

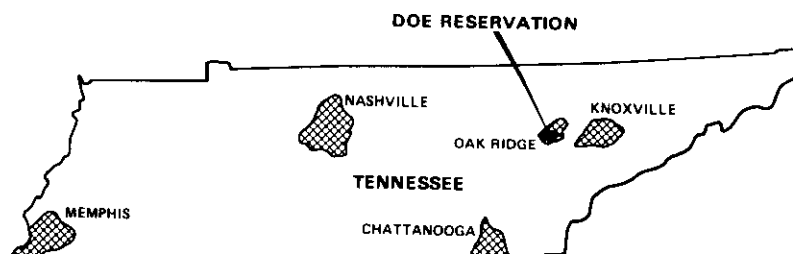
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**MARTIN MARIETTA**

# ENVIRONMENTAL SURVEILLANCE OF THE U.S. DEPARTMENT OF ENERGY OAK RIDGE RESERVATION AND SURROUNDING ENVIRONS DURING 1986

Volume 1: SUMMARY AND CONCLUSIONS



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**Volume 1: SUMMARY AND CONCLUSIONS**

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## EXECUTIVE SUMMARY

### OVERVIEW OF 1986 ENVIRONMENTAL SURVEILLANCE AND REPORT

This two-volume report, *Environmental Surveillance of the U.S. Department of Energy Oak Ridge Reservation and Surrounding Environs During 1986*, is the fifteenth in an annual series begun in 1972. It reflects 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 ground and surface waters, soil, air quality, vegetation and wildlife, and, through these multiple and varied pathways, the resident human population.

Data are included for the:

- **Oak Ridge Y-12 Plant**, which manufactures 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 (ORGD)**, where production operations in uranium enrichment now are on standby, 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 summaries and conclusions based on environmental monitoring at the three DOE installations and in the surrounding environs during calendar year 1986. Volume 2 presents the detailed data from which these conclusions have been drawn.

#### 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, pollutant 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 natural 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 maintaining and enhancing 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 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 indication and response* system that protects against, and provides the real-time data required to rapidly correct, 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 Oak Ridge Reservation 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 regular year-round 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 140 km (90 miles) to the north, south, east, and west of Oak Ridge;
- 8 meteorological towers;
- 50 surface water sampling stations;
- 115 on- and off-site groundwater monitoring wells;
- 51 on-site exhaust stack monitors for detecting uranium releases;
- 3 river and stream points where fish are sampled;
- 75 locations where vegetation and soil samples are taken;
- 126 stream sediment monitoring points;
- 9 milk sampling locations;
- 46 thermoluminescent dosimeters to detect external radiation fields; and
- 1600 Oak Ridge community soil, sediment, sludge, and shallow well samples.

### **State and Federal Regulation**

The regulatory environment that applies to the Oak Ridge operations is itself multifaceted and complex. A major recent 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.

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); and the Toxic Substances Control Act (TSCA). 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.

Standards groups and permitting systems whose guidelines are used as measures of safe operations at the installations and who grant permits for activities conducted by DOE's Oak Ridge Operations are: National Pollutant Discharge Elimination System (NPDES); National Emissions Standards for Hazardous Air Pollutants (NESHAP); and National Oceanographic and Atmospheric Administration (NOAA).

### **Summary Conclusion**

To summarize, comprehensive environmental monitoring data for 1986 show a continuation of progress in bringing the three major Oak Ridge installations into full compliance with permits and regulations issued by the above bodies and with their advice and recommendations. At the same time, past practices under which hazardous and radioactive wastes were disposed of in ways that do not represent the best practice available today—and ways no longer acceptable to regulatory agencies—continue to have adverse impacts through continuing releases to the area environment. In some cases also, improvements in monitoring techniques and in the range of emissions and effluents that are sampled and analyzed lead to reevaluation of previous estimates of pollutant loadings and their potential health or environmental effects.

Efforts to clean up contaminated storage and disposal areas and to close disposal sites that do not meet current standards now are the focus of long-term, very large-scale remedial action efforts. Likewise, new and improved treatment and isolation systems for gaseous, liquid, and solid wastes contribute, each year, 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 from current or past Oak Ridge operations.

### **Outline of Findings**

As in the past, the 1986 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 radiation; biological monitoring (fish, milk, waterfowl, and deer); vegetation, soil, and sediment sampling; monitoring for mercury and other contaminants in the Oak Ridge community; and potential chemical and radiation doses 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 Oak Ridge Reservation and surrounding areas during calendar year 1986.

## **SUMMARY OF 1986 ENVIRONMENTAL SURVEILLANCE DATA**

### **AIRBORNE DISCHARGES AND AIR AND METEOROLOGICAL MEASUREMENTS**

#### **Permitting Status**

Extensive air emission inventories conducted in 1986 at the three Oak Ridge installations included monitoring of more than 2700 emission points for which permits either have been granted or are being sought. About 35% of the air emission points (all of those located at the Oak Ridge Y-12 Plant and at ORGDP) are currently regulated under permits from the TDHE. Of the remaining 65%, almost all are exhaust hoods at ORNL, which are not expected to require permits.

Of the permitted emission points, all are in compliance with their permits with the exception of the steam plant at the Oak Ridge Y-12 Plant, which received three Notices of Violation during the year.

### Radioactive Discharges to the Atmosphere

During 1986, 92,600 Ci of radionuclides were released to the atmosphere from Oak Ridge installations, in comparison with 59,000 Ci released in 1985. This 33,600 Ci increase can be accounted for almost totally by tritium and by two inert gases, xenon and krypton, which have little or no interaction with the terrestrial biosphere, including humans. These increases in tritium and inert gases resulted from increased production of isotopes at ORNL. Figure 1 shows total curies and curies of tritium, Xenon-133, and Krypton-85 released to the atmosphere in 1985 and 1986. The doses resulting from these releases are shown in Table 1.

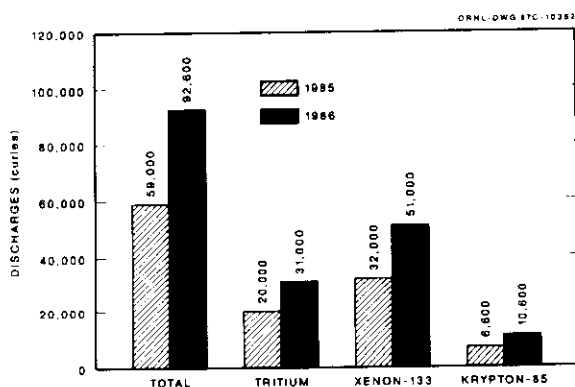


Fig. 1. Total curies and curies of tritium, krypton, and xenon discharged to the atmosphere in 1985 and 1986.

During 1986, it is estimated that a total of 0.19 Ci (211 kg) of uranium was released into the atmosphere from the Oak Ridge Y-12 Plant, including the release of 0.13 Ci (2.0 kg) of enriched uranium measured by continuous stack sampling equipment located on 35 major process exhaust stacks. An additional 0.06 Ci (209 kg) of depleted uranium is estimated to have been emitted into the atmosphere and is included in the plants's emission totals. Engineering estimates were used to approximate expected emissions from depleted uranium exhausts for 1986. The Oak Ridge Y-12 Plant is currently installing continuous stack sampling equipment on 45 process exhaust stacks serving depleted uranium exhausts to provide emission measurements in the future. Figure 2 shows the total curie discharge of uranium estimated to have been emitted into the atmosphere from the Oak Ridge Y-12 Plant from 1982 through 1986. Figure 3 shows the comparable total mass of uranium emitted from the Oak Ridge Y-12 Plant for the same years. The doses resulting from these uranium releases are shown in Table 2.

### Chemical Discharges to the Atmosphere

In 1986 it is estimated that 38 million kg of gaseous chemicals (mostly nontoxic) were released to the atmosphere from all three installations, compared with less than 3 million kg in 1985. These increases arise from production activities and more complete reporting procedures that are now in place. The five significant increases in releases are in acetylene, argon, nitrogen gas, hydrogen fluoride (HF), and steam plant discharges (particulates, sulfur dioxide, nitrogen oxides, carbon monoxide, and hydrocarbons).

Acetylene, argon, and nitrogen are not toxic and are not, therefore, subject to federal and state regulatory standards. Steam plant discharges are permitted under the Tennessee Air Emission Program.

Table 1. Calculated doses to the nearest resident from ORNL releases

	(millirem/year)		EPA NESHAP standard
	1985	1986	
Whole body	0.2	0.5	25
Effective	0.2	0.5	NA <sup>a</sup>
Bone	0.26	0.42	75
Lung	0.3	0.5	75
Thyroid	NC <sup>b</sup>	0.51	75
Kidney	0.31	NC	75

<sup>a</sup>There is no NESHAP standard, and the DOE guideline is 100 millirem.

<sup>b</sup>NC = not calculated.



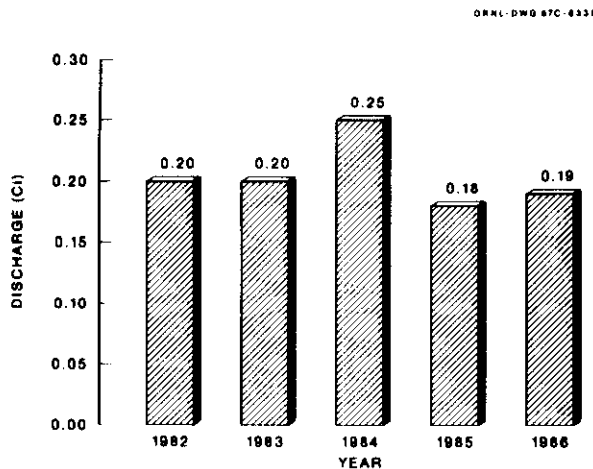


Fig. 2. Total curie discharges of uranium from the Y-12 Plant to the atmosphere.

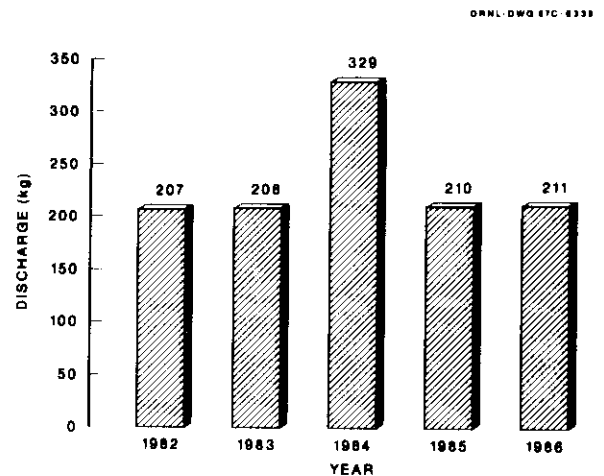


Fig. 3. Total kilograms of uranium discharged from the Y-12 Plant to the atmosphere.

Table 2. Calculated doses to the nearest resident from Y-12 Plant releases  
(millirem/year)

	1985	1986	EPA NESHAP standard
Whole body	$1.6 \times 10^{-5}$	$2.6 \times 10^{-4}$	25
Effective	1.7	2.0	NA <sup>a</sup>
Bone	0.78	1.0	75
Kidney	0.32		75
Lung	8.3	15.9	75

<sup>a</sup>There is no NESHAP standard, and the DOE guideline is 100 millirem.

Because of increased production activities at the Oak Ridge Y-12 Plant, there was an increase of about 4000 kg in emissions of HF at that site. Figure 4 shows the 1985-1986 trend in HF releases.

Emissions of toxic gases, trichloroethane, perchlorethylene, methylene chloride, and acetone, decreased from 565,048 kg in 1985 to 201,800 kg in 1986. Calculations show that the maximum air concentration would be 1/100,000 of a gram per cubic meter of air. (Data reported in Table 4.1.7 of Volume 2 and 1985 data have been updated.)

### Ambient Fluoride Monitoring

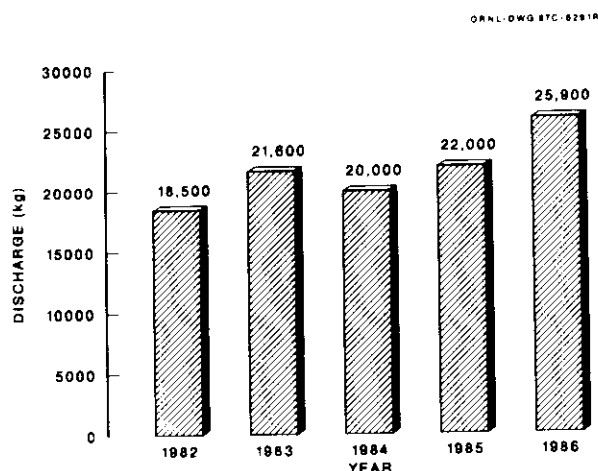
Of the some 260 ambient fluoride measurements taken at ORGDP in 1986 and approximately 570 taken at the Oak Ridge Y-12 Plant, none exceeded the 7-day ( $1.6 \text{ mg/m}^3$ ) or 30-day ( $1.2 \text{ mg/m}^3$ ) Tennessee Air Pollution Control Standard.

### Suspended Particulate Monitoring

Of the some 950 suspended particulate measurements taken at ORGDP, all were within primary and secondary Tennessee air pollution control standards. Particulate emissions reached only 60% of the amount allowed by the primary standard and 76% of emissions allowed by the secondary standard.

At the Oak Ridge Y-12 Plant, 110 measurements were all in total compliance with standards, with the highest levels at 48% of the primary standard and 83% of the secondary standard.

Tennessee Air Pollution Control Standards are not required for monitoring at ORNL.



**Fig. 4. Total kilograms of hydrogen fluoride discharged from the Y-12 Plant to the atmosphere.**

### Sulfur Dioxide Measurements

Of the approximately 20,000 samples taken at the Oak Ridge Y-12 Plant in 1986, all were within both 24-hour and 3-hour standards. The highest level of the 24-hour standard was 31%, and the highest level of the 3-hour standard was less than 2%.

### Radionuclide Concentrations

No EPA or state standards exist for radionuclide concentrations in air. DOE concentration guidelines are being updated based on international and national guidelines, which have also changed in recent years. However, concentrations of radionuclides in air are monitored at all three installations for future calculations when guidelines are applied.

Measurements are taken of concentrations of the following radionuclides: gross alpha; gross beta; uranium-234, -235, -236, and -238; iodine-131; tritium; cesium-134 and -137; potassium-40; plutonium-238 and -239; ruthenium-103 and -106; strontium-90; and thorium-228 and -230. These measurements are used in radiation dose calculations.

It should be noted that area concentrations of iodine-131 increased in 1986 as a result of the April 25-26 Chernobyl-4 accident. Those increased concentrations, which were detected in May and June, are illustrated in Figs. 5-7. They contributed to effective radiation doses from milk consumption and to the thyroid that were higher in 1986 than in 1985 (Fig. 8).

Using estimates of releases from the three installations, measured air concentrations and meteorological data collected, and calculations, it has been ascertained that DOE facilities are in compliance with EPA NESHAP standards for radiation doses to the public.

Two new meteorological towers at the Oak Ridge Y-12 Plant, which were in operation as of December 1985, are additional sources of data not available for 1985. Data from these towers were used, for example, to complete wind direction frequencies for 1986 dose calculations at the Oak Ridge Y-12 Plant site.

### WATERBORNE DISCHARGES AND SURFACE WATER MONITORING

Each of the Oak Ridge installations has a newly approved National Pollutant Discharge Elimination System (NPDES) permit. The most recent was granted to ORNL in April 1986. Under the new ORNL permit, the number of monitoring stations increased from 3 to 11.

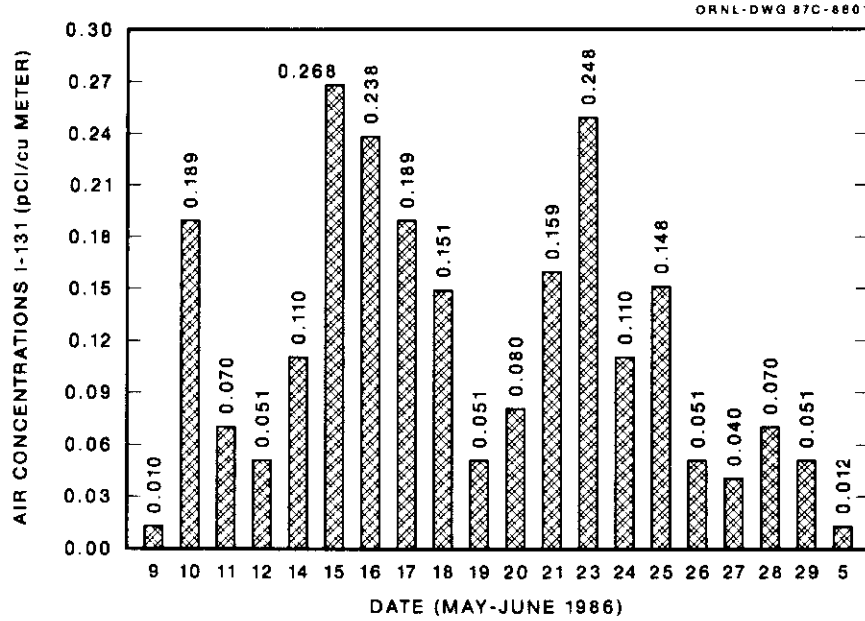


Fig. 5. Iodine-131 fallout from Chernobyl, May-June 1986, ORGDP station.

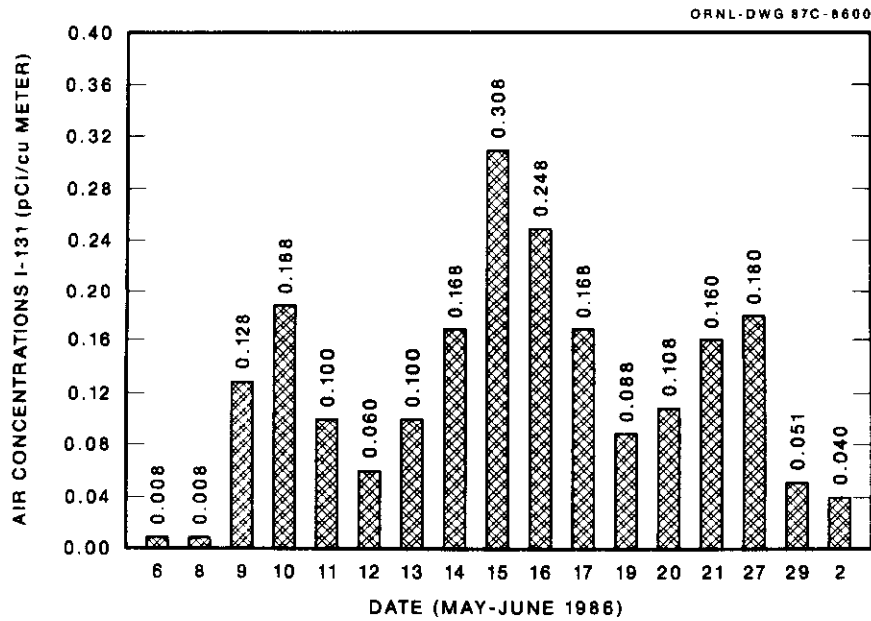


Fig. 6. Iodine-131 fallout from Chernobyl, May-June, 1986, Walker Branch station.

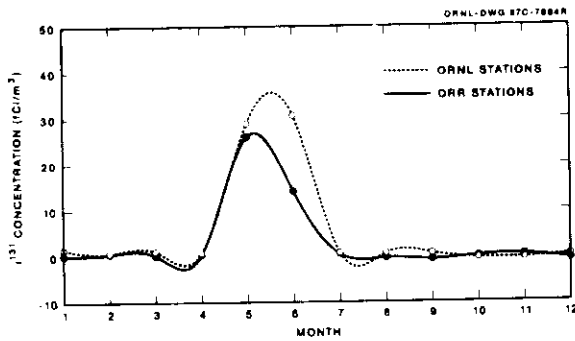


Fig. 7. 1986 concentration of iodine-131 in air at the ORNL and ORR monitoring stations.

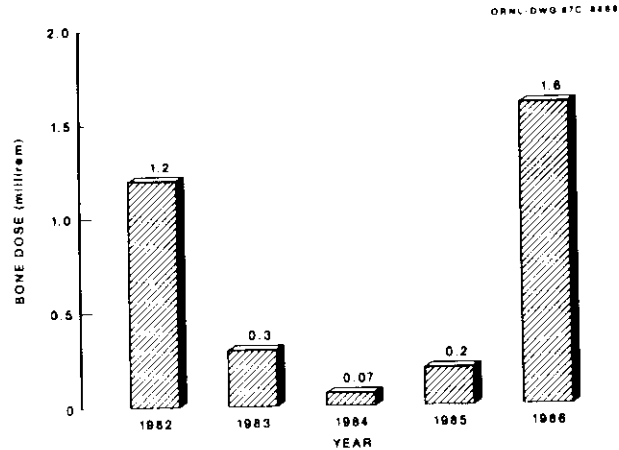


Fig. 8. Thyroid dose from milk consumption.

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 1986 the Oak Ridge Y-12 Plant, with 127 noncompliances, was 98.3% in compliance with NPDES standards (see Figs. 9 and 10); ORNL had 57 noncompliances and was 98.8% in compliance (see Figs. 11 and 12); and with 67 noncompliances ORGDP was 99.6% in compliance (see Figs. 13 and 14).

Major water pollution abatement systems that went into operation in 1986 are the Central Pollution Control Facility-II (CPCF-II) at the Oak Ridge Y-12 Plant and a new sewage treatment plant at ORNL. The CPCF-II was 99% in compliance with its NPDES permit for 1986, and the ORNL Sewage Treatment Plant was 99.1% in compliance.

**Radionuclide Discharges to Surface Streams**

In 1986, 2600 Ci of radionuclides were released to surface water areas from Oak Ridge installations, a decrease from the 3700 Ci released in 1985. The most significant contributor to the total for 1986 is

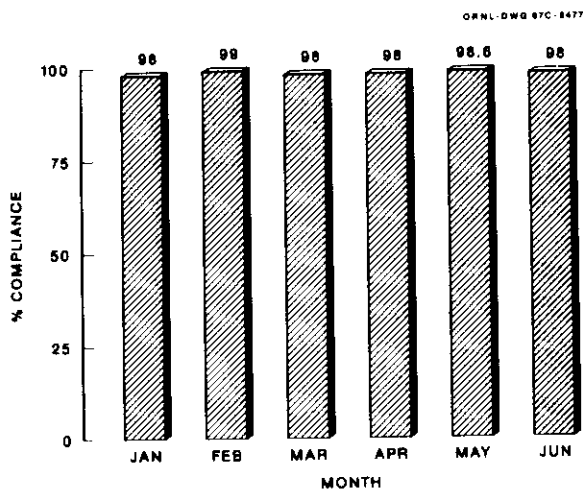


Fig. 9. Total 1986 NPDES compliance for the Y-12 Plant, January-June.

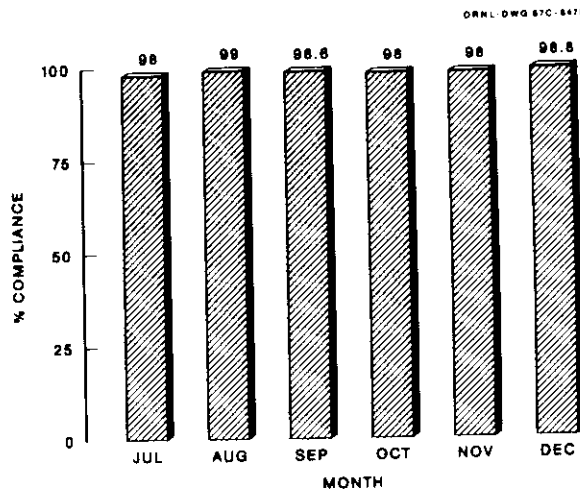


Fig. 10. Total 1986 NPDES compliance for the Y-12 Plant, July-December.

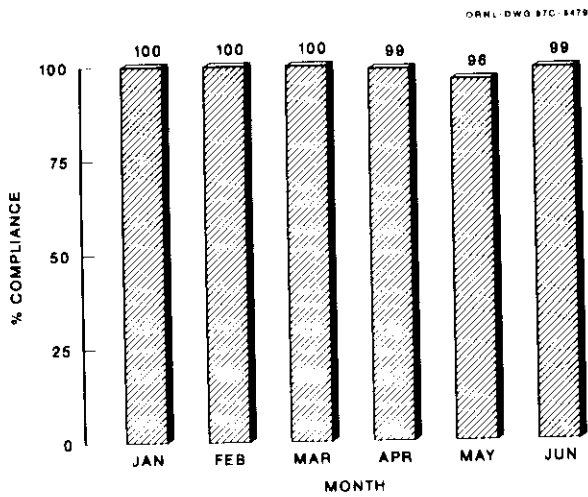


Fig. 11. Total 1986 NPDES compliance for ORNL, January-June.

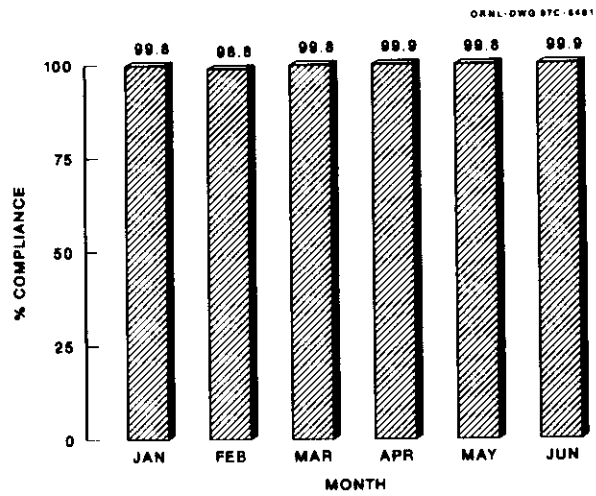


Fig. 13. Total 1986 compliance for ORGDP, January-June.

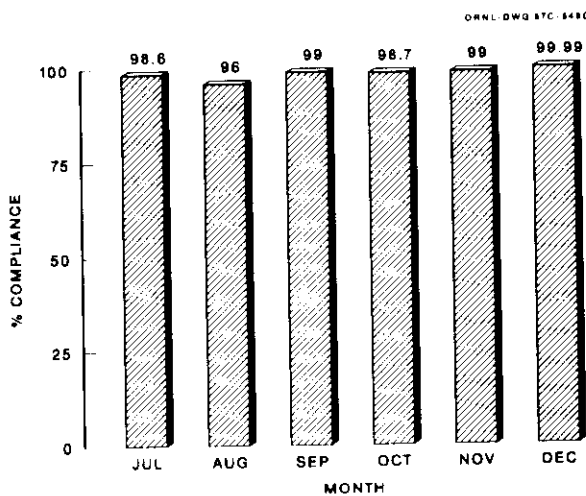


Fig. 12. Total 1986 NPDES compliance for ORNL, July-December.

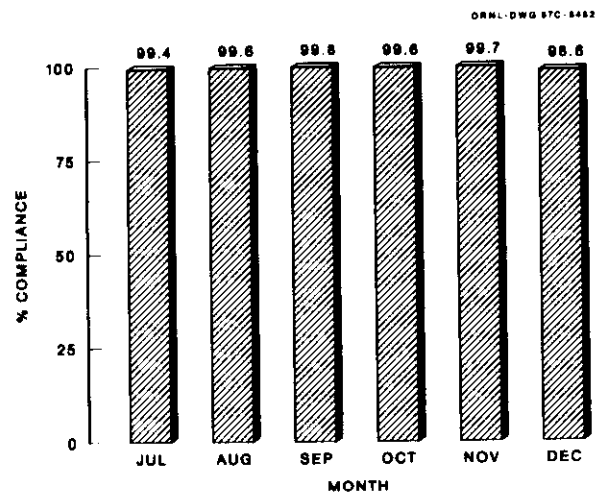


Fig. 14. Total 1986 compliance for ORGDP, July-December.

tritium, 2600 Ci, as compared with 3700 Ci released in 1985. This downward trend, which began in 1984 (see Fig. 15), results from decreases in precipitation for the period, and possibly from decreases in the source of tritium buried on site at ORNL.

### GROUNDWATER

There are approximately 1400 wells on the ORR divided into 5 main functional locations. The percentages of the wells located in each of these areas are shown in Fig. 16. The measurement uses of these groundwater wells are water level, water quality, priority pollutants, and radionuclides, with the percentage of total of each shown in Fig. 17.

While analyses of groundwater samples continue to indicate elevated levels of radionuclides, lead, chromium, cadmium, mercury, silver, and selenium, these appear to be confined to concentrations on site in

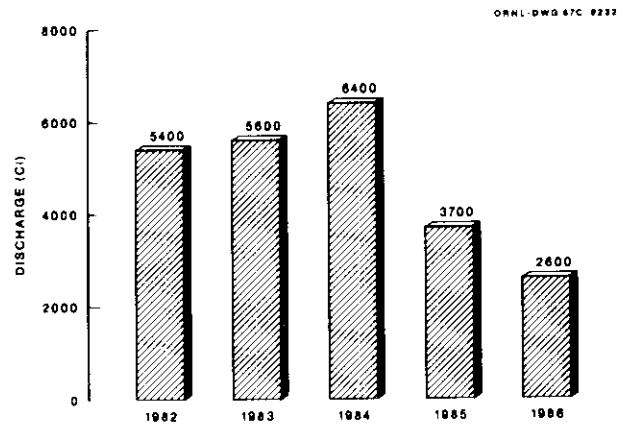


Fig. 15. Total discharges of tritium to surface waters.

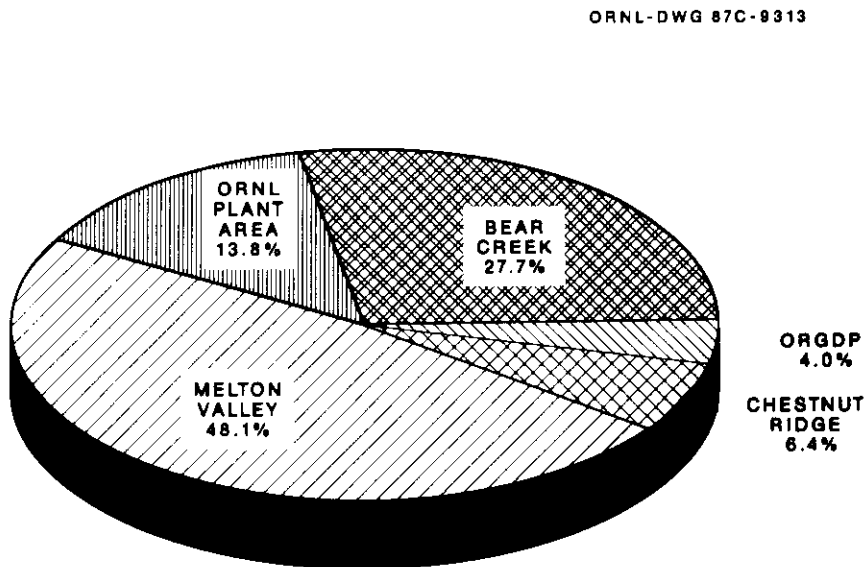


Fig. 16. Percentage of the total wells located in each area on the ORR.

the vicinity of waste disposal areas at all three installations. Results at ORNL were compared with EPA drinking water standards; parameters whose values exceeded those standards were gross alpha, radium, barium, chromium, NO<sub>3</sub>, and endrin. Parameters at ORGDP in exceedance of EPA drinking water standards were coliform, lead, and radium. Exceedances at the Oak Ridge Y-12 Plant were found for gross alpha, gross beta, nitrate nitrogen, lead, and chromium.

In 1986, all of the Oak Ridge installations came into compliance with groundwater monitoring standards of the Resource Conservation and Recovery Act.

### OTHER MONITORING

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

Fish sampling continues to show elevated levels of radionuclides, specifically cesium and strontium, and elevated levels of mercury and PCBs in Clinch River bluegill (see Fig. 18).

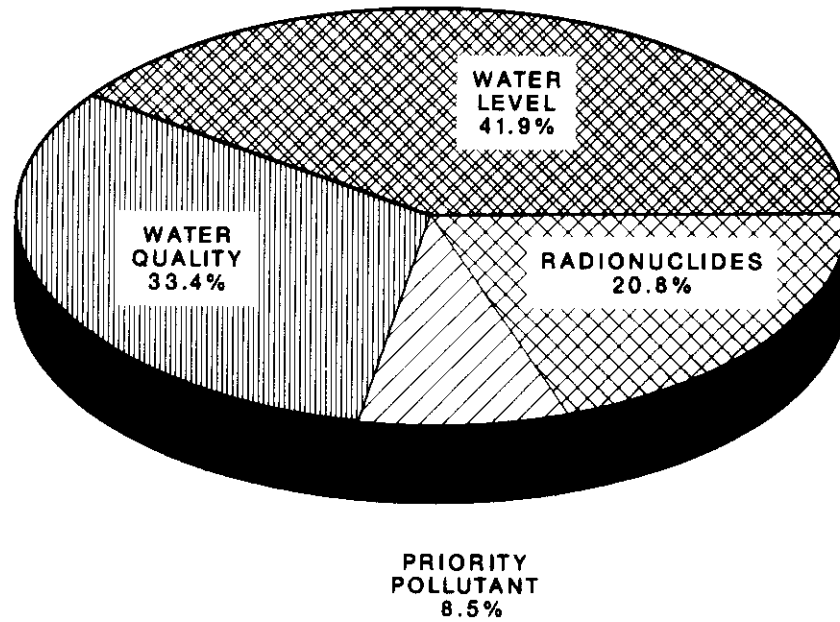


Fig. 17. Percentage of wells with water level and water quality measurements.

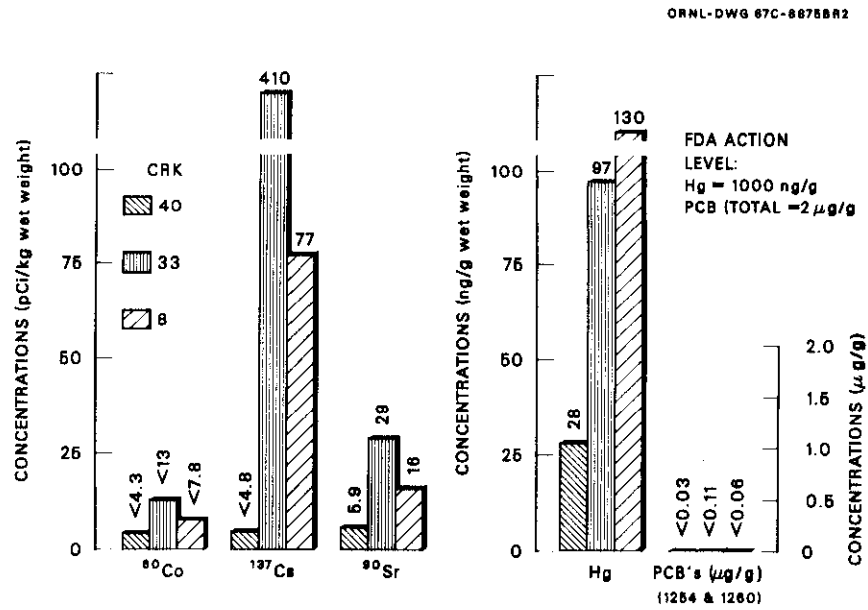


Fig. 18. Averaged sampling results for radionuclides, mercury, and PCBs in bluegill from the Clinch River.

Milk samples were collected from nine locations in the 80-km area around the Oak Ridge Reservation. Analyses for  $^{131}\text{I}$  and  $^{90}\text{Sr}$  were conducted and were compared with Federal Radiation Council guidelines as shown in Fig. 19.

Migratory waterfowl (Canada geese) were analyzed for concentrations of  $^{90}\text{Sr}$  in muscle and bone. The geese were collected from a low-level radioactive equalization basin (3524) at ORNL and from two control ponds on the Oak Ridge Reservation (see Fig. 20). Methods of preventing the geese from nesting near low-level radioactive basins are being investigated.

During the 1986 deer hunts, 660 deer were harvested on the Oak Ridge Reservation in October, November, and December. Each hunter's harvest was analyzed for gamma emitters and  $^{90}\text{Sr}$ . More than 90% of the deer had concentrations less than 0.5 pCi/g, and only 1% had concentrations greater than 1 pCi/g. The maximum concentration observed was 1.2 pCi/g. Twenty-nine deer had levels of 30 pCi/g or greater of  $^{90}\text{Sr}$  in bone, which is the retention level. The highest  $^{90}\text{Sr}$  concentration in deer that were retained from hunters was 810 pCi/g. Elevated  $^{131}\text{I}$  levels that resulted from the Chernobyl accident are shown in Fig. 21. Sources of  $^{90}\text{Sr}$  have been identified, and corrective actions (fencing and removal of vegetation) are to be completed by early fall of 1987. 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, as shown in Fig. 22.

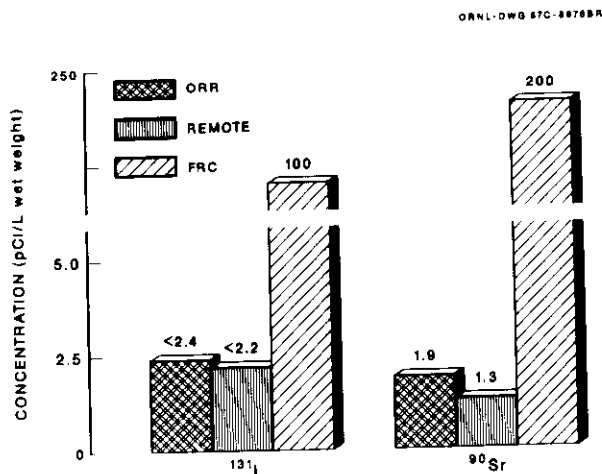


Fig. 19. Averaged  $^{131}\text{I}$  and  $^{90}\text{Sr}$  concentrations in raw milk obtained near the ORR and remote from the ORR compared with the FRC guidelines for milk consumption.

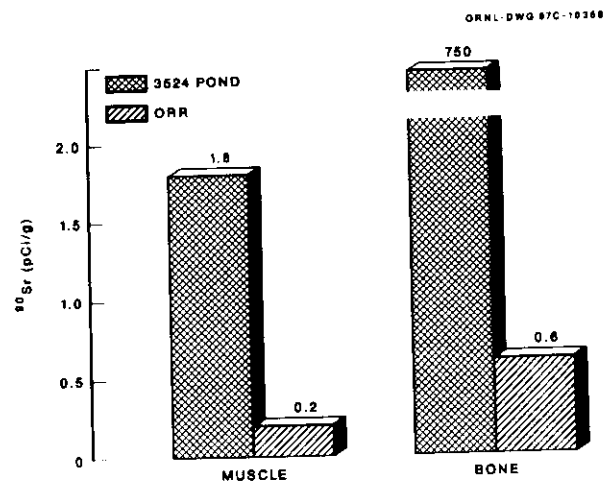


Fig. 20. Concentrations of  $^{90}\text{Sr}$  in the muscle and bone of Canada geese.

### Vegetation Sampling

Grass samples are collected at 36 locations, both on the Oak Ridge Reservation 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, are collected from six locations around ORGDP and analyzed also for uranium and  $^{99}\text{Tc}$  concentrations. Slight elevations in  $^{90}\text{Sr}$ ,  $^{234}\text{U}$ ,  $^{235}\text{U}$ , and  $^{238}\text{U}$  were observed on site as compared with remote sampling analyses. These elevated concentrations arise from airborne releases from plant operations.

### Soil Sampling

Soil sampling data are generally parallel to data for vegetation samples. Sampling locations for soils are in close proximity to those for vegetation. In sampling for fluorides, the highest concentrations were found



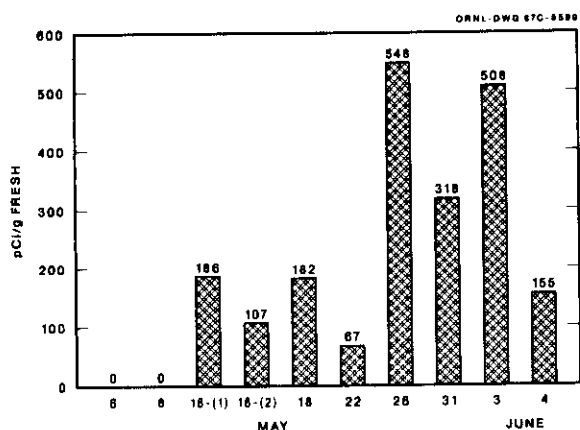


Fig. 21. Iodine-131 in deer thyroids.

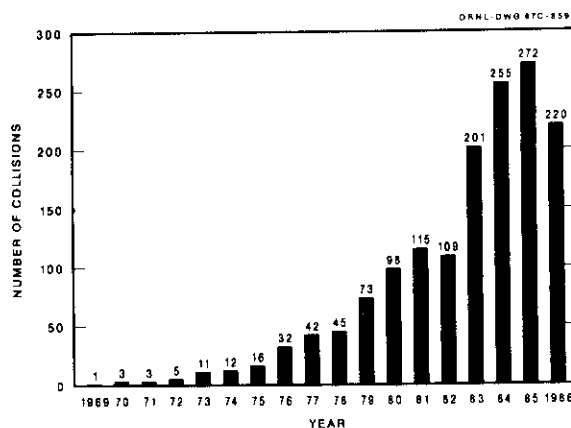


Fig. 22. Deer-vehicle collisions on the ORR.

in soil from station S19K, which is on the southeast end of ORGDP ( $880 \mu\text{g/g}$ ). Concentrations in both soil and vegetation are variable, and correlations between releases and concentrations in soils and vegetation have not been determined.

### Sediment Sampling

Sediment samples were collected twice during 1986 from each of eight locations in Poplar Creek, East Fork Poplar Creek, and the Clinch River. Analyses were conducted for mercury, nickel, lead, chromium, aluminum, and uranium.

Concentrations of mercury, nickel, and chromium in the Clinch River samples were lower than in samples from Poplar Creek. Concentrations in sediments vary widely according to time and place, and as a result, analyses are inconclusive.

The highest concentrations of uranium, chromium, nickel, lead, and mercury were found in Poplar Creek sediment.

### COMMUNITY MONITORING

During 1986, private property and East Fork Poplar Creek floodplain sampling continued, and water from off-site groundwater wells was analyzed. Samples were taken at the East Fork Poplar Creek locations shown in Fig. 23. Levels and depth of contamination at the four locations are shown in Fig. 24.

Groundwater sampling at the Kingston and Harriman areas revealed only background concentrations of  $^{90}\text{Sr}$ , mercury, and PCBs, indicating no contamination at the sampling sites.

### RADIATION DOSE TO THE PUBLIC

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

The total exposure (50-year committed effective dose equivalent) of the entire population within 80 km of the three installations is given in Fig. 25. The dose equivalent from natural radiation for this same population is also shown in Fig. 25. The whole-body, effective, and target organ doses from various pathways are shown in Figs. 26 through 28.

#### Whole-Body Doses from Direct Radiation

The whole-body dose equivalent from external gamma exposure in Tennessee, U.S. average, around ORNL, on the ORR, at remote locations, and around the Clinch River is given in Fig. 29. The average

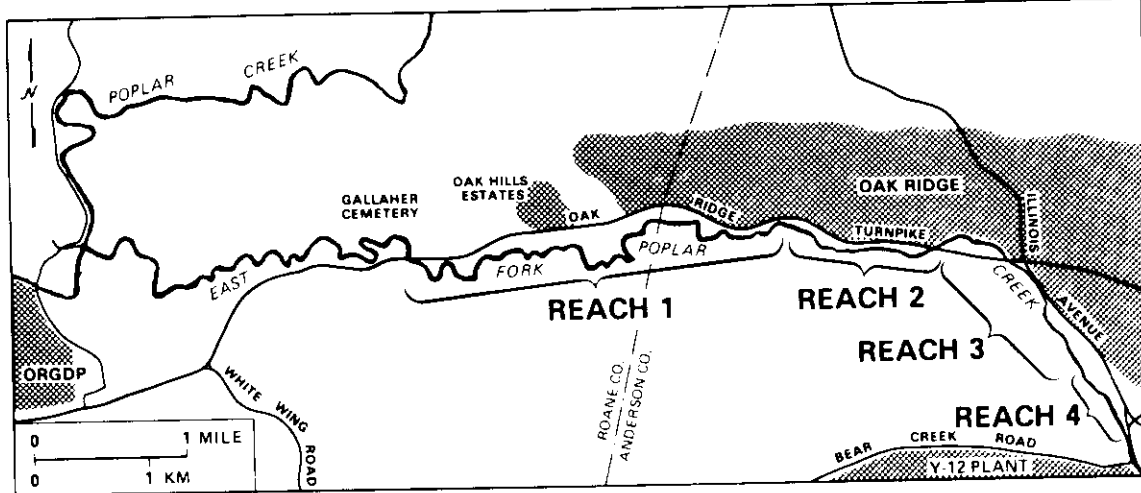


Fig. 23. EFPC and its subdivisions.

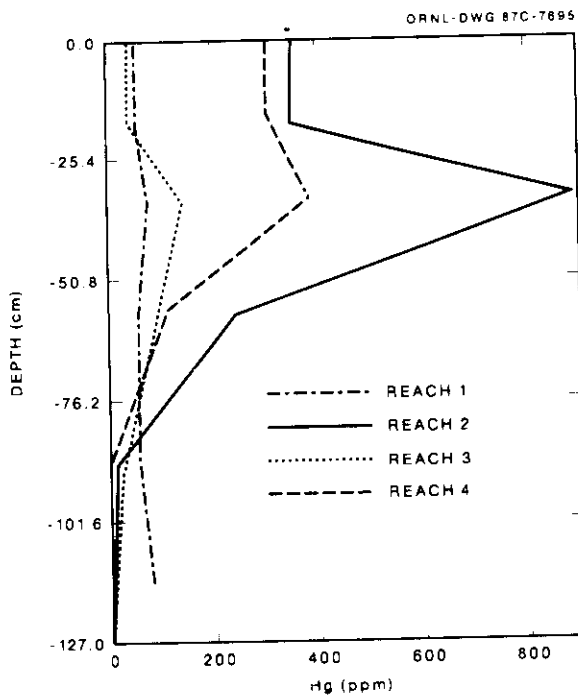


Fig. 24. Levels of contamination and depth of contamination at four locations (reaches) of EFPC.

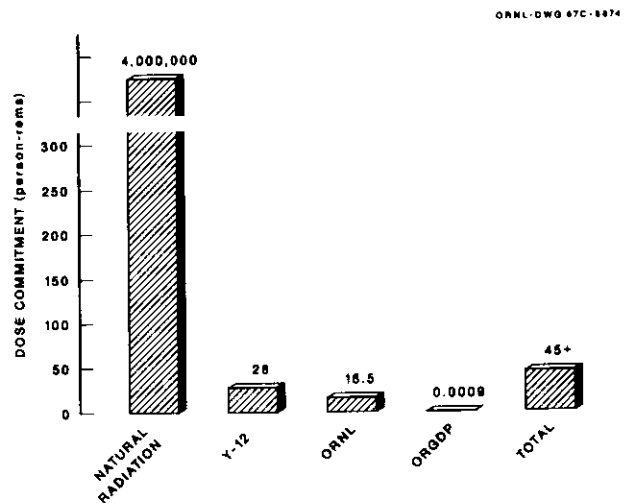


Fig. 25. The 50-year committed effective dose equivalent of the entire population within 80 km of the three installations.

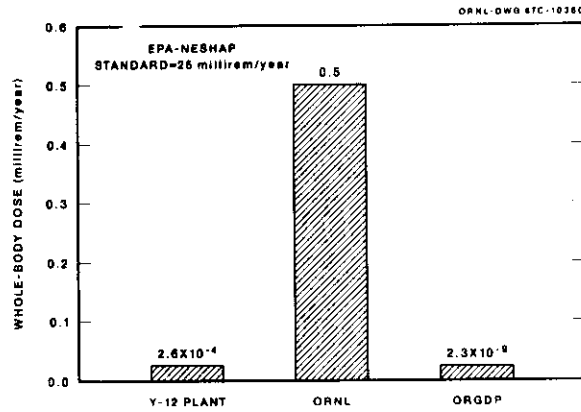


Fig. 26. Whole-body dose from inhalation pathway from ORR discharges.

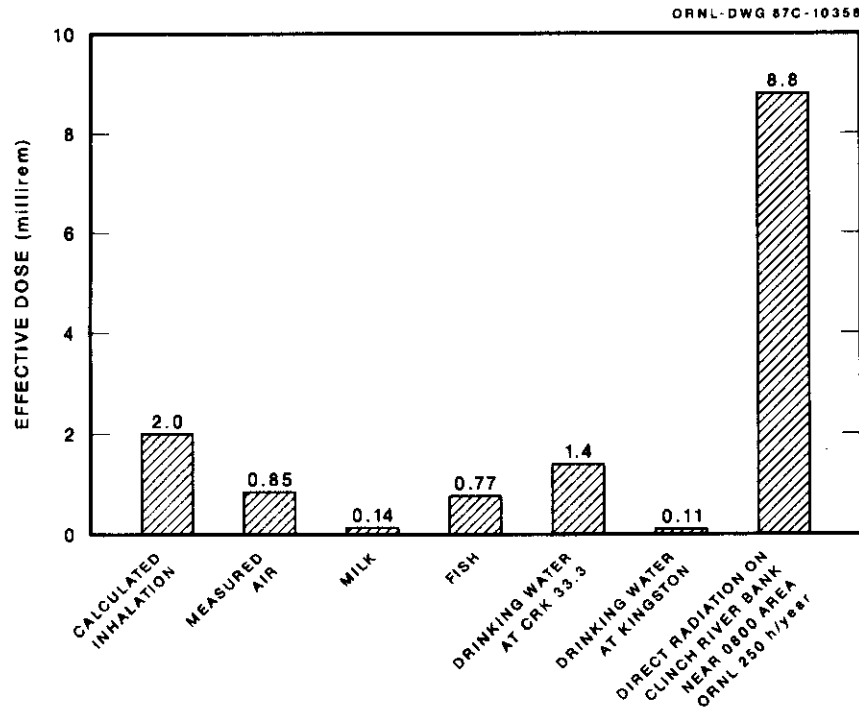


Fig. 27. Effective dose from various pathways from ORR discharges.

background external gamma exposure in various states and U.S. averages are given in Fig. 30, and cosmic terrestrial, and total exposures are shown in Fig. 31.

### CHEMICAL DOSE TO THE PUBLIC

In 1986, as in previous years, analyses were conducted for surface water, groundwater, and air, comparing the calculated daily intake to EPA standards for acceptable daily intake. Surface water was analyzed for mercury, chromium, beryllium, silver, lead, nickel, cadmium, and thorium. Exceedances for groundwater were found in lead, chromium, cadmium, mercury, and silver.

