of the ponds and disposal of the sediments in the bottom of the ponds under the Resource Conservation and Recovery Act (RCRA) regulations. The characteristics and treatment of water emitted from a seep from old burial pits have also been investigated.

One of the ponds contains about 350,000 gal of water, and during periods of no rainfall the amount of water flowing through the pond is less than 2 gal/min. Laboratory grab samples taken over a 4-month period showed that the water contained very small concentrations of inorganic pollutants. The analysis also revealed that essentially no volatile organic compounds were present in the water.

Pilot plant tests were made over a 3-month period and more than 50,000 gal of water was processed. The unit operations included filtration to remove solids, air stripping to remove trace volatile organic compounds, and carbon filtration to remove nonvolatile organics. More than 120 laboratory analyses were made during these tests and each analysis included inorganic and organic analyses. No significant amounts of impurities were found in the water before or after treatment. Biological toxicity tests were also conducted. The water was not toxic to *Ceriodaphnia* either before or after treatment.

Water from the second pond was also treated in the pilot plant and found to be of the same quality as that in the first both before and after treatment. A formal report of these tests is being prepared and will recommend no treatment of the pond water other than filtration to remove suspended solids.

Tests of the oil seep that feeds the first pond are in progress. Tentative results indicate that treatment of this water will be required and that the proposed unit operations will adequately purify the water from the seep.

#### Recovery of Waste Paper

Approximately 10 tons of waste paper is generated each day and buried in the Y-12 Plant's sanitary landfill. The land in the state-approved landfill is limited and construction costs of a new landfill would be high. A fabrication process has been developed that combines the waste paper with coal and water-soluble binder and is currently being investigated. Coal-like pellets are formed that could be burned in an existing steam plant to produce useful energy

from the waste paper. The recycle of the paper would also conserve valuable land in the landfill, reduce security concerns because the landfill is located outside the plant's secured area, and reduce the amounts of biodegradable material put into the landfill. The 10 tons of paper has a heating value of 7 tons of coal, which means that the purchased amount of coal would decrease.

Commercially available pilot plant equipment was leased and pilot plant tests were completed. Pellets were produced having compressive strengths similar to coal and heat values about the same as coal. A report on the development of the process is being prepared.

The equipment and binder costs are higher than desired for the process. A second phase of the program is planned in which the paper would be chopped, shredded, and pulped to eliminate security concerns. The pulped paper would be analyzed to detect any radioactive material present. A test program involving several buildings in the plant is expected to begin in the near future. During the test, paper will be collected from offices and the test will determine the effectiveness of sorting using administrative control measures. Evaluation of different types of chopping and shredding equipment will be a part of this test. If the test is successful, substantial cost reduction would occur because of the elimination of the binder costs and labor required to form the pellets. Commercial sale of the pulped and baled waste paper would produce the same benefits as those obtained by incineration in an existing steam plant.

#### **Reduction of Mercury in Plant Effluents**

The goal of this project was to reduce the quantity of mercury leaving the Y-12 Plant and entering EFPC. The sources of mercury are area-wide; however, it is primarily concentrated in the areas surrounding the former lithium isotope separation process equipment (mercury-use areas). This process was in operation between 1955 and 1963 and used mercury as an isotope-concentration media. Even though the process equipment has been drained and some of the equipment removed, a considerable amount of mercury remained trapped inside the building

structure and drain lines, the storm sewer system, and in soils where spills and trackout from dismantling operations occurred.

The project involved removing accessible sources of mercury and isolating inaccessible sources, starting in the areas where mercury release was highest. The storm sewer system in the mercury-use areas contained considerable mercury both in its elemental form and in contaminated sediments. These storm sewers were cleaned. Certain storm sewers were relined using the Insituform process. Selection of storm sewers to be relined was based on water flow and the degree of contamination in the line as well as in the surrounding soil. The purpose of the lining was to keep clean water flowing through the sewers from becoming contaminated by contact with mercury in sediments and surrounding soils.

Within former lithium isotope separation buildings, drain lines that were highly contaminated with mercury were replaced. Followup sampling to determine the impact of the project will be done after construction activities in and adjacent to the mercury-use areas are completed. Construction activities disturb the steady-state flow characteristics, thus stifling meaningful comparison of new data with baseline data.

#### **Y-12 Plant Surface Characterization Project**

The Y-12 Plant Surface Characterization Project was initiated in late 1985, sampling was completed in 1986, and the report with a data base was issued in 1987. The initial concern of this project was the potential for exposure of employees to radioactivity when they are working outdoors. Because the methodology of this assessment involved collecting surface soil samples for radionuclide analysis, the samples were also analyzed for mercury.

Mercury was selected because of its use in years past, its persistence in the Y-12 Plant environment, and the widespread area that is the source of the mercury entering the EFPC. The objectives of the project were to

- characterize the surface environment for radionuclides and mercury,

- locate areas of concern that may require additional investigation or remediation,
- provide reports summarizing results and recommendations of the survey, and
- establish a data base that environmental managers can access to obtain existing environmental data or add new information as it becomes available.

The sampling methodology involved measuring ambient gamma radiation levels and collecting soil samples across the entire installation and surrounding valley from Scarboro Road to the intersection of Bear Creek and Old Bear Creek roads. About 2000 soil samples were collected and analyzed for radionuclides using neutron activation, gamma spectrography, and mass spectrography on a limited number of samples. Mercury analyses were performed using cold-vapor atomic absorption.

The limited nature and extent of the radionuclide contamination in the Y-12 Plant should not, under present conditions, pose any health hazard to personnel or others who may come into contact with residuals. The radionuclide contaminants are not present in large amounts, nor are they in a form that may lead to significant redistribution or migration in the environment.

Mercury contamination in soils followed use patterns. It was found in the areas surrounding former lithium isotope separation facilities and staging areas where decommissioned equipment was located. Some elevated mercury concentrations were found in the floodplains along the creek and at New Hope Pond. No large amounts of mercury were found, nor is it likely that mercury will be redistributed by natural means.

#### **Y-12 Plant Airborne Mercury Monitoring Program**

During 1987, the Y-12 Plant continued and expanded the on-site airborne (ambient) mercury monitoring program begun in July 1986. This program has been established to provide a historical data base on mercury concentrations in

ambient air and to demonstrate protection of the environment and human health from releases of mercury to the atmosphere. Airborne mercury primarily results from vaporization of mercury in soils, burning of coal in the 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 and added an additional site in August 1987. Sampling locations include ambient air stations Nos. 2 and 8 on the east and west ends of the plant, two portable stations near Building 9201-4 and the steam plant, and a station at New Hope Pond. Airborne mercury is collected by pulling ambient air through a Teflon filter followed by a flow-limiting orifice and an iodated charcoal sampling tube. Particulate mercury is collected on the Teflon filter for 28 d, and mercury vapor is collected in the charcoal absorber for 7 d. The flow-limiting orifice is used to restrict air flow to approximately 1 L/min.

Mercury collected on the filters and charcoal is analyzed by cold vapor atomic absorption spectrophotometry after digestion in nitric perchloric acid. Average air concentration during the sample collection period is calculated by dividing the total quantity of mercury collected on the charcoal and filter by the total volume (uncorrected to STP) of air sampled.

Table 6.10 shows the maximum, minimum, and average concentrations of airborne mercury at the five sampling locations since installation. The results indicated that on-site airborne (ambient) mercury concentrations are well below the Environmental Protection Agency (EPA) National Emissions Standards for Hazardous Air Pollutants (NESHAP) guideline for mercury in ambient air of  $1 \mu\text{g}/\text{m}^3$  (30-d av) and the industrial hygiene standard of  $50 \mu\text{g}/\text{m}^3$ . The monitoring site located southwest of Building 9201-4 has usually shown the highest concentrations among the five sites. Concentrations of particulate mercury have consistently been less than  $0.001 \mu\text{g}/\text{m}^3$  at all stations.

Table 6.10. 1986-1987 results of the Y-12 Plant airborne mercury monitoring program

Site	Sampling period	Mercury concentration ( $\mu\text{g}/\text{m}^3$ )		
		Max	Min	Av
Ambient No. 2 (east end of Plant)	7/18/86-12/29/87	0.058	0.003	0.010
Ambient No. 8 (west end of Plant)	8/12/86-12/29/87	0.067	0.006	0.027
Building 9404-13 (SW of Building 9201-4)	7/15/86-12/29/87	0.465	0.033	0.150
Building 9805-1 (SE of Building 9201-4)	9/23/86-12/29/87	0.226	0.026	0.101
New Hope Pond (near discharge point)	8/19/87-12/29/87	0.039	0.006	0.016

### Landlord Activities

The controlled standby of the former lithium isotope separation facilities project at the Y-12 Plant (FY 1984-1990, EXP, \$11,785K) will provide for the stabilization and control of Building 9201-4. This building houses a former mercury solvent extraction process for lithium isotope separation, known as Colex, which was in operation during the late 1950s and early 1960s. The system consists of liquid-liquid separation columns and associated pumps, piping, trays, and tanks, which still retain a large quantity of mercury. In addition, the building structure is contaminated with mercury resulting from process losses during operation.

Before May 1986, plans and studies had been ongoing to disassemble and decommission this former lithium isotope separation facility. This would have consisted of dismantlement, disassembly, removal, and decontamination of mercury-contaminated equipment and materials to return the building to a more useful form. However, after review and evaluation of the economic benefits, security requirements, and risks to human health and the environment, a decision was made to place the facility in controlled standby rather than disassemble and decommission. Controlled standby will retain flexibility for future use and reduce the potential for release of mercury to the environment.

Disassembly of equipment and decommissioning of Building 9201-4 will remain an option for this facility.

Since 1984, work on the project has included removal of combustible materials to reduce fire potential, removal of asbestos insulation, and isolation of building drains from the storm sewer system to prevent spills of mercury and other pollutants from reaching EFPC. Characterization studies are ongoing to determine the amount of mercury contained in the process equipment and in the contaminated building materials. Current estimates are that 250 tons of mercury remains in the system.

Controlled standby will consist of the following actions and is scheduled to be essentially completed by 1990.

1. Remove all combustibles from the building to reduce fire risks.
2. Remove outside piping and equipment. Clean and refurbish four 128,000-gal tanks.
3. Drain available mercury from equipment and continue the procedure annually.
4. Provide routine maintenance including replacement of the roof.
5. Further restrict access to the building.

In addition to these activities, mercury emissions to the atmosphere will be minimized by

controlling building air exhaust (see Sect. 3.4.1), and on-site ambient air monitoring will be conducted to verify that mercury concentrations are below established EPA guidelines (see Sect. 7.1.2). The drainage of mercury from process equipment will begin upon the receipt of approval from DOE.

#### **Enriched Uranium Stack Release at the Y-12 Plant**

Because of an unanticipated enriched uranium stack release that occurred from March 18 through April 2, 1987, at the Y-12 Plant, a modified type C investigation was initiated by the DOE in accordance with DOE Order 5484.1. The subject release occurred in Building 9212 at the Y-12 Plant when an exhaust filtration system failed and an unusually high amount of enriched uranium particulate matter was released. The release was detected by one of the Y-12 Plant real-time stack radiation detection systems installed by the stack radiological monitoring project in February 1987. Although the release was significantly above normal levels, no violation of EPA airborne radioactivity standards occurred.

The purpose of the modified type C investigation was to determine the cause and contributing factors of the release. The investigative board attributed the release to (1) an obsolete and faulty high-efficiency particulate air (HEPA) filter housing, and (2) a plugged condenser resulting from faulty maintenance. Upon detection of the release, production operations in the area were temporarily shut down. After recommended corrective actions were completed, operations were resumed and emissions returned to normal. The overall quantity of radioactivity released by the incident caused an estimated dose that was approximately 10% of the annual EPA standard, although off-site ambient air monitors measured uranium concentrations well below the calculated value (see Tables 2.1.18–2.1.20 in Vol. 2). Upon conclusion of the type C investigation, a final report was issued.

#### **Depleted Uranium Stack Release at the Y-12 Plant**

Production operations from a depleted uranium alloy area at the Y-12 Plant were temporarily shut down in April 1987 after new stack monitoring equipment detected an unusually high emission rate of depleted uranium particulate in the exhaust. Production operations in the area remained shut down for approximately 2 weeks until corrective actions were taken to reduce uranium stack emissions. The existing emission control filters were not of sufficient efficiency to adequately capture the fine depleted uranium particles. New HEPA filters were installed prior to restarting production operations, and emissions were significantly reduced from previous levels.

Stack sampling equipment detected the unusually high depleted uranium emission rate. The sampling system showed that depleted uranium emissions from the subject exhaust system were approximately 12 kg per month. This compares to a normal emission rate from the entire Y-12 Plant of approximately 13.5 kg per month. Although the higher than normal uranium emissions were well within EPA standards for airborne radioactivity, the improvements to the exhaust filtration system were completed to reduce uranium losses to as low as reasonably achievable (ALARA) levels.

#### **Completion of Y-12 Plant Stack Radiological Monitoring Project**

In February 1985, the EPA promulgated standards for airborne radioactivity in the Federal Register final NESHAP regulations. The EPA NESHAP regulations established maximum allowable off-site radiological dose levels that the public may receive due to DOE production operations. The NESHAP regulations also required each facility to demonstrate that airborne radioactivity emissions are maintained within the EPA standards. These requirements mean that each DOE facility must be able to accurately quantify its radiological emissions to ensure that off-site dose standards are not exceeded.

The Y-12 Plant, like many other DOE facilities, has many point sources of exhaust air that may potentially emit airborne radioactivity and that are regulated under the provisions of the EPA NESHAP regulations. Although emission control equipment is used extensively on the majority of these exhausts and off-site environmental monitoring results have shown very low radioactivity levels in the environment, a major project was initiated in October 1985 to significantly improve the plant's radiological stack monitoring capabilities. The Y-12 Plant stack radiological monitoring project (SRMP) was completed in February 1987 after major upgrades to 85 plant production area exhaust stacks were finished and new emissions monitoring equipment was installed and started up. The purpose of this \$9.5 million project was to upgrade the stack monitoring capabilities to demonstrate compliance with EPA NESHAP regulations for airborne radioactivity. The Y-12 Plant SRMP corrected the physical deficiencies of the plant's radiological stacks by extending stack lengths, replacing stacks, and constructing permanent stack sampling platforms to allow access to approved sampling locations.

In addition to upgrading a number of Y-12 Plant radiological exhaust stacks and installing stack sampling platforms, the SRMP installed new stack emissions sampling and monitoring equipment to give a continuous record of the plant's radiological air emissions. Continuous stack sampling equipment was installed on most of the Y-12 Plant's radiological exhaust stacks. In addition, real-time, alarmed radiation monitors were installed on stacks that have a potential to emit significant quantities of radionuclides from an upset condition (e.g., failure of emission control equipment, filter fire). The real-time radiation stack monitors alert the operating divisions whenever an emission excursion is detected so that immediate corrective action can be taken and emissions minimized.