ORNL-DWG 87C-10359

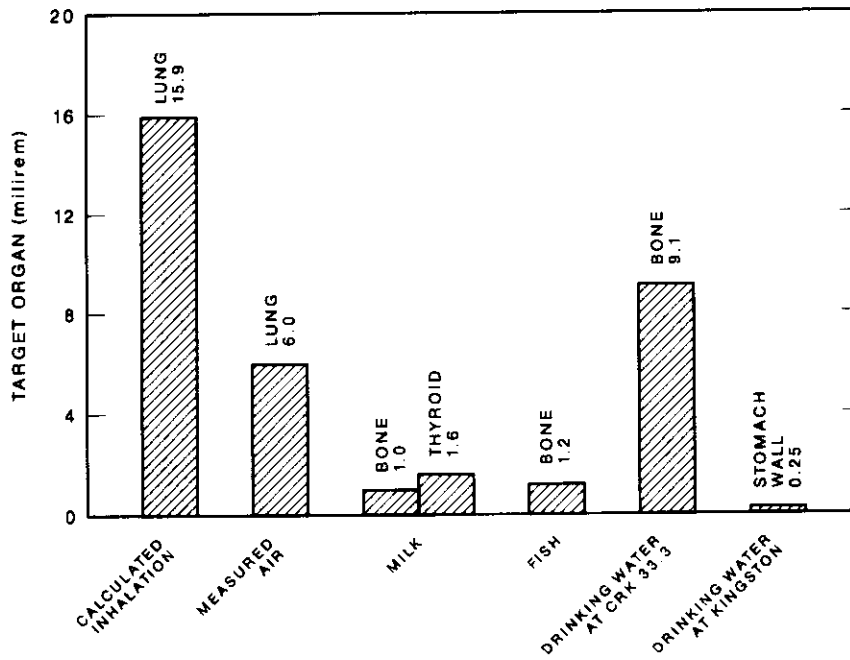


Fig. 28. Target organ dose from various pathways from ORR discharges.

ORNL-DWG 87C-9317A

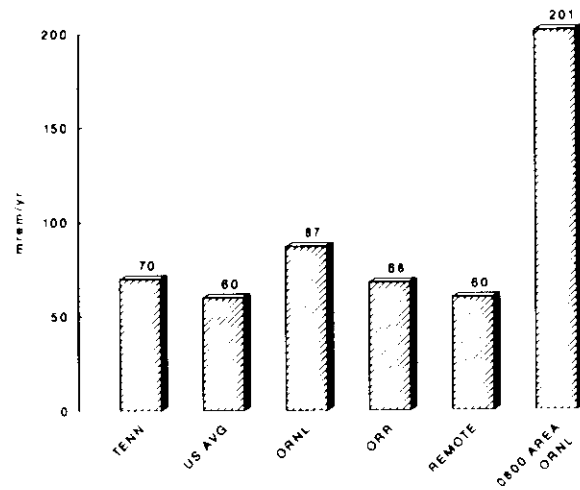


Fig. 29. East Tennessee external gamma exposure.

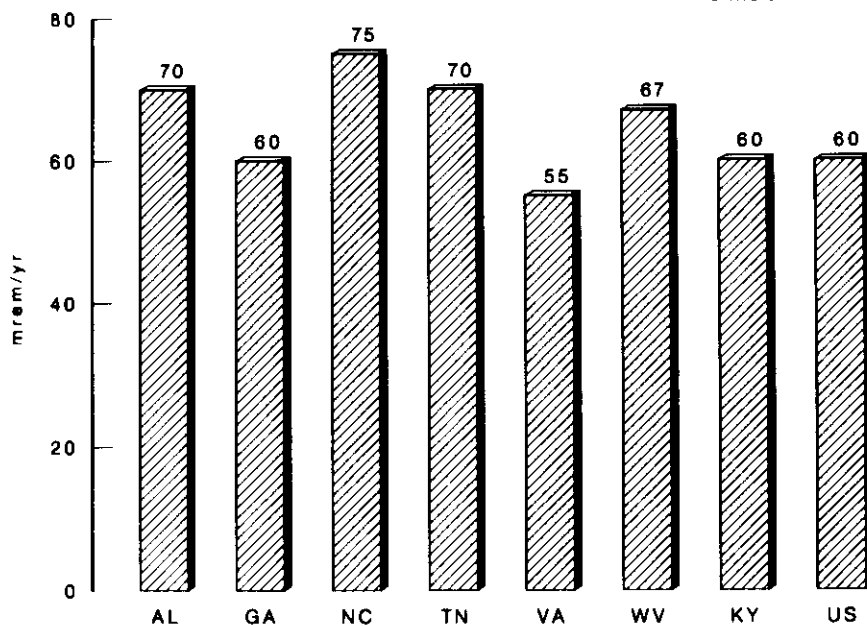


Fig. 30. External terrestrial gamma exposure.

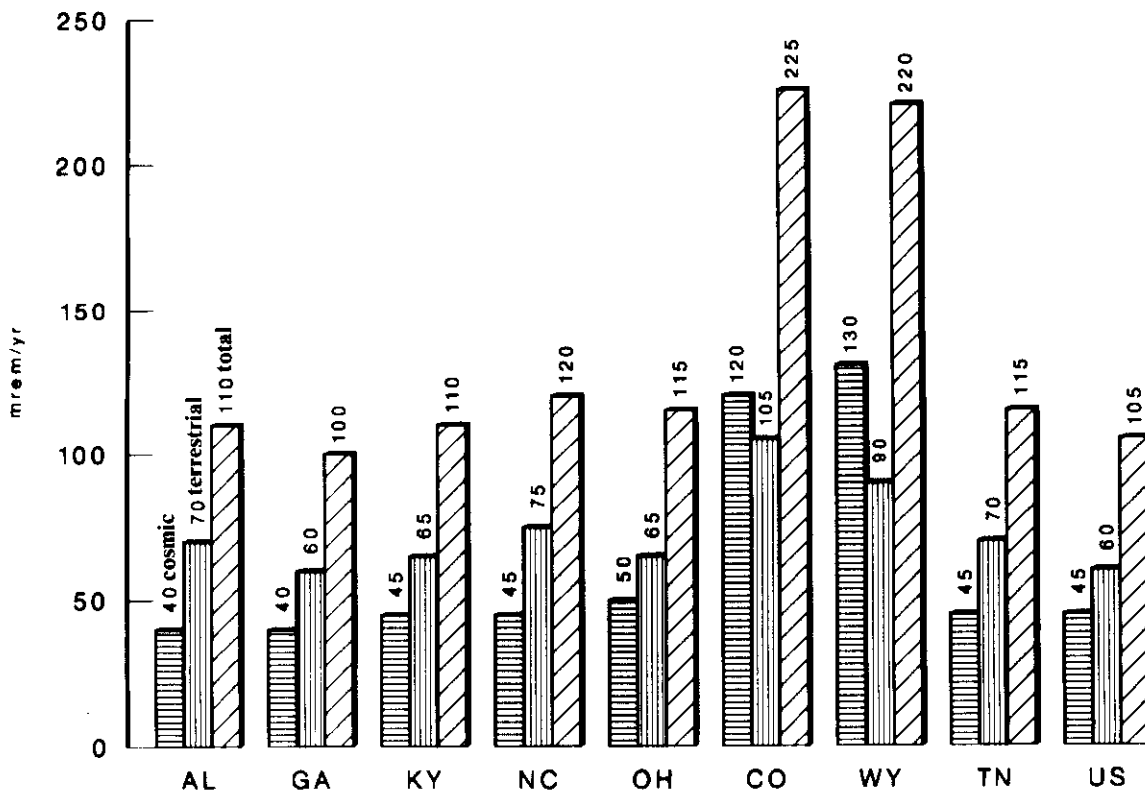


Fig. 31. External cosmic, terrestrial, and total gamma exposure.

## 1986 ENVIRONMENTAL SURVEILLANCE AND EFFLUENT MONITORING HIGHLIGHTS

### Notice of Violation—Tennessee Department of Health and Environment

Notices in the first three quarters of 1986 for excess opacity emissions resulted from hot standby firings of Oak Ridge Y-12 Plant steam plant boilers. At a "show cause" hearing on August 7, 1986, plant personnel presented a plan and schedule to convert the steam plant to natural gas ignition and thus eliminate the opacity problem. The conversion of the first two boilers was completed by January 19, 1987, and excess opacity emissions from hot standby firings were reduced below de minimus levels in the fourth quarter of 1986.

### Scarboro Ambient Air Monitoring Station

This station was brought on line October 1, 1986. It provided both DOE and the residents of the Scarboro community with ambient radiological information for the last quarter of 1986. The data collected from this station continue to provide feedback to DOE and the public via local meetings.

### Post-Chernobyl Radionuclide Monitoring in East Tennessee

The Russian Chernobyl-4 accident on April 25–26, 1986, released an estimated 7.3 million curies of  $^{131}\text{I}$  and 1 million curies of  $^{137}\text{Cs}$ . Many other radionuclides were also released. Air measurements made by Environmental Measurements Laboratory indicated that a portion of the radionuclides released into the atmosphere following the explosion and fire at the Chernobyl-4 reactor was transported by the Northern Hemispheric polar front westerlies at altitudes up to several kilometers. The world-wide release of radioactivity from Chernobyl led to a request for a special sampling effort to determine any local contamination resulting from that event. To prevent a disruption of routine monitoring programs, three new stations with the capability of sampling large volumes of air through particulate and iodine filters were set up. The samplers were located 30–40 m above ground level (to eliminate ground effects) at ORGDP, at Oak Ridge Y-12 Plant meteorological tower, and at the Walker Branch tower.

### ORGDP Groundwater Protection Program

Characterization well installation was completed in January, and field work was completed in February. Two reports on the hydrology at 14 waste disposal sites and the implications for groundwater monitoring were written, reviewed by TDHE and EPA, revised, and issued. A network of RCRA and CERCLA monitor wells was designed, and installation and groundwater monitoring were initiated. Construction of wells at an additional 39 sites requested by EPA and TDHE is being investigated and planned. When the hydrology of the sites is established, the well networks will be designed and installed.

### Response to NUS Audit

In 1985, an environmental audit of ORGDP was conducted by NUS, Inc. From this audit, 58 recommendations were made to improve the environmental monitoring program. By the end of 1986, actions had been taken to incorporate 57 of the recommendations into the program. The final recommendation, groundwater monitoring, is being implemented and is scheduled to be complete late in 1987.

A major NUS recommendation was to compile and upgrade existing environmental quality assurance (QA) procedures into an overall environmental QA plan, completed in December 1986, which addresses all phases of environmental data collection and analysis at ORGDP.

### **Fish Kill**

Approximately 1140 stoneroller minnows died in East Fork Poplar Creek in late November and early December. Investigation by a U.S. Fish and Wildlife Agency specialist identified the cause as the bacterium *Aeromonas hydrophila*. Outbreaks of this disease are usually brought on by environmental stresses, such as a significant temperature change, a change in pH, or overcrowding. As yet, no specific stress has been identified that could have caused the outbreak of disease.

### **Reduction of Uranium Losses**

The Metal Preparation Division at the Oak Ridge Y-12 Plant has reduced discharges of highly enriched uranium to East Fork Poplar Creek by 90% since 1981. Current efforts are expected to reduce the losses even further. Storm sewer sampling data show a reduction from an average of 1800 to 400 grams per year.

### **Mercury Reduction**

Several million liters of mercury-contaminated water are collected and discharged from buildings 9201-4, 9201-5, 9204-4, and 9201-2 at the Oak Ridge Y-12 Plant each month. The mercury is entrained in spring water that surfaces under these buildings. Funding is not currently available to fully treat this spring water. Approximately 90% of the mercury can be removed by filtration. Although this reduction is not enough to meet anticipated regulations, a filter system was installed to remove as much of the mercury as possible until funding for a highly efficient system can be obtained.

### **Oak Ridge Y-12 Plant Rad Stack Upgrade**

In October 1985, a program was undertaken to improve the monitoring and measuring of radioactive air emissions from the more than 120 process stacks at the Oak Ridge Y-12 Plant. These stacks serve equipment that processes enriched or depleted uranium. Typically, the stacks are being lengthened, monitoring platforms are being installed to allow sampling for particulate emissions, and continuous, alarmed stack sampling/monitoring equipment is being installed. In addition, EPA-approved isokinetic sampling of stacks emitting significant amounts of uranium is being aggressively pursued. Approximately 8 stacks had been so instrumented as of January; 85 stacks had been modified by August. Thirty-five breakthrough radiation stack monitors were purchased in April for installation in strategic process stacks at the Oak Ridge Y-12 Plant, and the instruments successfully passed an electromagnetic interference test in September. Installation was completed in December; testing and calibrating the instruments are being conducted.

Monitoring of uranium particulate discharges is complicated by the inability of current techniques to discriminate between uranium and radon. Testing for radon was carried out to determine whether high-efficiency particulate air (HEPA) filters remove all detectable decay daughters of radon. If this is the case, the certitude of uranium measurement in stacks equipped with HEPA filters will be significantly increased.





## SUMMARY OF 1986 ENVIRONMENTAL ACTIVITIES

### Notice of Violation—March 1986

A Notice of Violation was received following a March 18, 1986, inspection of RCRA facilities at the Oak Ridge Y-12 Plant. The inspection noted drums that were improperly labeled or closed. These conditions were immediately corrected.

### Notice of Violation—May 1986

On May 1, 1986, DOE received a Notice of Violation from TDHE for deficiencies in the operation and maintenance of solvent degreasers located at the Oak Ridge Y-12 Plant. The regulatory requirements were addressed, and corrective measures were implemented.

### Status of the New ORNL Hydrofracture Facility: Implications for the Disposal of Liquid Low-Level Radioactive Wastes by Underground Injection

From 1982 to 1984, ORNL disposed of approximately  $7.5 \times 10^5$  Ci of liquid low-level radioactive wastes by underground injection at its new hydrofracture facility.

Ultimately, regulatory and operational considerations led to the decision in early 1986 not to proceed with an underground injection control (UIC) permit application for the ORNL facility. There are no plans to reactivate the hydrofracture process. Closure will occur under both state and federal UIC regulations with the RCRA.

Nationally, because of an uncertain outlook for the disposal of wastes by underground injection, all Class I wells used for the injection of hazardous wastes are being reviewed.

### TSCA Incinerator

Construction work was completed on the TSCA incineration and offgas treatment facility in June. The initial RCRA and TSCA permit applications had been submitted in 1985. Comments on the RCRA Part B application and the TSCA permit application were received from EPA and TDHE in February, and additional comments were received from EPA in July and October. Energy Systems was assisted in responding to these comments by IT Corporation. A Notice of Deficiency regarding the TSCA application was responded to in June by IT. An NPDES permit and a Tennessee air permit were also applied for. In June, EPA requested a NESHAP document outlining the radionuclides that will be present in the facility's waste streams. This document was forwarded to DOE for approval and submission in July. A waste acceptance plan and an analytical protocol (necessary for a NESHAP permit) were completed and submitted to EPA and TDHE in September. The NPDES and air permits were received, and performance testing was begun by International Waste Energy Systems in October. Responses to EPA's comments on the NESHAP application were received in November. Responses were drawn up in December for submission in January 1987. At year's end, EPA's review of the responses to its Part B comments was not complete. EPA's trial burn is scheduled for November 1987.

### **PCB Inventory**

The *1985 Annual PCB Inventory* issued in June reported the presence of 1,302,222 kg of PCB material and PCB-contaminated waste at ORGDP as of December 31, 1985. The report was prepared to provide (1) detailed tables of PCB equipment in use and removed from service and (2) PCB wastes produced, stored, and shipped off site from ORGDP during 1985.

### **RCRA Closure of K-1070**

Past practices at ORGDP for handling hazardous waste materials called for their storage in 55-gal drums within the K-1070-D1, -D2, and -D3 drum storage dikes used for the staging, sampling, and storage of drums of waste solvents and oils. Upon completion of the K-1425 Waste Oil/Hazardous Waste/PCB Storage Facility, the use of the drum storage dikes was discontinued. A closure plan was submitted to the state proposing methods for closing the diked areas. This proposal included the removal of the hazardous waste inventory, followed by an extensive soil sampling survey and methods for closing the areas. The plan was approved May 12, 1986. The sampling results showed no RCRA-hazardous constituents in the soil, so no excavation was required. The areas were backfilled with dirt, contoured, compacted, graded, and seeded to provide proper drainage and erosion control. Upon completion of these items, a state-registered professional engineer certified that the areas were closed in accordance with the state-approved closure plan. DOE certified the closure on October 14, 1986, and submitted the certification to TDHE and EPA. The state accepted the closure on November 20, 1986. This is the first DOE-Oak Ridge Operations closure plan to be approved and completed under the RCRA rules governing hazardous waste management facilities in Tennessee.

### **Incinerator Closing**

The K-1421 incinerator was shut down because of excessive emission of particulates. If the facility is needed in the future, the problem will have to be corrected and the facility permitted before restart.

### **Waste Management Workshop**

The DOE-ORO Contractors' Environmental Protection and Waste Management Workshop was held in Oak Ridge on October 28 and 29. Workshop presentations covered current and planned environmental protection practices, monitoring programs, facilities development, and compliance activities at DOE sites. Forty-three technical papers were presented in sessions on waste minimization, biological toxicity testing, remedial actions, waste management projects, facility assessments and readiness, waste management technologies, and air emission monitoring and modeling. Registration for the workshop totaled 358.

### **New Facilities**

A contract was awarded for construction of the Plating Rinsewater Treatment Facility at the Oak Ridge Y-12 Plant and construction began in February. By August, core drillings for the foundation had been completed, all underground electrical ducts had been installed, and the 13.8-kV power line had been run to the site. By December, the majority of the engineering tests and checkout of the system had been completed.

The Central Pollution Control Facility completed its first year of operation. During 1986 the facility discharged approximately 3,720,000 L of treated effluent, produced 22,120 kg of dry solids, and generated 377 drums of sludge. Containment dikes were completed around the facility's truck unloading area in January. Construction of the Central Pollution Control Facility II, including double-contained piping, was completed on August 8. Operational compliance was demonstrated by November 14 in accordance with the schedule established in the Federal Facility Compliance Agreement.

Bids were received for the construction of the Biology Wastewater Treatment Facility, and a contractor was selected in August. The contract was cancelled in November because of the contractor's bonding problems. In December, DOE requested that Energy Systems evaluate additional alternatives to the current project plan and schedule.

The Sludge Fixation Facility at ORGL-2 was completed in December, and facility checkout will be completed in 1987. The facility fixes the sludges from K-1407-B and -C settling ponds.

The construction of the Central Neutralization Facility was completed in June and facility checkout was completed in October. The facility replaces the K-1407-A neutralization pit.

#### **Lithium Hydroxide Drum Repackaging**

Approximately 50,000 drums of LiOH were sent to ORGDP from the Oak Ridge Y-12 Plant for storage in the late 1950s. The LiOH was packaged in plastic-lined fiber drums that substantially deteriorated over the years. Because of the deterioration, it was speculated that water from an activated sprinkler system could combine with the LiOH to form a caustic solution that would be hazardous to both personnel and the environment. In view of this situation, studies were conducted in 1984 to investigate repackaging, relocation, or other alternative solutions to the potential hazard. Near-term sale of the material was ruled out for various reasons, leaving repackaging as ORO's preferred management option. This decision was made in August 1985. It was recommended that the LiOH be repackaged in polyethylene-lined Department of Transportation-approved "overpack" steel drums. Repackaging began in July 1985 and continued until September 30, 1985, when funding was interrupted. Funding was reestablished in November 1985, and repackaging was completed on September 5, 1986; 55,470 drums were repackaged.

#### **Visits**

Dana Isherwood of U.S. Senator Albert Gore's office met with environmental staff from DOE and Energy Systems on January 15 and 16 to obtain information on the Oak Ridge environmental situation, specifically as it bears on the proposed Monitored Retrievable Storage Facility.

Mary L. Walker, Assistant Secretary for Environment, Safety, and Health, DOE, visited each of the ORR installations on February 11 and 12 to gather information about the environment, health, and safety programs.

Jack E. Ravan, EPA administrator for Region IV, visited Oak Ridge on July 1 for a general tour of the waste management and environmental protection facilities.

TDHE commissioner James Word visited Oak Ridge with members of his staff on July 28 to participate in a detailed tour of local environmental projects and activities.

#### **Contaminated Scrap Metal**

A storage area for contaminated metal has been established at ORGDP. Contaminated metal from the Oak Ridge Y-12 Plant has been sorted by type and transferred to this area. By the end of the sorting period, more than 2700 tons of contaminated ferrous and aluminum metal had been transferred to ORGDP, where it was sheared and shredded to reduce its bulk. This portion of the work was completed in September. Acceptance of contaminated metal from a private firm was contracted, and shipment of the material was started in July. In all, 329 tons of contaminated metal was transferred to DOE installations under the contract. Equipment used in the project was decontaminated before it left the site. In October, three contractors were chosen to demonstrate decontamination techniques; work was initiated in November.

#### **Underground Storage Tank Inventory**

Underground storage tanks at the Oak Ridge Y-12 Plant were inventoried and described in terms of age, location, use, date out of service, responsible division, and other attributes. Data on these tanks were forwarded to EPA.

### Clean Air Act

A major effort to bring all airborne effluent permits up to date was initiated in 1983. In general, the ORGDP programs have required minimal upgrading, and significant efforts have been and are being expended at the Oak Ridge Y-12 Plant and ORNL. The Oak Ridge Y-12 Plant program was essentially up to date by October 1985 after more than 250 additional existing and new source permit applications were submitted to DOE. A detailed inventory of ORNL airborne effluent sources is under way; that study should allow a better understanding and correction of permit deficiencies. Based on preliminary results of this review and discussions with state regulators, it appears that as many as 47 new permit applications may have to be prepared.

The only new major Clean Air Act permit concern facing Energy Systems and DOE in the next few years is that associated with the stripping of Alpha-4 Building at the Oak Ridge Y-12 Plant. The release of mercury into the air during this program is likely to necessitate a PSD review, especially if roasting of scrap metal to remove residual mercury is a part of the project. The control of total site emissions to less than 0.1 ton/year (the PSD increment limit) during such a program appears to be very unlikely, even with extremely efficient treatment systems.

### RCRA/TSCA/CERCLA

Permitting of past, current, and future hazardous and PCB waste management facilities continues to be a monumental task. RCRA Part A and B permit applications and/or closure plans have been submitted for all treatment, storage, and disposal facilities. These applications are under review and minor notices of deficiencies are being received and answered in a timely fashion. As the notices are resolved, the individual facility permits will be issued by the state.

An error was uncovered in operating one facility (Solid Waste Storage Area 6) at ORNL. Contrary to previous claims, RCRA-hazardous wastes had been placed there. The facility was closed pending resolution of the problem, and revisions were made to the RCRA permit.

The primary hazardous waste efforts in 1986 were on (1) permitting the TSCA incinerator, (2) preparing post-closure applications for RCRA land units, and (3) obtaining approval for remedial action plans.

Post-closure applications for all RCRA land-based facilities will include plans for monitoring in all media (with primary emphasis on groundwater) and for corrective actions for any sources of environmental releases. A schedule for completion of these applications was developed and submitted to DOE for transmittal to the regulators.

Remedial action plans for old hazardous and radioactive waste sites are in the early stages of formulation. The plans are being developed according to DOE's CERCLA program criteria and in general provide for a five-phase program—assessments, confirmation (sampling), engineering assessments (alternative studies), remedial actions, and compliance and verification. As is evident from the sequence of program elements, the ultimate strategy cannot be finalized until the sampling program is complete. Energy Systems submitted Phase I assessments to DOE in April, and efforts are under way to provide the necessary sampling systems required by Phase II. EPA is requiring that these corrective actions be controlled through site RCRA Part B permits in accordance with the 1984 amendments to RCRA. It is anticipated that the ultimate commitment by DOE to effect corrective action will be in the form of Federal Facility Compliance Agreements.

## PREFACE

### OVERVIEW OF THE 1986 ENVIRONMENTAL SURVEILLANCE REPORT

Each year since 1972, a report has been prepared on the environmental surveillance activities for the Department of Energy (DOE) facilities in Oak Ridge, Tennessee, for the previous calendar year. Before 1972, the individual installations published quarterly and annual progress reports that contained some environmental monitoring data.

This calendar-year 1986 annual report on environmental surveillance of the DOE's Oak Ridge Reservation (ORR) and the surrounding environs reflects substantial changes in both content and organization from its predecessors. The report is divided into two volumes: *Summary and Conclusions* (Vol. 1) and *Data Presentation* (Vol. 2). The objectives of this report are to:

- Report 1986 monitoring data for the ORR and surrounding environs that may have been affected by operations on the ORR.
- Provide detailed information about the ORR.
- Provide detailed information on input and assumptions used in all calculations so that the reader could repeat these calculations.
- Integrate monitoring data and related studies in one document that is intended to highlight the information contained in hundreds of documents.
- Provide trend analyses, where possible, to indicate increases and decreases in concentrations and/or discharges.

Volume 1 contains the following sections:

- ***Executive Summary***—highlights of 1986 environmental conditions and monitoring data from each section and review of major environmental activities.
- ***Section 1: Introduction and General Information***—general information about the ORR and surrounding areas.
- ***Section 2: Summary of Sampling Methods and Data***—trends in the 1986 discharges to air and water, materials disposed of on site or shipped off site for disposal, and historic releases of uranium.
- ***Section 3: On-Site Disposal and Off-site Shipments of Waste***—data on the disposition of various hazardous wastes from all three installations, both on and off the Oak Ridge Reservation.
- ***Section 4: Airborne Discharges and Air and Meteorological Monitoring***—sources of airborne discharges, methods of monitoring those discharges, and meteorological measurements of the atmosphere.
- ***Section 5: Waterborne Discharges and Surface Water Monitoring***—various waterborne hazardous wastes, methods for monitoring surface water quality, and efforts to comply with National Pollutant Discharge Elimination System (NPDES) permit criteria.
- ***Section 6: Groundwater***—monitoring of hazardous wastes in the groundwater around the three Oak Ridge installations and methods of monitoring the groundwater and eliminating sources of contamination.

- *Section 7: External Gamma Radiation*—monitoring of radiation measurements on and near the ORR to determine the difference between natural background and levels resulting from facility operations.
- *Section 8: Biological Monitoring*—methods for determining levels of contamination in area fish and wildlife and efforts to find sources and eliminate them.
- *Section 9: Vegetation, Soil, and Sediment Sampling*—methods and findings in samplings of soil, sediment, and vegetation on the Oak Ridge Reservation and in the surrounding area.
- *Section 10: Community Monitoring*—monitoring of various parameters in the City of Oak Ridge and efforts to clean up areas of contamination.
- *Section 11: Summary of Potential Radiation and Chemical Dose to the Public*—estimates of doses from discharges.
- *Section 12: Special Studies, Unusual Occurrences, and General Reviews*—highlights of studies on monitoring, characterization, and cleanup activities that were completed and reported on in 1986. This section also provides brief reviews of unusual occurrences at the three Oak Ridge installations during 1986 and highlights the status of recommendations from the various reviews of the installations' surveillance.
- *Section 13: Summary of Quality Assurance*—highlights of the environmental monitoring quality assurance program.

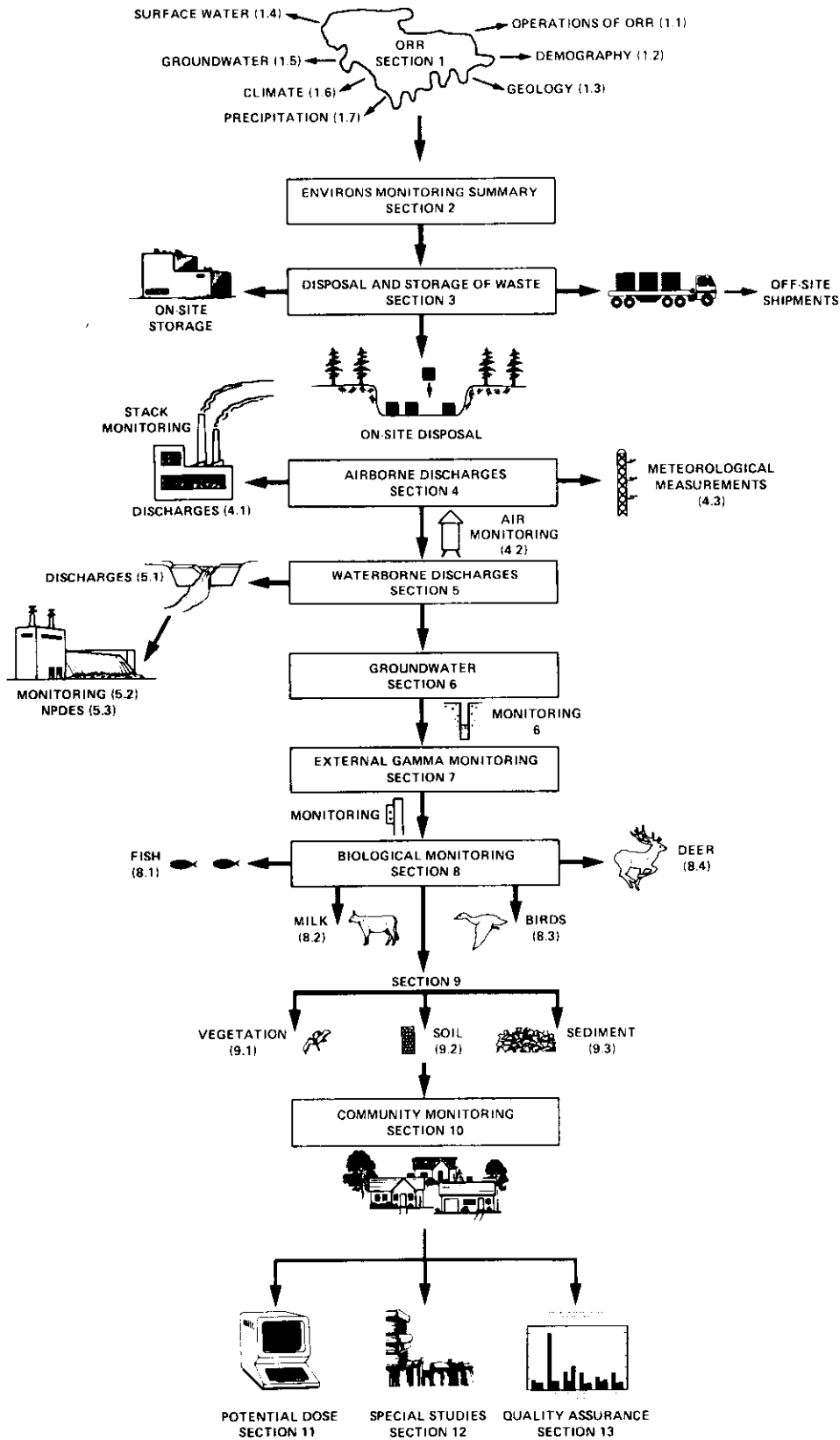
Volume 2 contains the following sections:

- *Section 1: Introduction*—detailed general information about the ORR and surrounding areas.
- *Section 2: Environmental Monitoring and Sampling Summary*—tabular data from meteorological measurements, disposals, air, surface water, groundwater, external gamma radiation, and biological, vegetation, soil, and sediment monitoring.
- *Section 3: On-Site Disposal and Off-Site Shipment of Waste*—tabular data on the amounts and kinds of hazardous waste handled at the Oak Ridge installations and methods for ensuring safe disposal of such wastes.
- *Section 4: Airborne Discharges and Air and Meteorological Monitoring*—data on the sources and kinds of airborne discharges from the three Oak Ridge installations, compiled on a regular basis.
- *Section 5: Waterborne Discharges and Surface Water Monitoring*—data on kinds and sources of waste discharges to area creeks and rivers, monitoring methods, and efforts to comply with NPDES criteria.
- *Section 6: Groundwater*—data on wastes released to the groundwater, including the construction of monitoring wells and the data gathered from them.
- *Section 7: External Gamma Radiation*—data on external gamma radiation from the installations' operations and "skyshine" from an experimental cesium plot, compared with natural background levels.
- *Section 8: Biological Monitoring*—studies of area fish and wildlife to determine levels and sources of contamination.
- *Section 9: Vegetation, Soil, and Sediment Sampling*—data derived from examination of area soils, sediment, and grasses both in and around the Oak Ridge Reservation.
- *Section 10: Community Monitoring*—data from the Oak Ridge community monitoring program and data being collected to support the Oak Ridge Task Force study and to respond to community sampling requests.

- *Section 11: Summary of Potential Radiation and Chemical Dose to the Public*—estimates of the doses from radiological discharges and radiological and chemical environmental measurements.
- *Section 12: Summary of Quality Assurance*—a summary of the internal and external quality control programs within environmental monitoring and sampling projects.

This report has been organized to flow as follows:

*Executive summary → General information on the ORR → Discharges to the environment → Monitoring data and trends → Dose calculations from these discharges → Special related studies → Quality assurance program for monitoring → Oak Ridge community monitoring.*





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## LIST OF ACRONYMS

ALARA	as low as reasonably achievable
ATDL	Atmospheric Turbulence and Diffusion Laboratory
BAT	best available technology
BCVWDA	Bear Creek Valley Waste Disposal Area
BMAP	biological monitoring and abatement plan
BMP	best management practices
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CNF	Central Neutralization Facility
CRK	Clinch River kilometer
CWA	Clean Water Act
DOE	Department of Energy
EFPC	East Fork Poplar Creek
EML	Environmental Measurements Laboratory
EP	extraction procedure
EPA	Environmental Protection Agency
FRC	Federal Radiation Council
G-M	Geiger-Müller
GDP	gaseous diffusion plant
HEPA	high-efficiency particulate air (filters)
HFIR	High Flux Isotope Reactor
LLW	low-level radioactive waste
MBAS	methylene-blue-absorbing substances
MSL	mean sea level
NAAQS	National Ambient Air Quality Standards
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NHP	New Hope Pond
NOAA	National Oceanographic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
ORAU	Oak Ridge Associated Universities
ORGDP	Oak Ridge Gaseous Diffusion Plant
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations
ORR	Oak Ridge Reservation
ORTF	Oak Ridge Task Force
PC	Poplar Creek
PCB	polychlorinated biphenyl
PW	process waste

PWTP	Process Waste Treatment Plant
QA	quality assurance
R&D	research and development
RAP	remedial action program
RCRA	Resource Conservation and Recovery Act
SDWA	Safe Drinking Water Act
SWSA	solid waste storage area
TCMP	toxicity control and monitoring plan
TDHE	Tennessee Department of Health and Environment
TRK	Tennessee River kilometer
TSCA	Toxic Substances Control Act
TSP	total suspended particulates
TVA	Tennessee Valley Authority
UIC	underground injection control
USGS	U.S. Geological Survey
VHAP	volatile hazardous air pollutant
VOC	volatile organic compound
WETF	West End Treatment Facility
WOC	White Oak Creek
WOCC	Waste Operations Control Center



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## 1. INTRODUCTION AND GENERAL INFORMATION

All of the Department of Energy's (DOE's) Oak Ridge Reservation (ORR) is located within the corporate limits of the City of Oak Ridge in eastern Tennessee. The ORR consists of about 14,440 ha (35,664 acres) of federally owned lands in this valley. 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.

### 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. Oak Ridge has a population of 28,000 within 75 km<sup>2</sup>. 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).

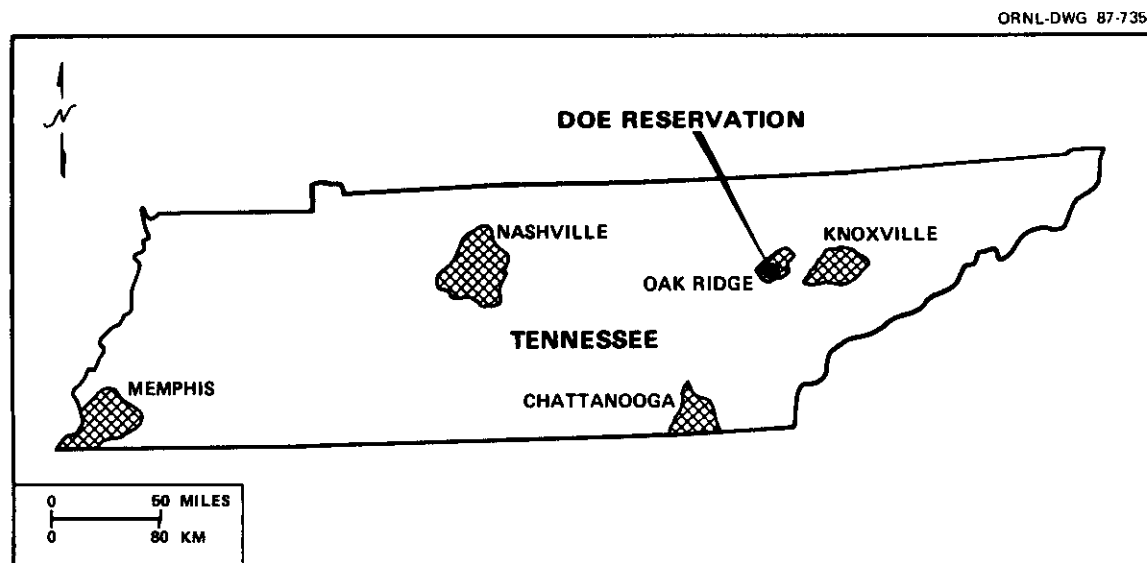


Fig. 1.1.1. Map showing the location of the Department of Energy's Oak Ridge Reservation in the State of Tennessee.

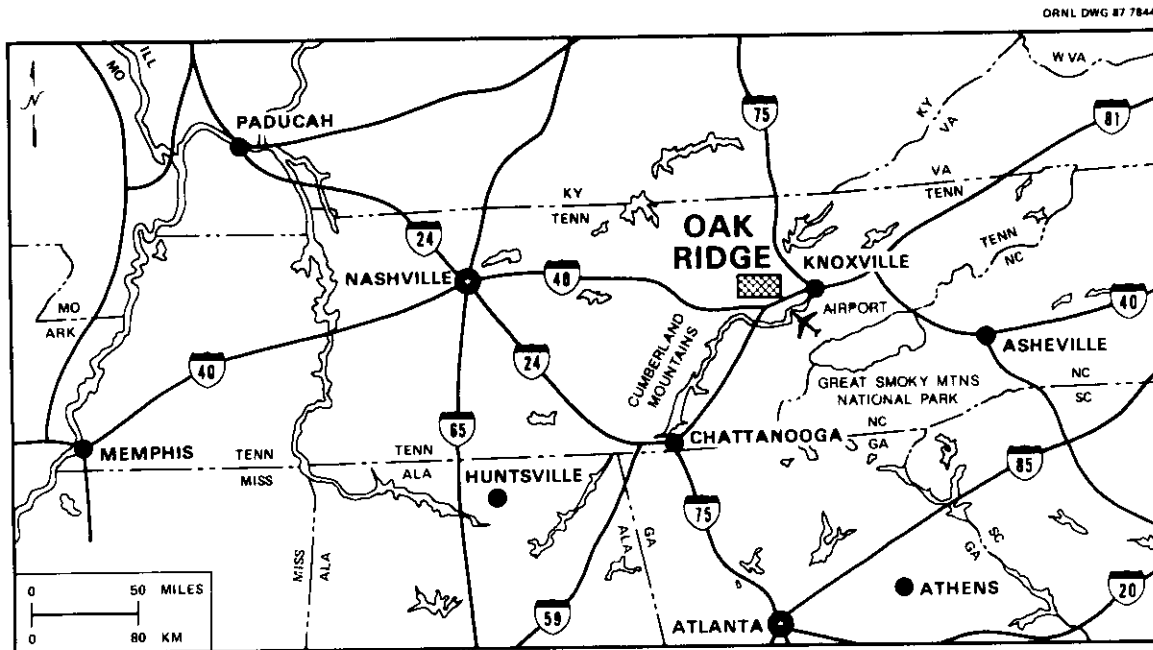


Fig. 1.1.2. Map showing location of Oak Ridge in relationship to geographic region.

The locations of these three facilities are shown on the map of the ORR (Fig. 1.1.3). The on-site 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 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 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 produce nuclear weapons components, (2) to process source and special nuclear materials, (3) to provide support to the weapons design laboratories, (4) to provide support to other Martin Marietta Energy Systems, Inc., installations, and (5) to provide support to other government agencies. Activities associated with these functions include production of lithium

compounds, recovery of enriched uranium from scrap material, and fabrication of uranium and other materials into finished parts and assemblies. Fabrication operations include vacuum casting, arc melting, powder compaction, rolling, forming, heat treating, machining, inspection, and testing.

ORNL (Fig. 1.1.5), located toward the west end of Bethel Valley, is a large, multipurpose research laboratory whose basic mission is to expand knowledge, both basic and applied, in all areas related to energy. To accomplish this mission, ORNL conducts research in all fields of modern science and technology. ORNL's facilities include nuclear reactors, chemical pilot plants, research laboratories, radioisotope production laboratories, and support facilities.

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. This is part of the overall nuclear fuel cycle, shown in Fig. 1.1.7. The gaseous diffusion process for uranium enrichment is a major part of the nuclear fuel cycle, based on the fact that lighter molecules diffuse slightly faster than heavier molecules through the walls of a porous tube



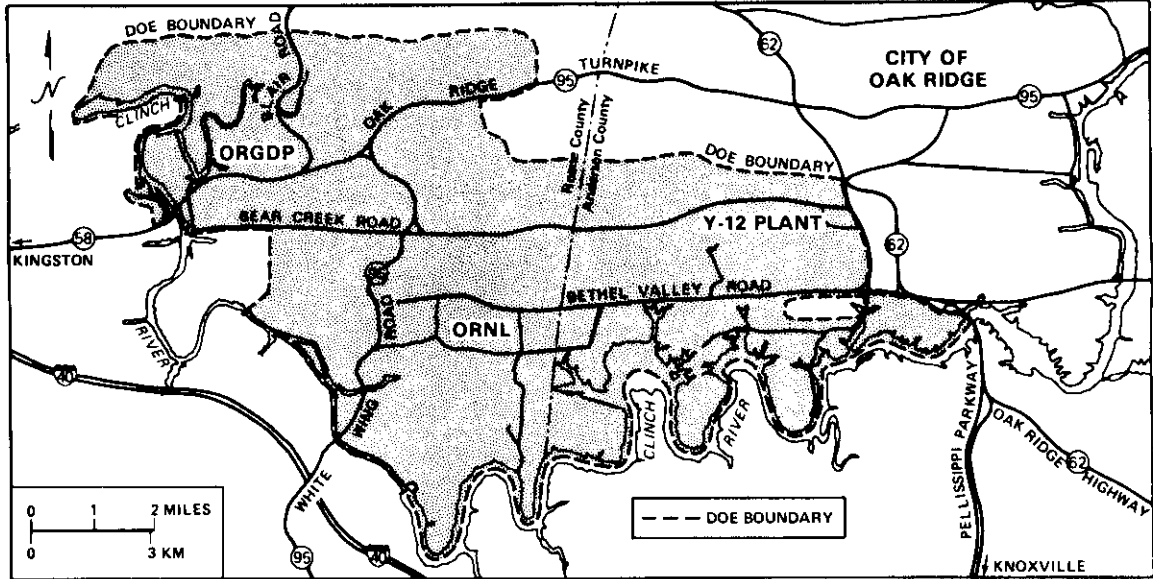


Fig. 1.1.3. Map showing the Department of Energy's Oak Ridge Reservation and the location of the three major installations.



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

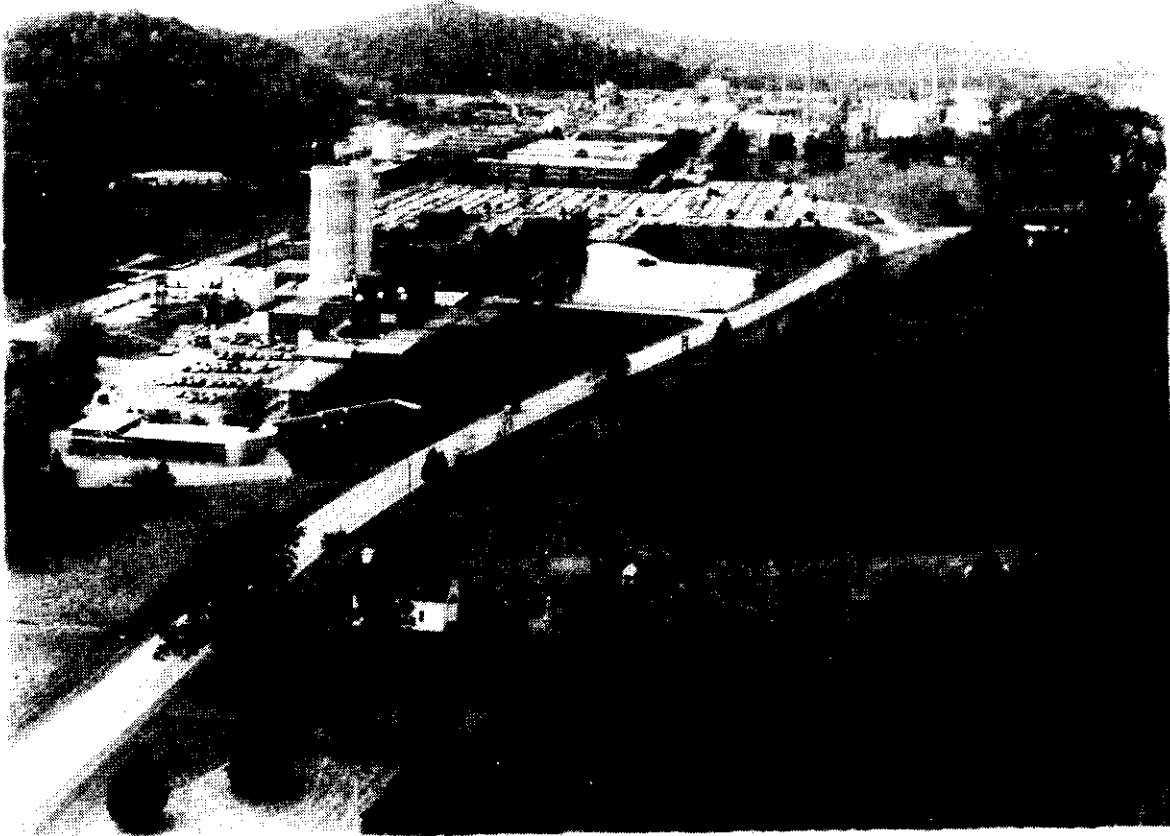


Fig. 1.1.5. ORNL (view looking west).

called a barrier. This process is shown in Fig. 1.1.8. The portion of gas passing through the barrier wall is slightly richer in  $^{235}\text{U}$ . The locations of the three U.S. gaseous diffusion plants (GDPs) are shown in Fig. 1.1.9; their interactions are shown in Fig. 1.1.10. ORGDP has now been placed in "ready standby" for possible future uranium enrichment. Other remaining missions include advanced enrichment technique research and development, various analytical laboratory programs, engineering and computer support, and various waste treatment

services. Several new waste treatment facilities are now under construction.

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, reactor operations, pilot plant operations involving radioactive materials, isotope separation processes, uranium enrichment, and uranium processing operations. Nonradioactive (including hazardous) wastes are generated by normal industrial-type support facilities and



**Fig. 1.1.6. ORGDP (view looking northeast).**

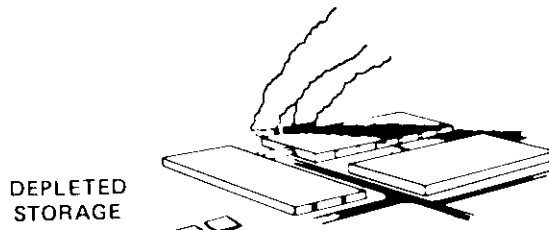
**1** **MINING**  
TYPICAL ORE CONTAINS  
ABOUT 0.11%  $U_3O_8$



**2** **MILLING**  
YELLOW CAKE ( $U_3O_8$ ) IS  
PRODUCED FROM THE ORE



**3** **CONVERSION**  
GASEOUS URANIUM  
HEXAFLUORIDE ( $UF_6$ )  
IS PRODUCED FROM  
YELLOW CAKE AND  
FLUORINE

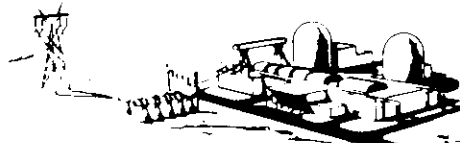


**4** **ENRICHMENT**  
URANIUM HEXAFLUORIDE  
WITH 0.711% U-235 IS  
ENRICHED TO ABOUT 3% U-235



**5** **FUEL FABRICATION**  
POWER PLANT FUEL  
PRODUCED

ELECTRICITY



**6** **POWER REACTOR**  
ABOUT 1/3 OF FUEL IN  
REACTOR REPLACED  
EACH YEAR

**SPENT FUEL**  
INTERIM STORAGE OF  
SPENT FUEL PENDING  
POSSIBLE REPROCESSING  
OR PERMANENT STORAGE



Fig. 1.1.7. Nuclear fuel cycle.

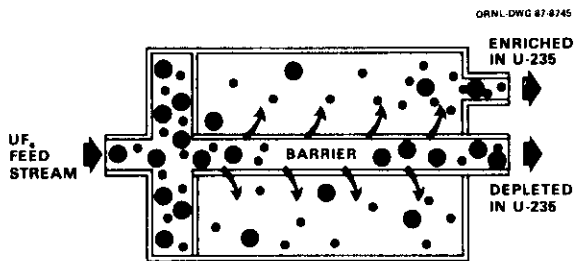


Fig. 1.1.8. Gaseous diffusion process.

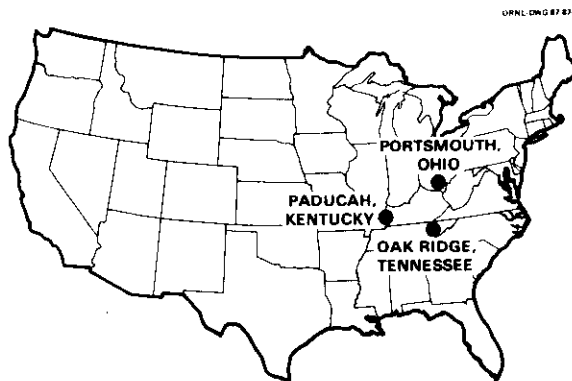


Fig. 1.1.9. Location map of the three U.S. gaseous diffusion plants.

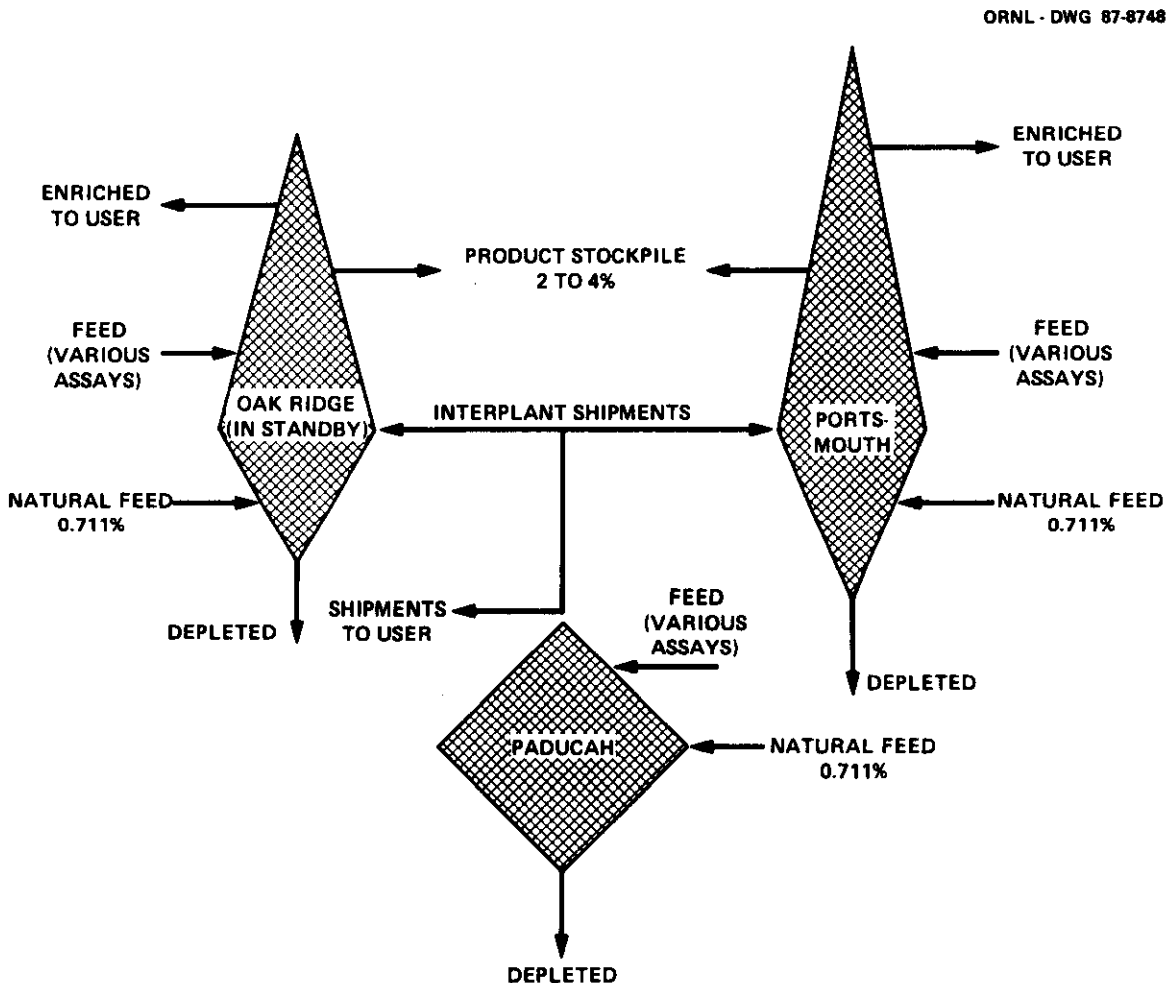


Fig. 1.1.10. Mode of interaction and operations of the three U.S. gaseous diffusion plants.

operations that include water demineralizers, air conditioning, cooling towers, acid disposal, sewage plants, and steam plants.

Nonradioactive solid wastes are buried in the Centralized Sanitary Landfill II or in designated burial areas. Hazardous wastes are shipped to approved disposal sites or stored on site. Radioactive solid wastes are buried in disposal sites 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, which may contain acceptably small quantities of radioactive or chemical pollutants, is discharged to White Oak Creek, Poplar Creek, East Fork Poplar Creek, and Bear 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 pasturage of cattle. 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. Knoxville, the major metropolitan area nearest Oak Ridge, is located about 40 km to the east and has a population of about 183,000. Directional 80-km population distribution maps, used to calculate population dose later in this section, are shown in Figs. 1.2.1 and 1.2.2. It should be noted that the center of these figures is the center of the ORR and that most of the 10-km area of these figures is the ORR. Fewer than 5000 people live within those 10 km.

## 1.3 GEOLOGY, TOPOGRAPHY, AND SOILS

### 1.3.1 Geology

The ORR is located in East Tennessee in valleys that lie between the Cumberland Mountains to the northwest and the Great Smoky Mountains to the southeast, in the Valley and Ridge Physiographic Province of the Appalachian Mountains. 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.

### 1.3.2 Topography

The entire Reservation is characterized by a rolling topography of subtle to exaggerated slopes with little or no expanse of flat land. The slopes are categorized into three ranges of relative constraint. 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 construction costs are highest. A vast amount of the ORR appears to fall within the mild 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

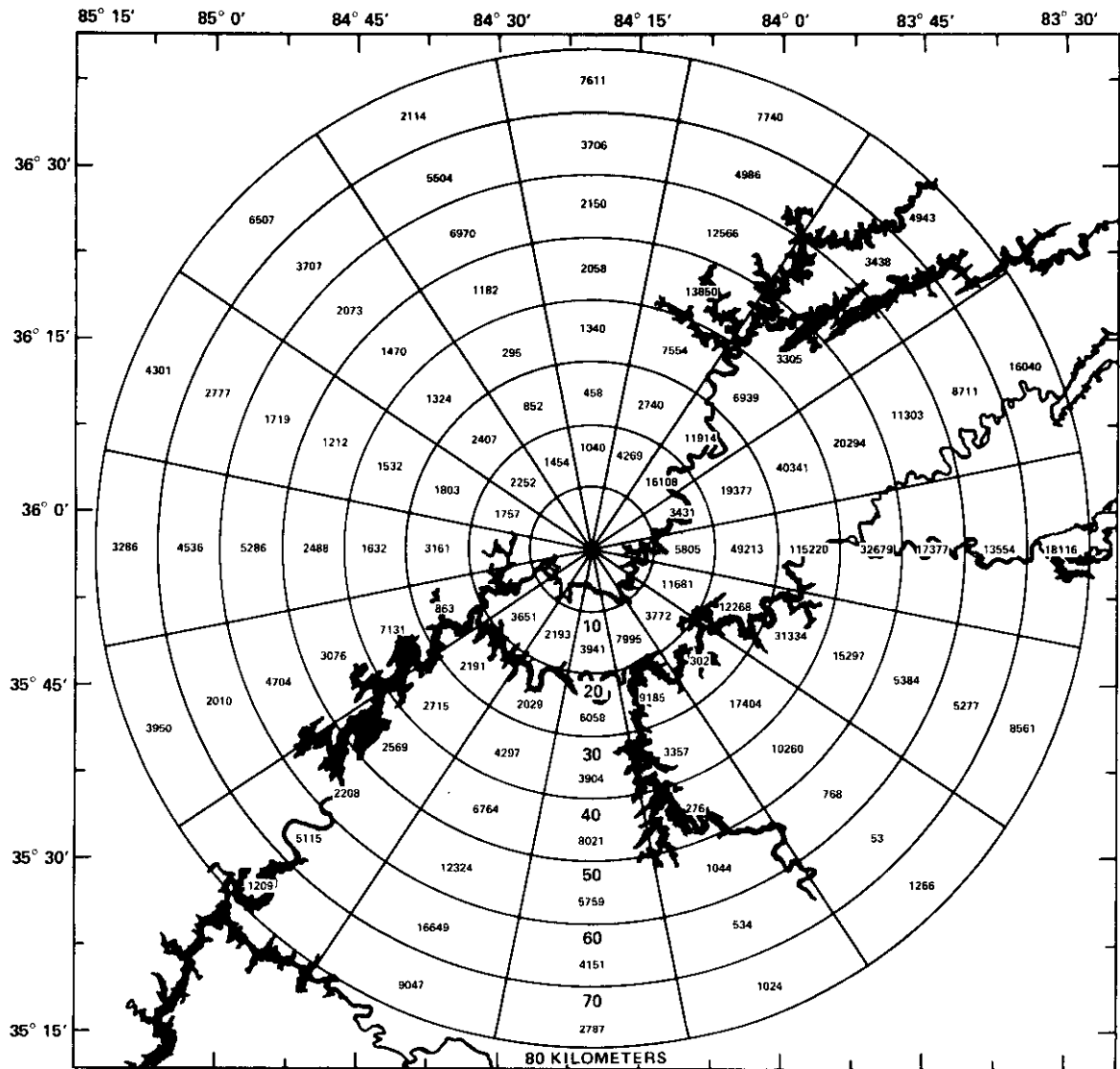


Fig. 1.2.1. Population by sector from the center of the Oak Ridge Reservation, based on 1980 census data.

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, and watershed characteristics.

##### 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

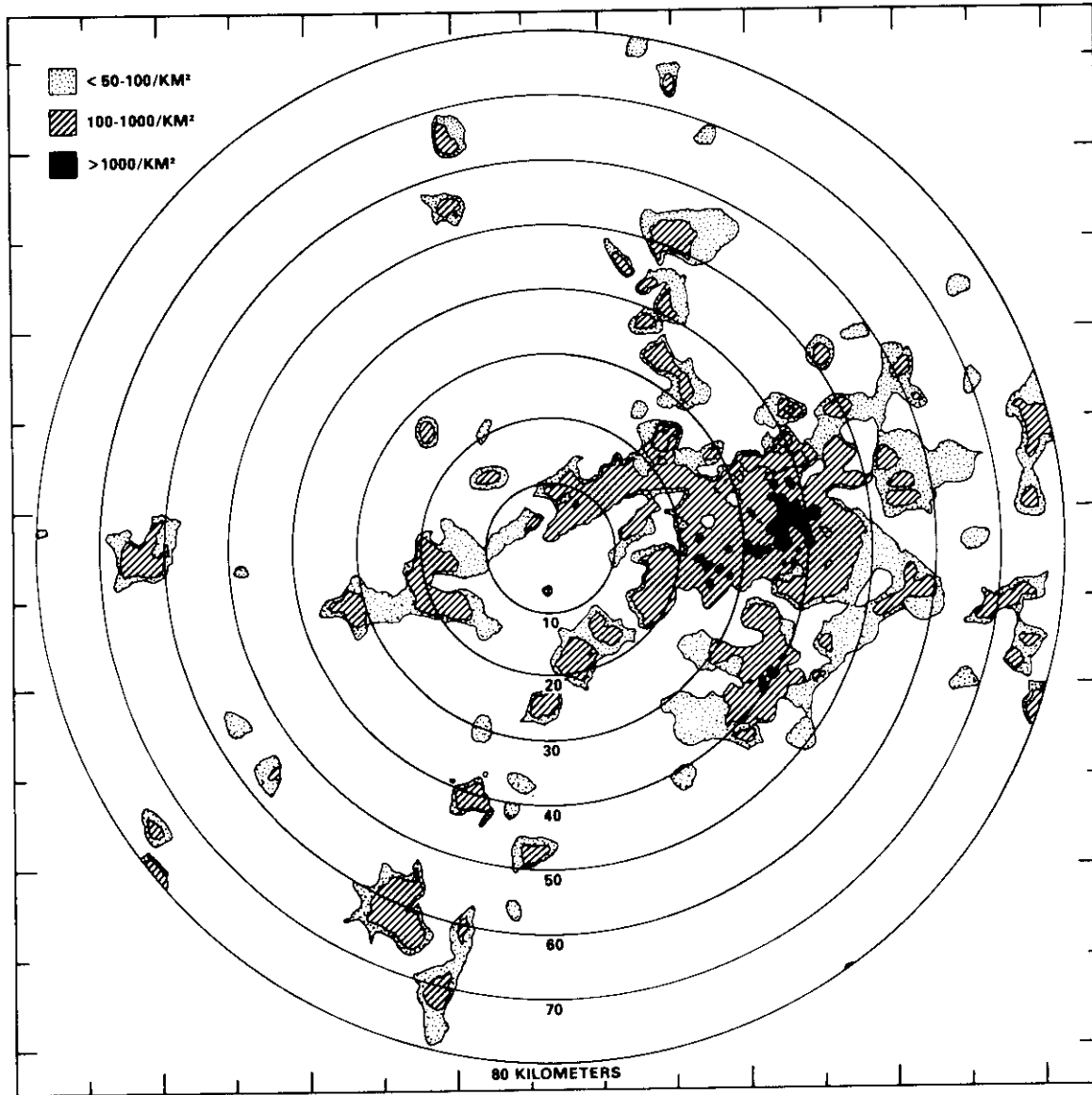


Fig. 1.2.2. Population densities by 10-km section of East Tennessee area, based on 1980 census data.

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). The water bodies are classified by use. Most of the streams on the ORR are classified for fish and aquatic life, irrigation, and livestock watering and wildlife.

#### 1.4.2 Surface Water Hydrology

Figure 1.4.1 shows the location of surface water bodies in the vicinity of the ORR. The ORR is bounded on the south and west by a 63-km stretch of the Clinch River. Melton Hill Dam is located at Clinch River kilometer (CRK) 37.2, forming the Melton Hill Reservoir. Several



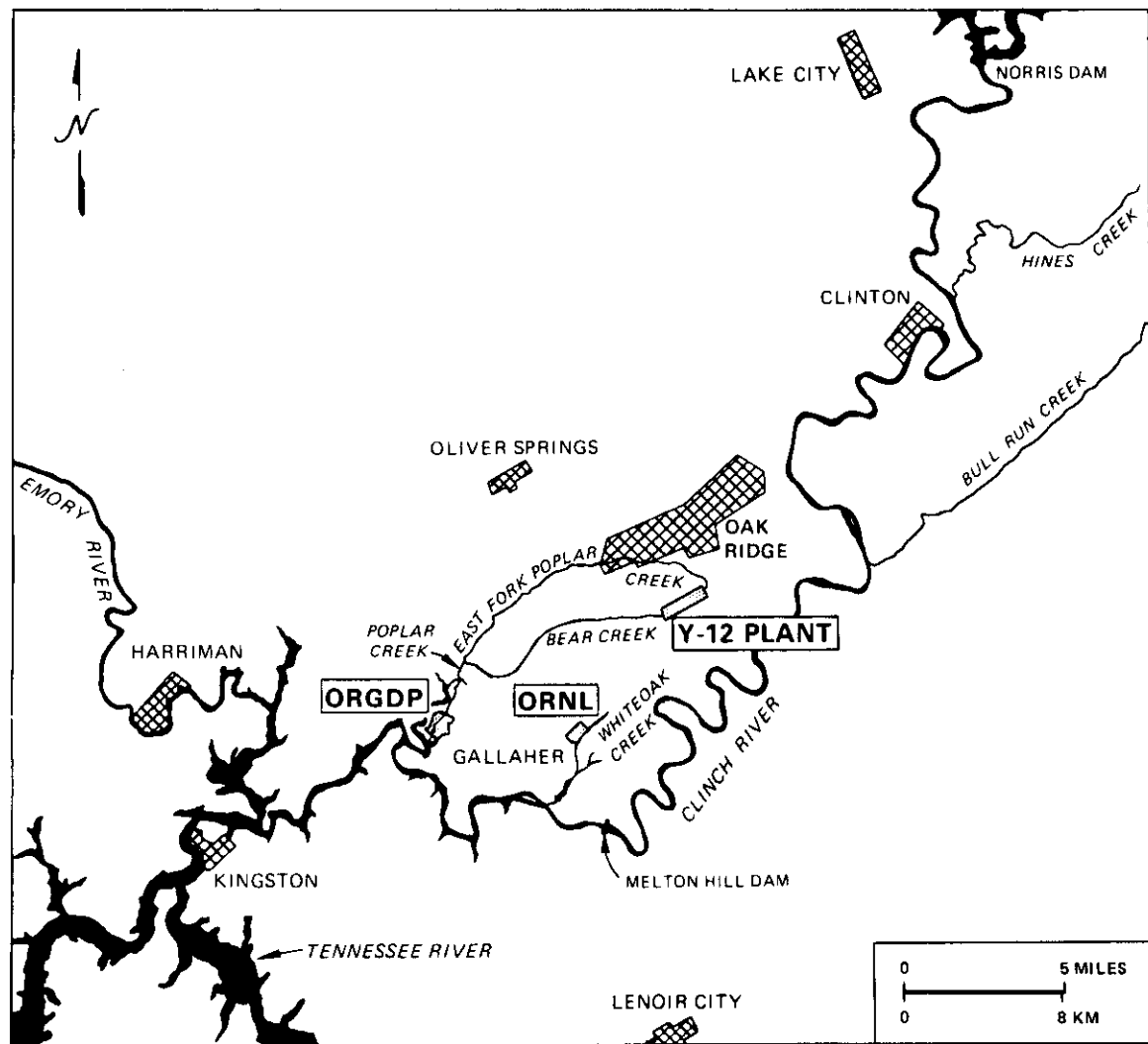


Fig. 1.4.1. Location map of major surface water bodies in the vicinity of the Oak Ridge Reservation.

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.

#### 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 nine 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, and public water supplies and the base flow to streams and rivers. Most farm use is for animals and washing. For example, one cow will consume 76L/d. This section includes discussion of groundwater occurrence in the region, local groundwater use, and geohydrologic conditions at waste disposal facilities.

### 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. The locations of some water wells in the Oak Ridge vicinity are shown in Fig. 1.5.2.

## 1.6 CLIMATE AND ATMOSPHERIC PROCESSES

Oak Ridge has a mild 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 dry and 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.

Total annual precipitation (water equivalent) is 1.36 m, including approximately 0.25 m of snowfall, with monthly precipitation peaking in January and February. Winter months are characterized by passing storm fronts of low intensity and long duration. Rainfall peaks in early winter, early spring, and again in mid-to-late summer, when heavy rains associated with thunderstorms are common. The year's minimum precipitation usually occurs in the fall. Typically in October, slow-moving high-pressure cells suppress rain and, while remaining nearly stationary for many days, provide outstandingly mild, clear, dry weather. Poor air dilution (and thus the primary air pollution episodes) occurs with the greatest frequency and severity during this period.

Oak Ridge is one of the country's calmest wind areas. Because of this, providing relief from the summer's humidity through ventilation is

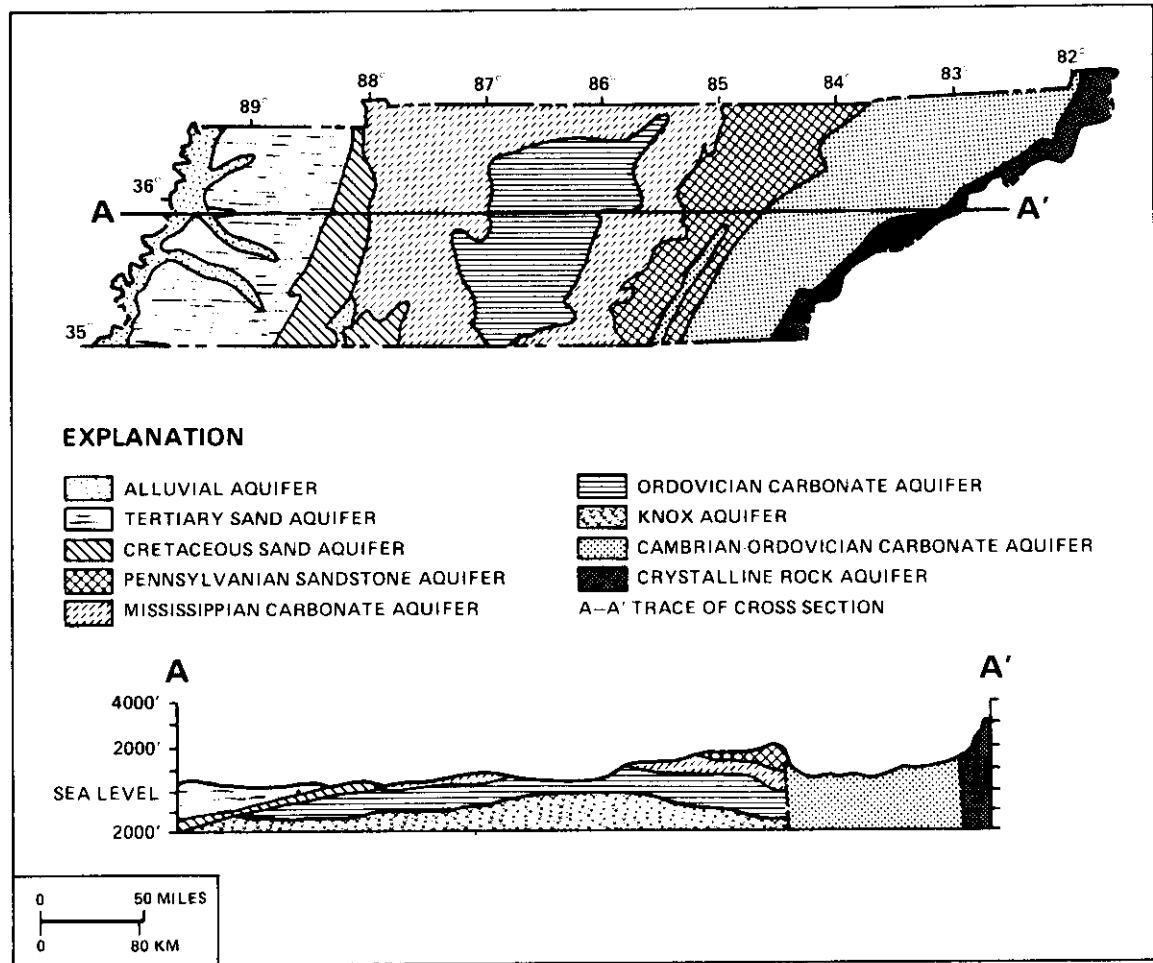


Fig. 1.5.1. Principal aquifers in Tennessee.

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. Figure 1.6.1 is an all-season wind rose for the Oak Ridge area from data collected from 1957 to 1969. Seasonal wind roses show that seasonal differences in the prevailing wind directions are insignificant, although there are differences in the frequency and speed of the seasonal winds. 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. 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. Precipitation in 1986 was 98.6 cm, about 40.5 cm short of the annual average.

ORNL-DWG 86-9141

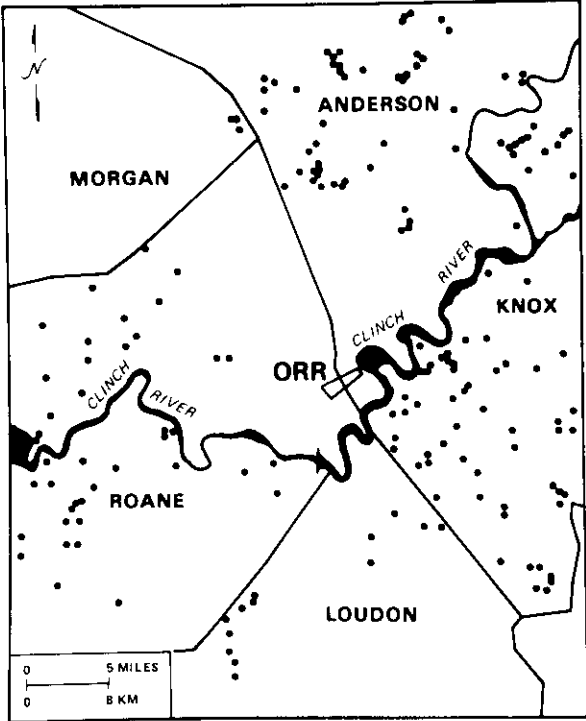


Fig. 1.5.2. Locations of water wells in the Oak Ridge vicinity.

ORNL-DWG 87C-8856

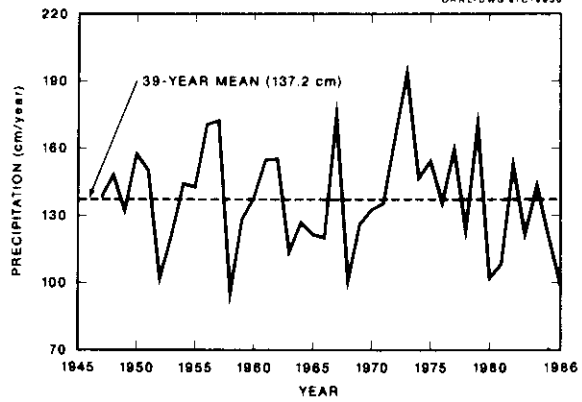


Fig. 1.7.1. Annual precipitation history of the Oak Ridge area.

ORNL-DWG 87-8700

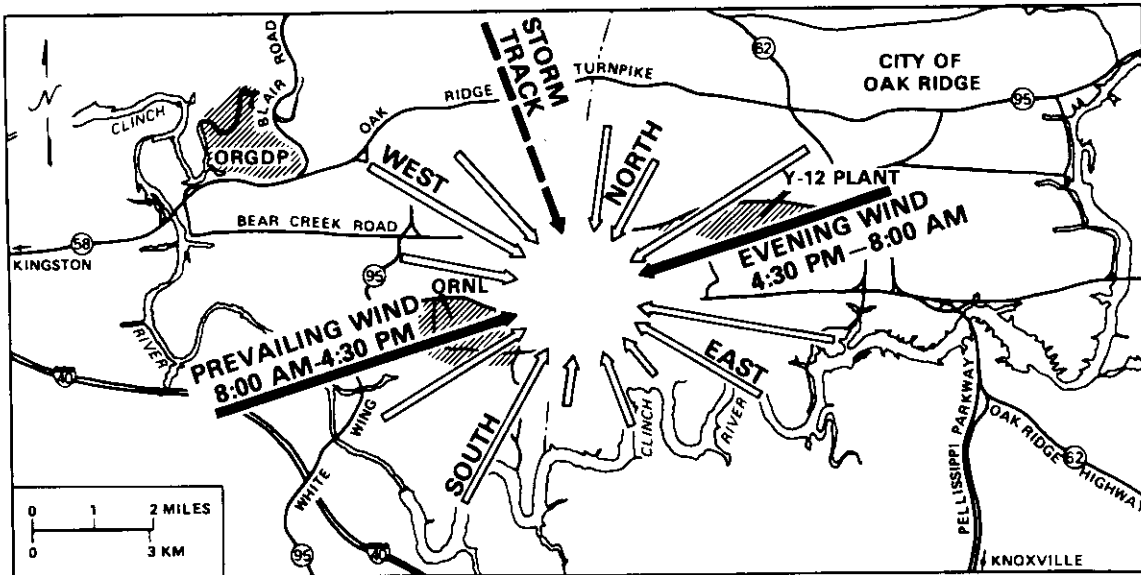


Fig. 1.6.1. Wind direction diagram depicting annual prevailing winds.

## 2. ENVIRONMENTAL MONITORING AND SAMPLING SUMMARY

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 reducing negative environmental impacts to the greatest degree practicable. Environmental monitoring information complements data on specific releases, trends, and summaries. An estimate of the number of measurements made in 1986 for each type of environmental monitoring program is given in Table 2.1. A summary of routine environmental monitoring on the ORR is given in Fig. 2.1 for a wide range of environmental media.

### 2.1 AIR MONITORING

Monitoring and sampling locations for various types of measurements are organized into eight groups:

- (1) Regional stations located at distances up to ~140 km from the ORR to provide a basis
- (2) Stations located within the ORR and in some residential and community areas to

Table 2.1. Environmental measurements in 1986

Sampling program	Number of measurements
Groundwater	94,000
Surface water	
NPDES	113,000
Non-NPDES	48,000
Continuous	666,000
Total surface water	827,000
Air	
Ambient SO <sub>2</sub>	18,000
Ambient fluoride	1,000
Ambient TSP	1,000
Radionuclide	7,000
Total air	27,000
Meteorological	929,000
Stream sediment	17,000
Soil	250
Grass	250
Pine needles	25
Milk	16
External gamma	140
Community sampling	24,000
Grand Total	~1,930,000

for determining conditions beyond the range of potential influence of these installations.

ORNL-DWG 87C-10357

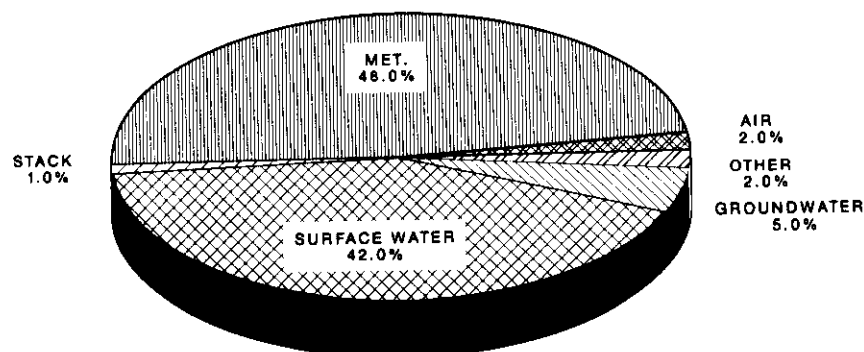


Fig. 2.1. Percentage of total samples in each medium (2 million, total).

- document conditions in areas occupied and visited by the public and potentially affected by these installations.
- (3) Perimeter stations located on the boundaries of ORGDP to document conditions in areas on its boundaries.
  - (4) On-site stations located on ORGDP areas accessible only to employees or authorized visitors.
  - (5) Perimeter stations located on the boundaries of ORNL to document conditions in areas on its boundaries.
  - (6) On-site stations located on ORNL areas accessible only to employees or authorized visitors.
  - (7) Perimeter stations located on the boundaries of the Oak Ridge Y-12 Plant to document conditions in areas on its boundaries.
  - (8) On-site stations located on Oak Ridge Y-12 Plant areas accessible only to employees or authorized visitors.
- Station ID, location, and reference to location maps are given in Table 2.1.1.

Table 2.1.1. Air monitoring stations<sup>a</sup>

Station ID	Location	Location map	Station ID	Location	Location map
A61	Perimeter of Oak Ridge Y-12 Plant	Fig. 4.2.1	A23	Oak Ridge Reservation	Fig. 4.2.4
A62	Perimeter of Oak Ridge Y-12 Plant	Fig. 4.2.1	A18	Oak Ridge Reservation	Fig. 4.2.4
A63	Perimeter of Oak Ridge Y-12 Plant	Fig. 4.2.1	A31	Oak Ridge Reservation	Fig. 4.2.4
A64	Perimeter of Oak Ridge Y-12 Plant	Fig. 4.2.1	A33	Oak Ridge Reservation	Fig. 4.2.4
A65	Perimeter of Oak Ridge Y-12 Plant	Fig. 4.2.1	A34	Oak Ridge Reservation	Fig. 4.2.4
A66	Perimeter of Oak Ridge Y-12 Plant	Fig. 4.2.1	A36	Oak Ridge Reservation	Fig. 4.2.4
A67	Perimeter of Oak Ridge Y-12 Plant	Fig. 4.2.1	A40	Oak Ridge Reservation	Fig. 4.2.4
A68	Perimeter of Oak Ridge Y-12 Plant	Fig. 4.2.1	A41	Oak Ridge Reservation	Fig. 4.2.4
A69	Perimeter of Oak Ridge Y-12 Plant	Fig. 4.2.1	A42	Oak Ridge Reservation	Fig. 4.2.4
A70	Perimeter of Oak Ridge Y-12 Plant	Fig. 4.2.1	A43	Oak Ridge Reservation	Fig. 4.2.4
A71	Perimeter of Oak Ridge Y-12 Plant	Fig. 4.2.1	A44	Oak Ridge Reservation	Fig. 4.2.4
A72	Perimeter of Oak Ridge Y-12 Plant	Fig. 4.2.1	A45	Oak Ridge Reservation	Fig. 4.2.4
			A46	Oak Ridge Reservation	Fig. 4.2.4
A3	Perimeter of Oak Ridge National Laboratory	Fig. 4.2.2	A51	Norris Dam	Fig. 4.2.5
A7	Perimeter of Oak Ridge National Laboratory	Fig. 4.2.2	A52	Ft. Loudon Dam	Fig. 4.2.5
A9	Perimeter of Oak Ridge National Laboratory	Fig. 4.2.2	A53	Douglas Dam	Fig. 4.2.5
A81	Perimeter of Oak Ridge Gaseous Diffusion Plant	Fig. 4.2.3	A55	Great Falls Dam	Fig. 4.2.5
A82	Perimeter of Oak Ridge Gaseous Diffusion Plant	Fig. 4.2.3	A56	Dale Hollow Dam	Fig. 4.2.5
A83	Perimeter of Oak Ridge Gaseous Diffusion Plant	Fig. 4.2.3	A57	Knoxville	Fig. 4.2.5
A84	Perimeter of Oak Ridge Gaseous Diffusion Plant	Fig. 4.2.3			
A85	Perimeter of Oak Ridge Gaseous Diffusion Plant	Fig. 4.2.3			
A86	Perimeter of Oak Ridge Gaseous Diffusion Plant	Fig. 4.2.3			
A87	Perimeter of Oak Ridge Gaseous Diffusion Plant	Fig. 4.2.3			
A88	Perimeter of Oak Ridge Gaseous Diffusion Plant	Fig. 4.2.3			
A89	Perimeter of Oak Ridge Gaseous Diffusion Plant	Fig. 4.2.3			
A90	Perimeter of Oak Ridge Gaseous Diffusion Plant	Fig. 4.2.3			
A91	Perimeter of Oak Ridge Gaseous Diffusion Plant	Fig. 4.2.3			
A92	Perimeter of Oak Ridge Gaseous Diffusion Plant	Fig. 4.2.3			
A93	Perimeter of Oak Ridge Gaseous Diffusion Plant	Fig. 4.2.3			
A94	Perimeter of Oak Ridge Gaseous Diffusion Plant	Fig. 4.2.3			
A95	Perimeter of Oak Ridge Gaseous Diffusion Plant	Fig. 4.2.3			
A96	Perimeter of Oak Ridge Gaseous Diffusion Plant	Fig. 4.2.3			
A97	Perimeter of Oak Ridge Gaseous Diffusion Plant	Fig. 4.2.3			

<sup>a</sup>Fold-out maps are included as an appendix.

## 2.2 METEOROLOGICAL MEASUREMENTS

Meteorological towers are located on each of the three installation sites (two at the Oak Ridge Y-12 Plant, three at ORNL, and one at ORGDP), and two are located on the ORR. Wind speed, wind direction, and temperature measurements are made at various levels on each tower. Tower ID, location, and reference to the location map are given in Table 2.2.1.

Table 2.2.1. Meteorological towers<sup>a</sup>

Tower ID	Location	Location map
MT 1	Oak Ridge Gaseous Diffusion Plant site	Fig. 4.3.1
MT 2	Oak Ridge National Laboratory site	Fig. 4.3.1
MT 3	Oak Ridge National Laboratory site	Fig. 4.3.1
MT 4	Oak Ridge National Laboratory site	Fig. 4.3.1
MT 5	Oak Ridge Y-12 Plant site	Fig. 4.3.1
MT 6	Oak Ridge Y-12 Plant site	Fig. 4.3.1
MT 7	Walker Branch watershed	Fig. 4.3.1
MT 8	TVA land, west end of Reservation	Fig. 4.3.1

<sup>a</sup>Fold-out maps are included as an appendix.

## 2.3 SURFACE WATER MONITORING AND SAMPLING

Surface water samples are collected as part of the Clean Water Act requirements and DOE Orders. Water monitoring and sampling were performed on McCoy Branch, East Fork Poplar Creek, West Fork Poplar Creek, First Creek, Fifth Creek, Melton Branch, White Oak Creek, Raccoon Creek, and the Clinch and Tennessee rivers. Station ID, location, and reference to location maps are given in Table 2.3.1.

## 2.4 GROUNDWATER MONITORING

Groundwater monitoring and sampling are performed to meet RCRA, CERCLA, and DOE Orders requirements. Samples were collected at waste management units at each installation, on the ORR, and at some off-site locations. The well ID, location, and reference to location maps are given in Table 2.4.1.

## 2.5 EXTERNAL GAMMA RADIATION MEASUREMENTS

A number of external gamma radiation measurements are made annually according to DOE guidelines. These measurements are made at the ORNL perimeter, on the ORR, at remote locations, and along the banks of the Clinch River. Station ID, location, and reference to location maps are given in Table 2.5.1.

## 2.6 BIOLOGICAL MONITORING

Samples of milk and fish and animal tissues are collected according to DOE guidelines. Fish samples were collected at three locations on the Clinch River during 1986, and milk samples were collected at nine locations. Nine geese and 660 deer samples were analyzed during the year. The sample ID, location, and reference to location maps are given in Table 2.6.1.

## 2.7 VEGETATION SAMPLING

Grass and pine needle samples were collected in 1986 following DOE guidelines. Samples were collected at ORNL perimeter, ORR, ORGDP, and remote sites. Sample ID, location, and reference to location maps are given in Table 2.7.1.

## 2.8 SOIL SAMPLING

Soil samples were collected following DOE guidelines. During 1986, samples were collected at ORNL perimeter, ORGDP perimeter, ORR, and remote sites. The sample ID, location, and reference to location maps are given in Table 2.8.1.

## 2.9 SEDIMENT SAMPLING

Samples were collected in 1986 according to DOE guidelines from Poplar Creek and Clinch River sediment; sample ID, location, and reference to location maps are given in Table 2.9.1.

Table 2.3.1. Water monitoring stations<sup>a</sup>

Station ID	Location	Location map
W1	Melton Hill Dam	Fig. 5.2.1
W2	Confluence of White Oak Creek	Fig. 5.2.1
W3	White Oak Dam (WOD)	Fig. 5.2.1
W4	Melton Branch 1	Fig. 5.3.1
W5	Melton Branch 2	Fig. 5.3.1
W6	White Oak Creek headwaters	Fig. 5.3.1
W7	White Oak Creek	Fig. 5.3.1
W8	East weir WOC	NA <sup>b</sup>
W9	West weir WOC	NA
W10	HFIR/TRU	NA
W11	NSPP	NA
W12	7500 bridge	Fig. 5.3.4
W13	Northwest Tributary	Fig. 5.3.4
W14	First Creek	Fig. 5.3.4
W15	STP	Fig. 5.3.4
W16	PWTP	Fig. 5.3.4
W17	3500 (190 ponds) Ponds	Fig. 5.3.4
W18	Flume Station 2	NA
W19	Fifth Creek	Fig. 5.3.4
W20	Raccoon Creek	NA
W21	Ish Creek	NA
W22–W27 unassigned		
W28	ORGDP (K-1407-B)	Fig. 5.3.8
W29	ORGDP (K-901 at 892)	NA
W30	ORGDP sanitary water (K-1513)	Fig. 5.2.1
W31	Poplar Creek above Blair Bridge (K-1710)	Fig. 5.2.1
W32	Poplar Creek near Clinch River (K-716)	Fig. 5.2.1
W33	West Fork Poplar Creek	Fig. 5.2.1
W34	East Fork Poplar Creek	Fig. 5.2.1
W35	Bear Creek <sup>b</sup>	NA
W36	K-1515-C	Fig. 5.3.8
W37	K-710-A	Fig. 5.3.8
W38	K-901-A	Fig. 5.2.1
W39	K-1007-B	Fig. 5.3.8
W40	K-1203	Fig. 5.3.8
W41	K-1700	Fig. 5.3.8
W42	Upper Bear Creek	Fig. 5.3.1
W43	Kerr Hollow (301)	NA
W44	Rogers Quarry (302)	Fig. 5.3.1
W45	New Hope Pond (303)	Fig. 5.3.1
W46	Bear Creek (304)	Fig. 5.2.1
W47	Oil Pond 1 (305)	NA
W48	Oil Pond 2 (306)	NA
W49	Steam Plant Fly Ash Sluice Water (623)	Fig. 5.3.1
W50	S-3 Ponds Liquid Treatment Facility (507)	NA
W51	Mobile Waste Water Treatment Facility (508)	Fig. 5.3.1
W52 unassigned		
W53	Central Pollution Control Facility (501)	Fig. 5.3.1
W53a	Central Pollution Control Facility—Phase II (502)	Fig. 5.3.1
W54	Poplar Creek <sup>b</sup>	NA
W55	Kingston Water Plant (Clinch River)	Fig. 5.2.1
W56	New Hope Pond inlet	NA
W57–W60 unassigned		

<sup>a</sup>Fold-out maps are included as an appendix.

<sup>b</sup>Not available.



Table 2.4.1. Groundwater wells<sup>a</sup>

Well ID	Location	Location map
GW173	Chestnut Ridge Security Pits, Y-12 Plant	Fig. 6.3.1
GW174	Chestnut Ridge Security Pits, Y-12 Plant	Fig. 6.3.1
GW176	Chestnut Ridge Security Pits, Y-12 Plant	Fig. 6.3.1
GW177	Chestnut Ridge Security Pits, Y-12 Plant	Fig. 6.3.1
GW179	Chestnut Ridge Security Pits, Y-12 Plant	Fig. 6.3.1
1089	Chestnut Ridge Security Pits, Y-12 Plant	Fig. 6.3.1
GW142	Kerr Hollow Quarry, Y-12 Plant	Fig. 6.3.2
GW143	Kerr Hollow Quarry, Y-12 Plant	Fig. 6.3.2
GW144	Kerr Hollow Quarry, Y-12 Plant	Fig. 6.3.2
GW145	Kerr Hollow Quarry, Y-12 Plant	Fig. 6.3.2
GW146	Kerr Hollow Quarry, Y-12 Plant	Fig. 6.3.2
GW147	Kerr Hollow Quarry, Y-12 Plant	Fig. 6.3.2
GW231	Kerr Hollow Quarry, Y-12 Plant	Fig. 6.3.2
GW148	New Hope Pond, Y-12 Plant	Fig. 6.3.3
GW149	New Hope Pond, Y-12 Plant	Fig. 6.3.3
GW150	New Hope Pond, Y-12 Plant	Fig. 6.3.3
GW151	New Hope Pond, Y-12 Plant	Fig. 6.3.3
GW152	New Hope Pond, Y-12 Plant	Fig. 6.3.3
GW153	New Hope Pond, Y-12 Plant	Fig. 6.3.3
GW154	New Hope Pond, Y-12 Plant	Fig. 6.3.3
GW220	New Hope Pond, Y-12 Plant	Fig. 6.3.3
GW222	New Hope Pond, Y-12 Plant	Fig. 6.3.3
GW223	New Hope Pond, Y-12 Plant	Fig. 6.3.3
GW240	New Hope Pond, Y-12 Plant	Fig. 6.3.3
GW155	Sludge disposal basin, Y-12 Plant	Fig. 6.3.4
GW156	Sludge disposal basin, Y-12 Plant	Fig. 6.3.4
GW157	Sludge disposal basin, Y-12 Plant	Fig. 6.3.4
GW158	Sludge disposal basin, Y-12 Plant	Fig. 6.3.4
GW159	Sludge disposal basin, Y-12 Plant	Fig. 6.3.4
GW241	Sludge disposal basin, Y-12 Plant	Fig. 6.3.4
1095	Sludge disposal basin, Y-12 Plant	Fig. 6.3.4
1096	Sludge disposal basin, Y-12 Plant	Fig. 6.3.4
GW203	United Nuclear site, Y-12 Plant	Fig. 6.3.5
GW205	United Nuclear site, Y-12 Plant	Fig. 6.3.5
GW221	United Nuclear site, Y-12 Plant	Fig. 6.3.5
1090	United Nuclear site, Y-12 Plant	Fig. 6.3.5
1091	United Nuclear site, Y-12 Plant	Fig. 6.3.5
GWY-MW-1	Centralized Sanitary Landfill II, Y-12 Plant	Fig. 6.3.6
GWY-MW-2	Centralized Sanitary Landfill II, Y-12 Plant	Fig. 6.3.6
GWY-MW-3	Centralized Sanitary Landfill II, Y-12 Plant	Fig. 6.3.6
GW115	Bear Creek Valley Waste Disposal Area, Y-12 Plant	Fig. 6.3.6
GWY-GMW-2	Bear Creek Valley Waste Disposal Area, Y-12 Plant	Fig. 6.3.6
GWY-GMW-3	Bear Creek Valley Waste Disposal Area, Y-12 Plant	Fig. 6.3.6
GWY-GMW-4	Bear Creek Valley Waste Disposal Area, Y-12 Plant	Fig. 6.3.6
GWY-GMW-5	Bear Creek Valley Waste Disposal Area, Y-12 Plant	Fig. 6.3.6
GWY-GMW-6	Bear Creek Valley Waste Disposal Area, Y-12 Plant	Fig. 6.3.6
GWY-GMW-7	Bear Creek Valley Waste Disposal Area, Y-12 Plant	Fig. 6.3.6
GWY-GMW-8	Bear Creek Valley Waste Disposal Area, Y-12 Plant	Fig. 6.3.6
GWY-GMW-9	Bear Creek Valley Waste Disposal Area, Y-12 Plant	Fig. 6.3.6
GWY-GMW-10	Bear Creek Valley Waste Disposal Area, Y-12 Plant	Fig. 6.3.6
GWY-GMW-13	Bear Creek Valley Waste Disposal Area, Y-12 Plant	Fig. 6.3.6
GWY-GMW-15	Bear Creek Valley Waste Disposal Area, Y-12 Plant	Fig. 6.3.6
GWY-GMW-17	Bear Creek Valley Waste Disposal Area, Y-12 Plant	Fig. 6.3.6
GWY-GMW-18	Bear Creek Valley Waste Disposal Area, Y-12 Plant	Fig. 6.3.6
GWY-GMW-19	Bear Creek Valley Waste Disposal Area, Y-12 Plant	Fig. 6.3.6
GWY-GMW-20	Bear Creek Valley Waste Disposal Area, Y-12 Plant	Fig. 6.3.6
GW-89	Bear Creek Valley Waste Disposal Area, Y-12 Plant	Fig. 6.3.6
GW-90	Bear Creek Valley Waste Disposal Area, Y-12 Plant	Fig. 6.3.6

Table 2.4.1. (continued)

Well ID	Location	Location map
GW-234	Bear Creek Valley Waste Disposal Area, Y-12 Plant	Fig. 6.3.6
GW31-001	3524 pond, ORNL	Fig. 6.4.1
GW31-002	3524 pond, ORNL	Fig. 6.4.1
GW31-003	3524 pond, ORNL	Fig. 6.4.1
GW31-004	3524 pond, ORNL	Fig. 6.4.1
GW31-0013	3524 pond, ORNL	Fig. 6.4.1
GW31-0015	3524 pond, ORNL	Fig. 6.4.1
GW31-005	3539 and 3540 ponds, ORNL	Fig. 6.4.1
GW31-006	3539 and 3540 ponds, ORNL	Fig. 6.4.1
GW31-007	3539 and 3540 ponds, ORNL	Fig. 6.4.1
GW31-008	3539 and 3540 ponds, ORNL	Fig. 6.4.1
GW31-009	3539 and 3540 ponds, ORNL	Fig. 6.4.1
GW31-010	3539 and 3540 ponds, ORNL	Fig. 6.4.1
GW31-011	3539 and 3540 ponds, ORNL	Fig. 6.4.1
GW31-012	3539 and 3540 ponds, ORNL	Fig. 6.4.1
GW32-001	7905, 7906, 7907, and 7908 ponds, ORNL	Fig. 6.2.14
GW32-002	7905, 7906, 7907, and 7908 ponds, ORNL	Fig. 6.2.14
GW32-003	7905, 7906, 7907, and 7908 ponds, ORNL	Fig. 6.2.14
GW32-004	7905, 7906, 7907, and 7908 ponds, ORNL	Fig. 6.2.14
GW32-005	7905, 7906, 7907, and 7908 ponds, ORNL	Fig. 6.2.14
GW33-001	7905, 7906, 7907, and 7908 ponds, ORNL	Fig. 6.2.14
GW33-002	7905, 7906, 7907, and 7908 ponds, ORNL	Fig. 6.2.14
GW33-003	7905, 7906, 7907, and 7908 ponds, ORNL	Fig. 6.2.14
GW345	Solid Waste Storage Area 6, ORNL	Fig. 6.2.15
GW388	Solid Waste Storage Area 6, ORNL	Fig. 6.2.15
GW186A	Solid Waste Storage Area 4, ORNL	Fig. 6.2.16
GW189	Solid Waste Storage Area 4, ORNL	Fig. 6.2.16
GW191	Solid Waste Storage Area 4, ORNL	Fig. 6.2.16
GW195	Solid Waste Storage Area 4, ORNL	Fig. 6.2.16
GW196	Solid Waste Storage Area 4, ORNL	Fig. 6.2.16
GW201	Solid Waste Storage Area 4, ORNL	Fig. 6.2.16
GW001	Solid Waste Storage Area 5, ORNL	Fig. 6.2.17
GW133	Solid Waste Storage Area 5, ORNL	Fig. 6.2.17
GW420	Solid Waste Storage Area 5, ORNL	Fig. 6.2.17
GW423	Solid Waste Storage Area 5, ORNL	Fig. 6.2.17
GW427	Solid Waste Storage Area 5, ORNL	Fig. 6.2.17
GWWT7-5	Pits at ORNL	Fig. 6.2.18
GWWT5-3	Pits at ORNL	Fig. 6.2.18
GW84	Pits at ORNL	Fig. 6.2.18
GW095	Pits at ORNL	Fig. 6.2.18
GW117	Pits at ORNL	Fig. 6.2.18
GMMW-1	3513 pond, ORNL	Fig. 6.2.20
GMMW-1A	3513 pond, ORNL	Fig. 6.2.20
GMMW-2	3513 pond, ORNL	Fig. 6.2.20
GMMW-3	3513 pond, ORNL	Fig. 6.2.20
GMMW-4	3513 pond, ORNL	Fig. 6.2.20
GMMW-1	Old hydrofracture pond, ORNL	Fig. 6.2.23
GMMW-2	Old hydrofracture pond, ORNL	Fig. 6.2.23
GMMW-3	Old hydrofracture pond, ORNL	Fig. 6.2.23
GMMW-4	Old hydrofracture pond, ORNL	Fig. 6.2.23
GMMW-1	Homogeneous Reactor Experiment pond	Fig. 6.2.25
GMMW-2	Homogeneous Reactor Experiment pond	Fig. 6.2.25
GMMW-3	Homogeneous Reactor Experiment pond	Fig. 6.2.25
GMMW-4	Homogeneous Reactor Experiment pond	Fig. 6.2.25
GW-UNW-1	K-1407-B and -C ponds, ORGDP	Fig. 6.2.26
GW-UNW-2	K-1407-B and -C ponds, ORGDP	Fig. 6.2.26
GW-UNW-3	K-1407-B and -C ponds, ORGDP	Fig. 6.2.26

Table 2.4.1. (continued)

Well ID	Location	Location map
GW-UNW-4	K-1407-B and -C ponds, ORGDP	Fig. 6.2.26
GW-UNW-5	K-1407-B and -C ponds, ORGDP	Fig. 6.2.26
GW-UNW-6	K-1407-B and -C ponds, ORGDP	Fig. 6.2.26
GW-UNW-7	K-1407-B and -C ponds, ORGDP	Fig. 6.2.26
GW-UNW-8	K-1407-B and -C ponds, ORGDP	Fig. 6.2.26
GW-UNW-9	K-1407-B and -C ponds, ORGDP	Fig. 6.2.26
GW-UNW-10	K-1407-B and -C ponds, ORGDP	Fig. 6.2.26
GW-UNW-11	K-1407-B and -C ponds, ORGDP	Fig. 6.2.26

\*Fold-out maps are included as an appendix.