The completion of the \$9.5 million SRMP in February 1987 represented a significant accomplishment for the Y-12 Plant. The installation of real-time radiation detection capability on major process exhaust stacks

significantly enhanced the plant's emergency preparedness and has allowed the plant to continue to ensure that radiological emissions are maintained at ALARA levels.

#### **Investigation of Coal Ash Disposal Operations at the Y-12 Plant**

The Y-12 Plant disposes of coal ash from its steam plant operations in a slurry form through a filled ash retention impoundment on the southern slope of Chestnut Ridge, through the spillway of the impoundment dam, and into McCoy Branch. McCoy Branch then flows into Rogers Quarry, where the ash solids settle. Since 1986 the Y-12 Plant has been investigating this disposal method and evaluating alternatives. Investigations in 1986 included characterization of the ash slurry discharge, geotechnical and hydrologic study of the ash impoundment dam, and a preliminary water balance on Rogers Quarry.

In January 1987, the state of Tennessee declared that McCoy Branch and Rogers Quarry are waters of the state and requested that the ash discharge be treated or eliminated. Subsequently, the Y-12 Plant began an extensive feasibility study to evaluate ash disposal alternatives. Various long-term actions were considered, including (1) constructing a new coal-fired steam plant; (2) purchasing steam from an outside source; (3) converting the existing steam plant to use natural gas as the primary fuel; and (4) installing ash handling, treatment, and disposal systems on the existing steam plant. Different options were evaluated within each of these alternatives.

The feasibility study, which was completed in July 1987, consisted of life-cycle-cost (LCC) analysis and a reliability, availability, and maintainability (RAM) analysis of each option. In addition, an evaluation was made of the environmental acceptability, implementation time, and capital cost of each option. After considerable review of the results of the feasibility study, the Y-12 Plant has recommended that an FY 1990 line item project be pursued to construct facilities to collect the fly ash dry, dewater the bottom ash, and dispose of the ash in a permitted landfill. Interim measures to mitigate the

environmental impact of current ash handling, such as shifting to natural gas as a primary fuel and using coal only during peak load periods, are also under active investigation.

#### **East Fork Poplar Creek Area Source Pollution Assessment and Control Program**

The Y-12 Plant NPDES permit requires evaluation of area source discharges from within and around the plant to determine their impact on the water quality of EFPC. Area source discharges, also referred to as nonpoint source pollution, result when uncontaminated surface water or groundwater flows over or through contaminated surfaces and results in the transfer of pollutants to a receiving stream. To characterize area source discharges into EFPC and 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 for implementation 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 will consist of flow monitoring and water quality sampling at 17 sites within the Y-12 Plant and within the EFPC drainage basin. Sampling intervals will 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. Once these data are available, appropriate control measures will be developed to minimize area source discharges into EFPC.

#### **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*, was issued in October and recommended changing the method of analysis for stack samples from alpha counting to fluorometric analysis.

Uranium stack samples are traditionally analyzed by alpha counting. The counts are 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 losses 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 the calculations to convert 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 conjunction with changes being made in the laboratory, improvements in data handling are being made within the Environmental Management Department at the Y-12 Plant with the installation of the Flow Gemini-Environmental Information System (EIS). The EIS will maintain data not only from stack sampling but also from all other environmental sampling programs.

Completing the package will be the inception of bar code labeling for environmental samples. All three improvement projects, which will increase the accuracy and efficiency of the uranium stack sampling program, were begun in 1987 and are scheduled for completion in 1988.

#### **Y-12 Stack Sampling Program: Probe Retention Study**

As part of the calculations to estimate the amount of uranium stack emissions, a factor is

introduced to account for the loss of sample through the sampling train. The purpose of the probe retention study in 1987 was to determine the appropriate probe retention factors for the new Y-12 Plant continuous uranium stack samplers and monitors. To adequately define a probe retention factor for each of 85 stack monitors/samplers, the stack probes and any connecting tubing upstream of the sample filter collector were washed clean, with care being taken to collect the wash for subsequent laboratory analysis for uranium. This procedure was repeated three times on all stacks at approximately 60-d intervals in March, May, and July of 1987. The probe wash samples were collected by the Systems and Equipment Technology Department at ORGDP and submitted to the Y-12 Plant laboratory for fluorometric analysis.

Stack sample filter papers were changed out by Environmental Management personnel at routine intervals (average, three times per week) and submitted to the Y-12 Plant laboratory for analysis by alpha counting. The filter sample results over the period of the probe retention study were summed together for each stack, and calculations were made to convert this to an equivalent mass of uranium.

The probe factors for the samplers and monitors were determined by summing the amount of uranium found in the probe and tubing washes plus the filters, then dividing by the amount of uranium on the filters for that time period. Three sets of data were collected, and a probe factor was calculated for each phase on individual stacks. The data from the study, completed in 1987, are presently being reviewed by a statistician to determine the appropriate probe retention factors for each stack and whether the same factor might apply to all stack samples.

#### **Y-12 Plant Ambient Air Sampling for Uranium: Fluorometric Study**

Ambient air sampling for uranium particulates is conducted at 12 sampling stations located on the perimeter of the Y-12 Plant. These filter samples are analyzed by mass spectroscopy

to determine isotopic distribution of the uranium captured. However, in emergency events (such as accidental excessive uranium stack emission) these filters are collected for priority analysis by the fluorometric method, which gives the total amount of uranium, to determine if significant amounts of material may have left the plant site. For these special samples to be of use, a data baseline to which they could be compared was needed.

Parts of the routine ambient uranium filter papers are archived by the Environmental Management Department. Archived samples from February 1986 through July 1987 were submitted to the Y-12 Plant laboratory for fluorometric analysis. The resulting data were reviewed by a statistician to determine maximum, minimum, mean, median, and standard deviation values for each sampling station. Plots of all the data and charts of mean results for each station were developed for ease in reviewing the information. This information will be very useful in evaluating accidental uranium releases with respect to possible exposure off site.

## **OAK RIDGE NATIONAL LABORATORY**

### **Barge Terminal Site at Clinch River Kilometer 21.1**

A barge-handling facility was proposed for the east bank of the Clinch River at kilometer 21.1, which is just upstream from the old ORGDP steam plant. Before the appropriate Army Corps of Engineers permit was obtained, it was necessary to determine whether radiological or toxic contaminants were present in the sediment and soil that would be distributed by earth-moving activities. A sample plan was prepared by ORNL, and soil and sediment samples were taken for both radiological and toxic materials analyses. No contamination above standards was identified.

### **Fish Kills**

During 1987, two fish kills were recorded in the ORNL area. The first of these was discovered February 5, 1987, when dead and dying shad

were observed in White Oak Lake just above the dam. The Environmental Sciences Division joined with the Environmental Monitoring and Compliance Department (EMC) in tracking this fish kill. During the collecting period, which ran from February 5, 1987, through April 6, 1987, over 1800 fish, primarily shad, were collected in White Oak Lake just below White Oak Dam and just below Melton Branch weir.

The fact that other East Tennessee lakes and streams experienced rather massive fish kills during this same time period led to the conclusion that this was a natural die-off rather than the result of an environmental insult.

On August 12, 1987, the second fish kill was recorded when seven dead fish were discovered just below the White Oak Creek weir, and these mortalities were believed to be related to an ethylene glycol spill that occurred at ORNL on August 7, 1987. No other dead fish were found during subsequent sampling.

#### **ORNL Nonradiological Waste Treatment Plant Site Work**

Ongoing efforts at the ORNL nonradiological waste treatment plant (NRWTP) site south of White Oak Creek across from the 190 ponds and Building 3544 required the preparation of sample plans and subsequent sampling on several occasions during 1987.

The first sampling was carried out during December 1986 and involved samples taken from a test trench excavated on the site. In January 1987 water and ash samples were collected, and in June 1987 soil core sampling was undertaken. In September 1987 additional soil core sampling was undertaken in the tank site investigation portion of the NRWTP site.

#### **ORNL Surface Water Monitoring**

Design work was completed by ORNL in 1987 for a new station on the White Oak Creek headwaters. This station will be located north of the 7000 area and will provide background data for surface water prior to any influence from the plant. Construction is scheduled to start in January 1988.

A dye study was performed in the Clinch River beginning at the mouth of White Oak Creek. The plume was followed downstream past ORGDP and almost to the Kingston Water Plant. This ORNL EMC-funded project was a cooperative effort among the Tennessee Valley Authority (TVA), ORNL Environmental Sciences Division (ESD), EMC, and ORGDP personnel. Study results are incorporated into flow and dispersion models developed by TVA and adapted by ORNL.

ESD and EMC personnel later performed a second, smaller dye study of water from the White Oak Creek weir, through White Oak Lake, and out at White Oak Dam. The results of this study will be used in the White Oak Creek watershed models for flow and dispersion modeling.

During 1987, DOE and Energy Systems Engineering took several steps to address issues of hazards associated with White Oak Dam. A hazard rating has been obtained by ORNL, according to Tennessee Department of Health and Environment (TDHE) and the Corps of Engineers standard. A hazard analysis was also performed. Additional efforts to evaluate and ensure integrity of the dam will include seismic testing and core sampling during early 1988.

#### **Westinghouse Pyroplasma Demonstration**

Westinghouse Plasma Systems, along with Westinghouse Electric Corporation and Pyrolysis Systems, Inc., was at ORGDP to perform a Toxic Substances Control Act (TSCA) demonstration on their Pyroplasma Mobile System. The purpose of the demonstration was to prove that PCB liquids could be safely treated in the Pyroplasma Mobile System.

Energy Systems personnel worked closely with Westinghouse to effect the demonstration the week of April 20, 1987. Before the demonstration could be conducted, a TSCA permit, Tennessee state air permit, and permission to discharge the liquid blowdown through an NPDES location were required.

EPA representatives from Washington, D.C., were present to view the demonstration. The initial test was scheduled to begin on Monday,

April 20, but because of operational problems, the first test was not run until Thursday, April 23. During that test, more operational problems occurred, which prompted the EPA to terminate the demonstration. At DOE's request all further testing at the ORGDP was terminated.

The project was closed out and materials that were generated during the demonstration were disposed of.

#### **Small Mammals as Bioindicators for Radioactivity**

Several small mammals were trapped on the Oak Ridge sewage sludge field. These animals were quantitatively assayed for radioactivity by counting techniques and qualitatively by autoradiography.

The original Oak Ridge sewage sludge disposal field was a 65-acre tract near Rogers Quarry where sewage sludge from the City of Oak Ridge was tilled into the soil. In early 1984, radioactive contamination was discovered in the sludge being applied at that time. The contamination source was traced to an industrial operation in Oak Ridge. A large volume of contaminated sludge was in storage at the time of discovery. The stored material was applied to the 65-acre site until all of it was disposed of. At the conclusion of the contaminated application, an overall assessment by ORNL of radioactive materials inventory in the tract yielded estimates of 80, 50, and 10 mCi of  $^{60}\text{Co}$ ,  $^{137}\text{Cs}$ , and  $^{90}\text{Sr}$ , respectively, in the top 3 in. of soil in 1984. No significant additions have been made to the field since then. The highest level of activity in the soil at any location at that time was 45 pCi/g dry weight ( $^{60}\text{Co}$ ).

Small animals have been trapped on the sludge disposal field by ORNL to determine if radionuclides have spread into the environment and the food chain. In all, 28 raccoons, opossums, ground hogs, squirrels, and rats were trapped on the sludge field. These animals were measured with a small-animal whole-body counter containing a sensitive gamma-ray spectrometer to determine the presence of any contamination caused by the radioactivity that had been deposited with the sludge. Following the whole-

body count, the animals were released. All 28 animals were found to be free of any significant gamma activity. Additionally, 13 rabbits were trapped on this field and sacrificed for analysis of  $^{90}\text{Sr}$ , a beta-emitting, bone-seeking radionuclide. All of the rabbits contained less than 1 pCi/g  $^{90}\text{Sr}$  in bone, and none contained any significant gamma activity in the muscle. Thus, there is no current evidence for transport of man-made radionuclides to wildlife from the soil of the Oak Ridge sewage sludge field.

#### **Rabbits as Indicators for $^{90}\text{Sr}$ Contamination**

Some deer harvested during the 1985–1987 Tennessee Wildlife Resources Agency (TWRA) hunts contained  $^{90}\text{Sr}$  in their bones (66 deer from a total of 2117) without an increased body burden of  $^{137}\text{Cs}$ . By use of rabbits, which have a vegetarian diet not unlike deer but with a considerably reduced range, sources of contamination for the deer herd may be found.

Rabbits were trapped on ORNL's SWSA 4 and SWSA 5 to search for contamination sites. The rabbits were sacrificed and their bones were analyzed by Cerenkov counting for  $^{90}\text{Sr}$ , muscle tissue was analyzed by germanium spectroscopy for gamma activity, and the distribution of radioactivity within the bones was determined by autoradiographic methods. Bone concentrations of  $^{90}\text{Sr}$  ranged from 52 to 1850 pCi/g and none of the muscle contained more than 7 pCi/g  $^{137}\text{Cs}$ .

There are four prominent contaminated seeps (springs) in SWSA 4 and SWSA 5 from which much of the contamination in deer probably originates. Current trapping is being conducted around those seeps. To date, the highest level of  $^{90}\text{Sr}$  has been in a young rabbit trapped near the seeps on SWSA 4.

The distribution of  $^{90}\text{Sr}$  in bone is determined by autoradiography with a goal of trying to determine the time at which the rabbit received its exposure. Preliminary indications show that rabbits trapped near the seeps have freshly deposited activity, whereas those on SWSA 4, but away from the seep, have deposits indicating an earlier exposure. Apparently, the seep locations are prominent sources of the  $^{90}\text{Sr}$  contamination in the deer herd.

### Miscellaneous ORNL Spills

During 1987, ORNL had a total of 92 spills and/or releases of various types of materials (see Fig. 6.1). This compares with 109 for 1986. Each of these was investigated by EMC staff members 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 Hazardous Waste Operating Group in EMC. All cleanup materials were disposed of according to ORNL procedures.

ORNL reports all spills to various levels of ORNL management and DOE officials as soon as possible after the spill via the electronic mail system; updates are provided as necessary. This

reporting system has resulted in an increased awareness of spills by ORNL staff members.