Table 2.5.1. External gamma radiation measurements<sup>a</sup>

Station ID	Location	Location map
T3	ORNL perimeter	Fig. 7.2
T7	ORNL perimeter	Fig. 7.2
T9	ORNL perimeter	Fig. 7.2
T21	ORNL perimeter	Fig. 7.2
T22	ORNL perimeter	Fig. 7.2
T8	Oak Ridge Reservation	Fig. 7.3
T23	Oak Ridge Reservation	Fig. 7.3
G31	Oak Ridge Reservation	Fig. 7.3
G33	Oak Ridge Reservation	Fig. 7.3
G34	Oak Ridge Reservation	Fig. 7.3
G36	Oak Ridge Reservation	Fig. 7.3
G40	Oak Ridge Reservation	Fig. 7.3
G41	Oak Ridge Reservation	Fig. 7.3
G42	Oak Ridge Reservation	Fig. 7.3
G43	Oak Ridge Reservation	Fig. 7.3
G44	Oak Ridge Reservation	Fig. 7.3
G45	Oak Ridge Reservation	Fig. 7.3
G46	Oak Ridge Reservation	Fig. 7.3
T51	Norris Dam	Fig. 7.4
T52	Ft. Loudon Dam	Fig. 7.4
T53	Douglas Dam	Fig. 7.4
T55	Great Falls Dam	Fig. 7.4
T56	Dale Hollow	Fig. 7.4
T57	Knoxville	Fig. 7.4
T45	Along banks of Clinch River	Fig. 7.1
T46	Along banks of Clinch River	Fig. 7.1
T47	Along banks of Clinch River	Fig. 7.1
T48	Along banks of Clinch River	Fig. 7.1
T49	Along banks of Clinch River	Fig. 7.1
T50	Along banks of Clinch River	Fig. 7.1
T51	Along banks of Clinch River	Fig. 7.1
T52	Along banks of Clinch River	Fig. 7.1
T53	Along banks of Clinch River	Fig. 7.1
T54	Along banks of Clinch River	Fig. 7.1

\*Fold-out maps are included as an appendix.

Table 2.6.1. Biological monitoring<sup>a</sup>

Sample ID	Location	Location map
F 40.0 (Fish)	Clinch River Km 40.0	Fig. 8.1.1
F 33.3 (Fish)	Clinch River Km 33.3	Fig. 8.1.1
F 8.0 (Fish)	Clinch River Km 8.0	Fig. 8.1.1
M 1 (Milk)	Bradbury	Fig. 8.2.1
M 2 (Milk)	Broadacre Dairy	Fig. 8.2.1
M 3 (Milk)	Clinton	Fig. 8.2.1
M 4 (Milk)	Frost Bottom	Fig. 8.2.1
M 5 (Milk)	Solway	Fig. 8.2.1
M 6 (Milk)	Harriman	Fig. 8.2.1
M 11 (Milk)	Stinking Creek	Fig. 8.2.2
M 13 (Milk)	Sevierville	Fig. 8.2.2
M 14 (Milk)	Crossville	Fig. 8.2.2
G 1 (Goose)	3524 pond, ORNL	Fig. 8.3.1
G 2 (Goose)	3524 pond, ORNL	Fig. 8.3.1
G 3 (Goose)	3524 pond, ORNL	Fig. 8.3.1
G 4 (Goose)	3524 pond, ORNL	Fig. 8.3.1
G 5 (Goose)	Pond in front of ORGDP	Fig. 8.3.2
G 6 (Goose)	Pond in front of ORGDP	Fig. 8.3.2
G 7 (Goose)	Pond in front of ORGDP	Fig. 8.3.2
G 8 (Goose)	Pond in front of ORGDP	Fig. 8.3.2
G 9 (Goose)	New Hope Pond Y-12 Plant	Fig. 8.3.3
G 10 (Goose)	New Hope Pond Y-12 Plant	Fig. 8.3.3
660 Deer	Oak Ridge Reservation	Fig. 8.3.2

\*Fold-out maps are included as an appendix.

## 2.10 COMMUNITY SAMPLING

The Oak Ridge community sampling program continued in 1986. Soil, sediment, vegetation, deer tissue, sludge, and groundwater well samples were collected and analyzed. The number of samples taken, locations, and reference to location maps are given in Table 2.10.1.

Table 2.7.1. Vegetation sampling<sup>a</sup>

Sample ID	Location	Location map
V3	ORNL perimeter	Fig. 9.1.3
V7	ORNL perimeter	Fig. 9.1.3
V9	ORNL perimeter	Fig. 9.1.3
V8	Oak Ridge Reservation	Fig. 9.1.2
V23	Oak Ridge Reservation	Fig. 9.1.2
V31	Oak Ridge Reservation	Fig. 9.1.2
V33	Oak Ridge Reservation	Fig. 9.1.2
V34	Oak Ridge Reservation	Fig. 9.1.2
V36	Oak Ridge Reservation	Fig. 9.1.2
V40	Oak Ridge Reservation	Fig. 9.1.2
V41	Oak Ridge Reservation	Fig. 9.1.2
V42	Oak Ridge Reservation	Fig. 9.1.2
V43	Oak Ridge Reservation	Fig. 9.1.2
V44	Oak Ridge Reservation	Fig. 9.1.2
V45	Oak Ridge Reservation	Fig. 9.1.2
V46	Oak Ridge Reservation	Fig. 9.1.2
V1K	ORGDP perimeter	Fig. 9.1.1
V2K	ORGDP perimeter	Fig. 9.1.1
V3K	ORGDP perimeter	Fig. 9.1.1
V4K	ORGDP perimeter	Fig. 9.1.1
V5K	ORGDP perimeter	Fig. 9.1.1
V6K	ORGDP perimeter	Fig. 9.1.1
V7K	ORGDP perimeter	Fig. 9.1.1
V9K	ORGDP perimeter	Fig. 9.1.1
V10K	ORGDP perimeter	Fig. 9.1.1
V11K	ORGDP perimeter	Fig. 9.1.1
V12K	ORGDP perimeter	Fig. 9.1.1
V13K	ORGDP perimeter	Fig. 9.1.1
PN1 (Pine needle)	ORGDP perimeter	Fig. 9.1.1
PN2 (Pine needle)	ORGDP perimeter	Fig. 9.1.1
PN3 (Pine needle)	ORGDP perimeter	Fig. 9.1.1
PN4 (Pine needle)	ORGDP perimeter	Fig. 9.1.1
PN5 (Pine needle)	ORGDP perimeter	Fig. 9.1.1
V51	Norris Dam	Fig. 9.1.4
V52	Ft. Loudon Dam	Fig. 9.1.4
V53	Douglas Dam	Fig. 9.1.4
V55	Great Falls Dam	Fig. 9.1.4
V56	Dale Hollow Dam	Fig. 9.1.4
V57	Knoxville	Fig. 9.1.4
V58	Watts Bar Dam	Fig. 9.1.4

<sup>a</sup>Fold-out maps are included as an appendix.

Table 2.8.1. Soil sampling<sup>a</sup>

Sample ID	Location	Location map
S3	ORNL perimeter	Fig. 9.2.1
S7	ORNL perimeter	Fig. 9.2.1
S9	ORNL perimeter	Fig. 9.2.1
S18K	ORGDP perimeter	Fig. 9.2.2
S19K	ORGDP perimeter	Fig. 9.2.2
S20K	ORGDP perimeter	Fig. 9.2.2
S21K	ORGDP perimeter	Fig. 9.2.2
S22K	ORGDP perimeter	Fig. 9.2.2
S23K	ORGDP perimeter	Fig. 9.2.2
S24K	ORGDP perimeter	Fig. 9.2.2
S25K	ORGDP perimeter	Fig. 9.2.2
S26K	ORGDP perimeter	Fig. 9.2.2
S27K	ORGDP perimeter	Fig. 9.2.2
S28K	ORGDP perimeter	Fig. 9.2.2
S29K	ORGDP perimeter	Fig. 9.2.2
S30K	ORGDP perimeter	Fig. 9.2.2
S8	Oak Ridge Reservation	Fig. 9.2.3
S23	Oak Ridge Reservation	Fig. 9.2.3
S31	Oak Ridge Reservation	Fig. 9.2.3
S33	Oak Ridge Reservation	Fig. 9.2.3
S34	Oak Ridge Reservation	Fig. 9.2.3
S36	Oak Ridge Reservation	Fig. 9.2.3
S40	Oak Ridge Reservation	Fig. 9.2.3
S41	Oak Ridge Reservation	Fig. 9.2.3
S42	Oak Ridge Reservation	Fig. 9.2.3
S43	Oak Ridge Reservation	Fig. 9.2.3
S44	Oak Ridge Reservation	Fig. 9.2.3
S45	Oak Ridge Reservation	Fig. 9.2.3
S46	Oak Ridge Reservation	Fig. 9.2.3
S51	Norris Dam	Fig. 9.2.4
S52	Ft. Loudon Dam	Fig. 9.2.4
S53	Douglas Dam	Fig. 9.2.4
S55	Watts Bar Dam	Fig. 9.2.4
S56	Great Falls Dam	Fig. 9.2.4
S57	Dale Hollow Dam	Fig. 9.2.4
S58	Knoxville	Fig. 9.2.4

<sup>a</sup>Fold-out maps are included as an appendix.

Table 2.9.1. Sediment sampling<sup>a</sup>

Sample ID	Location	Location map
SS1	Poplar Creek	Fig. 9.3.1
SS2	Poplar Creek	Fig. 9.3.1
SS3	Poplar Creek	Fig. 9.3.1
SS4	Poplar Creek	Fig. 9.3.1
SS5	Poplar Creek	Fig. 9.3.1
SS6	Poplar Creek	Fig. 9.3.1
SS7	Clinch River	Fig. 9.3.1
SS8	Clinch River	Fig. 9.3.1

<sup>a</sup>Fold-out maps are included as an appendix.

Table 2.10.1. Community sampling<sup>a</sup>

Number of Samples	Location	Location map
40	Fairbanks Road area	Fig. 10.2.1
374	Illinois Avenue area	Fig. 10.2.1
139	Robertsville area	Fig. 10.2.1
62	Scarboro area	Fig. 10.2.1
242	West End Water Treatment area	Fig. 10.2.1
15	Woodland area	Fig. 10.2.1
726	East Fork Poplar Creek	Fig. 10.2.2
6	Sewage Sludge, Oak Ridge, Knoxville, and Lenoir City	NA <sup>b</sup>
13	Shallow wells, Oak Ridge and Knoxville	NA

<sup>a</sup>Fold-out maps are included as an appendix.

<sup>b</sup>NA = not available.

### **3. ON-SITE DISPOSAL AND OFF-SITE SHIPMENTS OF WASTE**

#### **3.1 REGULATORY REVIEW**

The RCRA, which replaced the Solid Waste Disposal Act in 1976, regulates the generation, transportation, treatment, and disposal of hazardous wastes and regulates facilities that dispose of all solid wastes. Source materials, special nuclear materials, and by-product materials are generally excluded from RCRA. DOE is proposing to issue regulations regarding by-product materials to clarify its obligation under RCRA for these wastes. Radioactive material mixed with hazardous wastes is regulated by RCRA. Hazardous wastes are defined in RCRA by specific source lists, nonspecific source lists, and characteristic hazards. 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 monitoring analysis and testing criteria for sanitary landfills.

The RCRA of 1976 was amended in November 1984 by the Hazardous and Solid Waste Amendments, which have two principal purposes: (1) to regulate previously exempt generators and sources, and (2) to regulate land disposal more stringently, eliminating it where possible. Requirements imposed by the new RCRA amendments are specific, detailing the standards they impose. The amendments reauthorize and expand RCRA through 1988 and require 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. The Part A permit applications were submitted in 1984, and Part B permit applications were submitted in 1985. Facilities with interim status could have filed for closure and cease operations instead of filing for a Part B permit application.

#### **3.2 OAK RIDGE Y-12 PLANT SOLID WASTE MANAGEMENT PROGRAM**

The Oak Ridge Y-12 Plant has developed an extensive Solid Waste Management Program. In accordance with the RCRA and the Tennessee Solid Waste Act, a solid waste is defined as any solid, liquid, semisolid, or contained gas that is being discarded. Therefore, the Solid Waste Management Program addresses liquid wastes and contained gaseous wastes if they may present a problem, as well as solid wastes. The Solid Waste Management Program has been divided into five subprograms, each reflecting differing regulatory authority.

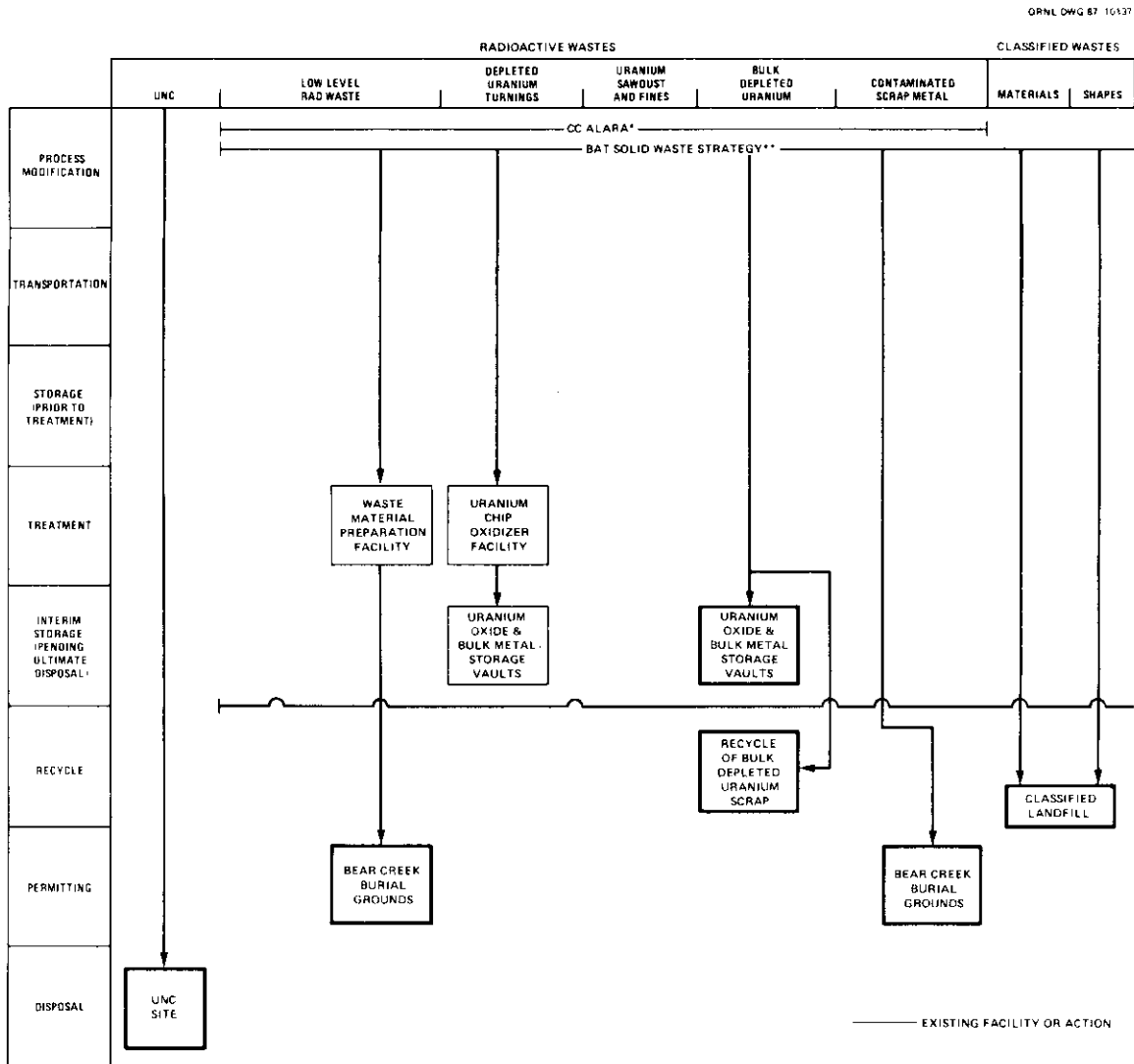
The concern common to all Oak Ridge Y-12 Plant solid waste management programs, as well as to research and development goals, is prudent waste management. The Hazardous Waste Management Policy declares that it is policy to protect employees, the public, and the environment from hazardous wastes and material; equipment and procedures for waste management will be continually improved. In accordance with this policy and prudent waste management in general, the Oak Ridge Y-12 Plant has developed strategies for streamlining management of solid wastes. The chief goal is to minimize generation of solid wastes while achieving compliance with applicable environmental regulations. The Oak Ridge Y-12 Plant Solid Waste Management

Program (Energy Systems, 1987) is divided into five categories: radioactive wastes (Fig. 3.2.1), classified wastes (Fig. 3.2.1), hazardous wastes (Fig. 3.2.2), PCB wastes (Fig. 3.2.2), and conventional wastes (Fig. 3.2.3).

### 3.3 ORNL SOLID WASTE MANAGEMENT PROGRAM

In general, the objectives of solid waste management at ORNL are to provide long-term

isolation of waste contaminated with radioactivity and/or hazardous materials generated as a result of ORNL operations and research and to protect ORNL personnel, the public, and the general environment from these wastes. Two broad categories of radioactive solid waste materials are distinguished by the characteristics of the radionuclides present in the waste. Solid waste sources at ORNL can be classified into three general categories: (1) radioactive waste, (2) hazardous waste, and (3) conventional waste



\*CONTAMINATION CONTROL AS LOW AS REASONABLY ACHIEVABLE  
 \*\*BEST AVAILABLE TECHNOLOGY STRATEGY INCLUDES PROCESS INNOVATION, MATERIAL SUBSTITUTION, SOURCE SEGREGATION AND VOLUME REDUCTION

Fig. 3.2.1. Y-12 Plant radioactive and classified waste management program.

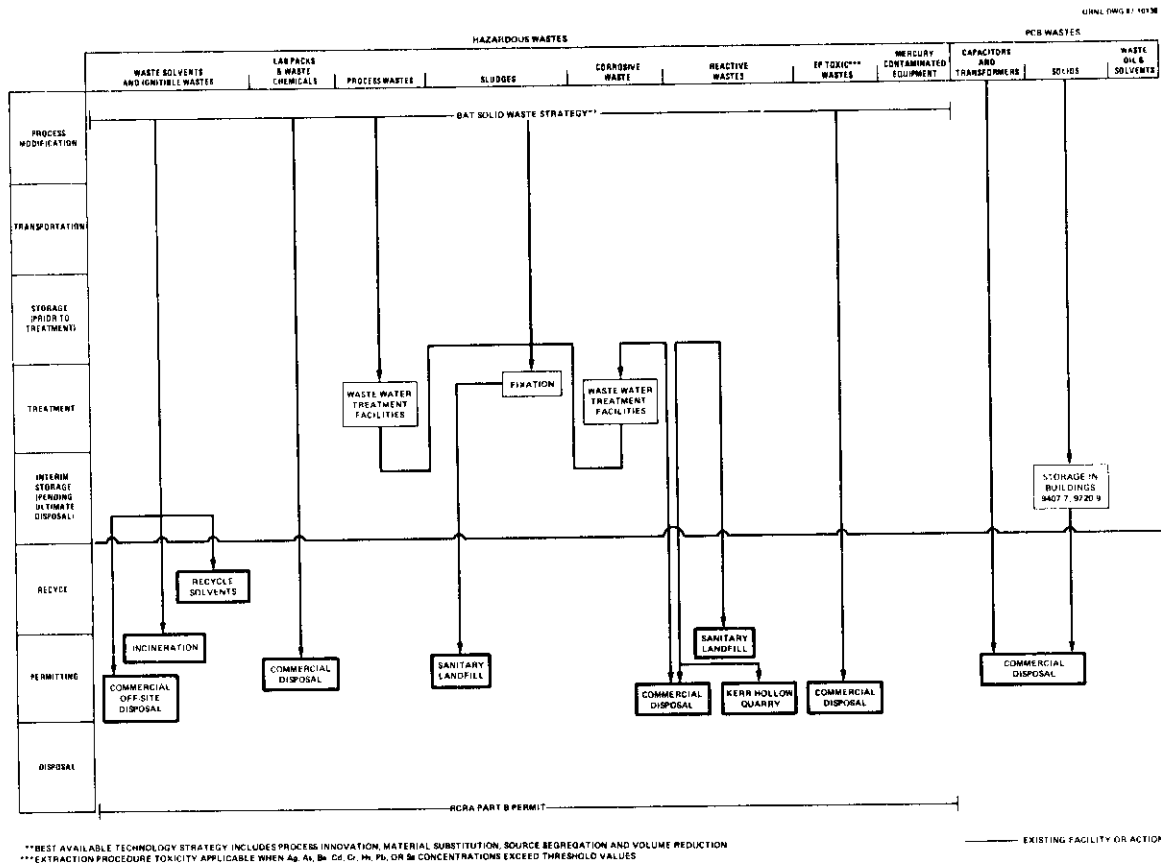


Fig. 3.2.2. Y-12 Plant hazardous and PCB waste management program.

(Bates et al., 1987). These categories and subcategories under each are shown in Fig. 3.3.1. Categories of low-level waste at ORNL are shown in Fig. 3.3.2. Sources and flow of chemical wastes, miscellaneous hazardous wastes, and mixed wastes are shown in Figs. 3.3.3 through 3.3.5. Currently, two conventional waste disposal sites receive waste from ORNL facilities. The sludge from the ORNL Sewage Treatment Plant, filter cake from the coal yard runoff treatment system, steam plant ash, and general refuse are handled as shown in Figs. 3.3.6 through 3.3.9.

### 3.4 ORGDP SOLID WASTE MANAGEMENT PROGRAM

In addition to air and water pollution control programs, ORGDP has developed a waste

management strategy designed to manage all waste as defined by the RCRA and Tennessee Solid Waste Act in accordance with the applicable state, federal, and DOE requirements. The waste management system at ORGDP (Energy Systems, 1987b) provides management for five categories of materials generated for disposal at the ORGDP: (1) radioactive materials, (2) classified waste, (3) hazardous waste, (4) PCBs, and (5) sanitary waste. These categories are shown in Fig. 3.4.1.

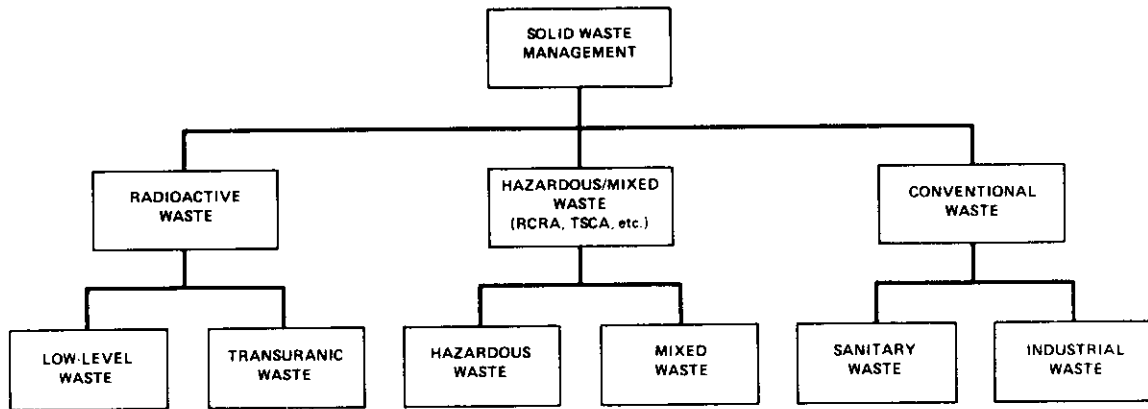


Fig. 3.3.1. Categories of solid waste at ORNL.

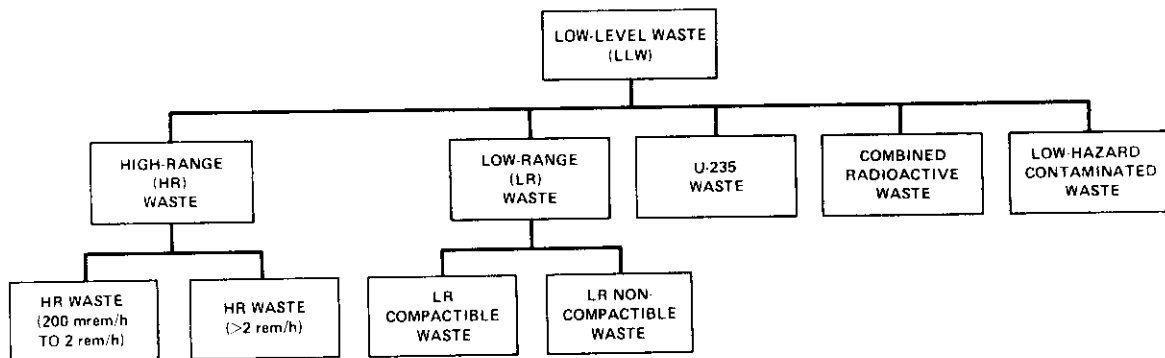


Fig. 3.3.2. Categories of low-level waste at ORNL.



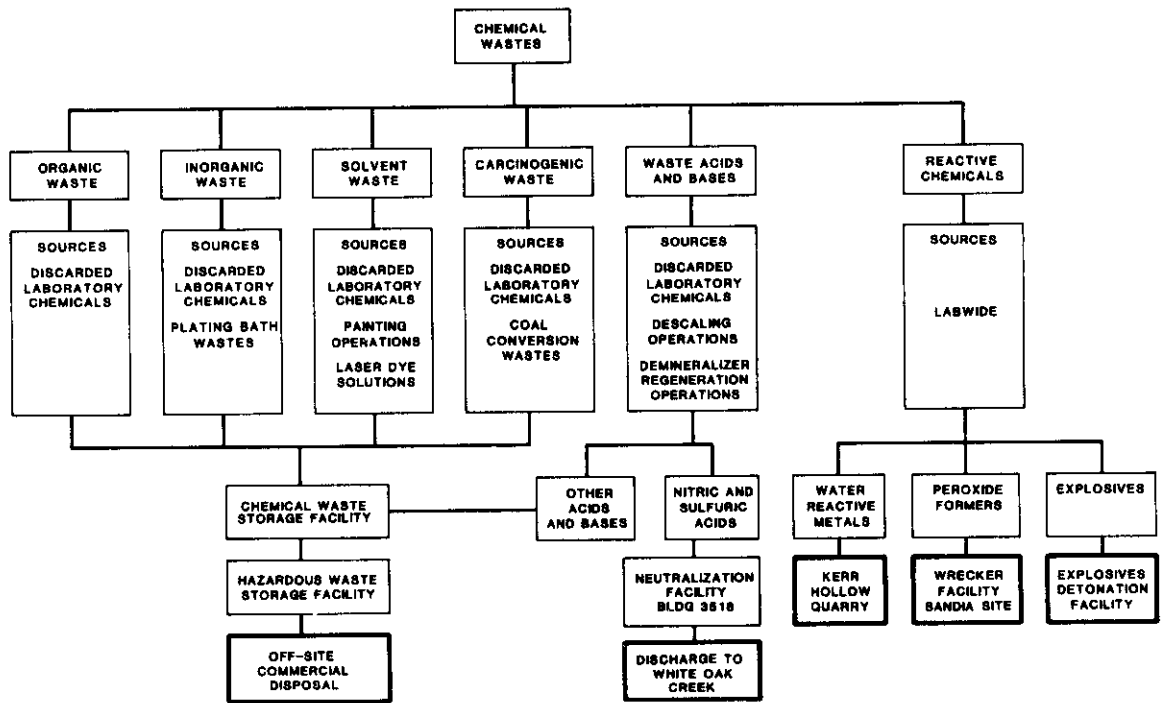


Fig. 3.3.3. Sources and flow of chemical wastes at ORNL.

ORNL DWG 86-17885R

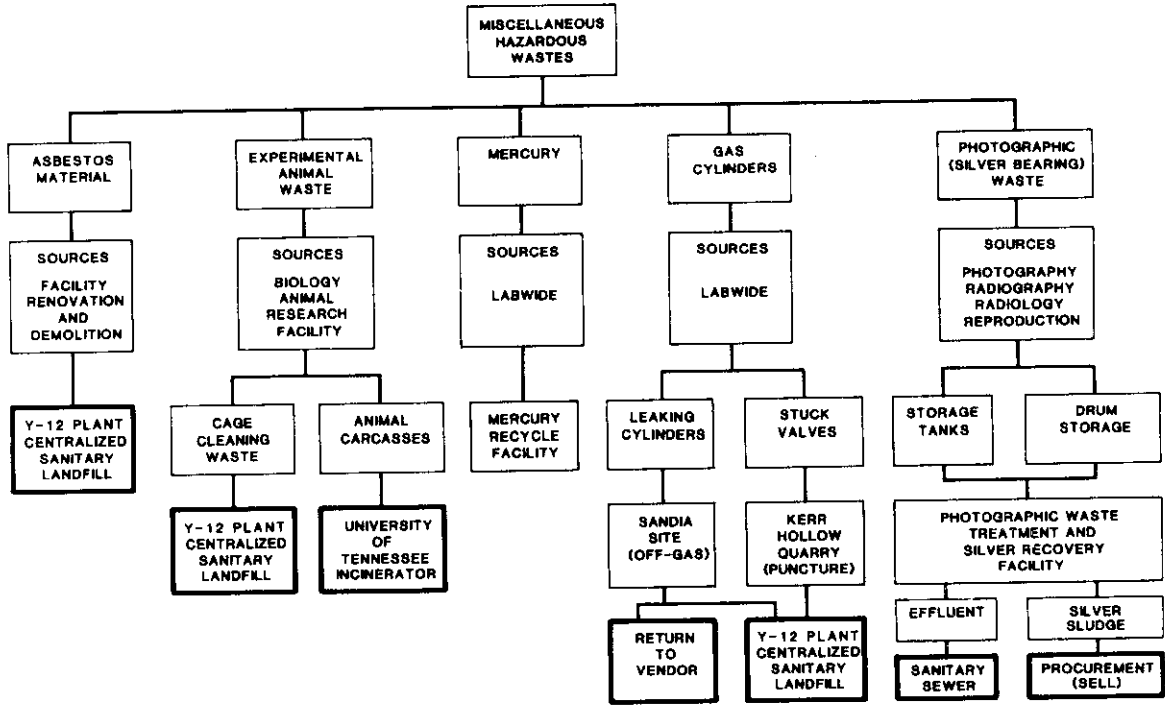


Fig. 3.3.4. Sources and flow of miscellaneous hazardous wastes at ORNL.

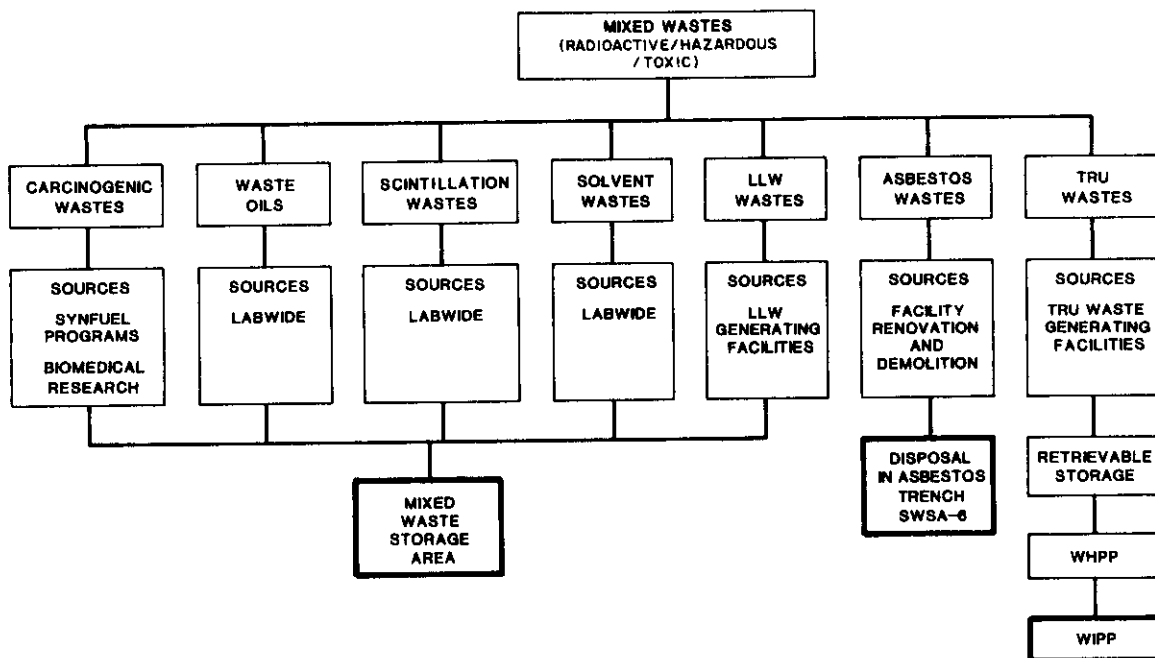


Fig. 3.3.5. Sources and flow of mixed wastes at ORNL.

ORNL-DWG 87-6961A

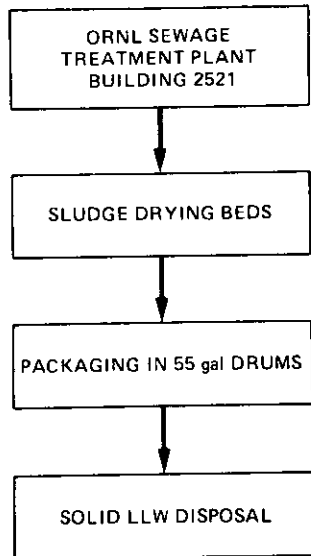


Fig. 3.3.6. Flow path for Sewage Treatment Plant sludge.

ORNL-DWG 87-6962A

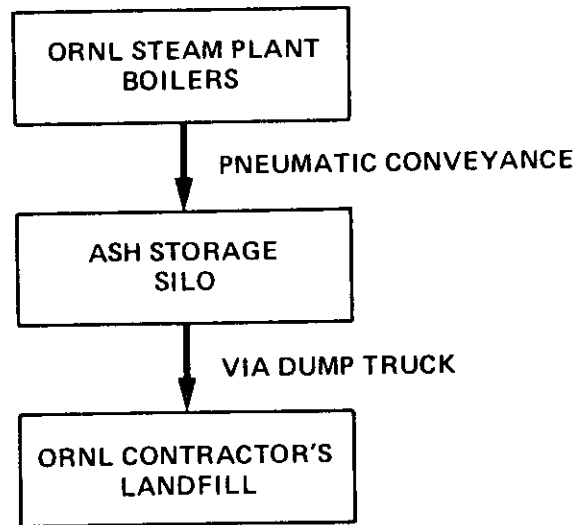


Fig. 3.3.8. ORNL steam plant ash.

ORNL-DWG 87-6963A

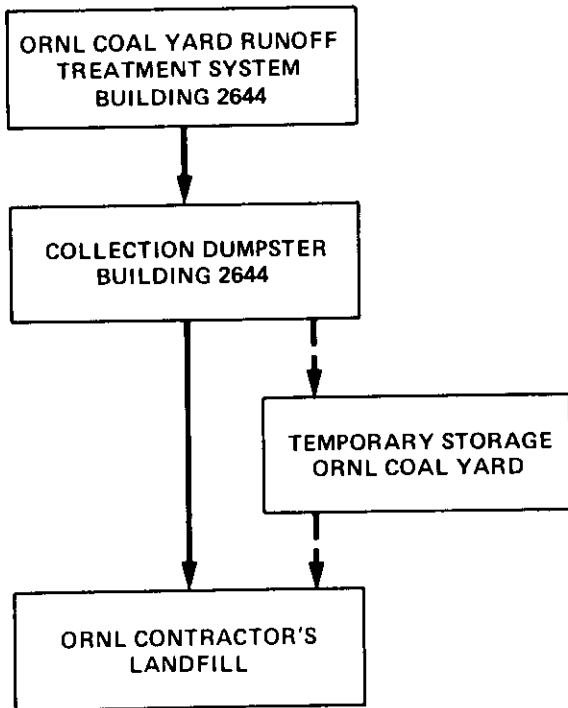


Fig. 3.3.7. ORNL coal yard runoff solids.

ORNL-DWG 87-6965A

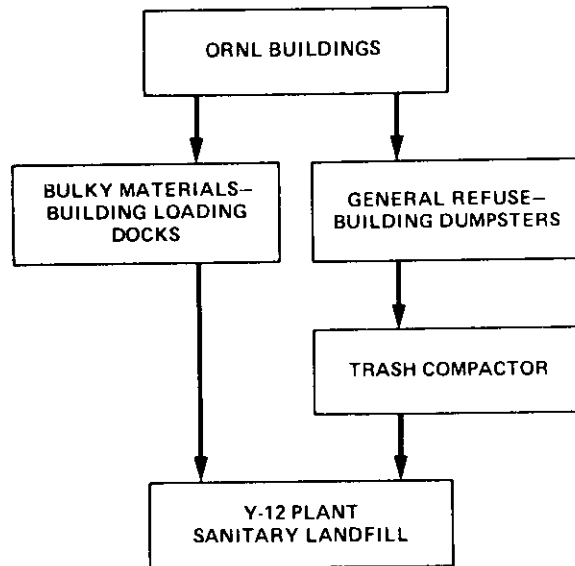


Fig. 3.3.9. ORNL general refuse.

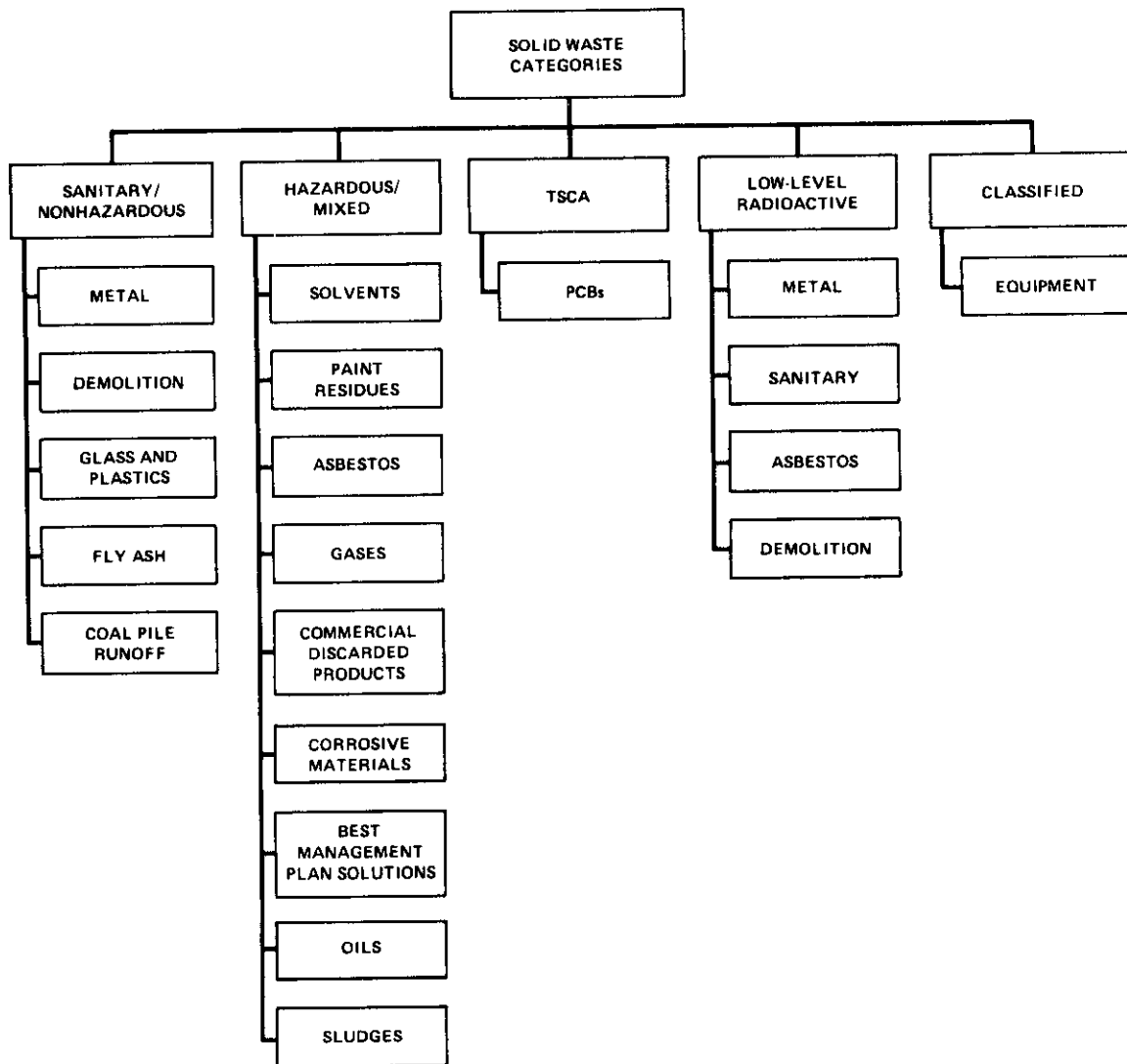


Fig. 3.4.1. Categories of solid waste at ORGDP.

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## 4. AIRBORNE DISCHARGES AND AIR AND METEOROLOGICAL MONITORING

The Clean Air Act (CAA) of 1970 is the basis from which all regulations for the control of air pollution within the United States are mandated. The CAA includes provisions for setting maximum allowable air pollution emission rates and relies on a combination of a technology-based program and an ambient-air-quality-based program to protect the nation's air resources. The primary responsibility for carrying out provisions of the CAA lies with the states, which must submit to the Environmental Protection Agency (EPA) plans and strategies to enforce CAA requirements. These state-issued plans are known as State Implementation Plans and are the basis for the state's regulatory authority under the CAA. The set of regulations that has developed as a result of the CAA is very comprehensive and complex. Certain segments of the regulations apply to given pollutants; others apply to all pollutants. The CAA separates all air pollutants into two specific classes: (1) criteria and (2) noncriteria pollutants. The pollutant categories addressed by CAA are given in Table 4.1. The criteria pollutants are those for which National Ambient Air Quality Standards (NAAQS) have been established. Hazardous air contaminants are those that may cause, or contribute to, an increase in serious irreversible or incapacitating reversible illness, as determined by EPA. Emission of these contaminants into the atmosphere is regulated under EPA's National Emission Standards for Hazardous Air Pollutants (NESHAP) program, which stems from Section 112 of the CAA mandating the stringent control of hazardous airborne pollution. The NESHAP program currently regulates five specific substances as hazardous air pollutants, although

Table 4.1. Clean Air Act (CAA) pollutant categories

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*CAA criteria pollutants*

Total suspended particulates (TSP)  
Sulfur dioxide (SO<sub>2</sub>)  
Nitrogen oxides (NO<sub>x</sub>)  
Carbon monoxide (CO)  
Ozone  
Volatile organic compounds (VOCs)  
Hydrocarbons (nonmethane)  
Lead

*Noncriteria pollutants*

- Hazardous air contaminants
    - Asbestos
    - Beryllium
    - Mercury
    - Vinyl chloride
    - Radionuclides
  - Nonhazardous, noncriteria contaminants
    - Fluorides (HF)
    - Sulfuric acid mists
    - Hydrogen sulfide (H<sub>2</sub>S)
    - Total reduced sulfur (TRS)
- 

additional substances are being studied by EPA for possible regulation in the future.

Specific work practices are mandated under hazardous air pollution regulations for asbestos, beryllium, mercury, vinyl chloride, and radionuclides. While only these five substances are specifically regulated under NESHAP, benzene and arsenic can also be regulated as hazardous pollutants if emitted from fugitive emission sources as volatile hazardous air pollutants (VHAP).

Although fluorides are not designated as criteria pollutants by EPA, the Tennessee Air Pollution Control Act does contain ambient air standards for fluoride (expressed as hydrogen

fluoride). The release of contaminants into the atmosphere is minimized at Oak Ridge DOE installations through a comprehensive air pollution control program. In addition to ensuring that atmospheric emissions are controlled to within DOE- and CAA-mandated emission standards, the installations must maintain accurate, up-to-date permits for all sources that emit contaminants into the atmosphere.

#### 4.1 AIRBORNE DISCHARGES

A summary of the air emission inventory for the Oak Ridge Energy Systems installations (shown in Table 4.1.1) resulted in a total of 2801 emission points at the three Oak Ridge installations, 1200 of which are small hoods and vents at ORNL.

##### 4.1.1 Oak Ridge Y-12 Plant

The locations of radioactive discharge points on the ORR are shown in Fig. 4.1.1. Air emission sources at the Oak Ridge Y-12 Plant are classified into three categories, as shown in Fig. 4.1.2. The management tools being used incorporate the use of existing air pollution control capabilities with an aggressive capital project program designed to meet the installation's dynamic operational needs and to comply with air pollution regulations. These management tools are illustrated in Fig. 4.1.3.

The Oak Ridge Y-12 Plant currently operates approximately 85 exhaust stacks which serve production areas that machine, fabricate, process, or otherwise handle enriched or depleted uranium. In addition, hundreds of other exhaust stacks vent room air or exhausts from nonuranium production operations. A number of these exhaust systems were sampled in 1986 to quantify emissions. However, a large number of the exhaust stacks are not routinely sampled, and increased monitoring of these stacks is anticipated throughout 1987 to better characterize emissions and demonstrate compliance with new regulatory requirements.

Throughout the past year, the Oak Ridge Y-12 Plant made significant progress in providing better effluent characterization and improved

Table 4.1.1. 1986 summary of air emission inventory

Type of emission	Number of discharge points for each type of emission
<i>Y-12 Plant<sup>a</sup></i>	
Enriched uranium	40
Depleted uranium	45
Particulates	253
Sulfur dioxide	11
Nitrogen oxide	53
Organic compounds	145
Carbon monoxide	7
Fluoride	5
Hazardous materials (Be, Hg, etc.)	67
Miscellaneous pollutants	78
Total (Y-12 Plant)	704
<i>ORNL</i>	
Radionuclides <sup>b</sup>	1
Sulfur oxides	8
Particulates	14
Miscellaneous pollutants <sup>b</sup>	1805 <sup>c</sup>
Total (ORNL)	1828
<i>ORGDP<sup>d</sup></i>	
Uranium and technetium	22
Fluorides	28
Particulates	41
Volatile organic compounds	16
Sulfur dioxide	4
Nitrogen oxides	4
Carbon monoxide	18
Hydrochloric acid	0
Miscellaneous pollutants	136
Total (ORGDP)	269
Grand total	2801

<sup>a</sup> Many emission points emit more than one pollutant.

<sup>b</sup> Radionuclides emitted from Stack 2026, Stack 3020, Stack 3039, Building 5505 vent, Stack 7025, Stack 7911, and small discharges from ORNL facilities at the Y-12 Plant.

<sup>c</sup> Hoods and vents.

<sup>d</sup> Inventory includes only those emission locations that the facility operated during 1986.

emissions sampling. The Oak Ridge Y-12 Plant NESHAP Stack Sampling Program was initiated in 1985 to isokinetically sample the radionuclide stacks that contribute significantly to off-site dose. This effort was designed to quantify, or "benchmark," radiological emissions during



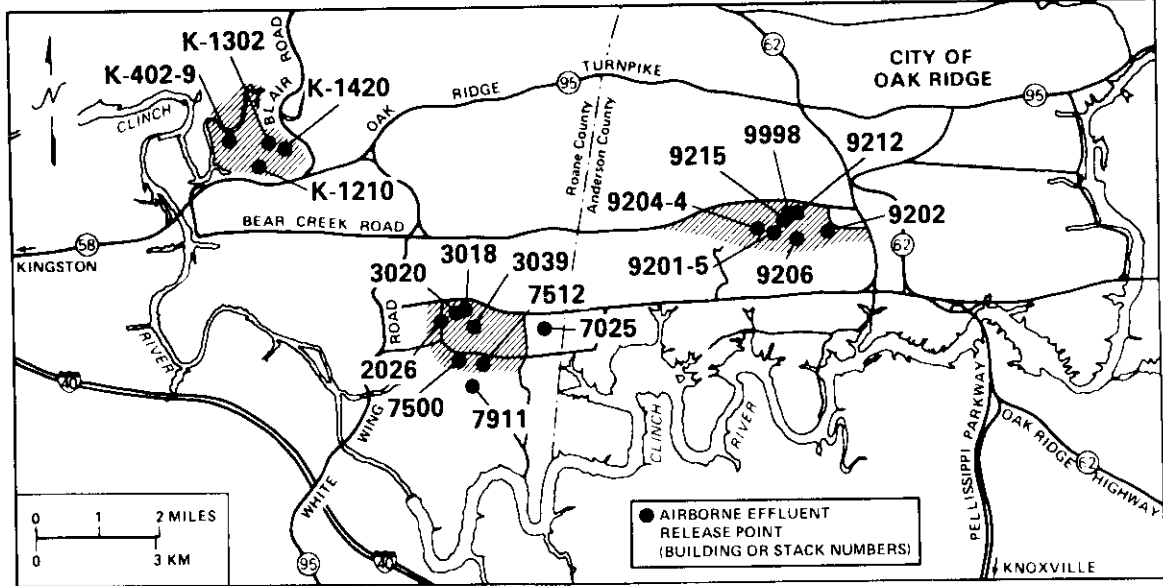


Fig. 4.1.1. Locations of radioactive airborne effluent release points on the ORR.

normal operations. The ongoing sampling program involves the use of EPA Method 5 stack sampling methods to quantify the mass emission rate of radionuclides out the stack as well as to gather solubility and particulate size distribution information required as input to radiological dose models. The extensive sampling program utilizes personnel located at ORGDP and is expected to continue indefinitely.

The Stack Radiological Monitoring Project was initiated in 1985 and continued throughout 1986 to bring Oak Ridge Y-12 Plant radiological exhaust stacks into compliance with expected EPA stack sampling criteria and to install new

continuous sampling and monitoring equipment to supplement periodic isokinetic sampling data. The configuration of the majority of the radiological exhaust has historically precluded the ability to collect EPA-accepted stack emission data; EPA specifies a number of criteria for particulate stack sampling that include requirements on minimum stack diameter, minimum allowable distances from flow disturbance, etc. The Stack Radiological Monitoring Project is correcting the physical deficiencies of the radiological stacks by extending stack lengths, replacing stacks, and installing permanent sampling platforms to allow access to approved sampling locations.

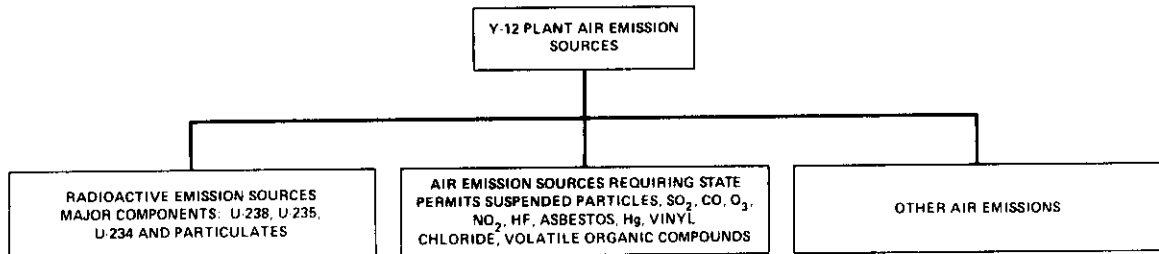


Fig. 4.1.2. Air emission sources at the Y-12 Plant.

DRIAL (DWG) 87-1487

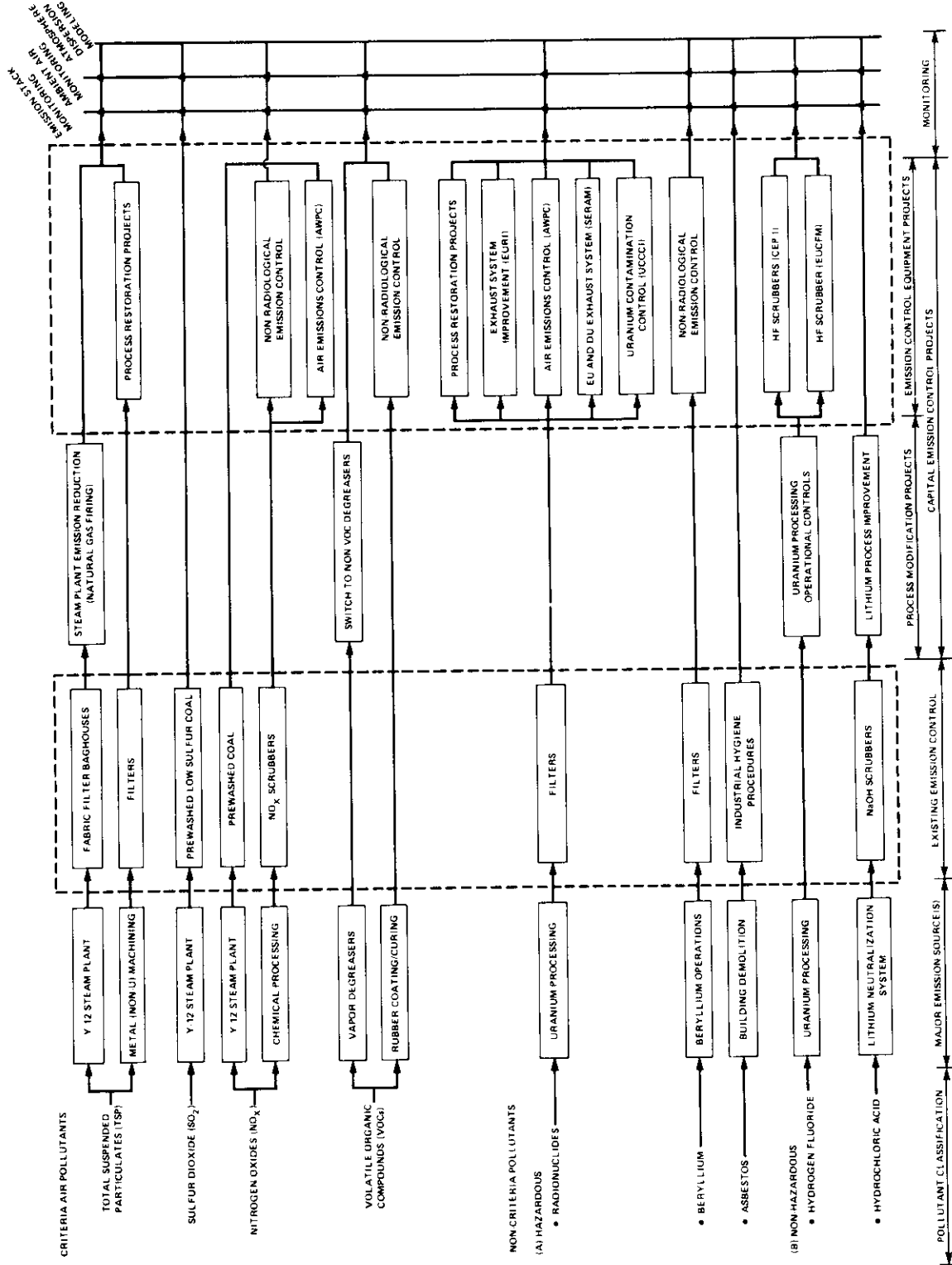


Fig. 4.1.3. Air pollution control program at the Y-12 Plant.

Completion of construction of the stack modifications and sampling platforms is scheduled for early 1987.

In addition to upgrading a number of radiological exhaust stacks and installing stack sampling platforms, the Stack Radiological Monitoring Project is installing new continuous emissions sampling and monitoring equipment to give a continuous record of the installation's radiological air emissions. In addition, real-time alarmed radiation monitors are being installed on stacks that have a potential to emit significant quantities of radionuclides in an upset condition (e.g., failure of emission control equipment, filter fire, etc.). The real-time monitors will alert the operating personnel when an emission excursion is detected so that immediate corrective action can be taken and emissions minimized.

An additional monitoring improvement being made at the Oak Ridge Y-12 Plant during 1986 was the installation of continuous isokinetic stack samplers on two radionuclide emitting sources. The Process Exhaust Equipment Restoration Project allows the Oak Ridge Y-12 Plant to collect actual operating experience of the very sophisticated sampling devices and to perform comparative emissions sampling studies.

The Nonradiological Stack Sampling Program will collect emission information from nonradiological process stacks needing further effluent characterization. EPA-accepted sampling will be conducted for volatile organic compounds, various acid fumes, and beryllium to collect quantitative emission rate information. A number of process stacks will be sampled for the presence of several organic compounds currently being considered by EPA as further NESHAP contaminants to provide preliminary information to be used in developing implementation plans with any new regulatory requirements. As with the NESHAP stack sampling program for radionuclides, this program is expected to continue indefinitely.

While a number of activities are under way and/or planned to significantly improve the Oak Ridge Y-12 Plant Stack Sampling Program, attention is also being given to examining emissions due to fugitive nonpoint sources within

and surrounding the installation. The fugitive emission source of the highest priority is the former lithium isotope separation facility (Building 9201-4). Mercury vapor is emitted through building ventilation systems from mercury trapped inside and throughout the building structure. A mercury vapor analyzer has been used exclusively in the past to measure concentrations inside the building, and comparative quality assurance testing of the instrument is under way using several different sampling techniques. Throughout FY 1987, testing of the mercury vapor analyzer will continue to determine if more accurate and verifiable methods of quantifying fugitive mercury emissions from Building 9201-4 are available. In addition, monitoring of potential fugitive emissions sources such as the S-3 Ponds and the Bear Creek Valley Waste Disposal Area (BCVWDA) will continue to ensure that no significant environmental impact to air quality occurs because of ongoing remedial action activities.

Of approximately 350 process exhaust stacks at the Oak Ridge Y-12 Plant, approximately 85 serve operations with a potential for generating airborne radioactive uranium. Today there are approximately 45 stacks for depleted uranium and approximately 40 for enriched uranium operations. The majority of these exhaust stacks are equipped with emission control systems ranging from simple fabric filters and bag houses to combination systems, including high-efficiency particulate air (HEPA) filters. Presently, stack monitoring is performed on 36 of the enriched process stacks and on 2 of the depleted uranium stacks. As previously discussed, the Oak Ridge Y-12 Plant stack sampling program is expected to undergo significant changes in early 1987 as emission sampling and monitoring equipment for the Stack Radiological Monitoring Project comes on line.

Stack sampling is performed with multipoint probes inserted into selected ducts or stacks. Samples are withdrawn continuously. Filter sample papers (Whatman 41) are usually replaced daily, and samples are analyzed for gross alpha activity and converted to grams of

uranium discharge per 24 h. Weekly, monthly, and annual discharge is documented. From 1976 to 1982 the annual discharge per year was sent to EG&G at Idaho Falls, Idaho, where it was entered into the *Radioactive Summary Report*, or "Radioactive Effluent Report," as it is commonly referred to at the Oak Ridge Y-12 Plant.

#### 4.1.2 Oak Ridge National Laboratory

Air emission sources at ORNL are classified into three categories, as shown in Fig. 4.1.4. ORNL facilities produce air emissions regulated both by ambient air standards (called criteria pollutants) and NESHAP standards, as illustrated by the air pollution control strategy outlined in Fig. 4.1.5.

Radioactive emission sources at ORNL are of three general categories: (1) cell ventilation, which consists of high-volume, low-activity streams from enclosed areas such as containment or confinement areas (i.e., hot cells); (2) off-gas, which consists of low-volume, potentially high-activity gas streams from process vessels and from other areas where release of radioactivity is routine and of relatively high concentration; and (3) laboratory hoods and individual vents that provide low-volume, low-activity ventilation for laboratory-type operations and normally vent at the source location. Airborne radioactive waste streams at ORNL are generated either in the course of reactor operations and isotope and

transuranic element production or as a consequence of experimental laboratory and pilot plant programs. The streams consist primarily of particulates and gaseous radioisotopes of tritium, noble gases ( $^{133}\text{Xe}$  and  $^{85}\text{Kr}$ ), iodine, and radon. Methods for removal of particulates and gaseous radioisotopes from these streams depend on concentration and chemical state in the carrier gas. As a rule, it is easier to separate them before they become diluted with large quantities of air and mixed with other contaminants. Hence, ORNL policy is to decontaminate gaseous effluents, insofar as practical, at the source—before they enter one of the plant ventilation systems. None of these systems includes facilities for collecting and storing radioactive gases. Before the gases are discharged from any stack, the effluents are filtered through roughing and HEPA filters to remove particulate matter and, where conditions dictate, through charcoal absorbers or chemical scrubbers to remove reactive gases such as halogens. In general, over 99.9% of the particulates and 95% of the reactive gases are removed before the gases reach the discharge point.

There are seven stacks currently in use at ORNL for disposing of most radioactive gaseous effluents. The locations of these discharge stacks are shown in Fig. 4.1.6.

Stacks 3039 and 7911 provide service for most of the ORNL facilities. The 3020 stack provides

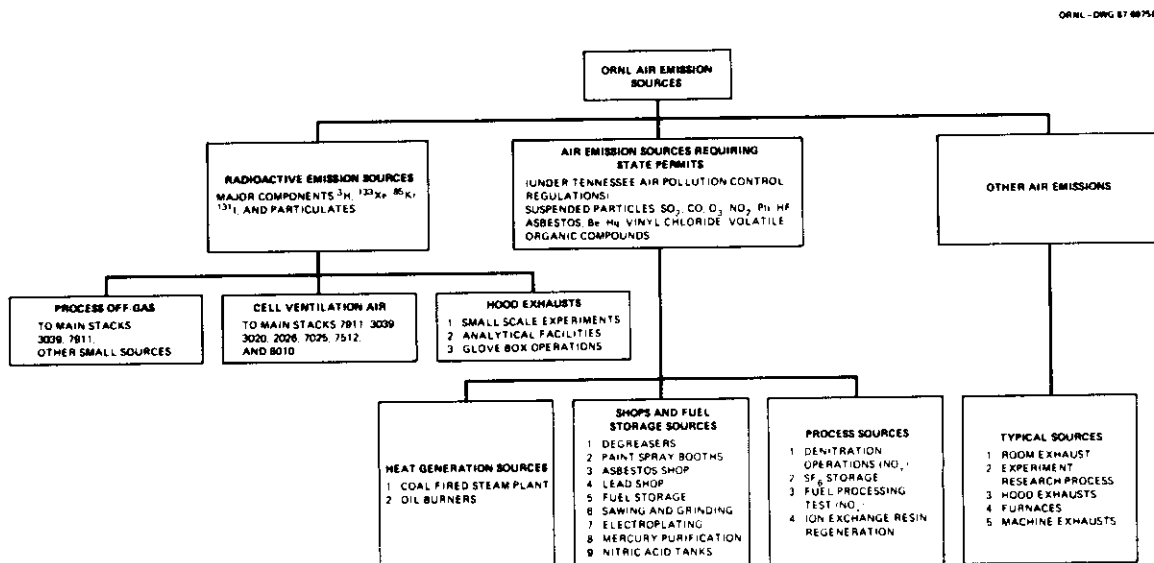


Fig. 4.1.4. Air emission sources at ORNL.

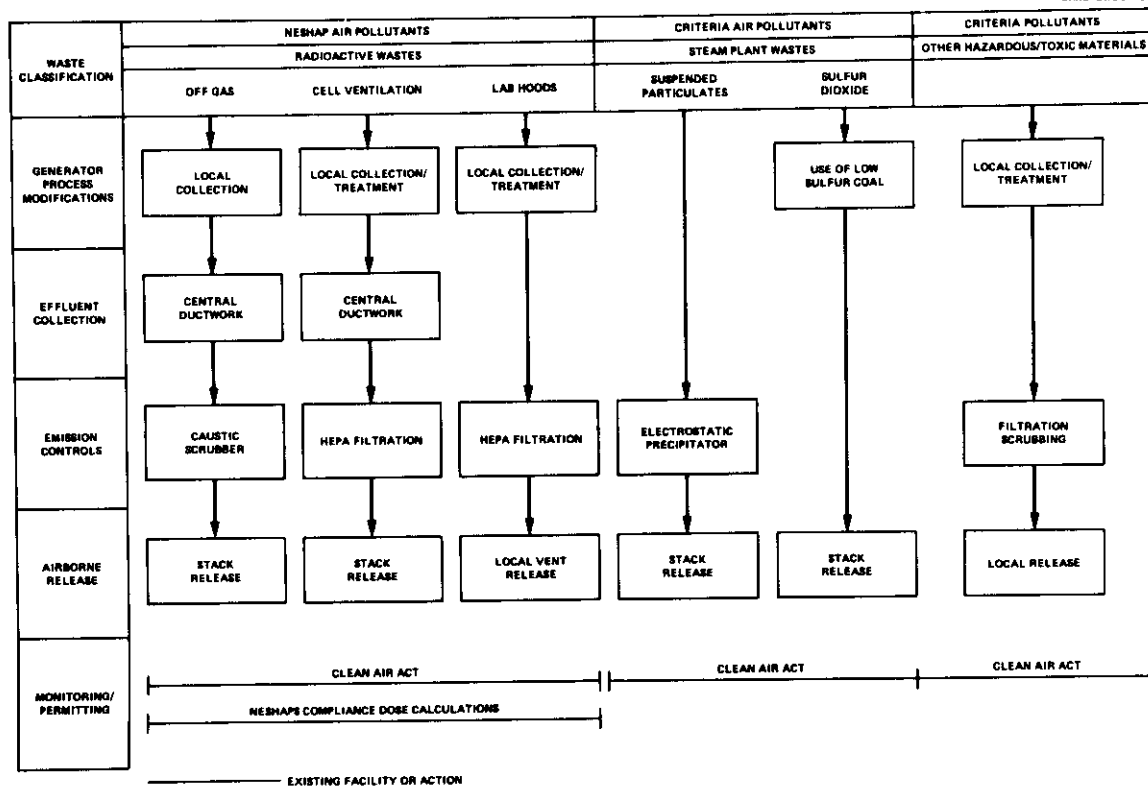


Fig. 4.1.5. Air pollution control program at ORNL.

cell ventilation for the Radiochemical Processing Plant, 3019. The other four (2026, 7512, 7025, and 6010) handle specific facilities and only very small quantities of activity. An eighth stack, 3018, is no longer in service, although it is used to supply a small flow of air through the ORNL Graphite Reactor, which has been shut down since 1963. Flowsheets for the three major stacks (3039, 7911, and 3020) are provided in Figs. 4.1.7, 4.1.8, and 4.1.9.

In addition to the major stacks, there are a number of individual vents through which small quantities of radioactive material are discharged. They are located throughout the ORNL facilities and consist mainly of vents from storage tanks and exhaust from hoods and glove boxes used for small-scale experiments and analytical chemistry work. The current approach for control of radioactive emissions from ORNL facilities is shown in Fig. 4.1.10.

There exists an uncertainty that representative sampling of stack effluents (all stacks) is being performed. None of the stack monitors currently has isokinetic sampling conditions; however, the sampling systems for the 3039 and 7911 stacks are being upgraded to provide isokinetic sampling. ("Isokinetic sampling" is defined as a technique for collecting airborne particulate matter in which the collector is so designed that the airstream entering it has a velocity equal to that of the air passing around and outside the collector.) The 7911 system will also have the capability to track changes in flow in the stack if they should occur. Additional data are needed on flow characteristics, isokinetic mixing, flow stability, and particle size distribution in the main stacks to determine optimum sampling conditions.

The gas effluent monitor systems of 3039, 7911, 7500, 3020, and 2026 stacks contain the following items.

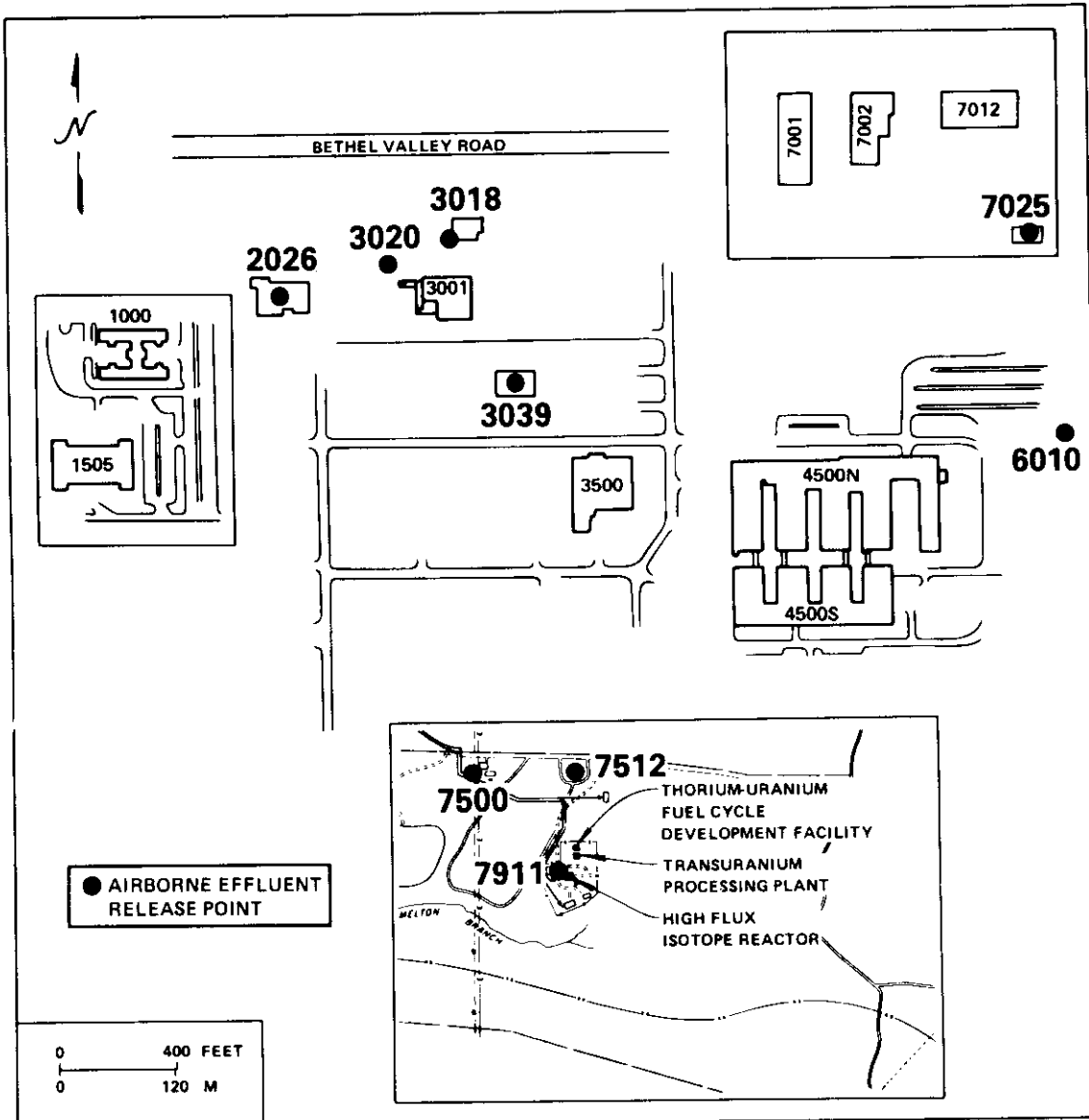


Fig. 4.1.6. Locations of airborne radioactive effluents at ORNL.

A **dual real-time iodine monitor** is installed in series with one of the particulate monitors. With this arrangement, the gas sample is withdrawn from the stack, passed through filter paper to remove the particulates, and then passed through a charcoal trap. The charcoal removes the radioiodine, which is then monitored by one to four Geiger-Müller (G-M) tubes connected in parallel.

A **real-time noble gas monitor and end-window-type G-M tube** are installed in a lead shield in

series with the particulate monitor and the iodine monitor. The effluent sample is withdrawn from the stack, passed through filter paper in a particulate monitor, through the iodine monitor, and then through the inert gas monitor before it is returned to the stack. The detector is connected to a scaler that is normally read and recorded every 24 hours.

A **real-time beta-gamma particulate monitor** consists of a filter paper tape deck, sample pump, and audible count rate meter in which visual

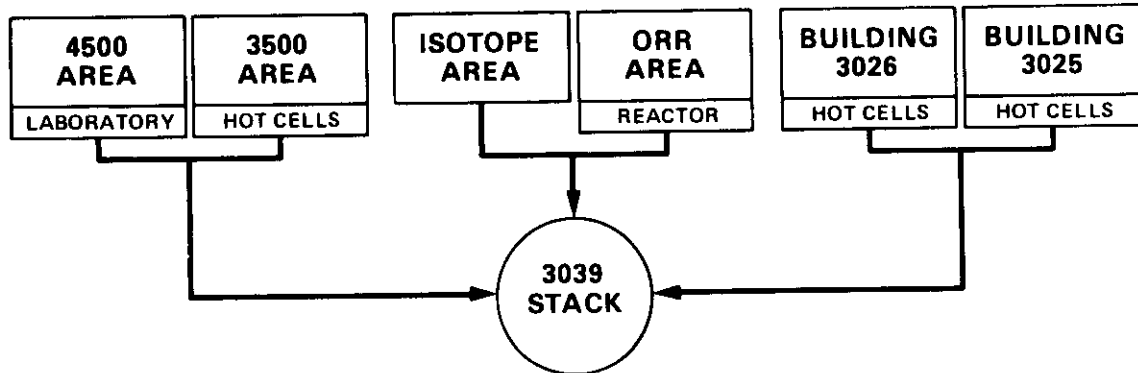


Fig. 4.1.7. ORNL central stack system for Bethel Valley facilities (3039).

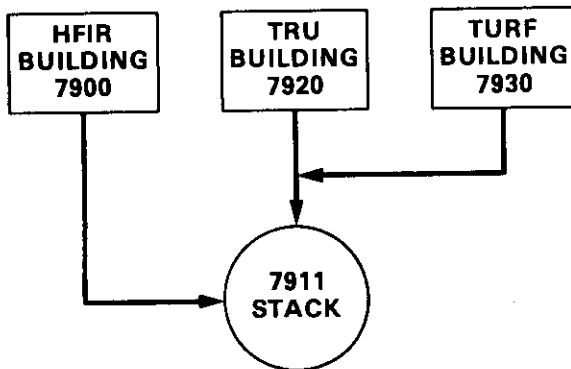


Fig. 4.1.8. ORNL central stack system for Melton Valley facilities (7911).

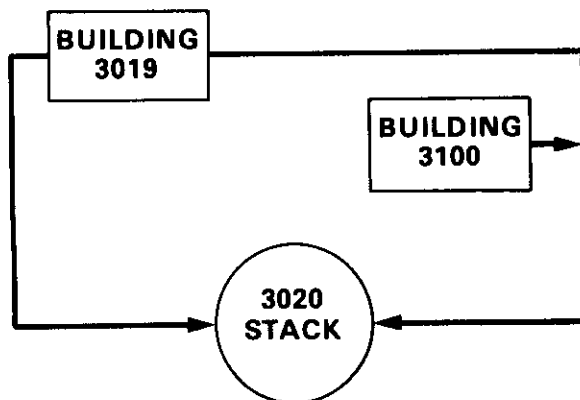


Fig. 4.1.9. Ventilation system for the Radiochemical Processing Plant (3020).

alarms are activated when the tape is expended or broken.

An **alpha particulate monitor** is the same as the beta-gamma monitor except for the detector and detector shielding. The detector is a scintillation type that uses silver-activated zinc sulfide as the scintillator.

The **high-level, wide-range gamma monitor** measures gross gamma dose rates at the detector location.

An attempt was made in the design of the **in-stack samplers** to comply with requirements for isokinetic sampling conditions as much as was practical. A blower is used to pump a sample of gaseous effluent from the stack and through a sample cartridge and return it to the stack.

#### 4.1.3 Oak Ridge Gaseous Diffusion Plant

As a result of ORGDP operations, point and nonpoint (fugitive) air pollution emission sources exist within ORGDP that 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 by ORGDP management. Continued development of this program involves constant cooperation and communication among ORGDP management, engineering, and operational groups, as well as the Energy Systems Central Staff organization. This program involves (1) maintenance of a flexible, well-documented environmental policy

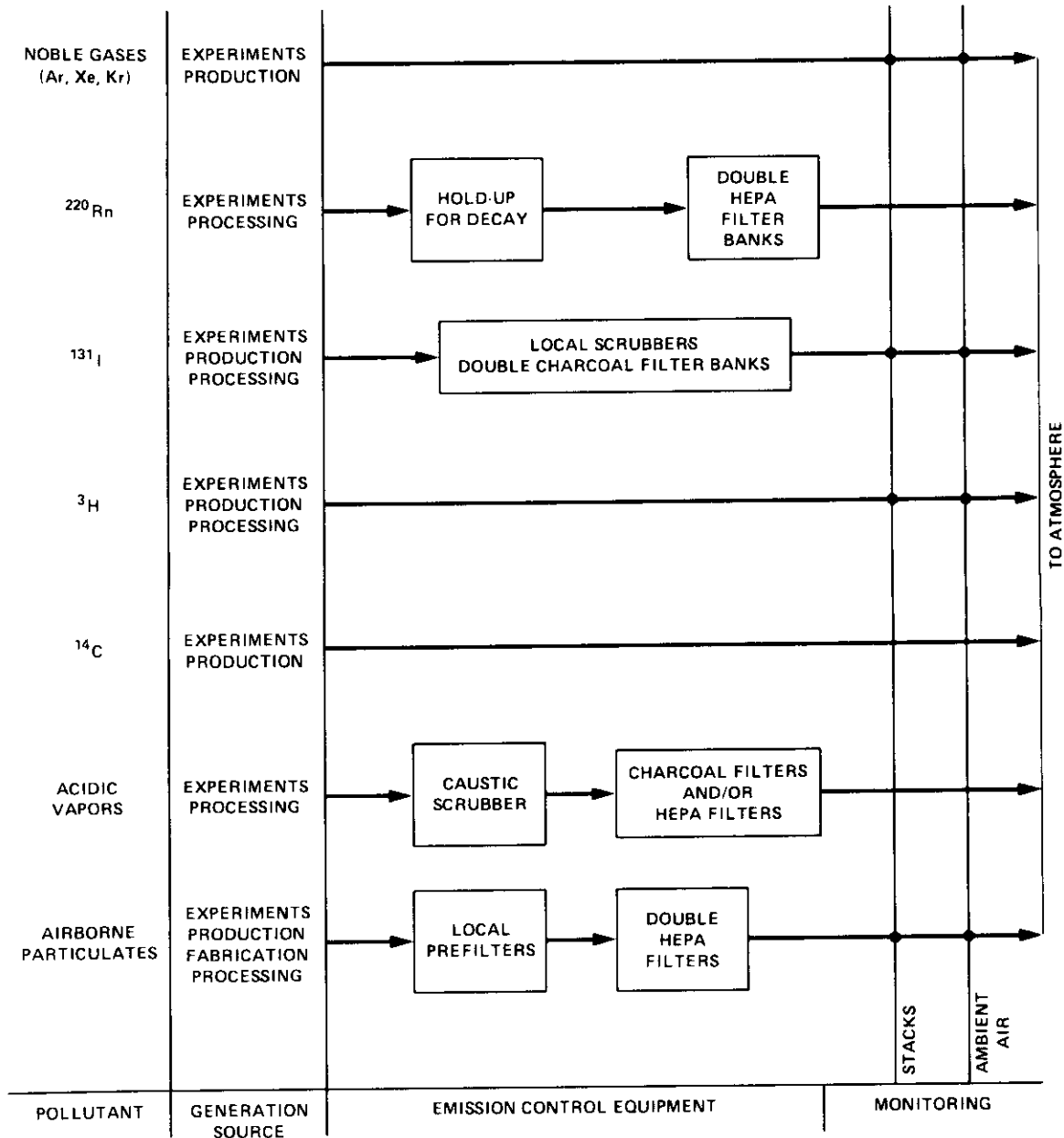


Fig. 4.1.10. Radioactive gaseous waste emission control at ORNL.

with regard to air pollution control; (2) continuous review of changes/modifications of air pollution regulations; (3) projects designed to keep ORGDP in full compliance with the CAA; and (4) operational monitoring to ensure compliance.

Most of these permitted sources are inactive at present because of the shutdown of the centrifuge

process and the standby condition of the gaseous diffusion process. Future permitting activities depend on the introduction of new processes.

The locations of airborne radioactive effluents at ORGDP are shown in Fig. 4.1.11. Figure 4.1.12 describes the general types of air emission sources at ORGDP, and Fig. 4.1.13 depicts the air pollution control program strategy in detail.



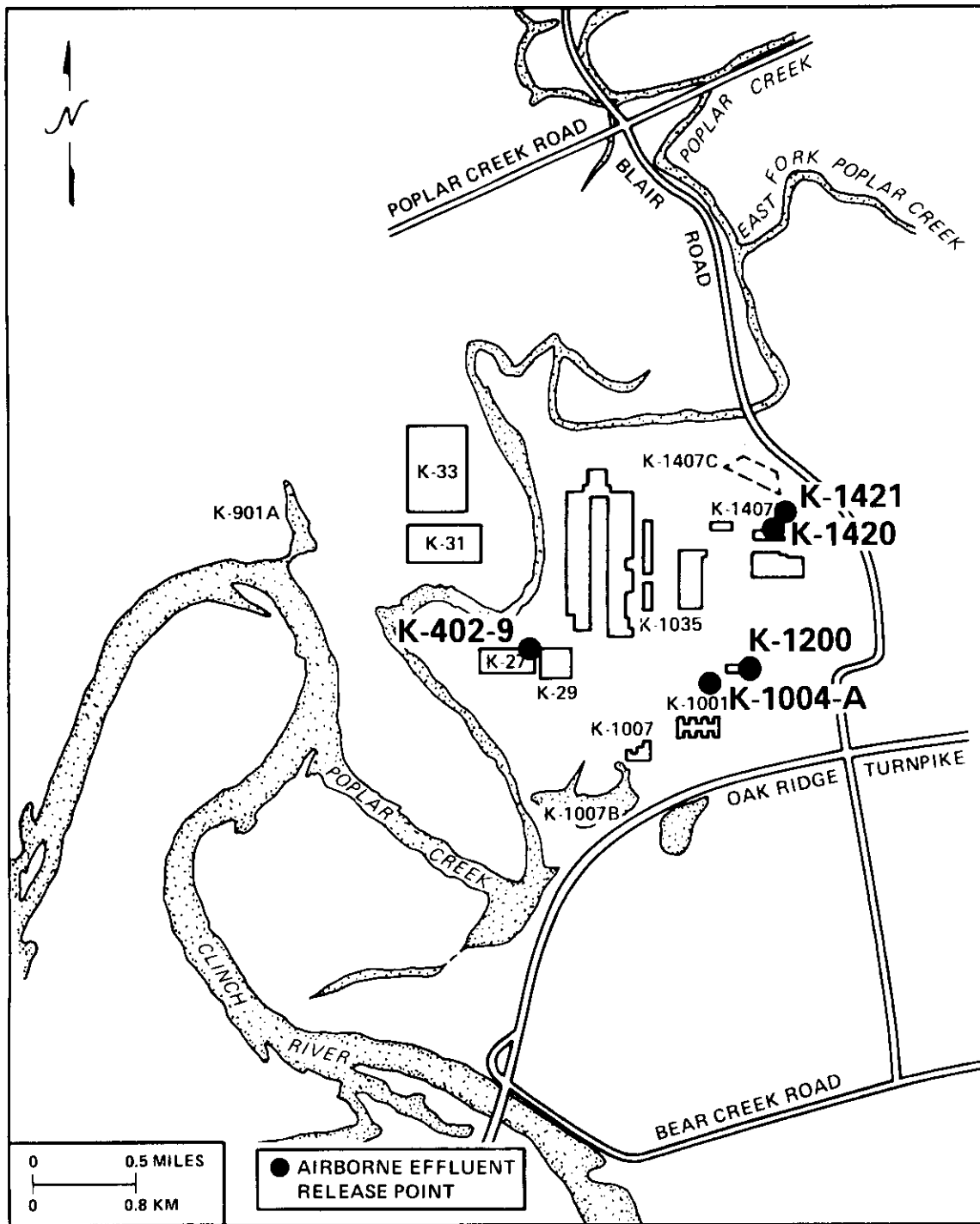


Fig. 4.1.11. Locations of airborne radioactive effluents at ORGDP.

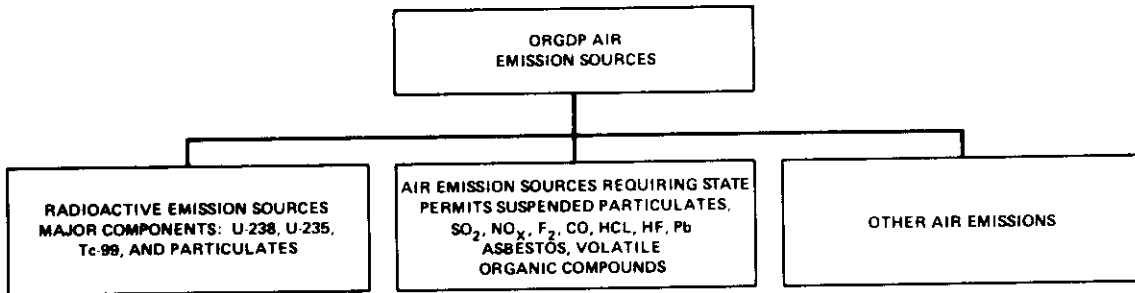


Fig. 4.1.12. Air emission sources at ORGDP.

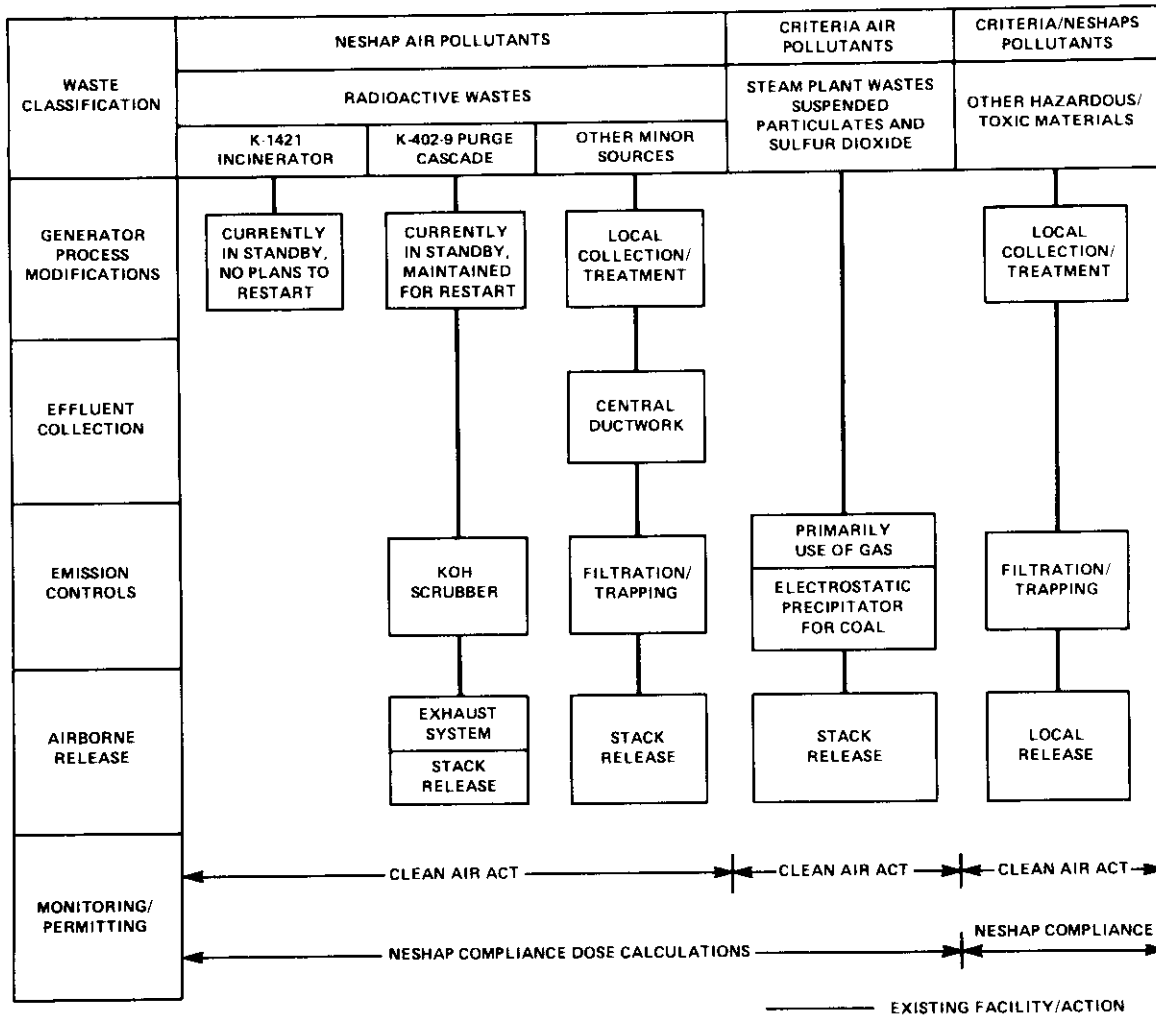


Fig. 4.1.13. Air pollution control program at ORGDP.

Before gaseous diffusion operations were placed in shutdown/standby mode, there were two emission points at ORGDP that were monitored continuously: the K-402-9 purge cascade scrubber vent and the K-1501 steam plant. Currently, the only major emission source operating is the K-1501 steam plant. The TSCA Incinerator, which is scheduled to be operating in January 1988, will be a new source.

The gaseous diffusion cascade was purged through the scrubber. The vent gas from the scrubber was sampled continuously and monitored for uranium, technetium-99, and fluoride emissions. This system was shut down when the cascade was shut down. During 1986, certain post-shutdown activities occurred and vented through the scrubber. Continuous monitoring of these emissions took place until all post-shutdown activities were completed. If the cascade should be restarted, monitoring will be reinstated. A flowsheet for the cascade is shown in Fig. 4.1.14.

The K-1501 steam plant has a continuous opacity monitor, and this system is still

operational. To reduce opacity excursions, a decision was made in 1985 to utilize natural gas as much as possible. Not enough natural gas capacity is available during very cold winter conditions and some coal must be utilized. A flowsheet for the steam plant is shown in Fig. 4.1.15.

During startup of the TSCA Incinerator, testing will be performed for a wide range of emissions. This will be necessary to obtain an operating air permit from the TDHE. After the facility is operational, the stack will be continuously monitored for opacity, CO, CO<sub>2</sub>, and O<sub>2</sub> emissions to meet RCRA and TSCA standards. Also, since the incinerator will be allowed to burn low-level radioactively contaminated materials, the stack will have to be sampled for radioactive emissions as regulated under NESHAP. It has been proposed to EPA to sample for uranium, <sup>125</sup>I, and <sup>131</sup>I quarterly for the first year and annually thereafter. Although the incinerator will burn a wide variety of radionuclides, only uranium, <sup>125</sup>I, and <sup>131</sup>I will be sampled because these are the isotopes that

ORNL-DWG 87-8424

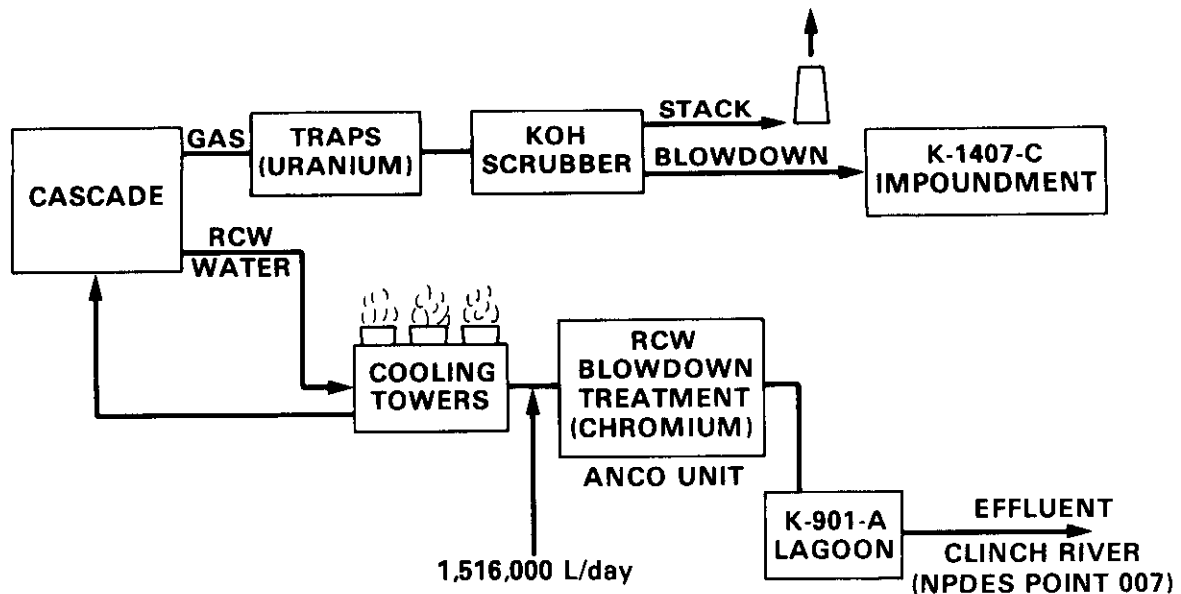


Fig. 4.1.14. Flowsheet for ORGDP cascade.

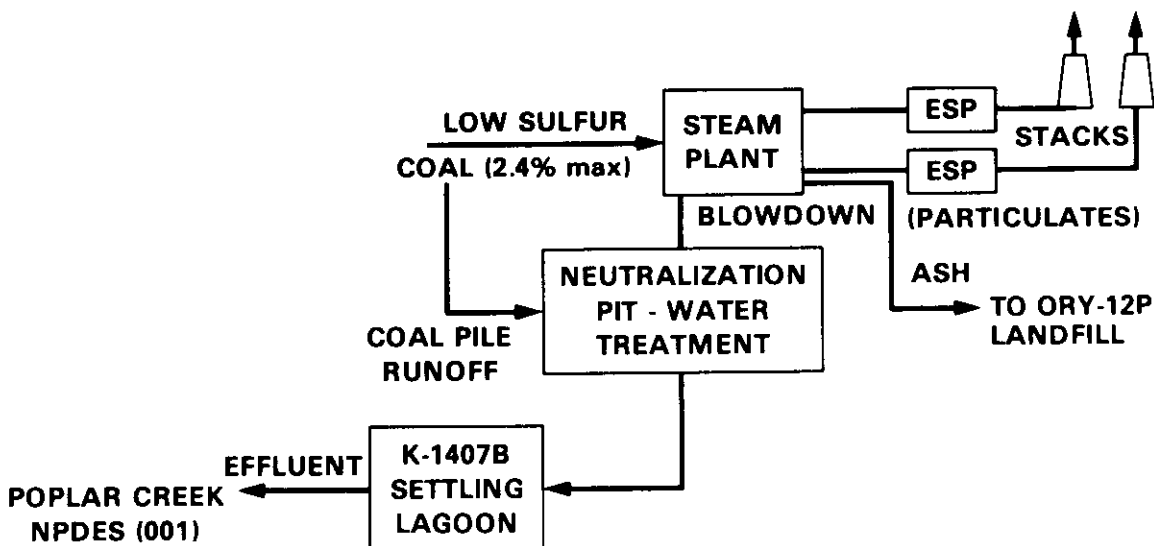


Fig. 4.1.15. Flowsheet for ORGDP steam plant.

predominantly contribute to the overall dose to the public.

A project initiated to identify the significant emission sources of uranium, technetium-99, and fluorides at ORGDP was completed in 1985. Two isokinetic samples were taken using an approximation to EPA Method 5 particulate and fluoride sampling at each of these emission sources. Accurate radionuclide emission levels were determined for the reporting requirements of NESHAP. A general flow diagram for ORGDP is shown in Fig. 4.1.16.

**4.1.4 1986 Discharges to the Atmosphere**

During 1986, it is estimated that a total of 0.19 Ci (211 kg) of uranium was released into the

atmosphere from the Oak Ridge Y-12 Plant. As shown in Table 4.1.2, this includes the release of 0.13 Ci (2.0 kg) of enriched uranium measured by continuous stack sampling equipment located on 35 major process exhaust stacks. An additional 0.06 Ci (209 kg) of depleted uranium is estimated to have been emitted into the atmosphere and is included in the plant's emission totals. Although the Oak Ridge Y-12 Plant has not historically measured emissions from depleted uranium stack exhausts, emission estimates can be made using engineering analysis and results from periodic sampling. Engineering estimates were used to approximate expected emissions from depleted uranium exhausts for 1986. The Oak Ridge Y-12 Plant is currently

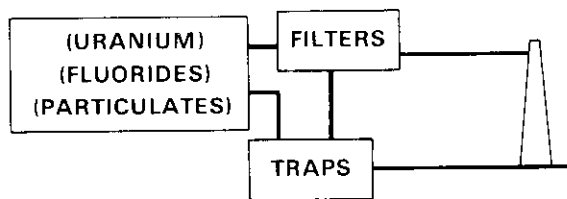


Fig. 4.1.16. General flow diagram for sources at ORGDP.

Table 4.1.2. 1986 uranium air emissions from the Oak Ridge Y-12 Plant

	Discharge	
	(Ci)	(kg)
Measured enriched U emissions	0.13	2
Measured depleted U emissions	0.001	4
Estimated depleted U emissions (process exhausts)	0.04	140
Estimated depleted U emissions (room exhausts)	0.02	65
<b>Total</b>	<b>0.19</b>	<b>211</b>

installing continuous stack sampling equipment on 45 process exhaust stacks serving depleted uranium exhausts to provide emission measurements in the future.

In previous years, no emission estimates were available for depleted uranium exhausts and, therefore, depleted uranium emissions were not included in emission totals as contained in the annual environmental surveillance reports. Figure 4.1.17 shows the total curie discharge of uranium estimated to have been emitted into the atmosphere from the Oak Ridge Y-12 Plant from 1982 through 1986 including engineering estimates of depleted uranium emissions. Figure 4.1.18 shows the comparable total mass of uranium emitted from the Oak Ridge Y-12 Plant for the same years. Total uranium discharged to the atmosphere from the Oak Ridge Y-12 Plant from 1944 through 1986 is estimated to be 13.73 Ci (6180 kg). The 1986 vs 1985 atmospheric discharges of uranium from the Oak Ridge Y-12 Plant were 0.01 Ci (1 kg) higher.

The total discharges of hydrogen fluoride from the Oak Ridge Y-12 Plant to the atmosphere from 1982 through 1986 (107,914 kg) are shown in Fig. 4.1.19. HF releases increased by 3933 kg over those of 1985.

The total fluoride discharges from ORGDP from 1982 through 1986 are given in Fig. 4.1.20. The 7 kg of fluoride discharged in 1986

ORNL-DWG 87C-8338

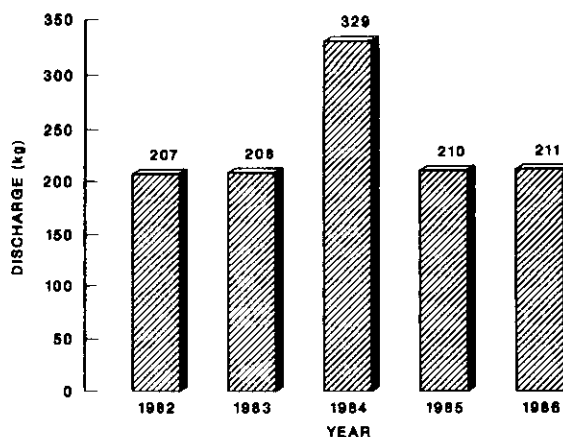


Fig. 4.1.18. Total kilograms of uranium discharged from the Y-12 Plant to the atmosphere.

ORNL-DWG 87C-8281A

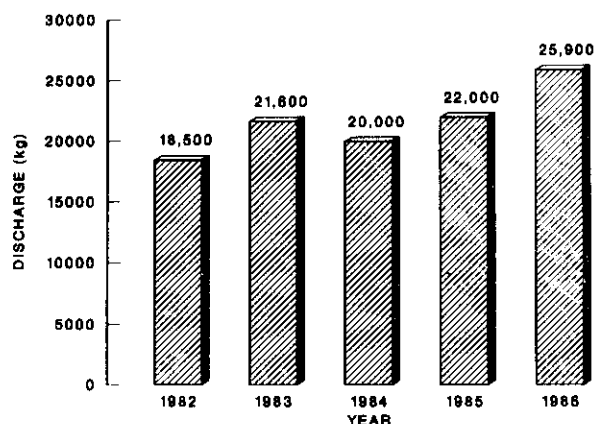


Fig. 4.1.19. Total kilograms of hydrogen fluoride discharged from the Y-12 Plant to the atmosphere.

ORNL-DWG 87C-8331

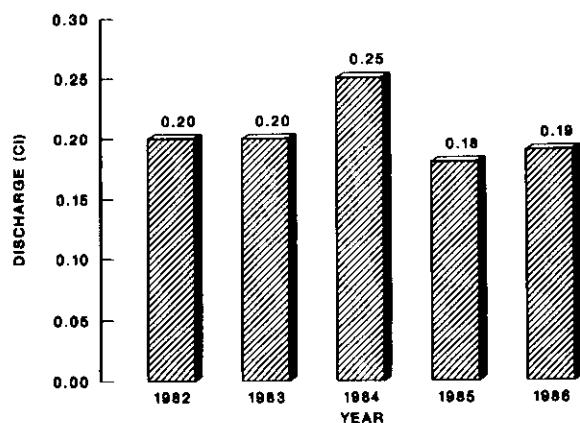


Fig. 4.1.17. Total curie discharges of uranium from the Y-12 Plant to the atmosphere.