As in 1986, many of the spills in 1987 were related to petroleum products. However, efforts to enhance spill prevention of petroleum products reduced the total number of petroleum product spills from 1986 levels and thus reduced the environmental impact. This was accomplished by increased monitoring of construction activities and storage areas where these types of spills often occur. These monitoring and site assessment activities, conducted by field interface staff, also provided an opportunity to detect and prevent other potential environmental problems. A total of 374 site assessments was conducted, and the site assessment reports were distributed throughout ORNL.

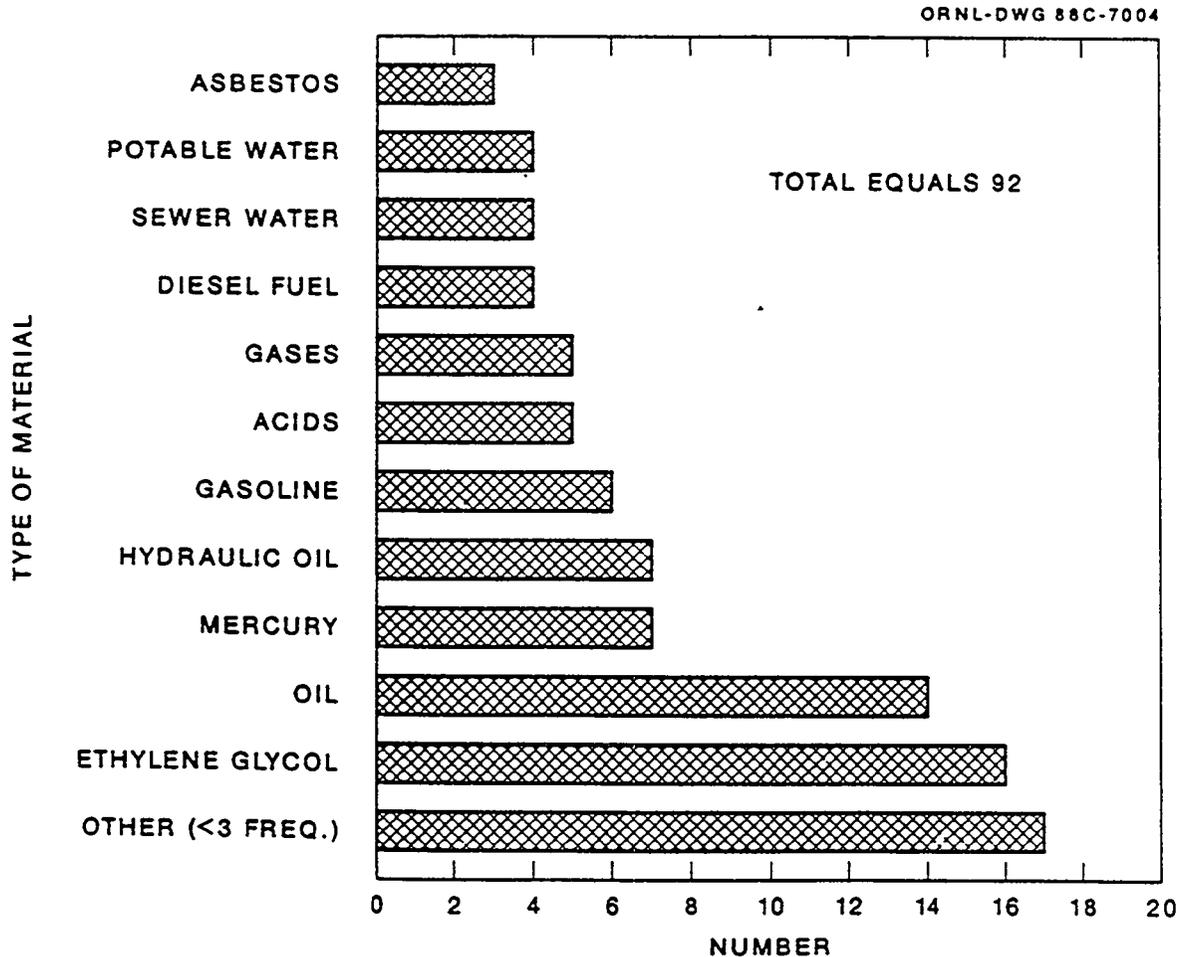


Fig. 6.1. Summary of ORNL spills in 1987.

## OAK RIDGE GASEOUS DIFFUSION PLANT

### ORGDP Storm Drain Survey

One requirement of the September 1986 NPDES permit modification was to characterize the plant storm drain discharges. All of the 135 storm drains were monitored during a 3-month period and samples were collected on the 40 drains experiencing flow. Four drains received additional monitoring in an effort to better assess the drains. The results of this study are presented in K/HS-128, Part 2. Further review is warranted on several of the drains that received additional monitoring to ensure that there is no discharge of untreated process sources. This information will be used during the permit renewal process, which is scheduled to be initiated in July 1988 and completed by February 1989.

### ORGDP RCRA Tank Survey

Regulations effective January 12, 1986, required an independent engineering firm to certify that all RCRA underground waste tanks do not leak and are fit for continued use. A summary of the ORGDP survey conducted by Lee Wan and Associates, Inc., is presented in Table 6.11. All leaking systems were required to be removed from service and an assessment as to the extent of environmental contamination conducted. All systems must be retrofitted by January 12, 1989, to allow continued use. Remedial action studies to evaluate environmental impacts and general plant projects for retrofits are presently in progress.

### Repacking of Radiogenic Lead Stored at ORGDP

Three forms of radiogenic lead from the Y-12 Plant, lead carbonate, lead slag, and lead

Table 6.11. Summary of 1987 waste tank survey at ORGDP

Tank system	Subsystem description	Assessment
K1407-H (CNF)	Central collection sump	Passed
	Lines from K1419	Passed
	Line to K1407-B pond	Passed
	Fluoride scrubber sump	Passed
K1435 (TSCA)	Sumps (6)	Passed
	Underground lines associated with sumps	Leaked
K1232	Lines to K1232-B-1 and -2 settling tanks	Leaked
	K1232-B-1 settling tank	Passed
	K1232-B-2 settling tank	Passed
	K1232 neutralization tank	Passed
	K1232-A equalization tank	Passed
K1401	K1232-A area underground lines	Passed
	Ventilation sumps	3 Leaked; 2 passed
K1420	Lines from ventilation sumps to K1407-A	Leaked
	Underground process lines	Leaked
	Underground lines to K1407-A	Leaked
K1501	Underground lines to K1407-H	Leaked
	Neutralization pit	Passed
K1407-A	K1501 line to neutralization pit	Leaked
	Neutralization pit	Passed
	Lines from pit to K1407-B pond	Passed

metal, are being stored in the K-311-1, RCRA-permitted vault in the K-25 building. The NUS environmental audit of 1985 recommended repackaging the lead because of the condition of the containers. During 1987, chemical operators repackaged 738 fiber casks of lead carbonate into steel containers. The lead slag and metal will be repackaged during the first quarter of 1988.

#### **K-1435 Toxic Substances Control Act Incinerator**

The K-1435 TSCA incinerator is a dual-purpose solid/liquid incinerator built at ORGDP to destroy PCBs and other hazardous organic waste in compliance with the TSCA and the RCRA. The facility can thermally destroy organic liquids and render organically contaminated solids and sludges nonhazardous. Many of these wastes are contaminated with low levels of radioactivity and cannot be shipped to a commercial facility for disposal. Thus, a NESHAP approval letter was requested from the EPA to emit trace quantities of radionuclides from the discharge stack of the incinerator.