ORNL-DWG 87C-8387

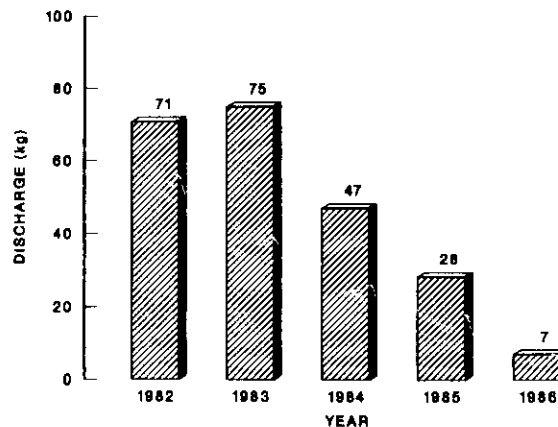


Fig. 4.1.20. Total kilograms of fluorides discharged from ORDGP to the atmosphere.

represents a 75% decrease over the 28 kg released in 1985.

The 31,000 Ci of tritium ( $^3\text{H}$ ) discharged in 1986 represents a 55% increase over the 20,000 Ci released in 1985, a result of ORNL  $^3\text{H}$  isotope work. Some of the differences in  $^3\text{H}$  discharges may be the result of the measurement method. Tritium was measured in 1984 and 1985; in all other years (including 1986) it was estimated from inventories. The total discharges of  $^3\text{H}$  to the atmosphere from 1982 through 1986 are shown in Fig. 4.1.21.

The 51,000 Ci of xenon-133 discharged in 1986 represents a 59% increase over the 32,000 Ci released in 1985. Xenon-133 discharges to the atmosphere from 1982 through 1986 are shown in Fig. 4.1.22.

The 11,000 Ci of krypton-85 discharged in 1986 represents a 60% increase over the 6,600 Ci released in 1985. The total discharge of krypton-85 to the atmosphere from 1982 through 1986 is shown in Fig. 4.1.23. The indicated increase in the noble gases ( $^{133}\text{Xe}$  and  $^{85}\text{Kr}$ ) discharged was partly the result of better measurements and an increase in processing of short-lived fission products at ORNL.

The 1986 discharge of iodine-131 represents a 67% decrease over the 0.086 Ci released in 1985. Iodine-131 discharges to the atmosphere from 1982 through 1986, shown in Fig. 4.1.24, have remained fairly constant since 1982. Apparent

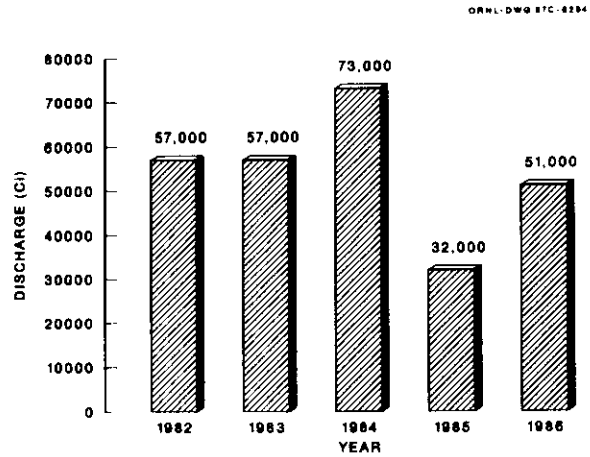


Fig. 4.1.22. Total discharges of xenon-133 from ORNL to the atmosphere.

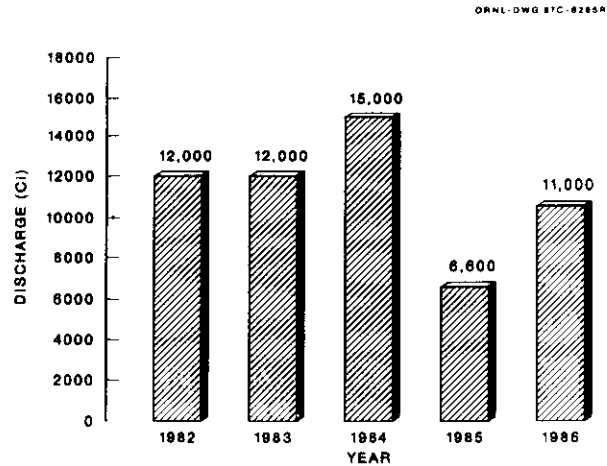


Fig. 4.1.23. Total discharges of krypton-85 from ORNL to the atmosphere.

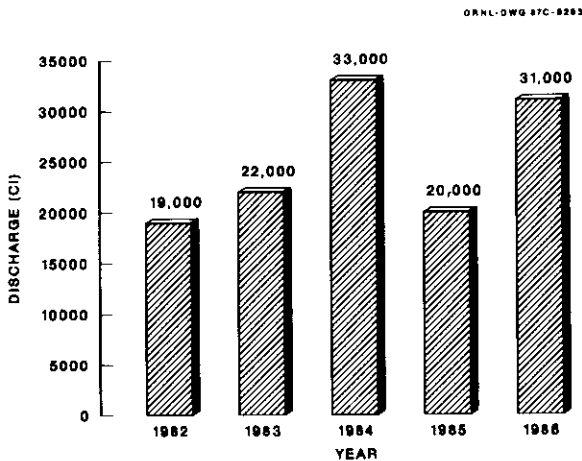


Fig. 4.1.21. Total curie discharges of tritium from ORNL to the atmosphere.

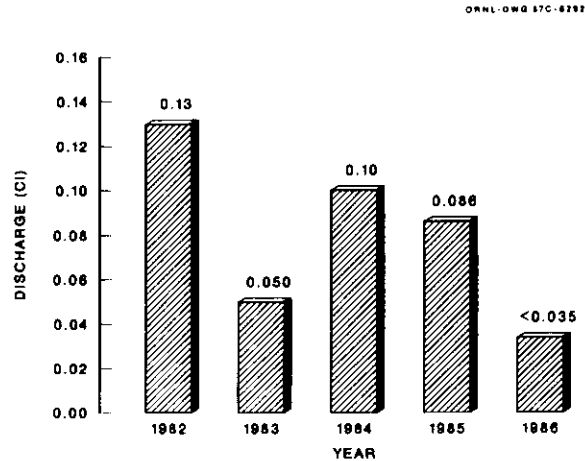


Fig. 4.1.24. Total discharges of iodine-131 from ORNL to the atmosphere.

decreases in <sup>131</sup>I are probably not real but rather a result of improved analytical techniques. During 1986 more sensitive sample counting techniques were employed, which resulted in lower detection limits. This in turn resulted in an overall decrease in the average value.

Total curies of technetium-99 discharged to the atmosphere from ORGDP from 1982 through 1986 are shown in Fig. 4.1.25. The 0.0038 Ci discharged in 1986 represents a 26% increase over 1985 releases. Mass in grams of <sup>99</sup>Tc from 1982 through 1986 is given in Fig. 4.1.26.

The total uranium discharges from ORGDP by curies and by mass to the atmosphere during 1986 are shown in Figs. 4.1.27 and 4.1.28. In both cases, 1986 discharges are significantly lower than in previous years because of the shutdown/standby status of ORGDP operations.

## 4.2 AIR MONITORING

### 4.2.1 Air Monitoring Systems

To assess the effect of Oak Ridge Y-12 Plant operations on ambient air quality and demonstrate compliance with CAA requirements, the Oak Ridge DOE facilities have a comprehensive air pollution monitoring program. Significant growth has occurred in Oak Ridge Y-12 Plant air pollution monitoring program in recent years as new operating permits were

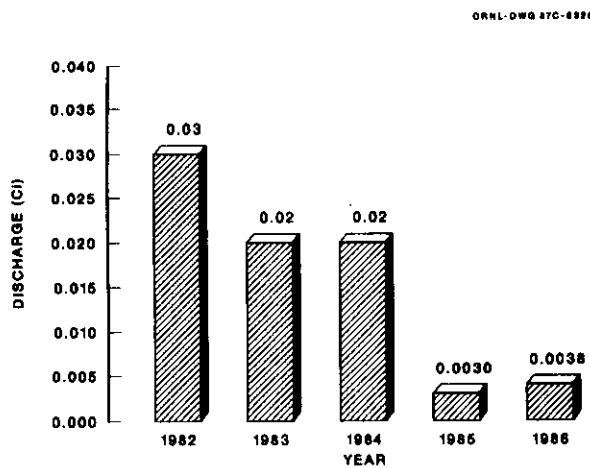


Fig. 4.1.25. Total curie discharges of technetium-99 from ORGDP to the atmosphere.

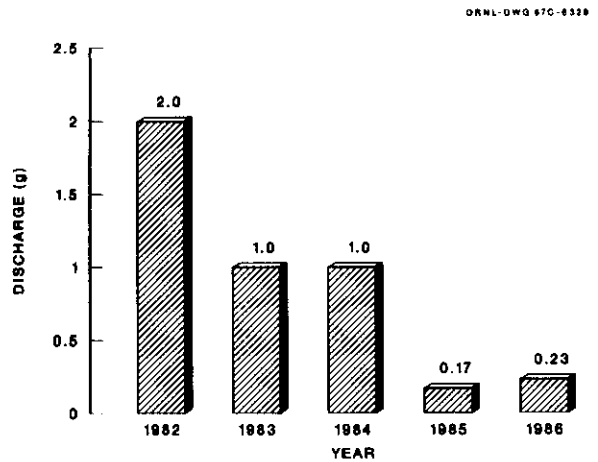


Fig. 4.1.26. Total kilograms of technetium discharged from ORGDP to the atmosphere.

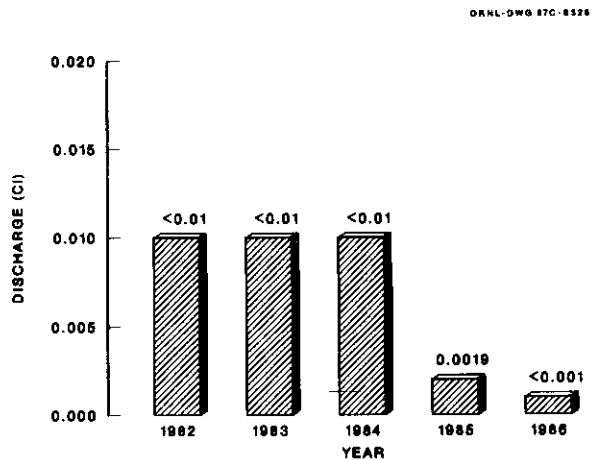


Fig. 4.1.27. Total curie discharges of uranium from ORGDP to the atmosphere.

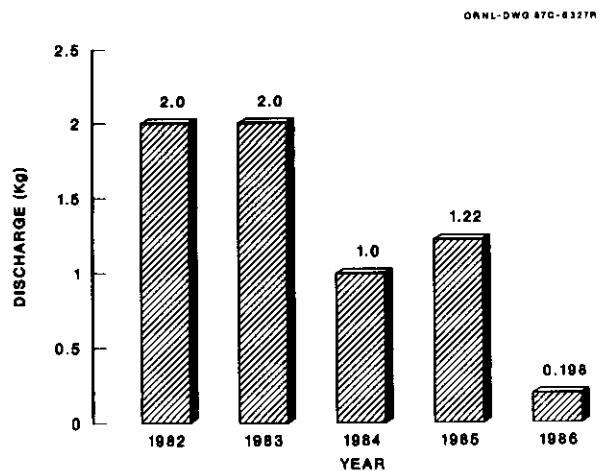


Fig. 4.1.28. Total kilograms of uranium discharged from ORGDP to the atmosphere.

obtained from TDHE and changes to air pollution regulations were completed. The promulgation of new NESHAP regulations for airborne radioactivity by EPA in 1985 imposed a number of new environmental monitoring requirements on the Oak Ridge DOE facilities. Continued growth in the air pollution monitoring program is expected in the future as EPA continues to consider modifications to air pollution regulations and new environmental monitoring activities are identified.

The Oak Ridge DOE facilities' air pollution monitoring programs involve three distinct, but interrelated, monitoring activities. The first activity, mandated by the CAA, is source emission testing (stack testing). This is required of owners and operators of air pollution sources to ensure that air pollution control devices are operating efficiently and that permitted emission rates (as contained within the source operating permit) are being met. Source emission testing is also required to quantify emissions for use in atmospheric dispersion air quality modeling.

The second activity routinely conducted under the Air Pollution Monitoring Program is atmospheric dispersion air quality modeling, which involves the use of sophisticated computer-aided mathematical models to predict the ground level concentration of pollutants at specified off-site locations. Specialized dispersion models must be used to calculate effective dose equivalents to determine compliance with EPA NESHAP regulations for radionuclides; these models utilize radiological uptake factors in addition to normal atmospheric dispersion calculations and are known as radiological dose models. Other specialized atmospheric dispersion models are used by the Oak Ridge Y-12 Plant to predict plume dispersion characteristics resulting from hypothetical short-term accidental atmospheric releases. These "puff models" are used exclusively by emergency response personnel to facilitate response activities.

Ambient air monitoring is the third method of environmental surveillance conducted at the Oak Ridge Y-12 Plant and is a method in which direct measurement of pollutants in the

atmosphere is performed at both on-site and off-site locations. This enables determination of the effect that operations have on the region's ambient air quality through direct sampling. Ambient air quality sampling is used to determine the compliance status of a region with ambient air quality standards and is also useful in protecting workers and other personnel from the hazards associated with stack emissions.

There are five systems for monitoring air at the Oak Ridge DOE installations: (1) stations around the perimeter of the Oak Ridge Y-12 Plant; (2) stations around the perimeter of ORGDP; (3) stations on and around the ORR; (4) stations around the perimeter of ORNL; and (5) stations remote from the ORR at distances of from 19 to 121 km.

The numbering system for air stations is as follows: ORNL stations are designated A1-A30; ORR stations are A31-A50; remote stations are A51-A60; ORY-12P stations are A61-A80; and ORGDP stations are A81-A100. There are more numbers assigned than there are stations at present, which allows additional stations to be added in the future without effect on the numbering system.

These air monitoring stations are categorized into five groups according to their geographical locations:

- (1) The Oak Ridge Y-12 Plant perimeter air monitoring network consists of stations A61-A72. These stations are located at or near the Oak Ridge Y-12 Plant boundaries (Fig. 4.2.1).
- (2) The ORNL perimeter air monitoring network consists of stations A3, A7, A9, A21, and A22. These stations are located at or near the ORNL boundary. Stations A21 and A22 are used only for external gamma radiation measurements; there is no sampling equipment. These stations are currently being upgraded to provide sampling capability (Fig. 4.2.2).
- (3) The ORGDP perimeter air monitoring network consists of stations A81-A98.



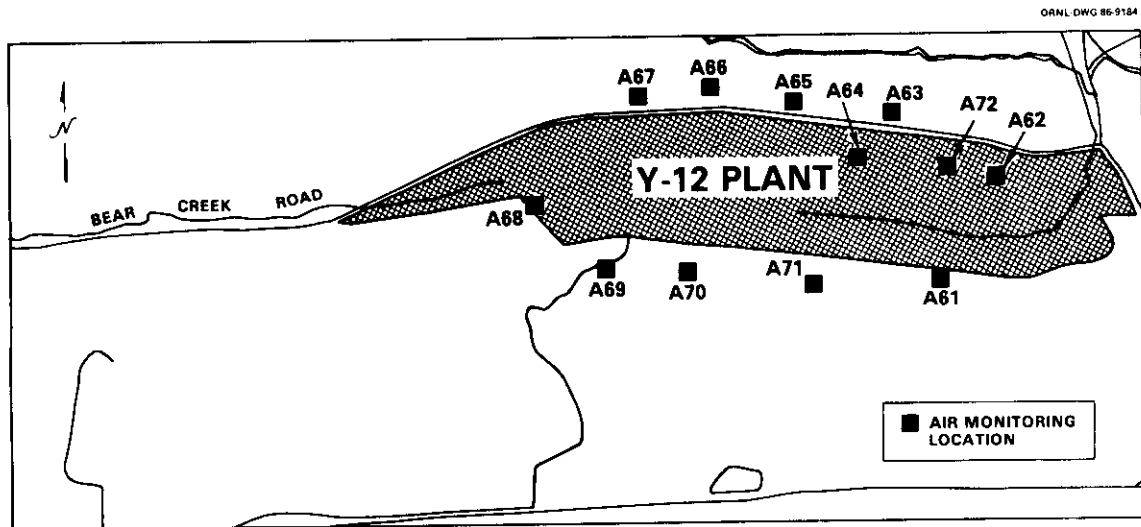


Fig. 4.2.1. Location map of perimeter air monitoring stations around the Y-12 Plant.

These stations are located at or near the ORGDP boundaries (Fig. 4.2.3).

- (4) The ORR network consists of stations A8, A23, A31, A33, A34, A36, and A40–46 (Fig. 4.2.4). During the latter part of 1985 and early 1986, ten of the ORR stations were upgraded. Each air station has the capability to perform both sampling and continuous monitoring. Station A46 is a new real-time monitoring location installed during the third quarter of 1986 in the Scarboro Community in Oak Ridge, and its sampling capability was activated in October 1986. The ORR air monitoring system consists of ten stations (A31 through A41) that are, with one exception, outside the Oak Ridge Y-12 Plant, ORNL, and ORGDP boundaries but inside the ORR boundaries. These provide data for evaluating releases from Oak Ridge installations to the immediate environment.
- (5) The remote air monitoring system consists of seven stations (A51 through A57) that are outside the ORR at distances of from 19 to 121 km (Fig. 4.2.5). This system provides background data to aid in evaluating local conditions and fallout data.

Most gaseous wastes are released to the atmosphere through stacks. Radioactivity may be present in gaseous waste streams as a solid (particulates), as an absorbable gas (iodine), or as a nonabsorbable species (noble gas). Most gaseous wastes that may contain radioactivity are processed to reduce the radioactivity to acceptable levels before they are discharged. In addition to stack discharges, there are potential airborne releases from burial grounds (e.g.,  $^3\text{H}$  and  $^{14}\text{C}$ ) and from uranium chip fires at the Oak Ridge Y-12 Plant. Atmospheric concentrations of materials occurring naturally in the general environment of East Tennessee are measured by several monitoring systems.

The Oak Ridge Y-12 Plant operates 11 perimeter ambient air monitoring stations within its boundaries to routinely measure fluorides. In addition, two stations are operated to monitor sulfur dioxide concentrations in the ambient air surrounding the installation, and two additional stations collect suspended particulates.

During 1986, the Scarboro station was added to the ORR network (A46) specifically to measure potential off-site impacts of Oak Ridge Y-12 Plant operations. It is located near the area of theoretical maximum public pollutant concentrations as calculated by air quality modeling.

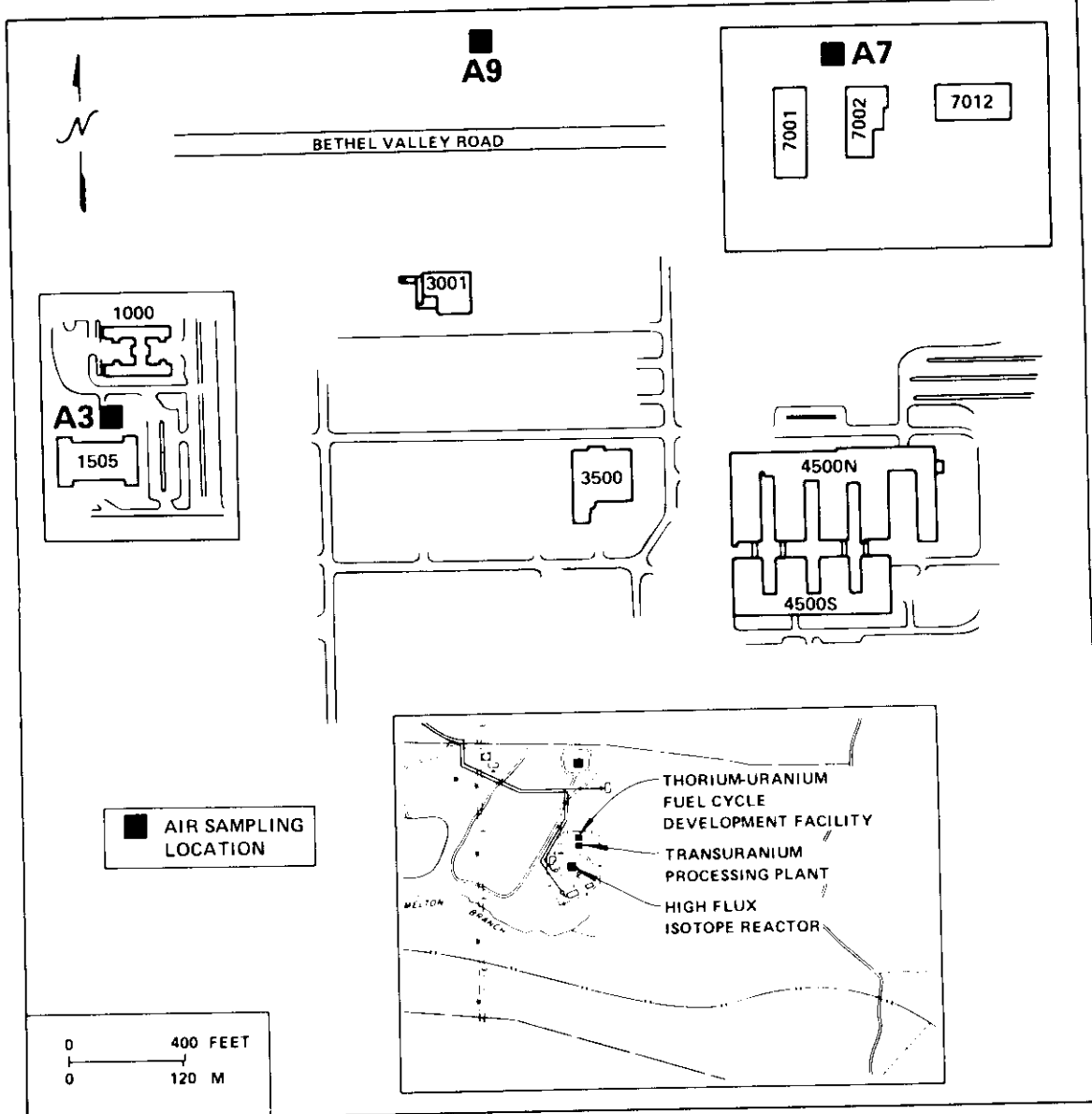


Fig. 4.2.2. Location map of perimeter air monitoring stations around ORNL.

Eleven of the perimeter air monitors surrounding the Oak Ridge Y-12 Plant at or near the boundary fence, as shown in Fig. 4.2.1, measure ambient uranium concentrations, gross alpha, gross beta, and other parameters of interest at the boundary. The results from the weekly samples were composited quarterly by station and evaluated for uranium, gross alpha,

and gross beta. Station A72 is used only for monitoring suspended particulates.

Environmental air samples were taken for determination of fluorides and suspended particulates around ORGDP and the Oak Ridge Y-12 Plant and for  $\text{SO}_2$  around the Oak Ridge Y-12 Plant. Fluorides, suspended particulates, and  $\text{SO}_2$  are not monitored around ORNL.

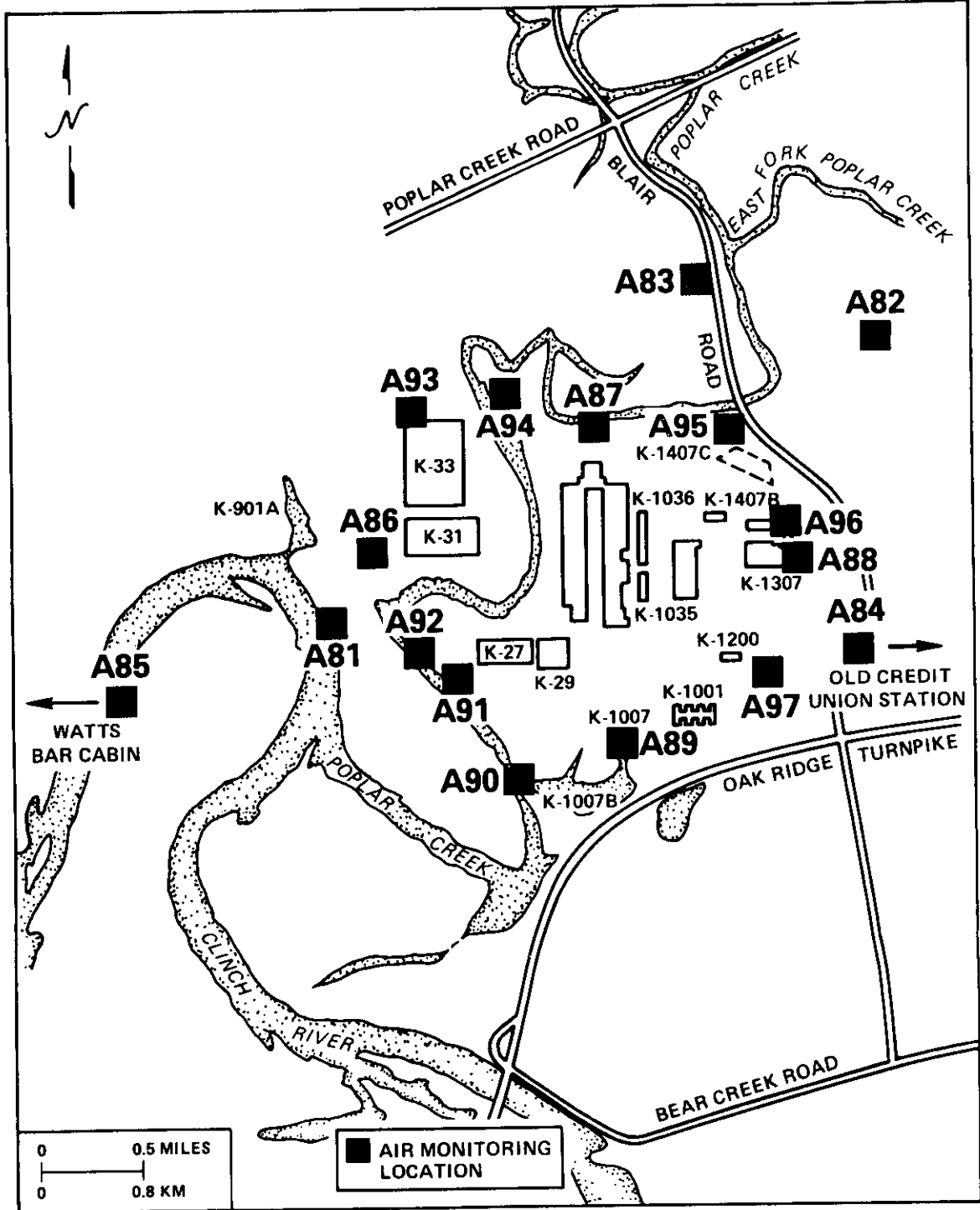


Fig. 4.2.3. Location map of perimeter air monitoring stations around ORGDP.

because releases are below regulatory limits. (Particulates from the steam plant are 818 kg and releases of SO<sub>2</sub> are 4091 kg annually.) Because sulfur compounds are released from ORR installations, SO<sub>2</sub> in the environment is being monitored.

Oak Ridge Y-12 Plant fluoride sampling is conducted at 11 stations for seven consecutive days each month. Atmospheric fluoride is collected by absorbing it on 50-mm-diam filters treated with potassium carbonate.

The Oak Ridge Y-12 Plant monitors suspended particulates in ambient air at the east and west ends of the site (Fig. 4.2.1). Sampling for suspended particulates consists of drawing air through a preweighed Whatman 41 filter paper for 24 h every 6 d. From the weight differential resulting from particle accumulation, sampling time, and air flow, the particulate concentration (expressed in  $\mu\text{g}/\text{m}^3$ ) can be calculated. These values are compared with the Tennessee primary and secondary ambient air standards. If a sample is found to exceed the state standard, the filter is studied under a high-powered microscope to determine the type of material present. If the majority of the filter is covered with road dust, insect parts, pollen, or other fugitive particles, the state does not consider it a violation.

Sulfur dioxide monitoring is conducted continuously at two stations at the Oak Ridge Y-12 Plant (Fig. 4.2.1). Ambient air is pumped into pulsed ultraviolet fluorescence analyzers that are connected to recording units housed in temperature-controlled shelters. The Oak Ridge Y-12 Plant is the only DOE Oak Ridge installation that must monitor SO<sub>2</sub>, and TDHE conducts a quarterly audit of each system. Concentrations of SO<sub>2</sub> are recorded hourly for each month. The day is averaged and compared with the 3- and 24-h ambient air standards. During the past calendar year, quality assurance in the laboratory was increased to provide a lower limit of detection. These values were then used in the calculation of the averages.

Radioactive noble gases originate from ORNL and are monitored with a real-time (continuous) monitor with an electronic integrator. The majority (about 99%) of the <sup>3</sup>H (tritium)

discharged during CY 1986 came from the isotope production facilities at ORNL and was released through stack 3039. The remaining <sup>3</sup>H came from the <sup>3</sup>H target facility through stack 7025 at ORNL. Tritium is measured with a real-time monitor at stack 3039 and with silica gel samplers at stack 7025.

Alpha and beta particles are measured in filters, and <sup>131</sup>I is absorbed onto charcoal samplers that are collected three times per week from stack 3039 and weekly from five other stacks at ORNL. Iodine-131 discharges come from the two main stacks at ORNL (3039 and 7911) and result from the processing of fuel elements and the production of medical isotopes. ORNL air monitoring stations are shown in Fig. 4.2.2.

The majority of the uranium discharged to the atmosphere comes from the Oak Ridge Y-12 Plant. It is currently measured using particulate samplers. Several projects were initiated during 1986 to upgrade the monitoring and treatment facilities of stack effluents, and further improvements are planned. ORGDP also measured air discharges for uranium and <sup>99</sup>Tc using Boyce-Thompson bubblers for the largest radionuclide emission point, the purge cascade. This installation's operation was placed in standby/shutdown mode about mid-1985, and there are presently only small uranium and <sup>99</sup>Tc emissions from this source.

ORGDP's five ambient air monitors (A81 through A85) surround the installation beyond the boundary fence, as shown in Fig. 4.2.3; they are used to measure ambient uranium concentrations and other parameters of interest. The results from weekly composite samples are evaluated monthly by station for uranium and the other parameters.

Fluoride sampling locations around ORGDP are indicated in Fig. 4.2.3 by A81 through A85 (A85 is located about 8 km from ORGDP, upwind of the predominant wind direction).

Suspended particulates are measured in the ORGDP area at locations A86 through A97. Locations A86 through A89 are sampled for particulates for 24 hours every sixth day. Locations A90 through A97 are continuous air

monitors; the filter paper is analyzed for particulates approximately every 48 to 72 hours.

At the ORR (Fig. 4.2.4) and remote stations (Fig. 4.2.5) there are monitors for gross alpha, gross beta, iodine, gross gamma, and noble gas; a rain gauge; and three process sensors that are used to calculate the volume of the sample collected. 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 whether radiation levels on the ORR 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, sampling is done at each station to quantify levels of iodine, tritium, gross alpha, and gross beta. The real-time monitoring system is the only measure of noble gases in the area.

Airborne radioactive particulates are collected weekly by pumping a continuous flow of air through a paper filter. Between February and April 1986, the air particulate sampling apparatus at all sampling stations was upgraded. The new apparatus 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 days after collection. The airborne  $^{131}\text{I}$  is collected weekly in the same fashion but using a cartridge that is packed with activated charcoal instead of filter paper. The charcoal cartridges are analyzed within 24 hours 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 flow rates at stations A3–A46 are set between 0.45 and 0.9  $\text{m}^3/\text{min}$  to minimize artifacts from extremely high or low flow rates. Flow rates at stations A50–A57 are between 0.9 and 0.21  $\text{m}^3/\text{min}$ , and flow rates outside these ranges are removed from

data analysis. The concentration of radionuclides in air is calculated by dividing the total activity per sample by the total volume of air.

Sampling for radioactive particulates is carried out by directing air continuously through filter papers. Filter papers from the perimeter and remote systems are analyzed weekly by gross alpha and beta counting techniques and composited quarterly by system for specific radionuclide analysis. One exception is that for stations A36, A40, and A41 there is enough material to analyze the filters quarterly for each station.

Airborne  $^{131}\text{I}$  is monitored in the immediate environment at the ORR stations (A31 through A41) by continuously directing air through cartridges containing activated charcoal. Gamma spectrometry was used to measure  $^{131}\text{I}$ .

#### 4.2.2 Air Monitoring Data

The data for  $\text{SO}_2$  are summarized in Figs. 4.2.6 and 4.2.7 for stations A62 and A68. Maximum 24-h average concentrations at A62 ranged from a low of 0.16 mg/L to a high of 0.26 mg/L. Sulfur dioxide at A68 ranged from a low of 0.008 mg/L to a high of 0.044 mg/L. The Tennessee ambient air standard is 0.14 mg/L for the maximum 24-h average.

Maximum fluoride concentrations at stations A61 through A71 are given in Figs. 4.2.8 through 4.2.11. Station A65 had the highest concentration (0.298  $\mu\text{g}/\text{m}^3$ ) during the first quarter, and station A64 had the highest concentration (0.333  $\mu\text{g}/\text{m}^3$ ) during the second quarter. The highest concentration (0.509  $\mu\text{g}/\text{m}^3$ ) during the third quarter was at station A64. Station A67 had the highest concentration (0.281  $\mu\text{g}/\text{m}^3$ ) during fourth quarter.

Quarterly percentages of primary and secondary standards for suspended particulates at stations A86 through A97 are given in Figs. 4.2.12 through 4.2.15. The highest percentage of the primary standard was 60 at station A88 during the third quarter; the highest percentage of the secondary standard was 76 at station A88 during the third quarter. The yearly average gross alpha and beta concentrations in air for

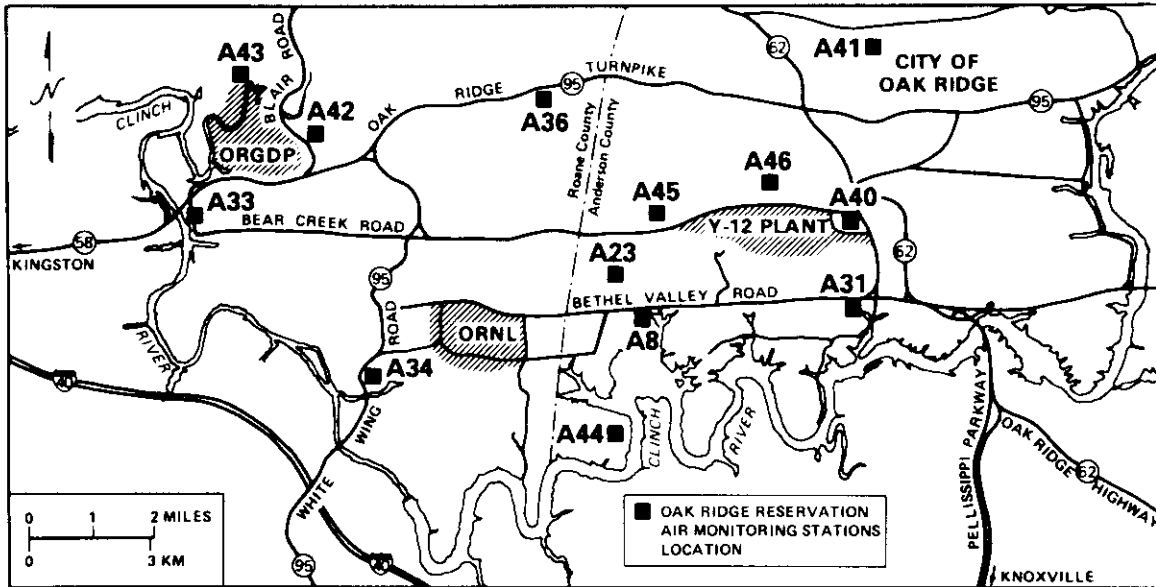


Fig. 4.2.4. Location map of the Oak Ridge Reservation air monitoring stations.

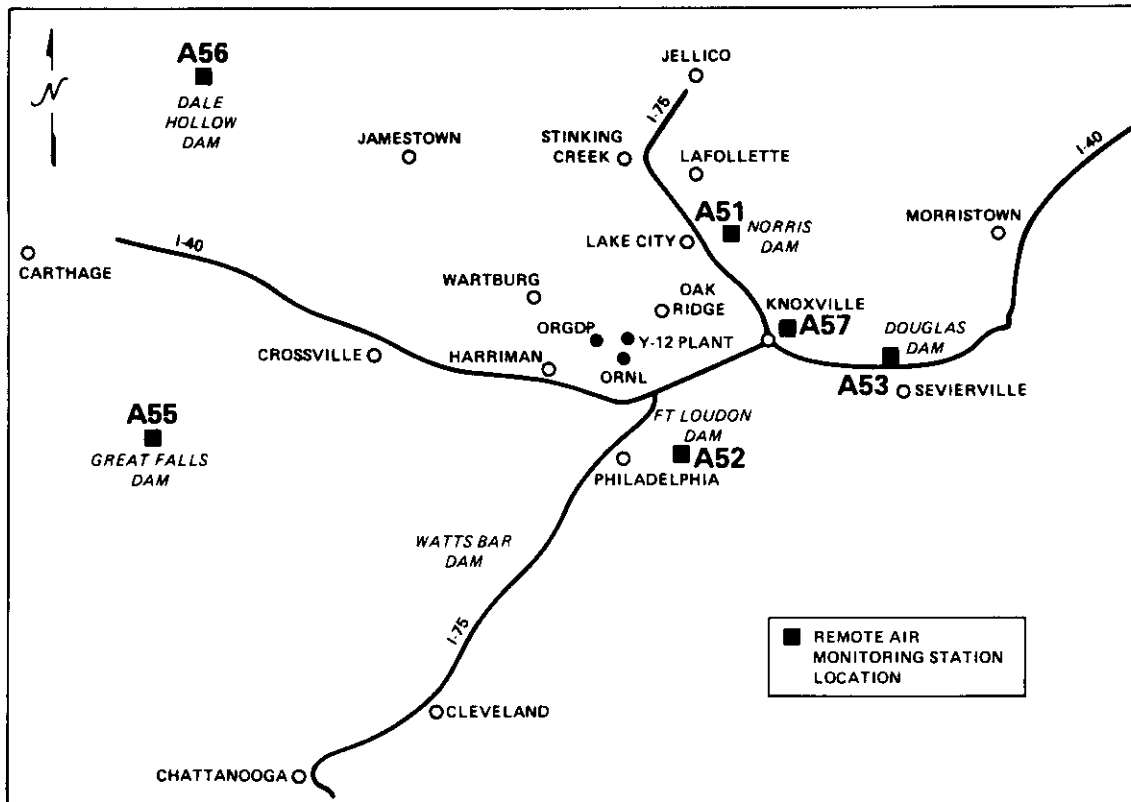


Fig. 4.2.5. Location map of the remote air monitoring stations.

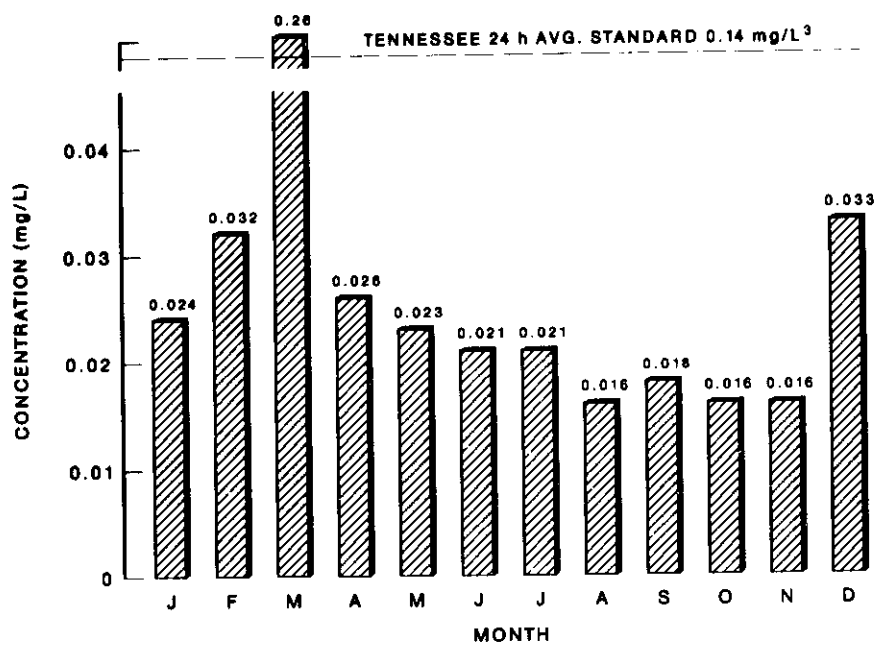


Fig. 4.2.6. Maximum 24-h average of sulfur dioxide concentrations at station A62.

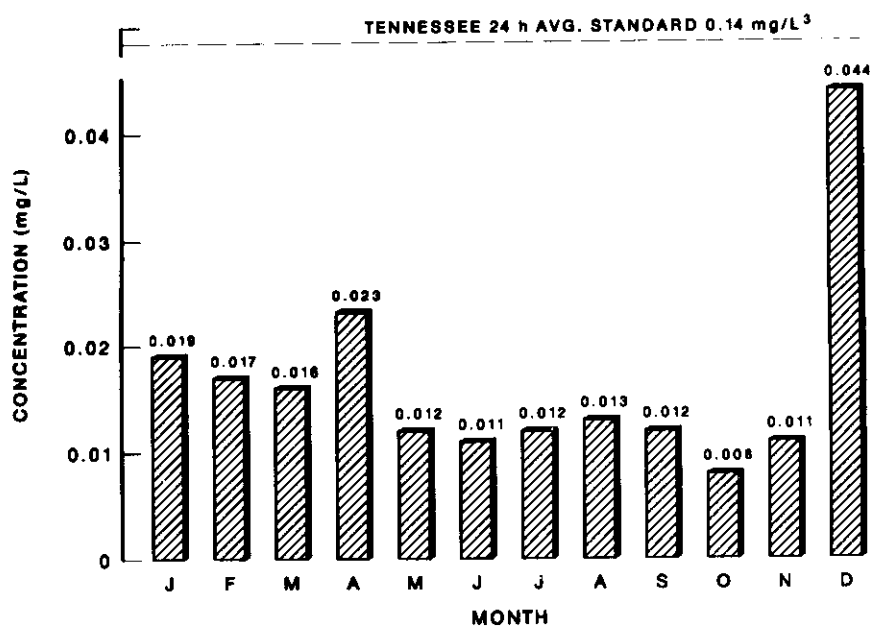


Fig. 4.2.7. Maximum 24-h average of sulfur dioxide concentrations at station A68.

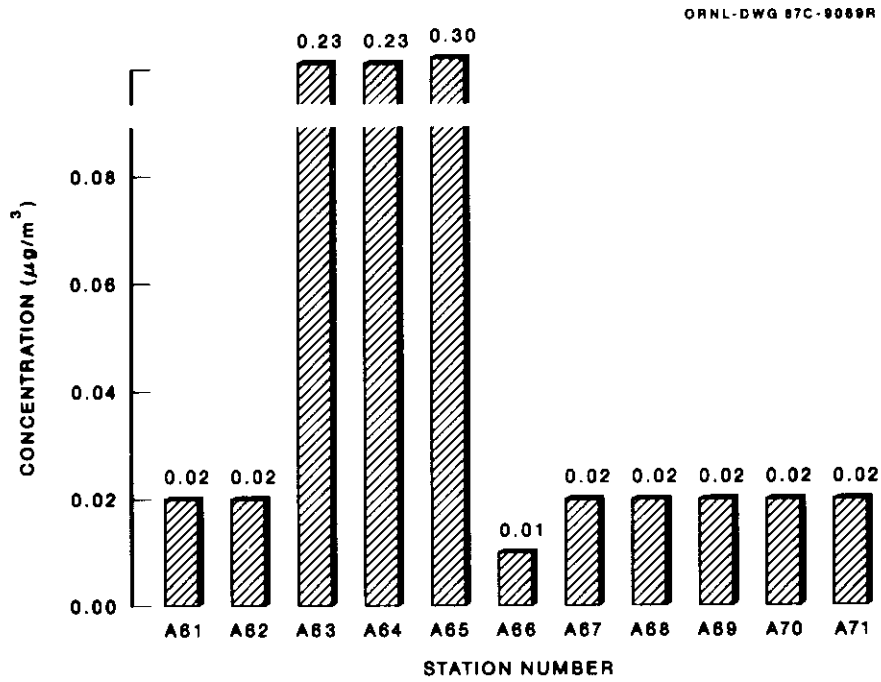


Fig. 4.2.8. Maximum fluoride concentrations at stations A61 through A71 for first quarter.  
Tennessee Standard:  $1.6 \mu\text{g}/\text{m}^3$  for 7-d average  $1.2 \mu\text{g}/\text{m}^3$  for 30-d average

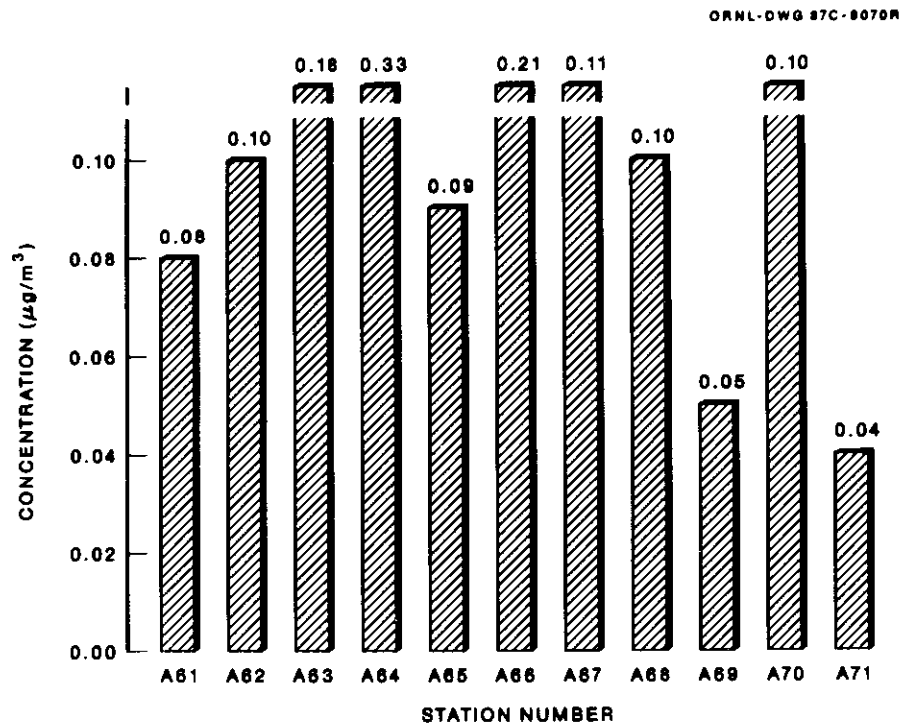


Fig. 4.2.9. Maximum fluoride concentrations at stations A61 through A71 for second quarter.  
Tennessee Standard:  $1.6 \mu\text{g}/\text{m}^3$  for 7-d average  $1.2 \mu\text{g}/\text{m}^3$  for 30-d average



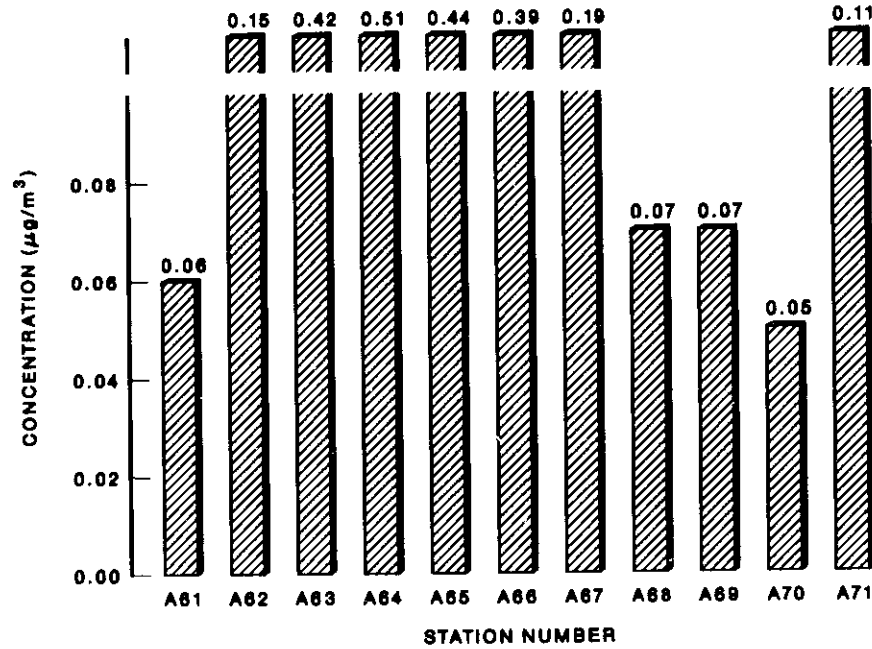


Fig. 4.2.10. Maximum fluoride concentrations at stations A61 through A71 for third quarter.

Tennessee Standard:  $1.6 \mu\text{g}/\text{m}^3$  for 7-d average  $1.2 \mu\text{g}/\text{m}^3$  for 30-d average

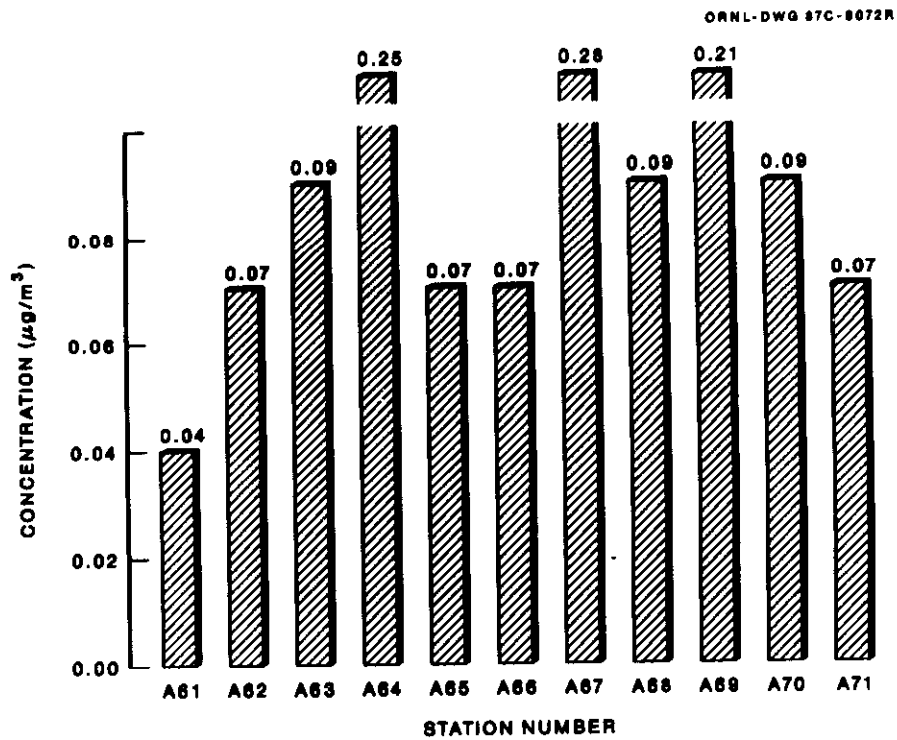


Fig. 4.2.11. Maximum fluoride concentrations at stations A61 through A71 for fourth quarter.

Tennessee Standard:  $1.6 \mu\text{g}/\text{m}^3$  for 7-d average  $1.2 \mu\text{g}/\text{m}^3$  for 30-d average

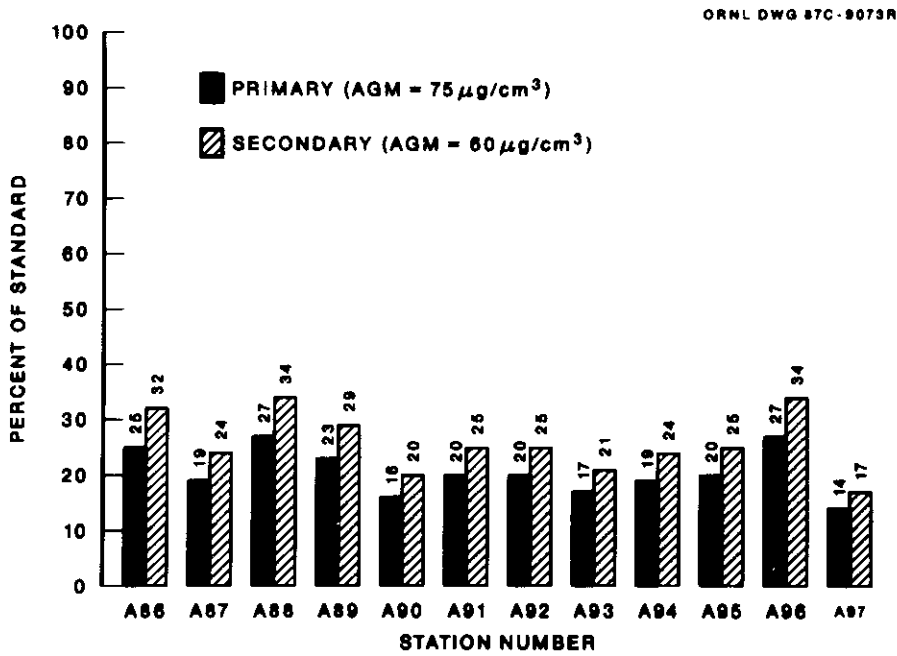


Fig. 4.2.12. Percentage of standards for suspended particulates in air at stations A86 through A97 during first quarter.

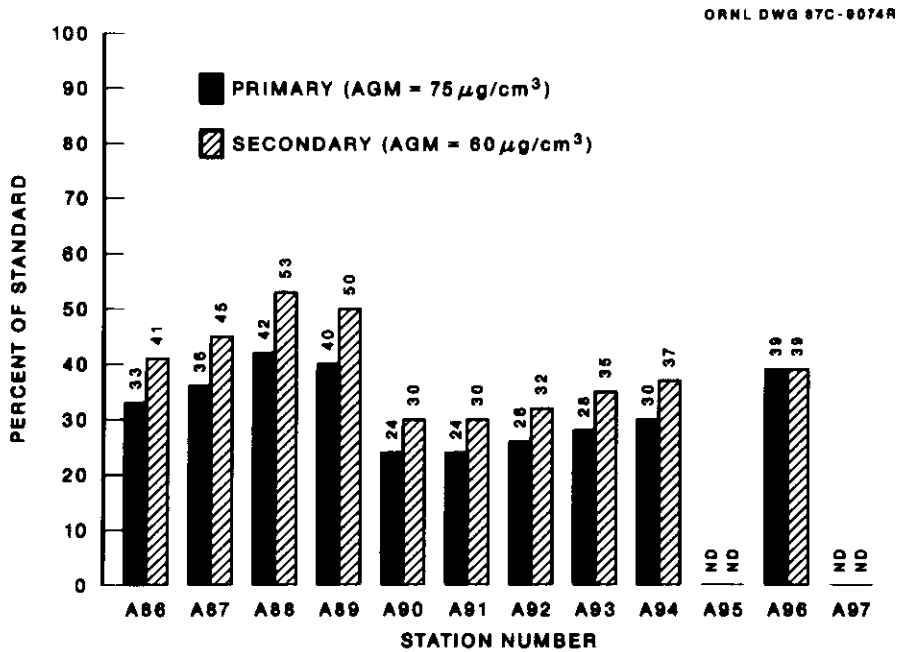


Fig. 4.2.13. Percentage of standards for suspended particulates in air at stations A86 through A97 during second quarter.

ORNL DWG 87C-8075R

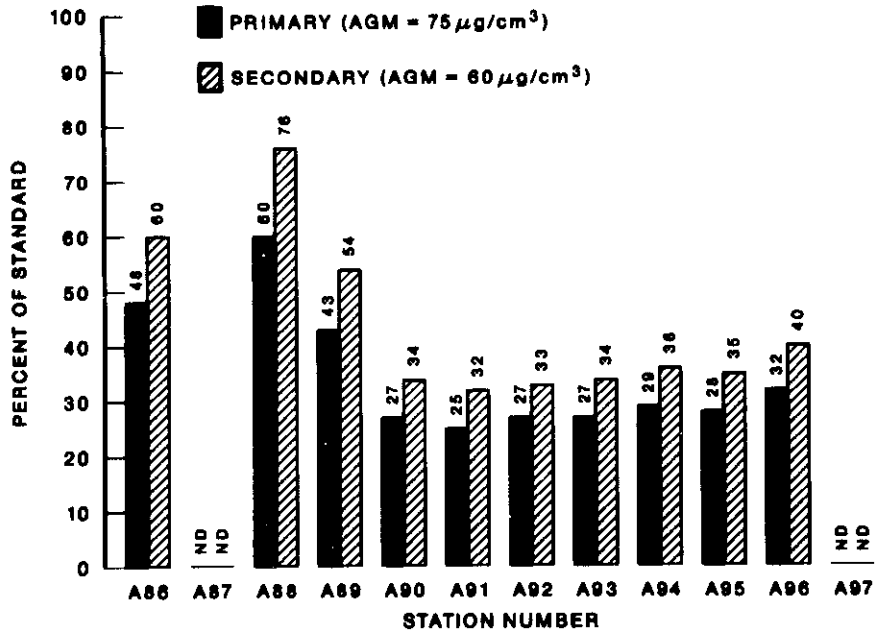


Fig. 4.2.14. Percentage of standards for suspended particulates in air at stations A86 through A97 during third quarter.

ORNL DWG 87C-8076R

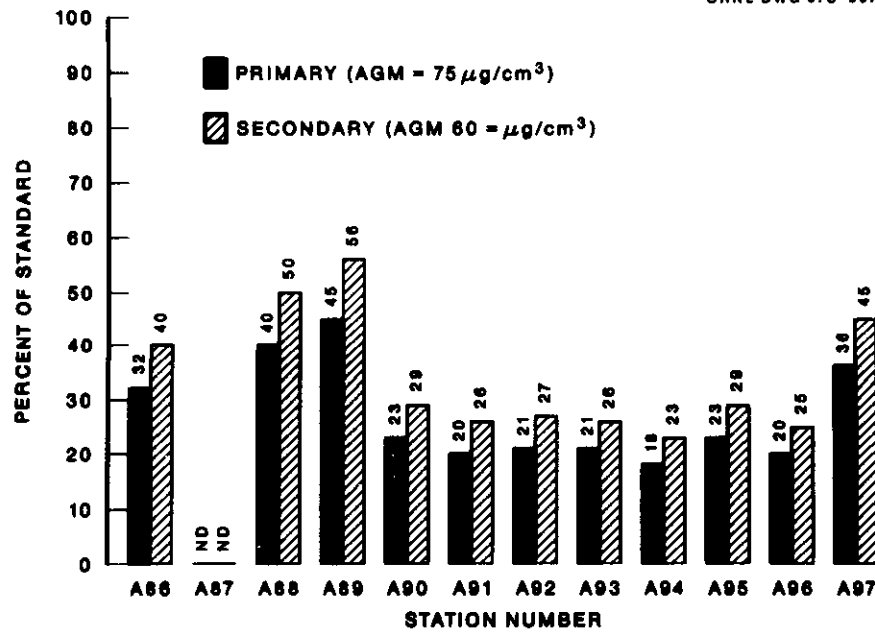


Fig. 4.2.15. Percentage of standards for suspended particulates in air at stations A86 through A97 during fourth quarter.

stations A61 through A71 are given in Figs. 4.2.16 and 4.2.17. The highest yearly average of gross alpha and beta occurred at station A64. The yearly average concentrations of  $^{234}\text{U}$ ,  $^{235}\text{U}$ ,  $^{236}\text{U}$ , and  $^{238}\text{U}$  in air at stations A61 through

A71 are given in Figs. 4.2.18 through 4.2.21. The average concentrations of radionuclides in air for ORR stations, A34, A36, A40, A41, A45, A46, and remote stations are given in Figs. 4.2.22 through 4.2.29.

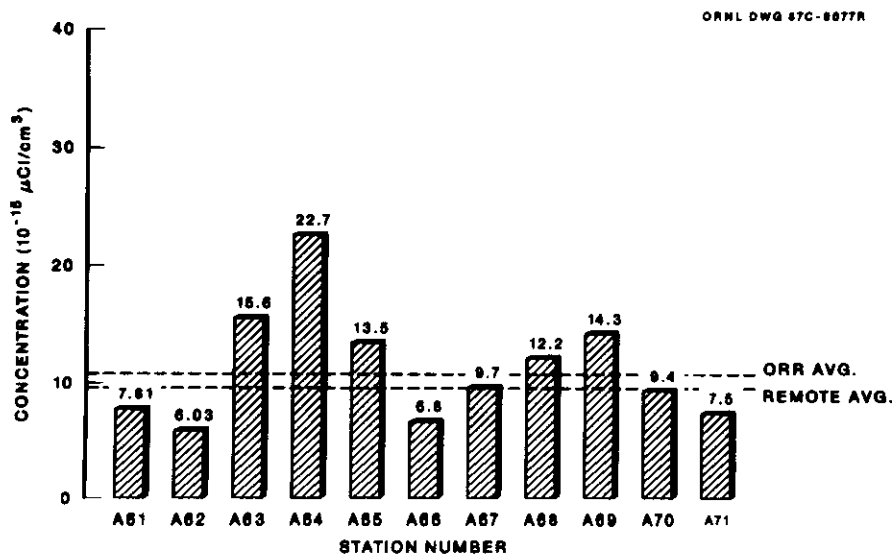


Fig. 4.2.16. 1986 average gross alpha concentrations in air at Y-12 Plant stations A61 through A71.

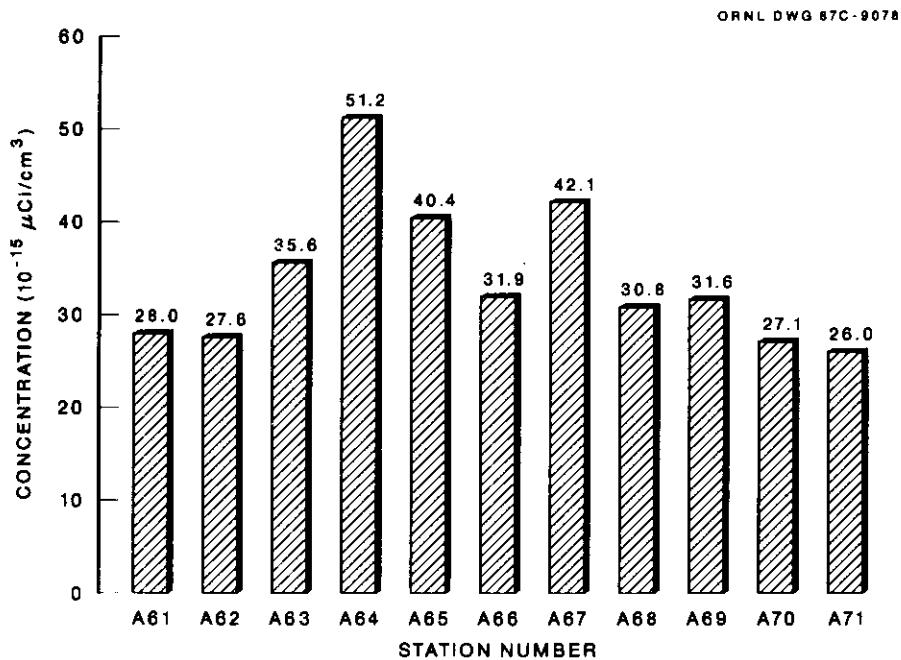


Fig. 4.2.17. 1986 average gross beta concentrations in air at Y-12 Plant stations A61 through A71.

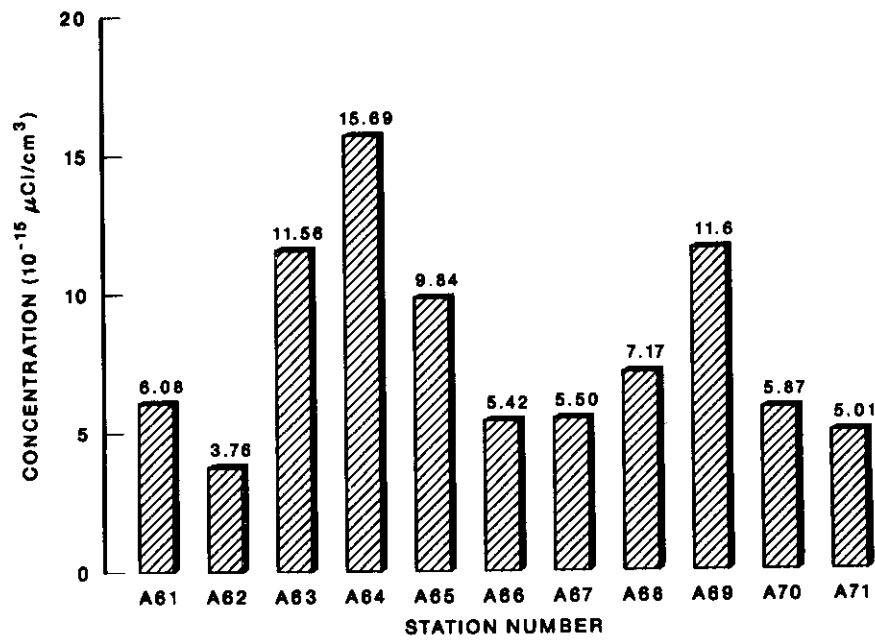


Fig. 4.2.18. 1986 average concentrations of  $^{234}\text{U}$  in air at Y-12 Plant stations A61 through A71.

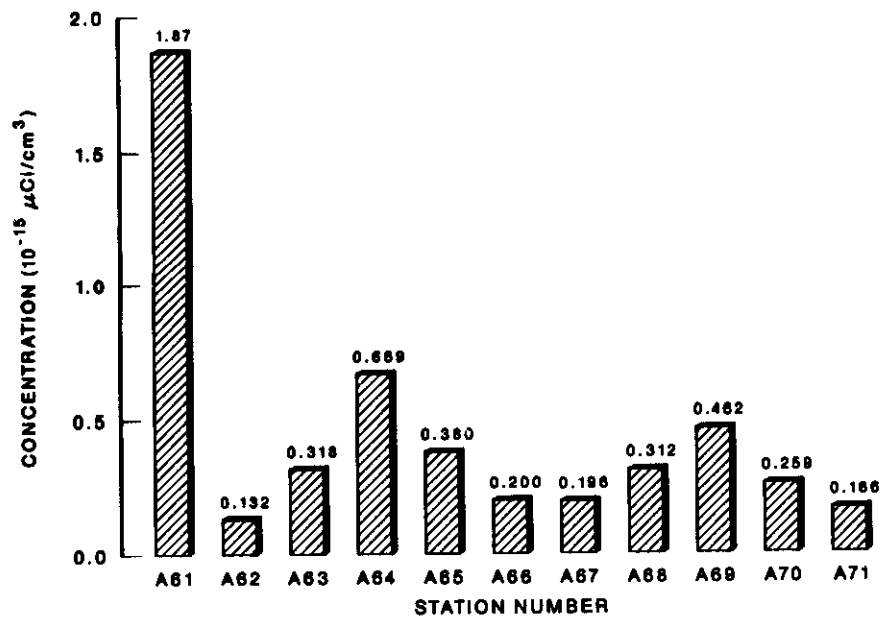


Fig. 4.2.19. 1986 average concentrations of  $^{235}\text{U}$  in air at Y-12 Plant stations A61 through A71.

ORNL 87C-9082

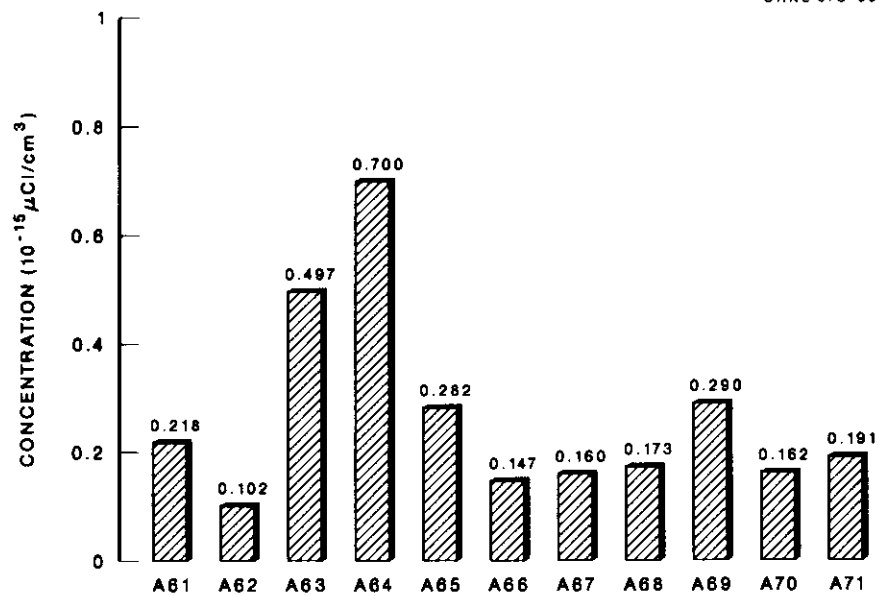


Fig. 4.2.20. 1986 average concentrations of  $^{236}\text{U}$  in air at Y-12 Plant stations A61 through A71.

ORNL DWG 87C-9079

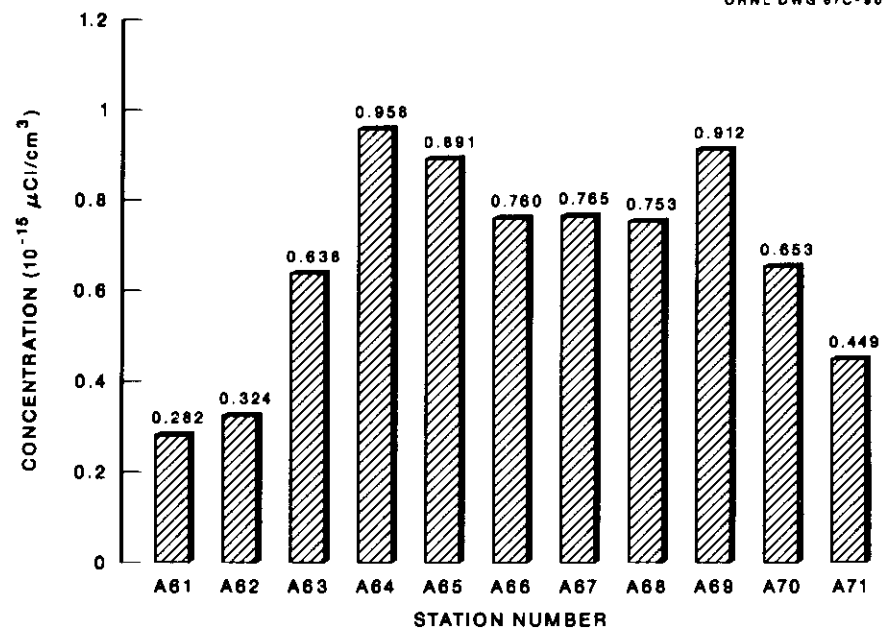


Fig. 4.2.21. 1986 average concentrations of  $^{238}\text{U}$  in air at Y-12 Plant stations A61 through A71.

ORNL-DWG 87C-9083

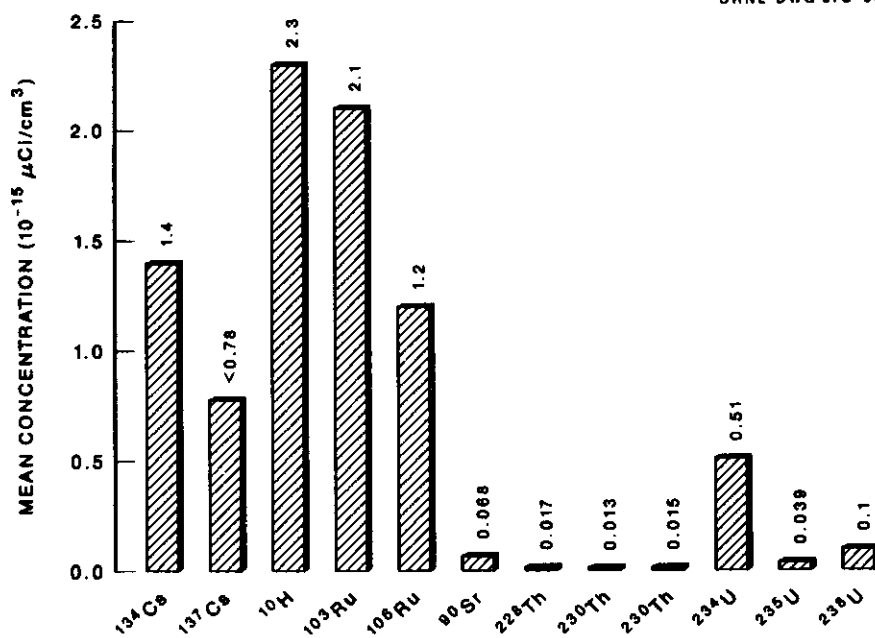


Fig. 4.2.22. 1986 average concentrations of radionuclides in air at the ORR stations.

ORNL-DWG 87C-9090

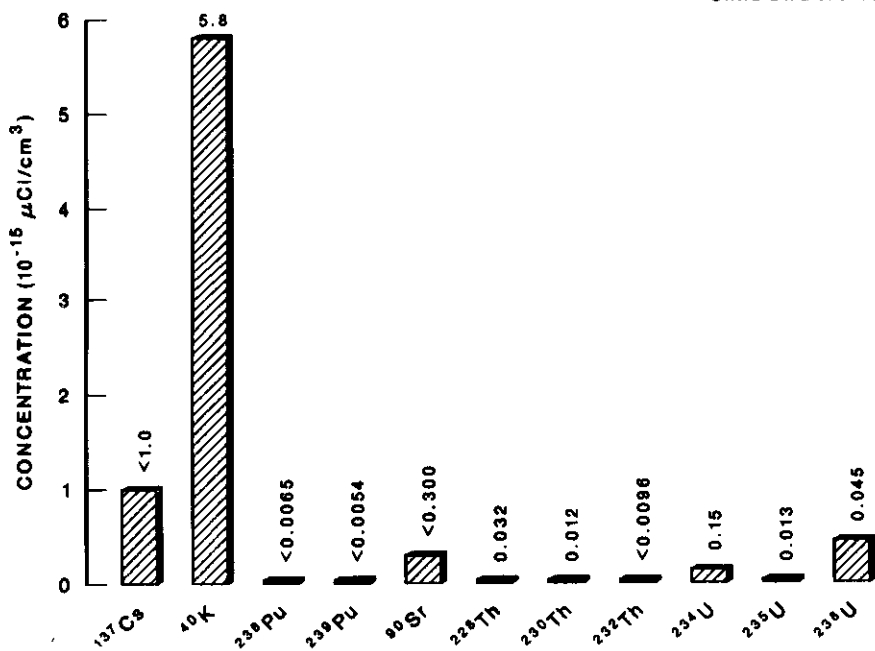


Fig. 4.2.23. 1986 average concentrations of radionuclides in air at station A34.

ORNL-DWG 87C-9089

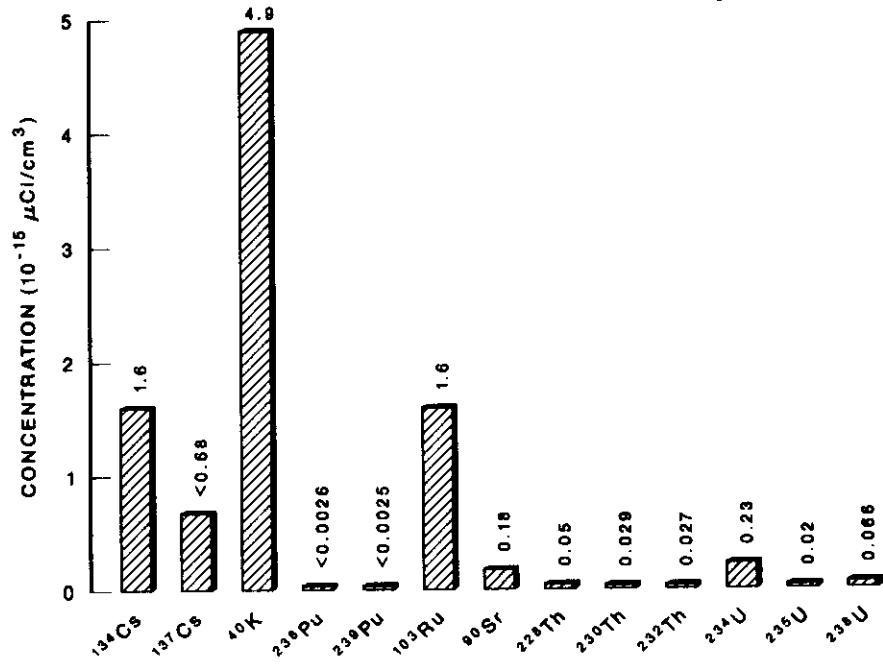


Fig. 4.2.24. 1986 average concentrations of radionuclides in air at station A36.

ORNL-DWG 87C-9089

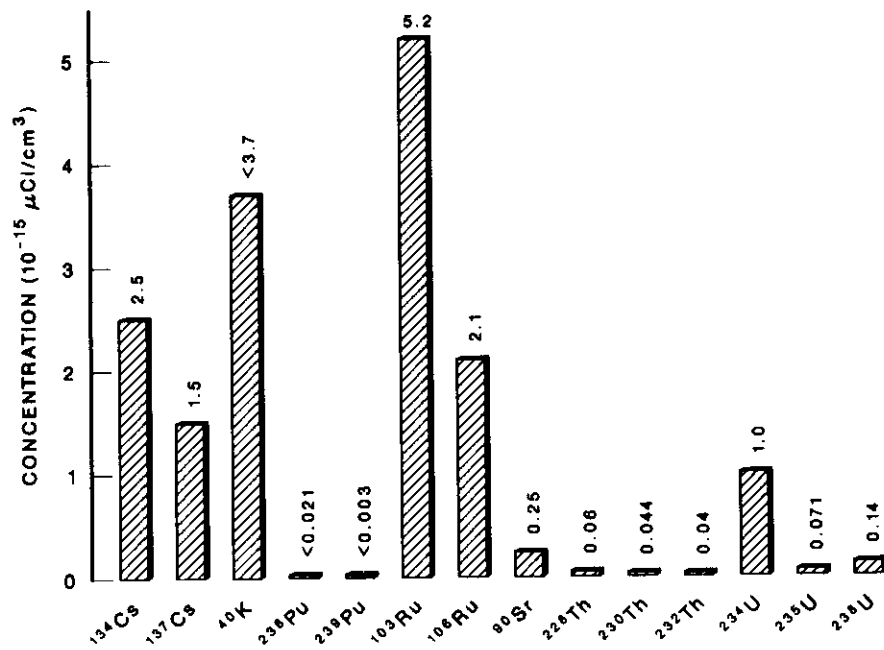


Fig. 4.2.25. 1986 average concentrations of radionuclides in air at station A40.



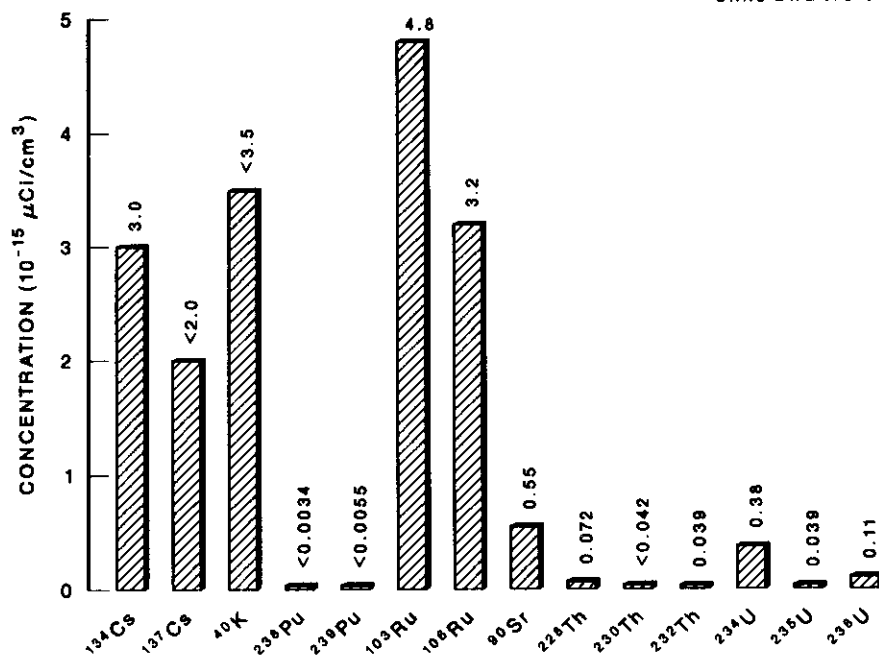


Fig. 4.2.26. 1986 average concentrations of radionuclides in air at station A41.

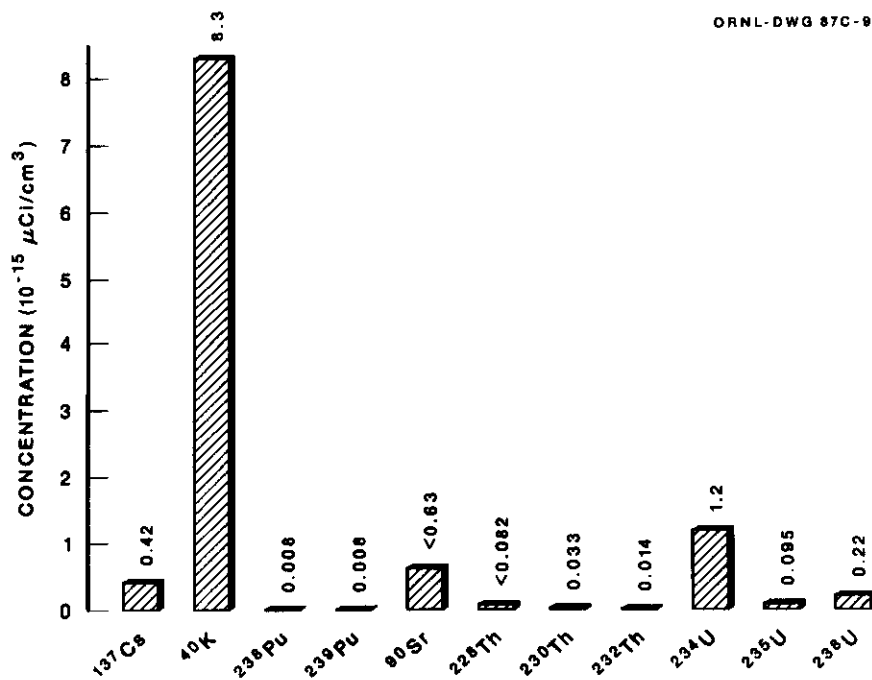


Fig. 4.2.27. 1986 average concentrations of radionuclides in air at station A45.

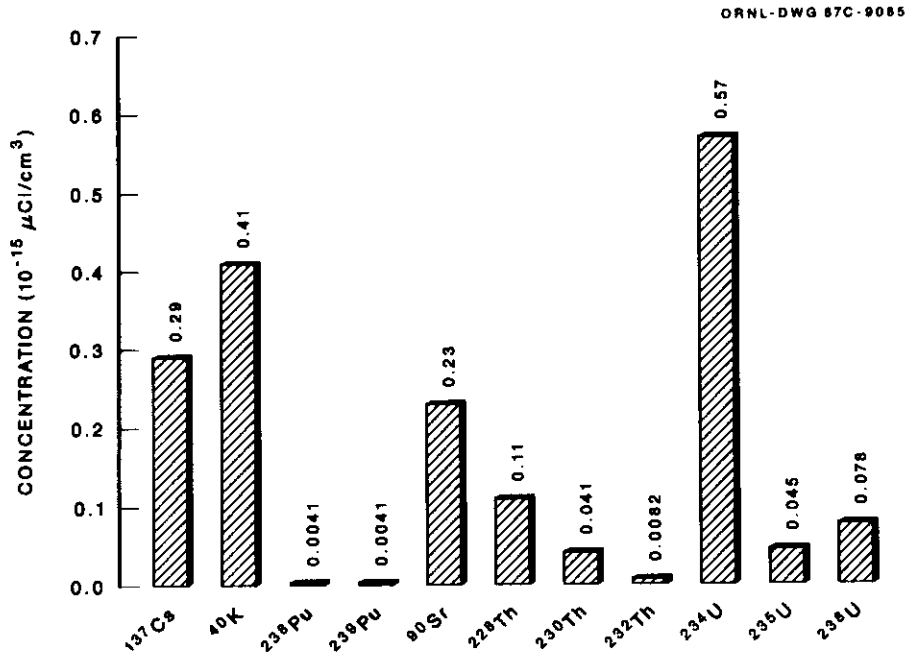


Fig. 4.2.28. Fourth-quarter average concentrations of radionuclides in air at station A46.

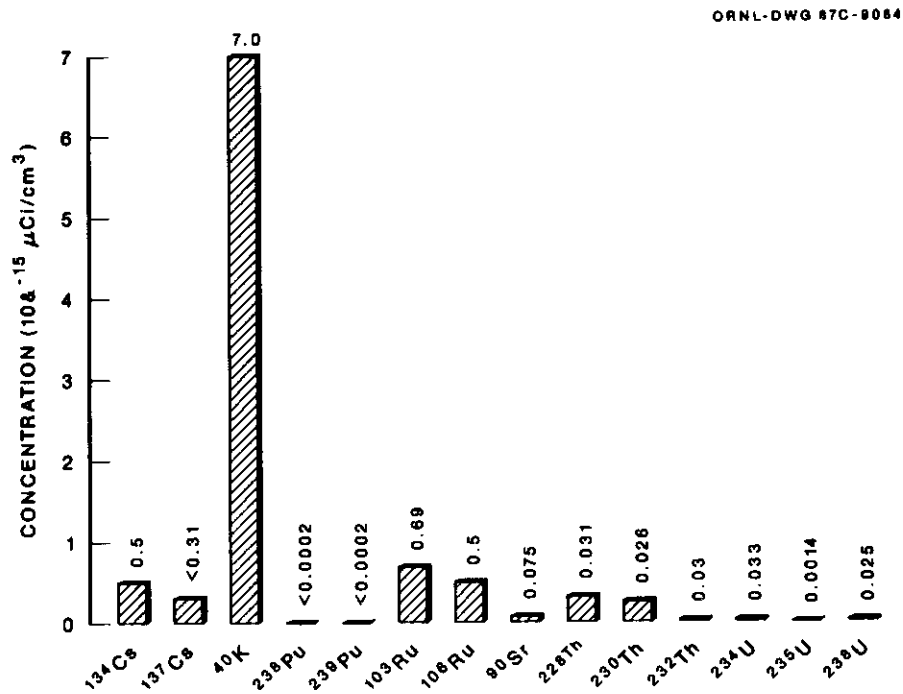


Fig. 4.2.29. 1986 average concentrations of radionuclides in air at remote stations.

### 4.3 METEOROLOGICAL MEASUREMENTS

Computerized atmospheric dispersion modeling is used to determine the effects of the Oak Ridge installations' present and future operations on the long-range transport of air contaminants.

Modeling is a very useful and accurate way of determining maximum calculated pollutant concentrations if meteorological and emission data used in the model are accurate.

To provide accurate meteorological data, construction of a network of meteorological observation towers was finished during 1985. This network consists of one 60-m tower at ORGDP (tower 1); one 100-m tower (tower 2) and two 30-m towers (towers 3 and 4) on the ORNL site; one 100-m tower (tower 5) and one 60-m tower (tower 6) on the Oak Ridge Y-12 Plant site; one 100-m tower (tower 7) located at Walker Branch watershed; and one 110-m tower (tower 8) on the Clinch River Breeder Reactor Project (CRBRP) site. Tower 7 is equipped for research; however,

the real-time data could be used as needed but are not useful for routine release calculations. The CRBRP tower data collection system is inoperative; thus 1986 data are not available. The locations of these towers on the ORR are shown in Fig. 4.3.1. The 1986 wind rose data are depicted in Figs. 4.3.2 through 4.3.14.

Examination of the annual wind roses reveals that the prevailing winds are almost equally split into two directions that are 180 degrees apart: one from the southwest to west-southwest sector, and the other from the northeast to east-northeast sector. The winds are so strongly aligned along these directions because of the channeling effect induced by the ridge and valley structure of the area. This orientation causes the winds at the lower layers of the atmosphere to flow along the valleys without crossing the ridges. The alignment of winds is not so pronounced at tower 1, which is located in a relatively open area. Another feature clearly observed on the wind roses is that the wind speeds increase with height (tower level) at each of the towers.

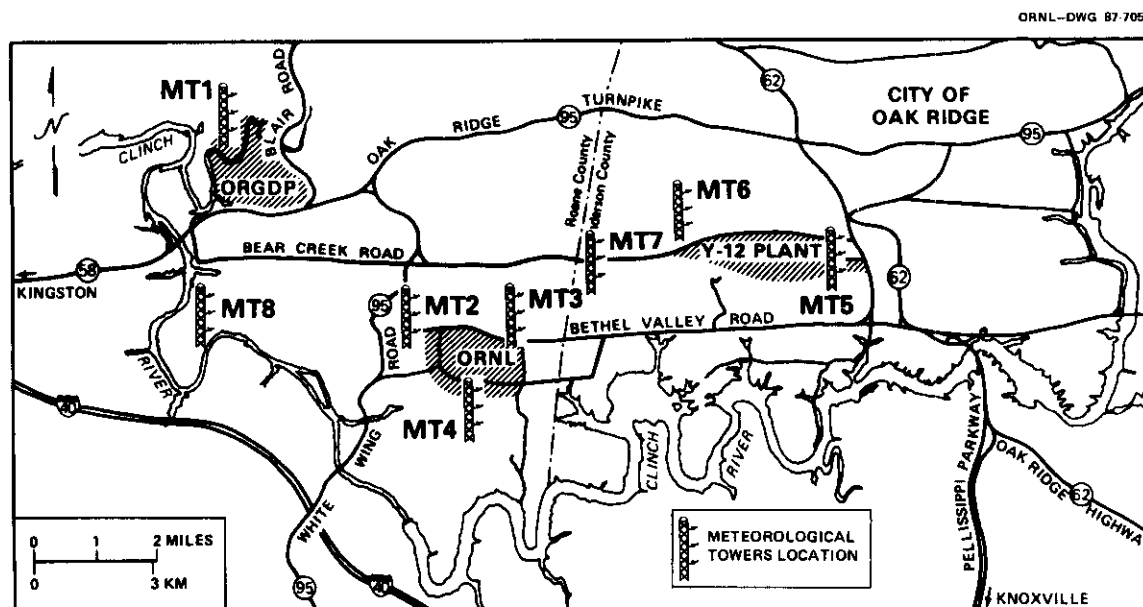


Fig. 4.3.1. Locations of meteorological towers on the Oak Ridge Reservation.

ORNL DWG 87-6250

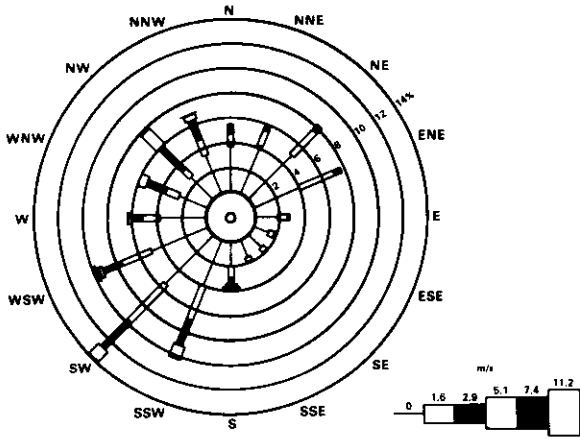


Fig. 4.3.2. 1986 annual wind rose at 10-m level of meteorological tower 1.

ORNL DWG 87-6246

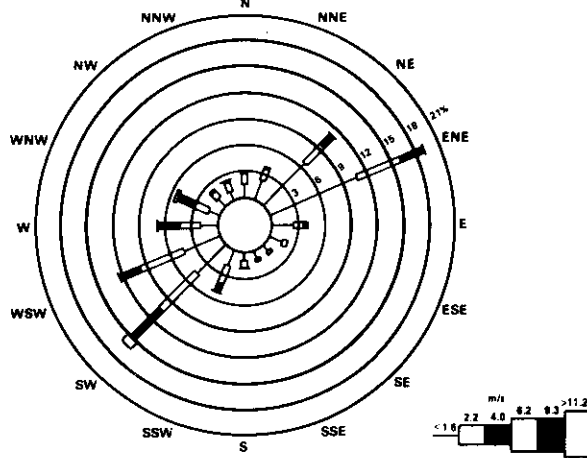


Fig. 4.3.5. 1986 annual wind rose at 30-m level of meteorological tower 2.

ORNL DWG 87-6249

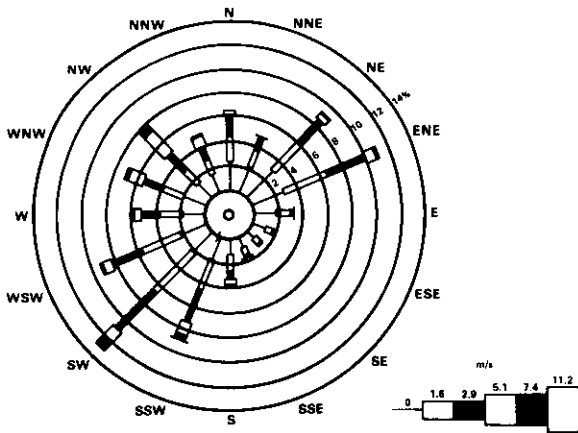


Fig. 4.3.3. 1986 annual wind rose at 60-m level of meteorological tower 1.

ORNL DWG 87-6247

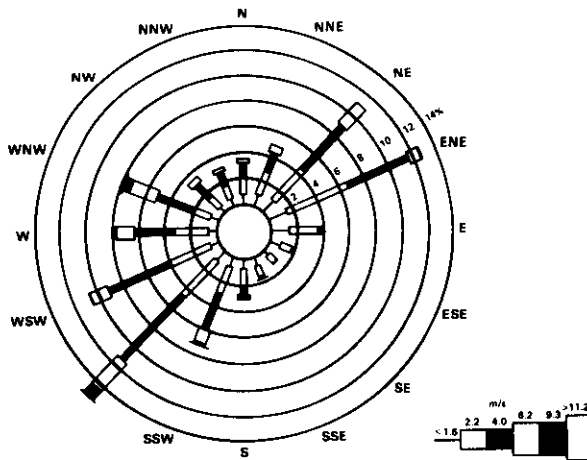


Fig. 4.3.6. 1986 annual wind rose at 100-m level of meteorological tower 2.

ORNL DWG 87-6245

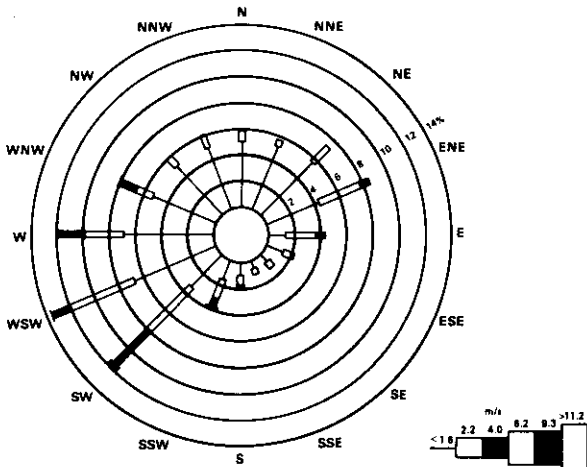


Fig. 4.3.4. 1986 annual wind rose at 10-m level of meteorological tower 2.

ORNL DWG 87-6243

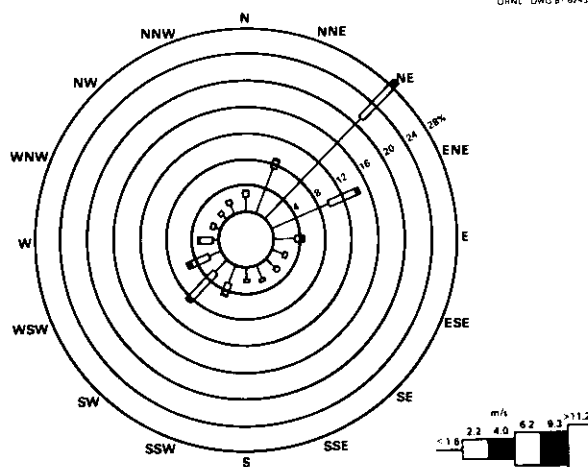


Fig. 4.3.7. 1986 annual wind rose at 10-m level of meteorological tower 3.

ORNL DWG 87-6244

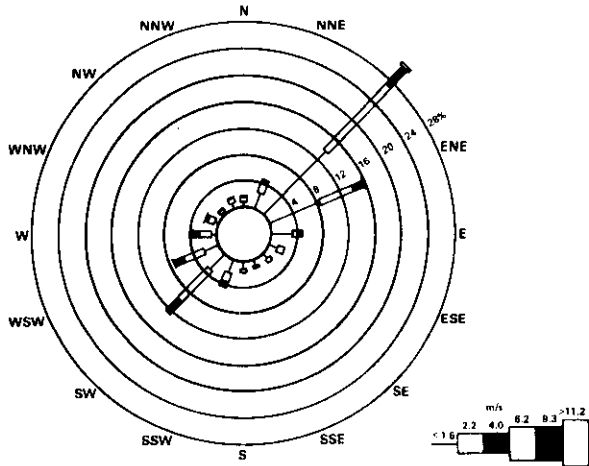


Fig. 4.3.8. 1986 annual wind rose at 30-m level of meteorological tower 3.

ORNL DWG 87-6252

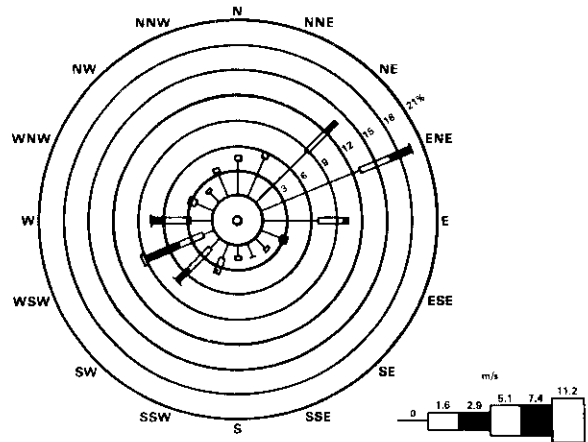


Fig. 4.3.11. 1986 annual wind rose at 10-m level of meteorological tower 5.

ORNL DWG 87-6248

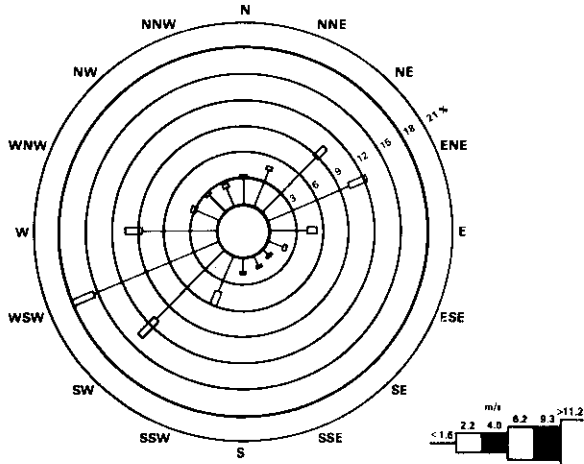


Fig. 4.3.9. 1986 annual wind rose at 10-m level of meteorological tower 4.

ORNL DWG 87-6253

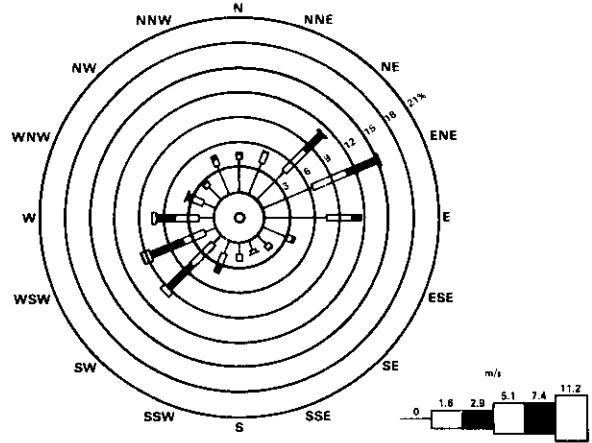


Fig. 4.3.12. 1986 annual wind rose at 30-m level of meteorological tower 5.

ORNL DWG 87-6247

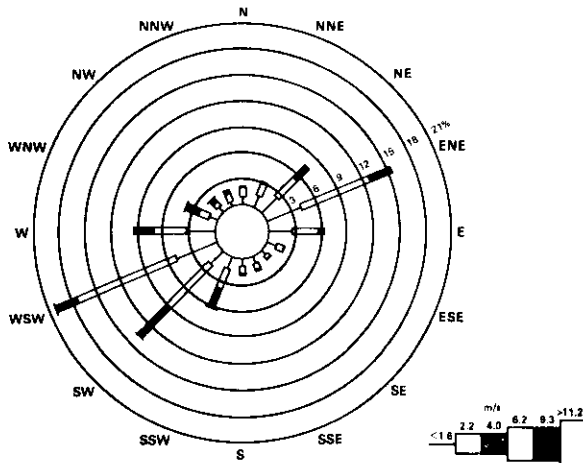


Fig. 4.3.10. 1986 annual wind rose at 30-m level of meteorological tower 4.