The wastes that will be fed to the TSCA incinerator are generated at the facilities managed by DOE-ORO, which include ORGDP, the Y-12 Plant, ORNL, Paducah Gaseous Diffusion Plant, Portsmouth Gaseous Diffusion Plant, the Feed Materials Production Center, and the RMI extrusion plant.

In October 1987, DOE received the first NESHAP-approval letter issued by the EPA to control emissions of radionuclides for the stack of a RCRA/TSCA incinerator. This approval letter allows for the controlled incineration of the vast quantities of stored hazardous wastes that are contaminated with low levels of radioactivity. The incinerator is currently scheduled to begin normal operation in July 1988.

#### **Receipt by DOE-ORO of the First NESHAP Construction Approval Letter for a Radionuclide Source Issued by EPA Region IV**

In September 1987, DOE received the first NESHAP construction approval letter issued by

EPA Region IV to control emissions of radionuclides from any new source. Also, this was the first NESHAP construction approval letter received by a DOE-ORO facility for the control of radionuclide emissions. This facility, the K-1419 20 fluoride scrubber, floor pan, and cylinder cleaning process, is scheduled to begin operation in April 1988.

This decontamination facility built at ORGDP will provide the ability to decontaminate and clean various types of equipment and cylinders. The airborne effluents from this process have the potential to emit small quantities of uranium of various assays and <sup>99</sup>Tc. Thus, a NESHAP construction approval letter was requested from EPA Region IV to allow emission of trace quantities of these radionuclides from two emission points in this process.

#### **K-1419 Sludge Fixation Facility at ORGDP**

The K-1419 sludge fixation facility (SFF) at ORGDP for the stabilization and solidification of hazardous waste in a cement matrix has been in operation since April 1987. Currently, the facility is being used to stabilize the sludge from the K-1407-B and K-1407-C surface impoundments at ORGDP:

The grout formulations were developed after an extensive waste characterization study was completed at ORNL and ORGDP. Fixation of wastes in cement significantly reduces the leaching characteristics of hazardous constituents. Based on studies of the K-1407-B and K-1407-C sludges, the resulting grout complies with RCRA guidelines as a nonhazardous matrix; an effort is under way to delist these wastes as hazardous wastes under RCRA.

The SFF is capable of solidifying inorganic materials with heavy metal concentrations. The solids concentration of the waste can vary from 1 to 50%. Future plans include large-scale technology demonstrations for the central neutralization facility sludge, ion exchange resins, and sludges generated at other sites.

## 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, and analysis. 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 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.

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 traceable to the National Bureau of Standards (NBS) 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, NBS, 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 1987 (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.

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.

The most common sample collection errors include the use of improper sampling techniques or equipment, inadequate decontamination and maintenance procedures, use of improper containers, failure to properly preserve samples, inadequate mixing during the sampling process,

and failure to coordinate sampling with the laboratory to ensure that holding times are met. Sample collection procedures addressing each of these areas are generally in place within each Energy Systems installation. Efforts to develop standardized procedures for use and guidance at the Oak Ridge facilities are under way. 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.

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. 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 of 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 solids (TSS) 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<sub>2</sub> are checked daily by technicians, certified weekly 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. A contract providing for the calibration of the flow measurements through the ambient air monitors is expected to be negotiated in 1988.

#### 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 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.

#### Independent stack sampling evaluation

ORNL initiated an independent stack sampling program in 1987 to provide data necessary for current and ongoing monitoring and sampling upgrade programs and to provide QA checks of new and existing equipment. The program, which was initiated before a DOE-Headquarters (HQ) D.C. survey of ORNL in August and September 1987, will address two of the survey's major findings that deal with stack volume assumptions and emissions data. The work under way is being done by ORGDP's Process Support Division. The contract requires all work to be done in accordance with standard EPA procedures. Sampling during 1987 was directed toward the following four areas:

- stack gas velocity and velocity profile,
- particulate size distribution,
- radiological isotope distribution of particulate matter, and
- radiological isotope distribution of noble gases.

All sampling work, except noble gas distribution, was completed on five of the eight stacks in 1987. Data from the sampling effort are currently being compiled and evaluated.

### 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 are being completed to address the requirements for emission monitoring for each operational stack at ORGDP. All stack sampling at ORGDP is conducted according to EPA procedures or modifications of those procedures developed by ORGDP's Process Support 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, preservations techniques, and chain-of-custody requirements (40 CFR Pt. 136, July 1, 1987). Sampling methods are continually 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. Procedures have been written to document the sample collection methods, which are currently under review and revision to ensure that appropriate techniques for installation, calibration, 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 calibrated every two weeks, or more frequently if needed. In the latter part of 1987, ORNL also developed an NPDES Sampling and Analysis Quality Assurance Program Plan, which is expected to be implemented in 1988. 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 was 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 1988. 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 for five sites at the Y-12 Plant are being developed. 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 detection 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. 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.

#### 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 analyses 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 are being reviewed in an attempt to standardize the protocols throughout the Energy Systems.

##### 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 internal laboratory QA program described in Sect. 7.2.

#### **7.1.7 External Gamma Radiation**

External gamma radiation monitoring for the Oak Ridge Reservation (ORR) is currently being done by ORNL. External gamma radiation levels are determined by placing environmental thermoluminescent dosimeters in the field and collecting and reading the dosimeters after a specified time has elapsed. Collection methods, measurement procedures, and QA/QC for this program are based on American National Standards Institute (ANSI) N545-1975 requirements. Performance criteria for the environmental dosimeters include consideration of uniformity, consistency, field cycle dependence, energy dependence, light dependence, and moisture dependence. The new ambient air monitoring stations have near-real-time in-line monitoring of external gamma radiation levels. The locations of the stations and monitoring results for 1987 are described in Sect. 2.6.

#### **7.1.8 Solid Waste Monitoring**

Each Oak Ridge installation uses SOPs and EPA manual (1986b) methods for the collection of solid waste samples. The manual provides a unified, up-to-date source of information on sampling and analysis related to compliance with RCRA regulations; details sampling and testing

methodology approved by the EPA Office of Solid Waste for use in implementing the RCRA regulatory program; and provides 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 is thus a daily responsibility.

### **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 NBS, EPA, or other DOE laboratories are used for such work. The laboratories operate under specific criteria for QA/QC activities documented in each installation's QA/QC manuals. 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 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, or other approved procedures. Listings of analysis procedures and lowest reported concentrations (LCRs) are given in Tables 7.2.1–7.2.5 of Vol. 2. Analysis methods and minimum QA requirements are dictated by State and EPA regulatory requirements, DOE orders, and established laboratory QA programs.

For radiological analyses, uncertainties are reported at the 95% confidence level and represent counting statistics only. Many concentrations of radioactive materials in ambient environmental samples are at or near zero. When an instrument background is subtracted from an environmental measurement, it is possible to obtain not only net values that are less than the LCR but also zero and negative values. All 1987 ORNL data, except those generated from gamma spectrometry, are reported with the instrument background subtracted from the environmental measurement. Gamma spectroscopy data were reported as "less than" values if results were below the LCR because the computer software was designed in this manner. However, the software was modified to allow the instrument background to be subtracted from the environmental measurement in the latter part of 1987. Beginning in 1988, the gamma spectrometry data will also include zeros and negative numbers. Uncertainties are reported with zeros and negative numbers, thus allowing the data to be understood more clearly, and provide a truer indication of actual environmental levels of contaminants.

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 NBS 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.

The nonradiological laboratories are also equipped with a variety of modern methods and instruments. In addition to many classical wet chemical analysis methods still in use, a range of instrumental methods are used to analyze environmental samples. These include ion chromatography, ion-selective electrodes, gas chromatography (GC), high-performance liquid chromatography, atomic absorption spectroscopy, inductively coupled argon plasma spectroscopy, and gas chromatography/mass spectroscopy (GC/MS). 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% of the laboratory effort (in accordance with EPA expectations) and probably reaches 20% in some activities.

QA/QC individuals external to the sample analysis group submit blind control samples to the analytical laboratories to monitor performance. Reliable suppliers such as NBS, EPA, and DOE are the sources for these standards. The results of this periodic measurement program 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 1987. 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 satisfactory results 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 7.2.6–7.2.8 of Vol. 2. Results for each of the laboratories generally compared well with the true values. One result for ORGDP was determined to be unacceptable, and one tritium and one gross beta result from ORNL were determined to be unacceptable. Most results from the Y-12 Plant compare favorably with the true values. Unacceptable values were reported for radium in both April and October.

#### 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 1987 are shown in Tables 7.2.9–7.2.14 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 are acceptable data.

The parameters measured vary between laboratories because of the equipment at each laboratory. ORGDP tests for all parameters that the existing radionuclide equipment can detect.

For the May samples, the lowest Y-12/EML ratio was 0.45 for  $^{137}\text{Cs}$  in air filters. The highest ratio was 3.75 for  $^{226}\text{Ra}$  in tissue. Other ratios showed reasonable agreement. In September, the

lowest Y-12/EML ratio was 0.47 for uranium in vegetation and the highest ratio was 1.30 for <sup>95</sup>Sr in air.

#### **7.2.2.2 Nonradioactive Quality Control**

DOE-ORO installation laboratories participated in several external nonradiological QC programs in 1987. Each installation has provided results from its participation in these programs.

#### **Proficiency Environmental Testing (PET) Program**

All DOE-ORO laboratories participate in the PET Program supplied by the Analytical Products Group, Inc., 2730 Washington Blvd., Belpre, OH 45714, the commercial supplier in 1987. At the DOE-ORO laboratories and the laboratories at Paducah, Kentucky, and at Piketon and Fernald, Ohio, samples at two concentration levels are analyzed monthly and reported to the supplier. About three weeks later, each laboratory 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 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 two standard deviations are acceptable, data between two and three standard deviations are marginal, and data of more than three deviations are unacceptable.

Tables 7.2.15-7.2.20 of Vol. 2 show results for each of the ORO laboratories. Of the 326 level 1 results reported by ORNL, 310 were

acceptable, 9 were marginal, and 7 were unacceptable. Only chemical oxygen demand yielded more than one unacceptable result. Of the 346 level 2 results reported by ORNL, 334 were acceptable, 6 were marginal, and 6 were unacceptable. No level 2 parameter yielded more than one unacceptable result.

Of the 440 level 1 results for ORGDP, 431 were acceptable, 8 were marginal, and 1 was unacceptable. Of the 440 level 2 results for ORGDP, 429 were acceptable, 9 were marginal, and 2 were unacceptable.

In Y-12 Plant testing, 478 of 489 level 1 results were acceptable, 9 were marginal, and 2 were unacceptable. Of the 490 level 2 results, 482 were acceptable, 2 were marginal, and 6 were unacceptable. An investigation was performed on each marginal and unacceptable result.

#### **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 ORO installations are required to inform the state of Tennessee of any necessary corrective actions. Tables 7.2.21-7.2.23 show the results for each of the Oak Ridge installations. All results from ORNL were determined to be acceptable. Only total residual chlorine from ORGDP and orthophosphate and chemical oxygen demand (COD) from the Y-12 Plant were determined to be unacceptable. 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 ORGDP and Y-12 Plant 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 evaluated by EPA-Athens (Region 4), and the results are furnished to the state of Tennessee. To maintain the qualified status, the laboratories must analyze the QC samples furnished on a routine schedule. During 1987, the ORGDP laboratory analyzed two sets of the control samples. Set No. WS-021 was completed in November, but evaluation data had not been received at the end of 1987. Data for set WS-020 are shown in Tables 7.2.24 and 7.2.25 of Vol. 2.

Sixty-two of 68 results for the Y-12 Plant and 57 of 65 results for ORGDP were determined to be acceptable. Investigations and corrective actions have been taken for the parameters shown to be unacceptable. As a result of WS-020, the fluoride was downgraded to "provisionally certified" for ORGDP, and "acceptable performance" was achieved on 14 of 16 volatile organic compounds.

#### **Quality Assurance for military activities**

ORNL provides program management to the military for the survey and remedial actions at waste disposal sites. One phase of the program is the certification of private laboratories to perform environmental analysis under the Contract Laboratory Program (CLP) protocol for engineering companies performing environmental assessment of military waste sites. The ORGDP laboratory has been assigned program management for certification and monitoring of these laboratories. This activity is performed by a special group of technical personnel who are well versed in the EPA regulatory requirements and are certified auditors for analytical laboratories.

Their primary assignment is the certification and monitoring of laboratories performing analyses relating to the environmental survey work at Department of Defense installations. The group also performs routine audits of the environmental related work within the ORGDP laboratory. This ensures that the ORGDP

laboratory operates under the same requirements as private laboratories.

#### **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 1987. 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 7.2.26-7.2.28 of Vol. 2. At ORNL, the average score for the inorganic laboratories was 91.2%. 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 AND REVIEWS**

#### **7.3.1 Y-12 Plant**

##### **7.3.1.1 External regulatory**

The major review of Y-12 Plant environmental activities by an outside regulatory

agency during 1987 was the NPDES Compliance Evaluation Inspection conducted by TDHE, June 3-5. This review examined the wastewater treatment facilities, NPDES discharge points, sampling, and the plant's compliance with the NPDES permit. The evaluation team expressed a generally positive viewpoint of overall environmental improvements, wastewater treatment facilities, waste minimization and NPDES sampling; however, concerns such as housekeeping along East Fork Poplar Creek, need for improved sediment erosion control at one construction project, and verification of abandoned outfalls were noted. A report of findings has not been received.

Other reviews at the Y-12 Plant conducted by the TDHE included a RCRA interim status facility inspection on July 13, 14, and 16 and a RCRA generator inspection on December 17, 18, and 22.

Items of concern that were cited for corrective action from the inspections included drum labeling and dating, developing an inspection log for generator accumulation areas to maintain all required RCRA operating records and notifications, and preventing an open-air drum storage area from accumulating storm water runoff.

All citations were corrected or resolved with the exception of the one concerning the drum storage area, which is scheduled for closure in 1988. New facilities will begin operation during 1988 to manage RCRA waste from this container storage area before closure can proceed.

In addition, a RCRA internal audit was conducted August 3-13 to review operating records/procedures for the Y-12 Plant's interim status facilities. This audit was part of a follow-up to a 1986 DOE appraisal recommendation.

Any discrepancies that were noted concerning the operating records/procedures were resolved or corrected.

### 7.3.1.2 Department of Energy

Several activities associated with the DOE-HQ survey, which was initiated in late 1986, continued during 1987. The NUS Corporation,

under contract to DOE-HQ, provided the technical expertise in conducting site surveys throughout the Y-12 Plant. In June 1987, the on-site sampling team, headed by personnel from Argonne National Laboratory, conducted sampling at 16 areas of interest.

The preliminary report of the DOE-HQ environmental survey was received in December 1987. While the survey identified a number of known or potential environmental problems at the Y-12 Plant, the findings generally supported the Y-12 Plant's and DOE-ORO's knowledge concerning the status of environmental conditions. An action plan, including a schedule of ongoing corrective programs and budget information, was submitted in February 1988 to DOE-ORO in response to the preliminary findings.

### 7.3.1.3 Internal

The Y-12 Plant laboratory received no audits from external regulatory agencies in 1987. However, a program was established to conduct self-audits of the laboratory to identify areas of opportunity for improvements in QA/QC. The QA coordinator of the Laboratory Technical Support Department conducted the audits of procedures and/or laboratories, documented the findings, and worked with management to implement changes. The audits were as follows:

July 9	Audit of the mercury analysis laboratory
July 14	Audit of the chlorine determination procedure
August 25	Audit of the phosphorus procedure
September 9	Audit of logbooks and documentation for various analytical methods
October 7	Audit of the GC/MS laboratory
October 22	Audit of fluorometric uranium procedures

This program has proved to be very useful and has become a permanent part of the Y-12 Plant internal QA program.

Also 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 discrepancies in the systems of organic nomenclature have been resolved, with full implementation to come in 1988. Resolution of the systems of inorganic nomenclature and full implementation is expected in 1988.

### 7.3.2 Oak Ridge National Laboratory

In 1987, 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 7.3.1 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 1987 was the NPDES Performance Audit inspection 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 analysis procedures, reporting and recordkeeping procedures, and QA. The audit found a number of minor problems and inconsistencies. The problems generally involved the lack of complete documentation or failure to consistently follow required documentation procedures. A number of minor problems in the way samples were handled or analyzed in the laboratory were identified also. While none of the problems were 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 7.3.1 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 1987 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, the sampling phase of the program for ORNL has been postponed.

As a result of ORNL's involvement in the DOE Headquarters survey 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 serious deficiencies were noted in the field sampling audits, the ORNL sampling team did gain a great deal of knowledge from the audit inspections. Several minor 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 laboratory audits conducted at ORNL involved the Organic, Inorganic, and Radiochemical sections. The laboratories involved in analyzing samples for this program are required to follow the CLP protocols, which include rigorous QA/QC components. For more discussion of this program, see Sect. 7.2.2.3.

### 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 a number of 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

In March an audit of Analytical Chemistry Division was conducted by EPA-LV and TechLaw Corporation for CLP qualification. A summary of findings and corrective actions follows:

- There were no major problems, and most of the deficiencies were the results of failure to follow existing written procedures. Supervisors took action to ensure compliance with the written procedures.
- Sample shipping coolers should be opened in a hood. A walk-in hood was available in the receiving area, and its use was made part of the receiving SOP.
- Signatures were not on all workbooks. This is required by Procedure 2323.
- Some standard preparation records were not acceptable. Approved methods of recording data are given in Procedure 2320.
- Lack of data review. Requirements are listed in Procedure 2309.

An audit was conducted in June by EPA personnel from Region 4 on NPDES activities.

Major deficiencies found in the NPDES program were related to the field portion, such as inaccurate flow devices and sample preservation. These deficiencies are being corrected. The laboratory performance associated with the NPDES program was acceptable and received commendable comments.

All deficiencies, which were within the laboratory phase of the activities, were minor, and most were corrected the day they were noted. These included a calculation that caused a high bias for one parameter (which could have resulted in the reporting of a violation when one had not occurred); use of unapproved instruments; and lack of supporting analytical data at the workstation. Approved instrumentation was put into use, and the supporting data were supplied to the workstation.

### 7.3.3.2 Department of Energy

This 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 minor 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 policy of the ORGDP laboratory is for the laboratory personnel to take notes of the deficiencies found by the auditors; to take immediate corrective actions, if possible; and to make a record of the action taken for correction of the deficiencies. A copy of the notes taken by the laboratory personnel is also forwarded to the auditors to avoid any misunderstanding of the findings. When the official findings are issued, an action plan is formulated to correct those deficiencies not previously corrected. A copy of the action plan is also forwarded to the auditors. Copies of prior audits and corrective actions are made available to audit personnel. This enables the auditors to concentrate on areas not covered in prior audits.

An internal audit was conducted in May by the ORGDP laboratory's Military QA and Auditing group. Each phase of NPDES sampling receipt and analysis was covered during the audit.

No major deficiencies were found. The minor deficiencies noted involved documentation related to preservation of samples, expired standards not discarded, and a central filing section for sampling data.

There was no field preservation as required by federal regulations. A central filing and

records system that was started during the year currently uses two full-time employees. Additional emphasis was placed by supervision on following written procedures for documentation, discarding unused or expired standards, and implementation of data validation procedures.

A management appraisal was conducted in August of the environmental activities of the ORGDP site, including the laboratory phase of the analytical procedures associated with monitoring of the radioactivity and discharge of radioactive substances to the environs.

No deficiencies were noted for this activity, and no recommendations were associated with the analytical work.

An audit was conducted in September by the Y-12 Plant Environmental staff on groundwater monitoring. An assessment was made of the ORGDP laboratory's compliance to EPA regulations subpart F and the state of Tennessee regulations 1200-I-II-.05.

ORGDP's Process Support Division is responsible for sampling the monitoring wells and performing all required analyses.

The report showed no major problems. According to the report, "The quality of the monitoring program is enhanced by the integration of sampling with the analytical activities."

Energy Systems central staff audited the analytical support group that provides services for environmental and industrial hygiene activities.

The findings listed the following recommendations: raw data sheets for asbestos are to be reviewed and approved prior to reporting; a recording of all data transmitted is to be maintained; calibrations on microscope and all data are to be recorded in logbooks and retained for 75 years. All recommendations were implemented by December 14, 1987.

## 7.4 QUALITY INCIDENTS

### 7.4.1 Oak Ridge Gaseous Diffusion Plant

The ORGDP laboratory has strict QC on all phases of work, and any incident that results from reporting incorrect data is investigated to determine the cause and to make recommendations to prevent future occurrences.

The following incidents occurred in 1987:

- *Polychlorinated biphenyl*. In January, samples from the K-1407B NPDES monitoring point showed trace levels of PCBs with one sample exceeding the permit limit. Blanks on the next batch of samples showed PCB contamination. These contaminated blanks made the previously reported PCB results questionable. An extended sampling program was instituted over the next several days. The samples were split, and one part was sent to a private lab for analysis. The other part was analyzed on site. The data from the private lab confirmed the presence of trace levels of PCBs.

The investigation within the ORGDP laboratory for determining the problem with the blanks showed that an oil sample with percent quantities of PCBs had been submitted to the laboratory without proper identification. This resulted in contamination of glassware; the contaminated glassware may have contributed to high levels of PCBs in the one NPDES permit sample. New operating

procedures were written to prevent this type of occurrence in the future.

- *Alpha and beta activity in ORGDP drinking water*. In September, the radiochemistry laboratory encountered a problem of increased activity in the water used for blanks in the processing samples. Water from several sources within the plant were obtained, and all showed activity higher than for prior blanks. This led to the suspicion that the water supply could be contaminated. This information was relayed by phone to middle management, and a notice was given not to drink water from the plant supply.

Samples submitted to ORNL for analysis showed no activity. An investigation conducted by the laboratory found that contamination had occurred within the laboratory area and that the water had become contaminated when it was brought into the laboratory. Appropriate actions were taken, including a specific written procedure for defining actions and the reporting of data without review by laboratory management.



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