ORNL DWG 87-6254

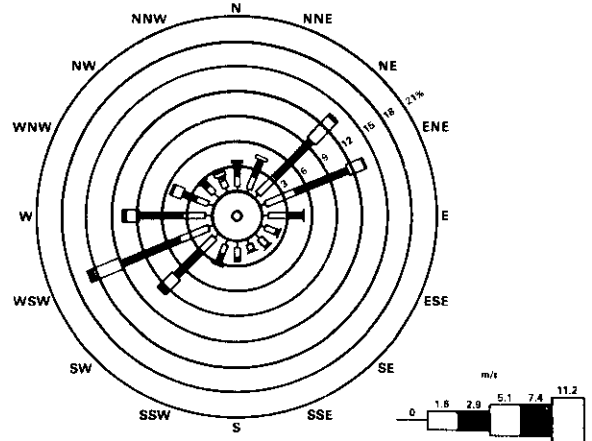
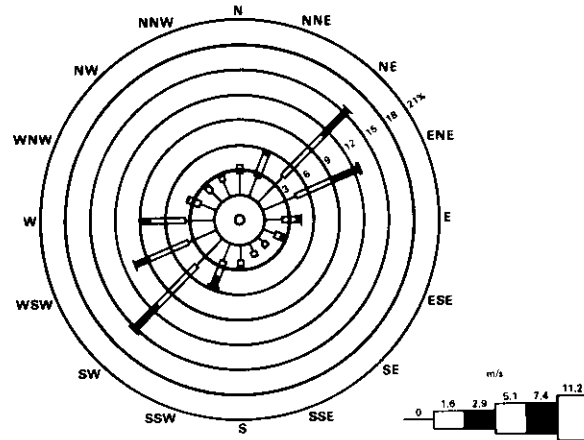


Fig. 4.3.13. 1986 annual wind rose at 100-m level of meteorological tower 5.

ORNL DWG 87-6251



**Fig. 4.3.14. 1986 annual wind rose at 10-m level of meteorological tower 6.**

## 5. WATERBORNE DISCHARGES AND SURFACE WATER MONITORING

Until 1977, EPA had total responsibility for enforcing the Federal Water Pollution Control Act at federal facilities. However, in 1977 it was amended as the Clean Water Act (CWA), and the CWA allowed the states to establish their own water quality standards based on EPA criteria. By law, these criteria took precedence over any EPA-issued National Pollutant Discharge Elimination System (NPDES) permits. The amended act allowed the state to declare that all waters that arise in the state are waters of the state even though they may flow through privately or federally owned property. Therefore, not only the current NPDES outfalls but all effluents to these waters must now be permitted.

### 5.1 WATER POLLUTION CONTROL STRATEGY

To comply with requirements of the CWA, the Oak Ridge installations have developed an environmental strategy for water pollution control. Attempts are being made to trace each pollutant source from initiation through final discharge, and all studies, countermeasures, and monitoring activities associated with it are identified.

#### 5.1.1 Oak Ridge Y-12 Plant

Figure 5.1.1 is a schematic depiction of the water pollution control strategy at the Oak Ridge Y-12 Plant, detailing program elements and the relationships between them.

A variety of liquid wastes (uranium-contaminated as well as noncontaminated) result from activities associated with metal finishing, plating, uranium recovery, and facility cleaning operations. In addition, a large variety of

conventional liquid wastes exist, such as domestic sewage, steam plant wastewaters, and coal-pile runoff. For the purpose of environmental planning, aqueous waste streams are divided into two categories: those with high nitrate content and those without. With the exception of nitrate content, all of the waste streams are amenable to similar treatment to provide pH control and to reduce levels of suspended and dissolved solids. A variety of wastewater treatment facilities are planned or are in place to handle specific waste streams.

Until the wastewater treatment complex is completed, wastewaters will be handled by one of the following methods.

- Wastewaters high in nitrate content are transported to ORGDP for neutralization. After neutralization, they are returned to the Oak Ridge Y-12 Plant for storage, biological denitrification, final polishing, and discharge.
- Wastewaters low in nitrates and with a collection system are transported to the Central Pollution Control Facility (CPCF).
- Wastewaters without a collection system or with volumes large enough to require a new treatment facility will discharge to East Fork Poplar Creek until their designated treatment facility is constructed.
- Domestic waste compatible with the Oak Ridge Wastewater Treatment Plant is discharged to the sanitary sewer.
- The Oak Ridge Y-12 Plant process wastes, including coal pile runoff, will be discharged to East Fork Poplar Creek until the treatment facility is completed.

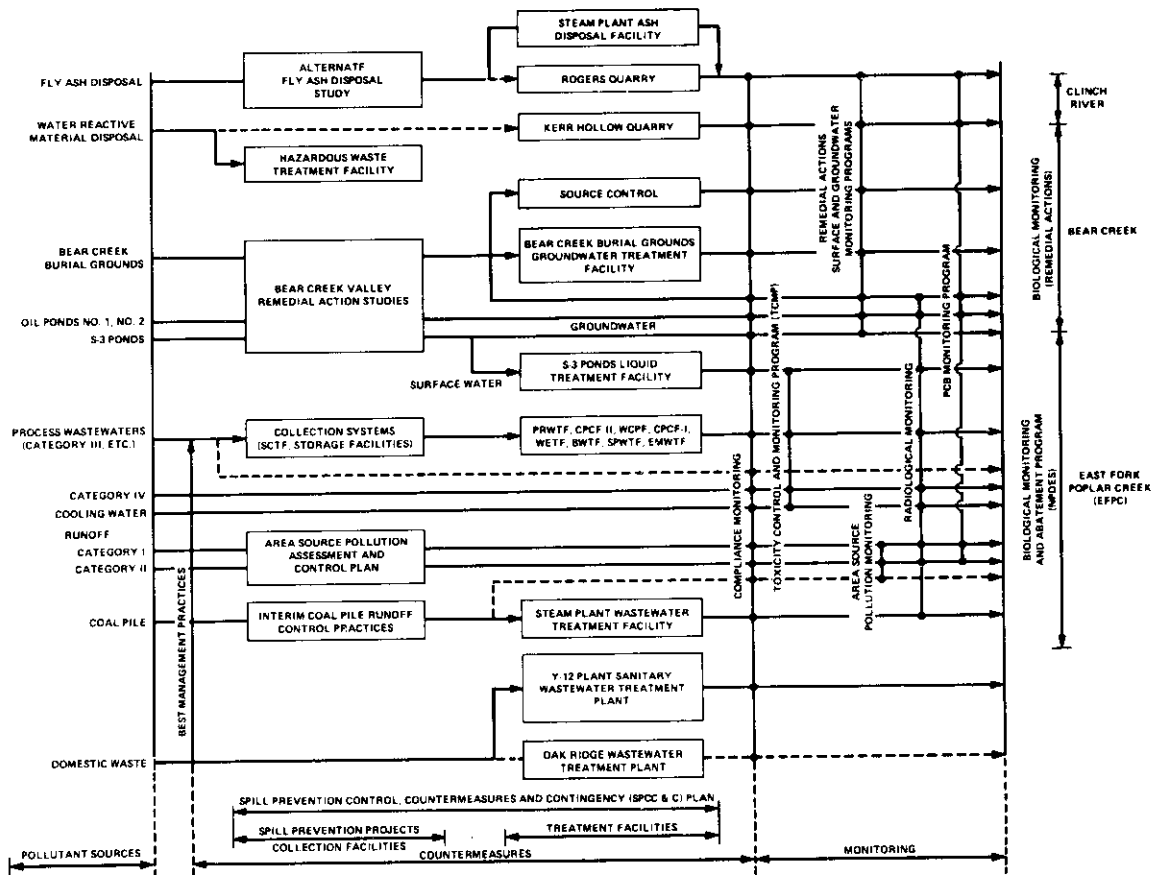


Fig. 5.1.1. Y-12 Plant water pollution control program.

- Untreated waste streams such as cooling tower blowdown are monitored to ensure compliance with the NPDES permit.

### 5.1.2 Oak Ridge National Laboratory

The diverse research and development (R&D) activities at the ORNL site and at the ORNL facilities at the Oak Ridge Y-12 Plant produce a wide variety of liquid process wastes (PW), and these, in combination with the natural characteristics of these sites, present an extremely complex disposal challenge. In this context, the plans and strategies must be flexible, dynamic, and responsive to effectively address this complexity in the climate of changing regulatory requirements. A general plan for upgrading liquid waste systems at ORNL to meet water pollution control program objectives is being developed.

To meet the general objective of reduction of generation rates to as low as practical, overall systems analysis planning will continue to emphasize this strategic objective. This mission will be supported by characterization and evaluation, project identification and definition, R&D support, capital project implementation, expense-funded activities, and operation of the waste management facilities. Particular attention will be given to source terms, collection and transfer systems, and processing and disposal facilities.

The liquid waste management program at ORNL is divided into five categories, which are shown in Fig. 5.1.2:

- Sanitary sewer system, which includes the sewer piping and collection system and the sewage treatment plant for processing typical industrial sanitary sewage at the ORNL site.



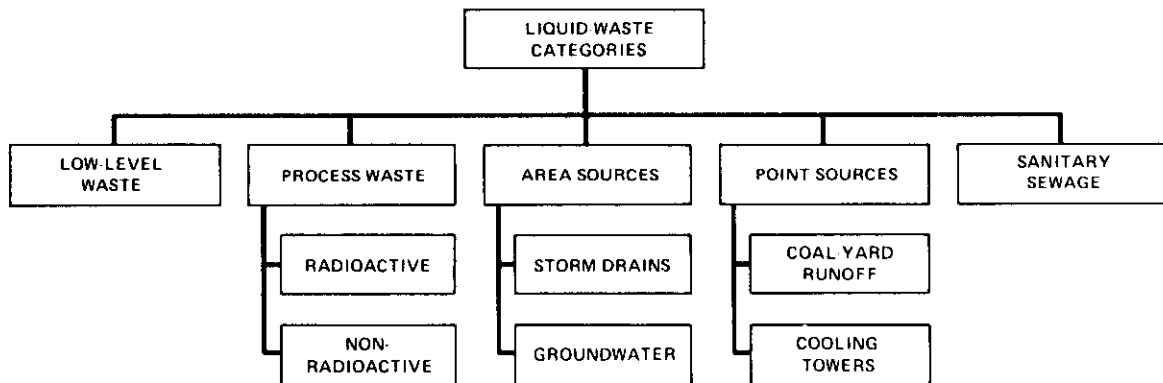


Fig. 5.1.2. Liquid waste categories at ORNL.

- Point sources, which include the runoff from the 2519 steam plant coal pile and several cooling towers located at the ORNL site and in the ORNL facilities at the Oak Ridge Y-12 Plant.
- Area sources, comprised of runoff from buildings, roads, parking areas, etc., and contaminated groundwater.
- Process waste from numerous generators in Bethel and Melton valleys and at ORNL facilities at the Oak Ridge Y-12 Plant. This general category of liquid waste can contain minute quantities of radioactive material, as well as small quantities of metals, anions, and organics.
- Low-level radioactive liquid waste system, which is designed to collect, neutralize, concentrate, and store aqueous liquid radioactive waste solutions having an activity level as high as 5.28 Ci/L that come from hot sinks and drains in R&D laboratories, radiochemical pilot plants, nuclear reactors at ORNL, and the Process Waste Treatment Plant (PWTP). This category is by far the most critical because of the discontinuation of the hydrofracture disposal option for low-level waste (LLW) and the need for dramatic volume reduction so that interim storage can be utilized until alternatives can be implemented. These categories are shown in Figs. 5.1.3 and 5.1.4.

Liquid hazardous wastes at ORNL fall under both the PW and LLW categories; their sources are laboratory chemical wastes, photographic wastes, and polychlorinated biphenyl (PCB) oils.

Laboratory chemical wastes originate from the large number of small chemical and biological laboratories where hazardous wastes can be generated, and they include spent experimental samples, by-products, and materials that have exceeded their shelf life and/or usefulness. These wastes are routinely collected, packed in approved containers, and either shipped to approved disposal sites or stored on site for further processing.

Photographic wastes are generated by photography and radiography laboratories and reproduction facilities at ORNL. Nearly all of the photographic fixer solutions and washes contain silver, and some of the solutions contain cyanide. A facility is available at ORNL where the silver and cyanide can be removed from these solutions, thereby allowing the supernatant to be neutralized and discharged to a PW system. These wastes are routinely collected and processed at the silver and cyanide recovery facility.

PCB oils in many of the electrical transformers at ORNL are now being routinely eliminated either by replacing the transformer (and disposing of the oils) or by replacing the PCB oil in the transformer with a non-PCB oil. Several

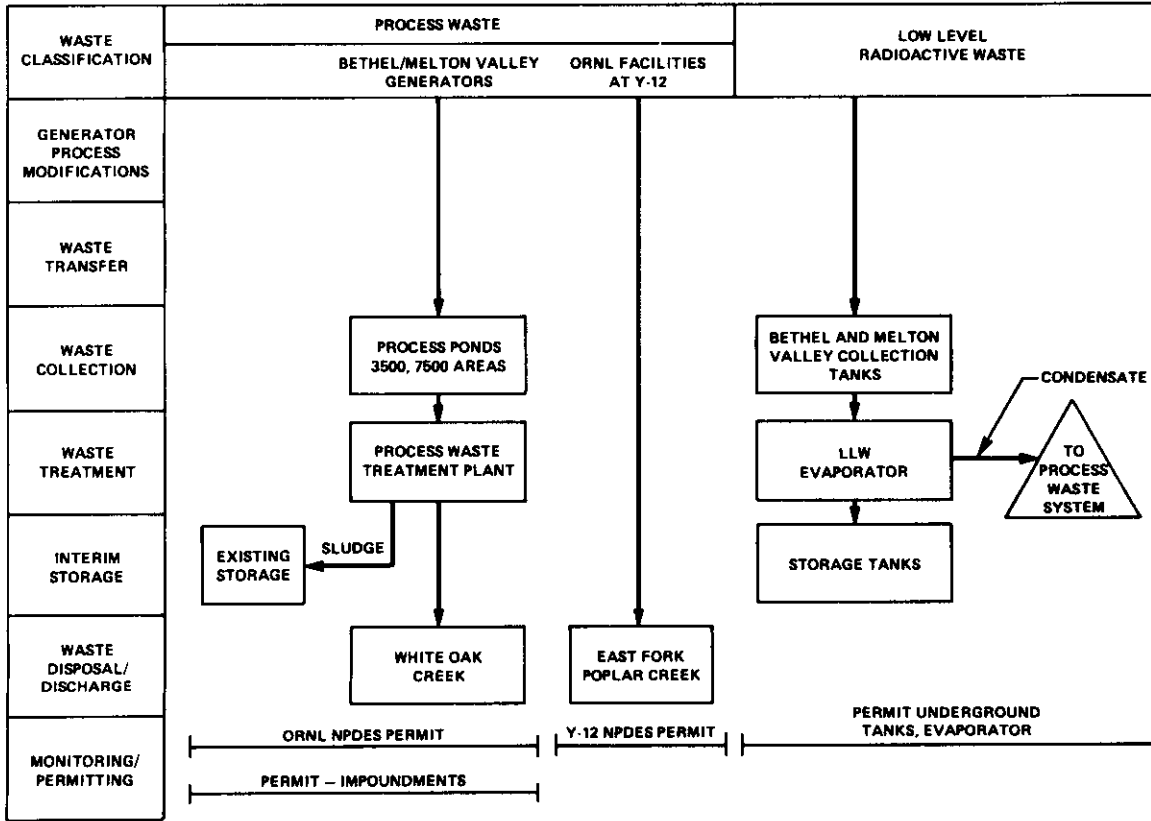


Fig. 5.1.3. ORNL water pollution control program—process and low-level radioactive waste.

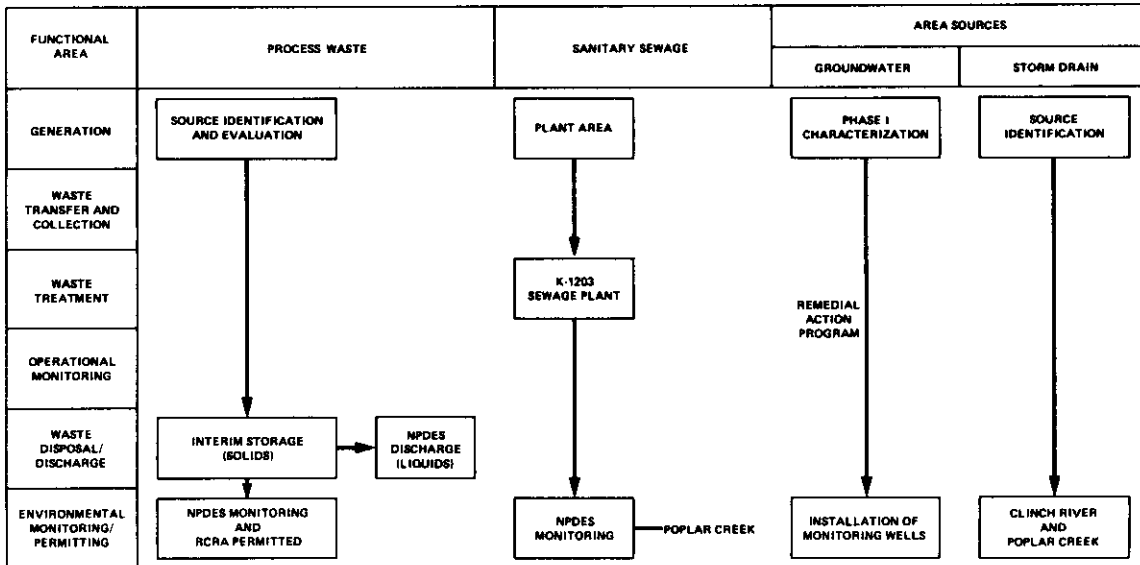


Fig. 5.1.4. ORNL water pollution control program strategy—sanitary, point, and area sources.

transformers have been retrofilled at ORNL, and several will be replaced in the near future. PCB oils are collected, packed in approved containers, and shipped to approved disposal sites for incineration. When transformers are replaced, the contractors dispose of the oil at EPA-approved incinerators.

**5.1.3 Oak Ridge Gaseous Diffusion Plant**

The water pollution control strategy is illustrated in Fig. 5.1.5 for process waste, area sources, and sanitary sewage. The ORGDP sewage treatment plant is shown in Fig. 5.1.6. The ORGDP Low Level Waste Program with liquid discharges is shown in Fig. 5.1.7.

**5.2 SURFACE WATER MONITORING**

The surface waters of the ORR are of a calcium-magnesium/bicarbonate chemical type, reflecting the abundance of limestone and dolomite bedrock in the watershed areas. 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

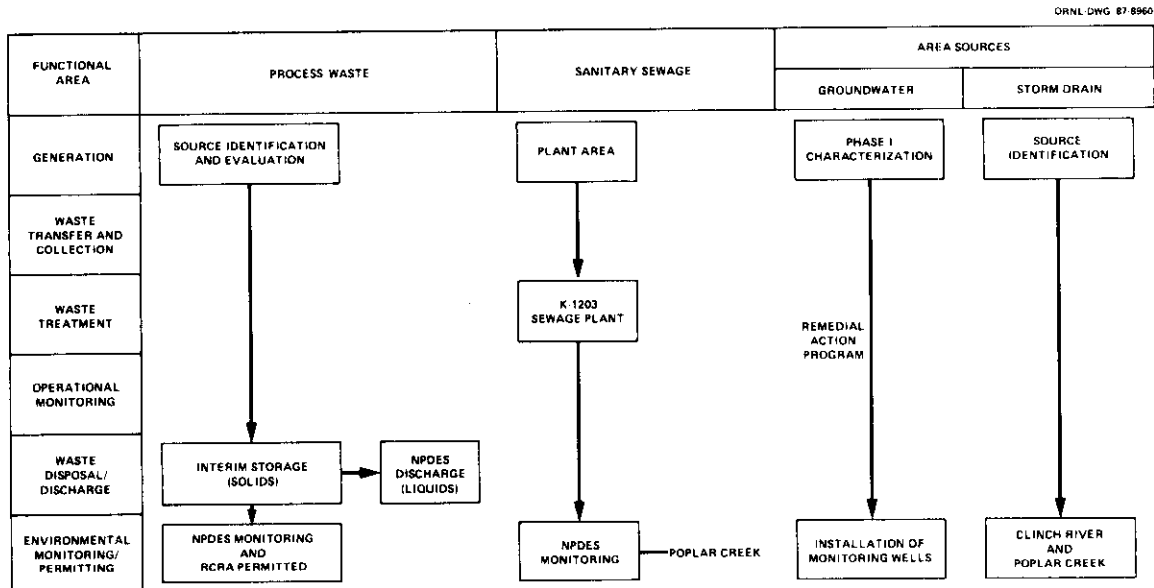


Fig. 5.1.5. ORGDP water pollution control program.

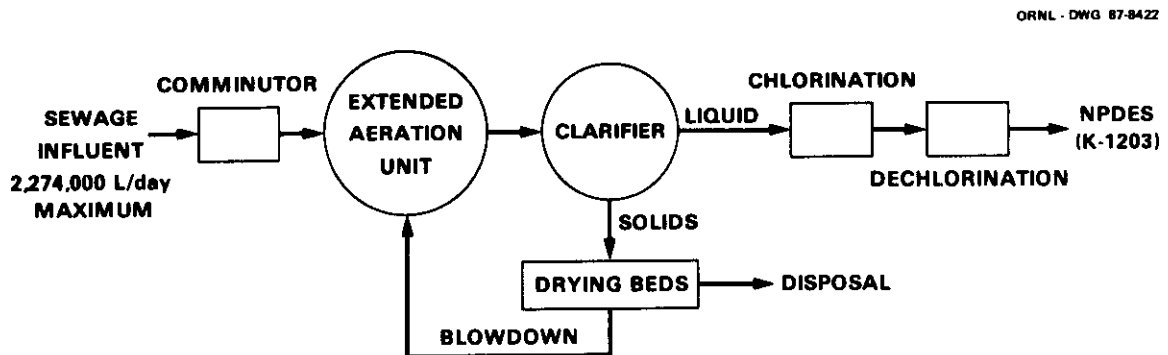


Fig. 5.1.6. ORGDP sewage treatment plant.

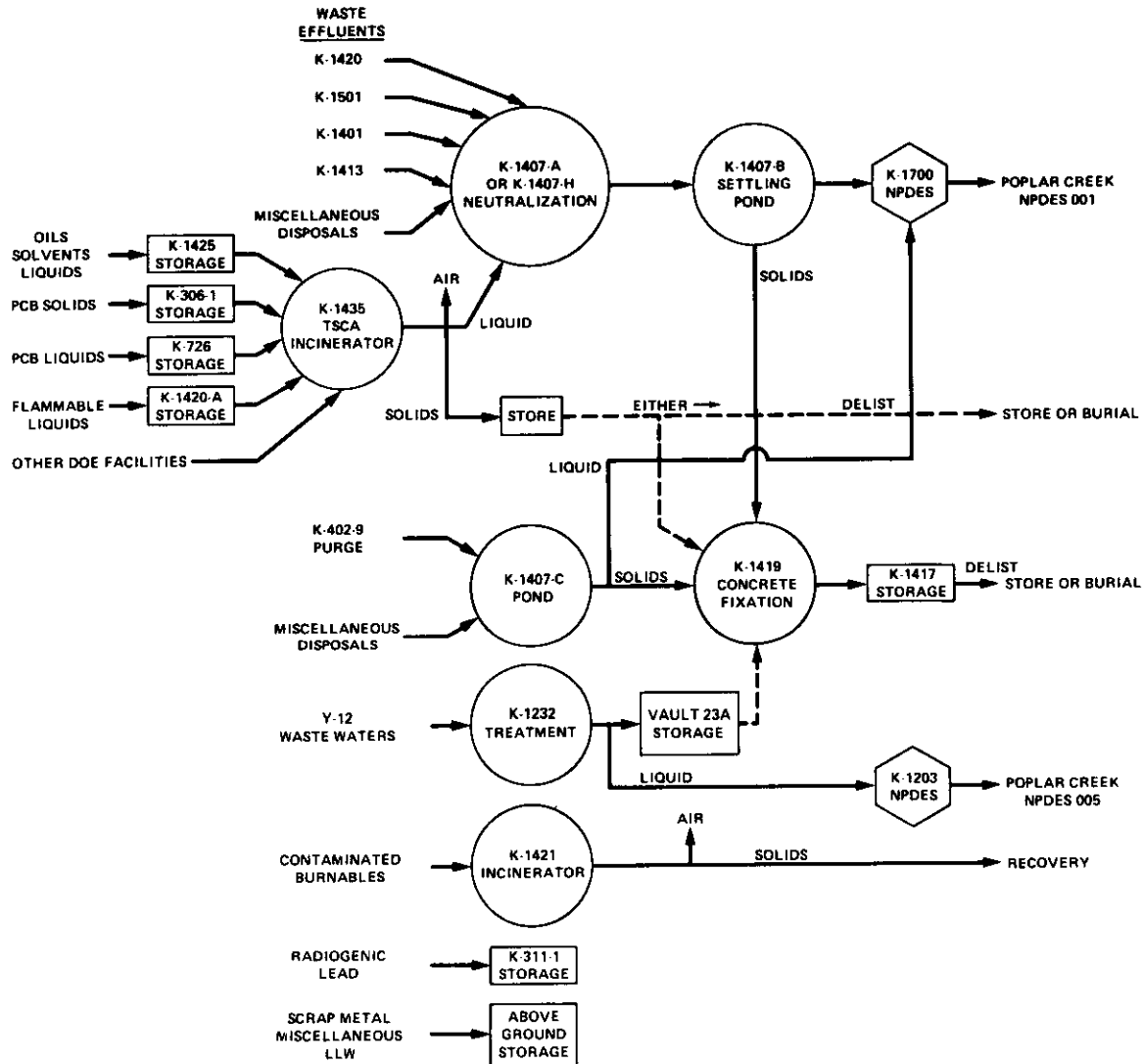


Fig. 5.1.7. ORGDP low-level waste program.

different contaminant loadings. For example, East Fork Poplar Creek shows higher levels of several substances than any other stream, probably reflecting the influence of effluents from the ORY-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 of the ORR, and by flow regulation at TVA dams. In general, stream impoundment results in increased water temperatures and retention of sediments and adsorbed contaminants

in impoundments. Intermittent release of water from dams causes scouring of the river channel downstream from the dam, as has occurred 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 TVA and the

USGS monitor water quality just below Melton Hill Dam. TDHE maintains a monitoring station at CRK 16.3 (3.2 km below the mouth of Poplar Creek and ORGDP).

Water quality, radioactivity, and flow measurements are made at a number of stations operated by Energy Systems for DOE. As a result of technical reviews of environmental monitoring programs during 1985, the numbering system was redone, as shown in Table 5.2.1.

Water samples were collected and analyzed at various intervals (weekly, monthly, etc.) for radiological and nonradiological content from the following stations:

- Melton Hill Dam (station W1, Fig. 5.2.1)—in the Clinch River 3.7 km above the White Oak Creek outfall. This is a background or reference point. Flow proportional samples were collected daily and composited for quarterly analysis.
- White Oak Dam (station W3, Fig. 5.2.1)—ORNL discharge point from White Oak Creek to the Clinch River. Flow proportional samples were collected daily and composited for weekly analysis.
- ORNL tap water—a reference sample. Samples were collected daily and composited for quarterly analysis.
- ORGDP sanitary water (station W30, Fig. 5.2.1)—10 km downstream from the confluence of White Oak Creek and the Clinch River. A grab sample was collected and analyzed quarterly.
- Water plant near Kingston (station W55, Fig. 5.2.1)—downstream from the entry of White Oak Creek. A sample was collected daily and composited for quarterly analysis.
- A number of additional water sampling stations in WOC and Melton Branch, Bear Creek, and Poplar Creek.

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

Figure 5.2.2 is a flow diagram of the water sampling stations on White Oak Creek and Melton Branch.

Water samples are collected for analysis of nonradioactive substances at many locations on and off the ORR. Concentrations of chemicals in streams and creeks on or around the ORR have been 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. Concentrations of chemicals in the outlet for the ORGDP sanitary water plant are compared with Tennessee water quality criteria for domestic water supply.

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

The total discharges to surface waters from 1982 through 1986 for tritium, strontium-90, technetium-99, cobalt-60, cesium-137, uranium, ruthenium-106, transuranics, iodine-131, and thorium-232 are given in Figs. 5.2.3 through 5.2.12.

### 5.3 NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMITS

#### 5.3.1 Oak Ridge Y-12 Plant NPDES Permit

In compliance with the CWA and a 1983 Memorandum of Understanding between DOE, EPA, and TDHE, the Oak Ridge Y-12 Plant submitted NPDES permit applications in the spring of 1984. After extensive negotiations between DOE, TDHE, EPA, and Energy Systems for approximately a year, EPA issued the Oak Ridge Y-12 Plant a new NPDES permit on May 24, 1985. The new permit combines water-quality and industry-based effluent limitations with biological and toxicological monitoring. Discharges authorized in the permit are as follows:

- Kerr Hollow Quarry, discharge point 301 (W43)

**Table 5.2.1. Listing of identifications  
and new numbers of surface water sampling stations<sup>a</sup>**

Location	New station number
Melton Hill Dam	W1
Confluence of White Oak Creek	W2
White Oak Dam (WOD)	W3
Melton Branch 1	W4
Melton Branch 2	W5
White Oak Creek (WOC) headwaters	W6
White Oak Creek	W7
East weir WOC	W8
West weir WOC	W9
HFIR/TRU	W10
NSPP	W11
7500 bridge	W12
Northwest Tributary	W13
First Creek	W14
STP	W15
PWTP	W16
3500 (190 ponds) Ponds	W17
Flume Station 2	W18
Fifth Creek	W19
Raccoon Creek	W20
Ish Creek	W21
	W22–W27 unassigned
ORGDP (K-1407-B)	W28
ORGDP (K-901 at 892)	W29
ORGDP sanitary water (K-1513)	W30
Poplar Creek above Blair Bridge (K-1710)	W31
Poplar Creek near Clinch River (K-716)	W32
West Fork Poplar Creek	W33
East Fork Poplar Creek	W34
Bear Creek <sup>b</sup>	W35
K-1515-C	W36
K-710-A	W37
K-901-A	W38
K-1007-B	W39
K-1203	W40
K-1700 (K-901 intake, K-1420-B)	W41
Upper Bear Creek	W42
Kerr Hollow (301)	W43
Rogers Quarry (302)	W44
New Hope Pond (303)	W45
Bear Creek (304)	W46
Oil Pond 1 (305)	W47
Oil Pond 2 (306)	W48
Steam Plant Fly Ash Sluice Water (623)	W49
S-3 Ponds Liquid Treatment Facility (507)	W50
Mobile Waste Water Treatment Facility (508)	W51
	W52 unassigned
Central Pollution Control Facility (501)	W53
Central Pollution Control Facility—Phase II (502)	W53a
Poplar Creek <sup>b</sup>	W54
Kingston Water Plant (Clinch River)	W55
New Hope Pond inlet	W56
	W57–W60 unassigned

<sup>a</sup>This new numbering system was put in place for CY 1986. Most of these stations did not have old numbers.

<sup>b</sup>Future location.

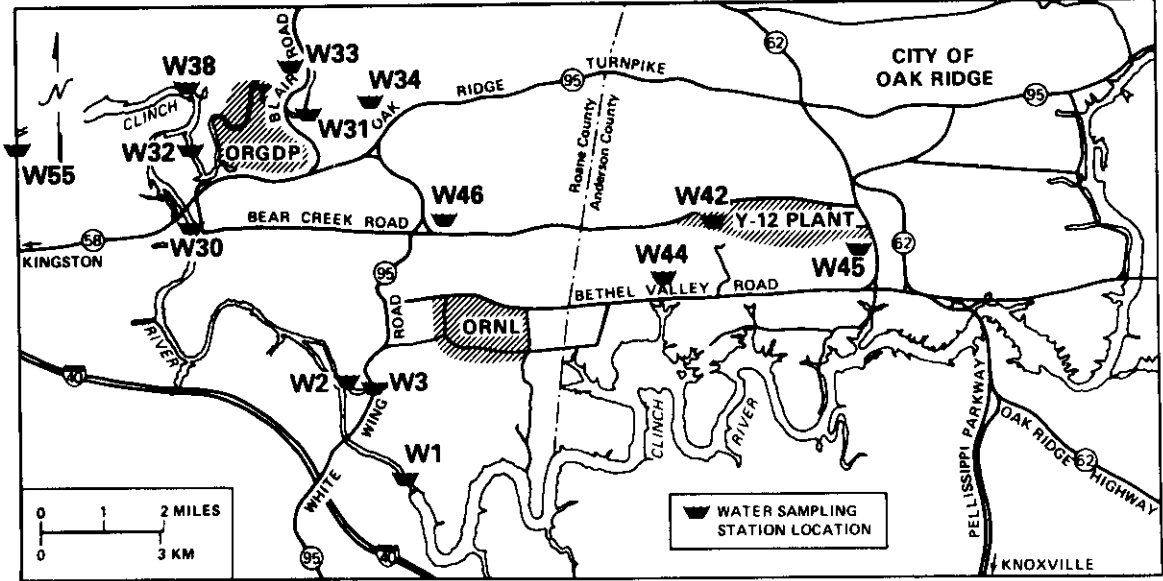


Fig. 5.2.1. Location map of water sampling stations on the ORR.

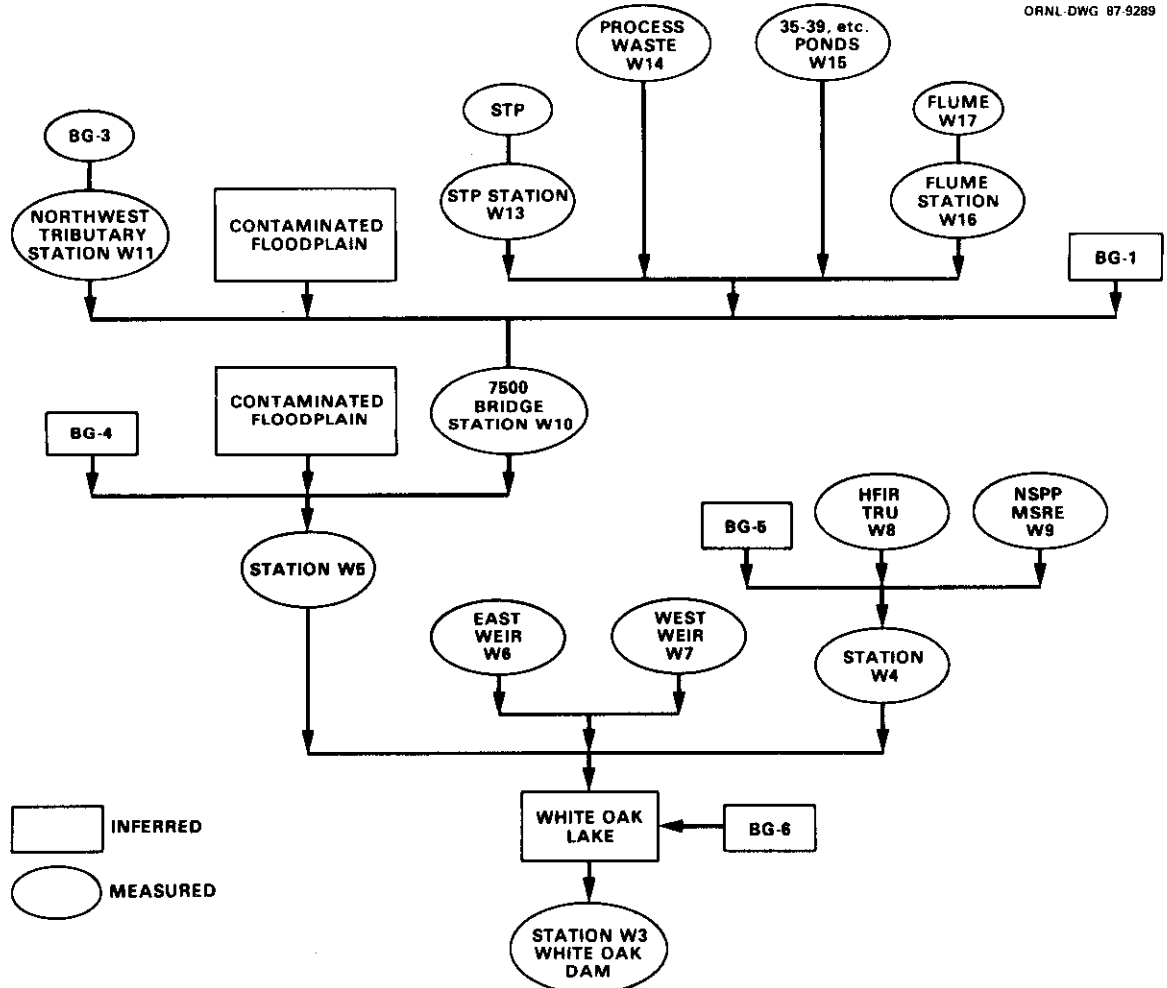


Fig. 5.2.2. Flow diagram of water sampling stations on White Oak Creek and Melton Branch.

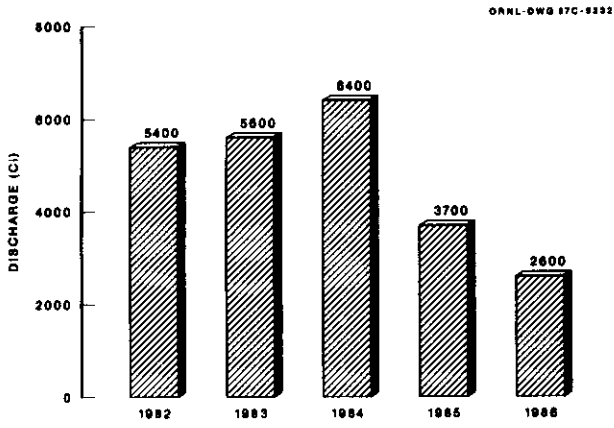


Fig. 5.2.3. Total discharges of tritium to surface waters.

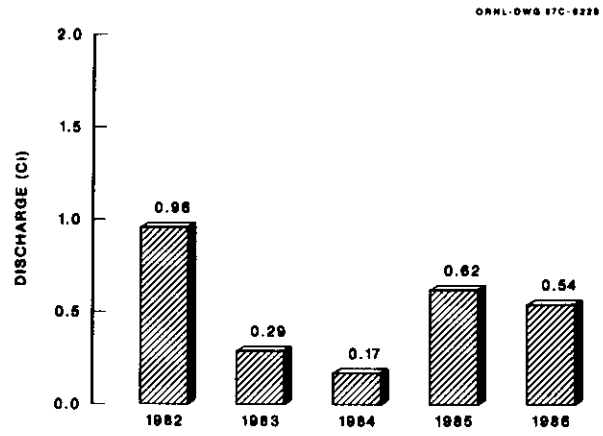


Fig. 5.2.6. Total discharges of cobalt-60 to surface waters.

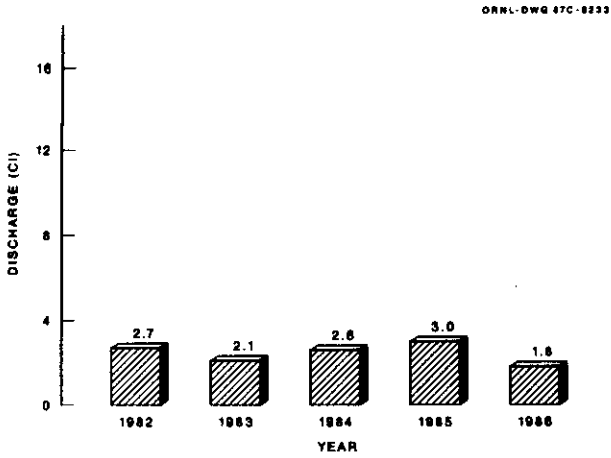


Fig. 5.2.4. Total discharges of strontium-90 to surface waters.

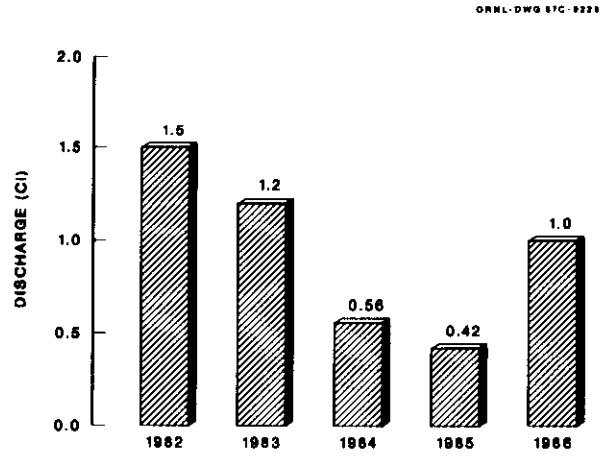


Fig. 5.2.7. Total discharges of cesium-137 to surface waters.

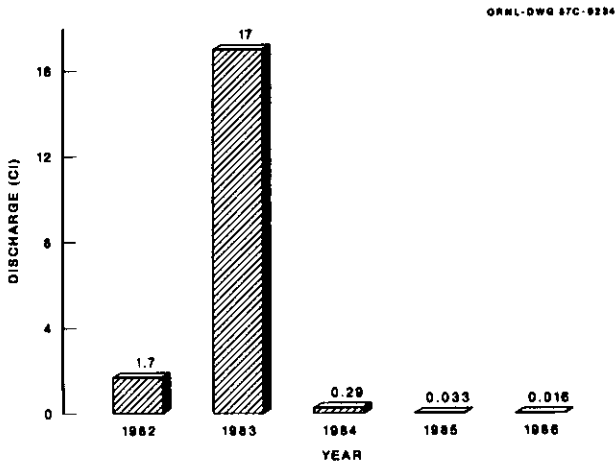


Fig. 5.2.5. Total discharges of technetium-99 to surface waters.

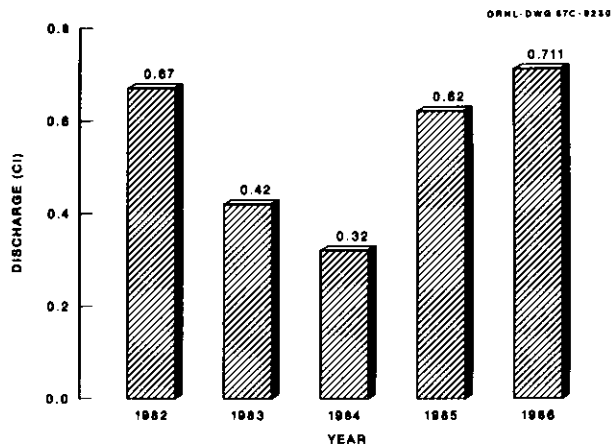


Fig. 5.2.8. Total discharges of uranium to surface waters.



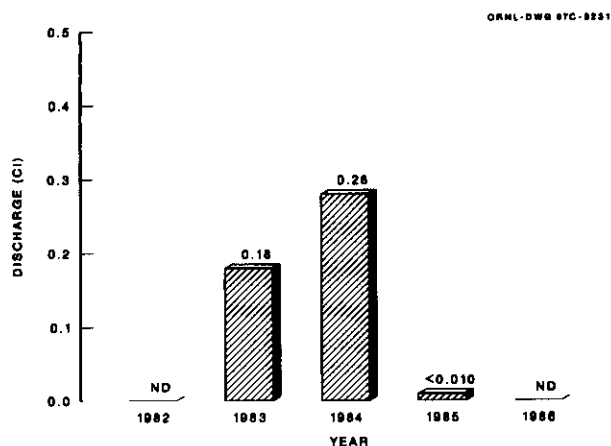


Fig. 5.2.9. Total discharges of ruthenium-106 to surface waters.

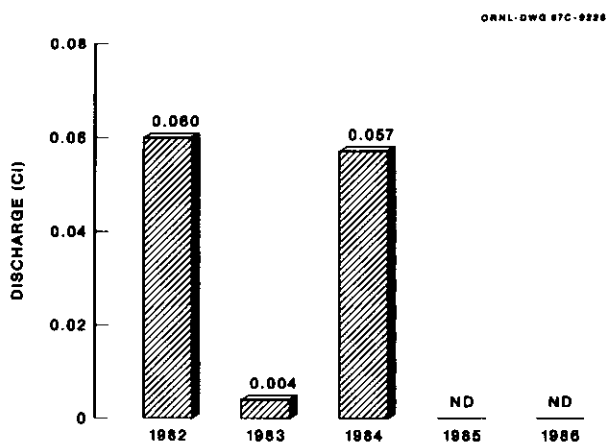


Fig. 5.2.11. Total discharges of iodine-131 to surface waters.

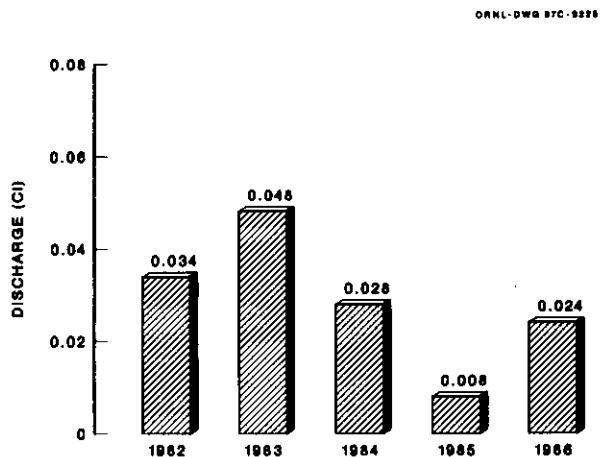


Fig. 5.2.10. Total discharges of transuranics to surface waters.

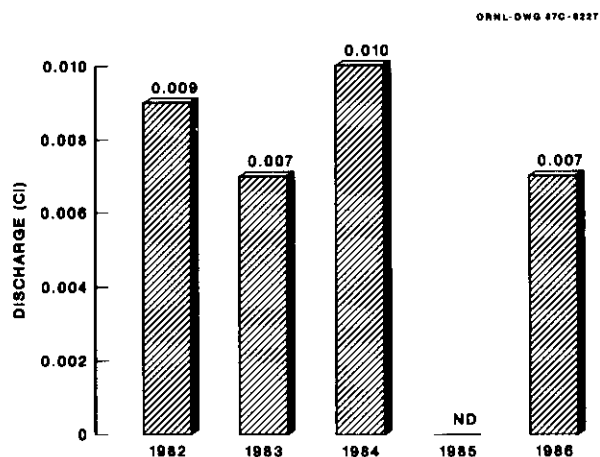


Fig. 5.2.12. Total discharges of thorium-232 to surface waters.

- Rogers Quarry, discharge point 302 (W44)
- New Hope Pond, discharge point 303 (W45)
- Bear Creek, discharge point 304 (W46)
- Leaking Burial Grounds (Oil Pond 1), discharge point 305 (W47)
- Seepage from Burial Pit (Oil Pond 2), discharge point 306 (W48)
- 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
- Category IV Discharges—process wastewaters
- Steam plant fly ash sluice water, discharge point 623 (W49)
- Central Pollution Control Facility, discharge point 501 (W53)
- Central Pollution Control Facility-Phase II, discharge point 502 (W53A)
- West End Treatment Facility
- Steam Plant Wastewater Treatment Facility, discharge point 503 (W49)

- Plating Rinse Water Treatment Facility, discharge point 504
- Biology Wastewater Treatment Facility, discharge point 505
- Experimental Mobile Wastewater Treatment Facility, discharge point 508 (W51)
- Building 9204-3 Sump Pump Oil Separator
- S-3 Ponds Liquid Treatment Facility, discharge point 507 (W50)
- Sump pump oil separator, discharge point 506
- Miscellaneous discharges (cooling towers, regeneration wastes, vapor blasters)
- Upper Bear Creek (W42)

The locations of many of these NPDES discharge points are shown in Fig. 5.3.1.

These wastewater treatment facilities have effluent limitations based upon best available technology (BAT) effluent limitations for the metal finishing and electric power generation industries. In addition, effluents discharged from most of the treatment facilities must be deemed nontoxic by a toxicity control and monitoring program (TCMP). The Oak Ridge Y-12 Plant is committed to achieving effluent characteristics better than those specified by BAT; and, after one year of operation, effluent limits may be lowered to reflect actual treatment capabilities.

The effluent limitations for each treatment facility may also be lowered if the treated effluent results in in-stream toxicity as determined by the TCMP or if East Fork Poplar Creek does not display a healthy ecological system as determined by the Biological Monitoring and Abatement Program (BMAP).

Total NPDES compliance at the Oak Ridge Y-12 Plant by month is given in Figs. 5.3.2 and 5.3.3.

### 5.3.2 Oak Ridge National Laboratory NPDES Permit

Under the requirements of the CWA, a new NPDES permit issued to ORNL became effective on April 1, 1986. Before that time, only three stations were sampled for compliance with permit limits. These points were in two major drainage areas (White Oak Creek and Melton Branch) and at the Sewage Treatment Plant. The new permit has over 183 stations and is designed to monitor point sources at their point of discharge into receiving streams. In addition, there are some sampling locations that are located in the streams as reference points or for additional information. The sampling locations and permit requirements are described as follows.

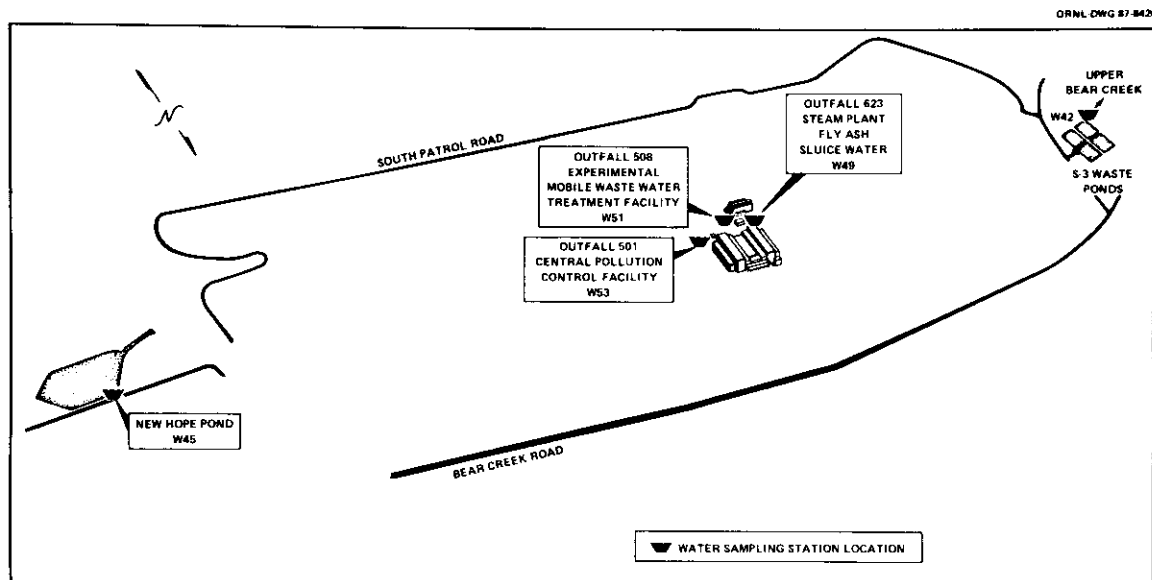


Fig. 5.3.1. Locations of Y-12 Plant NPDES points.

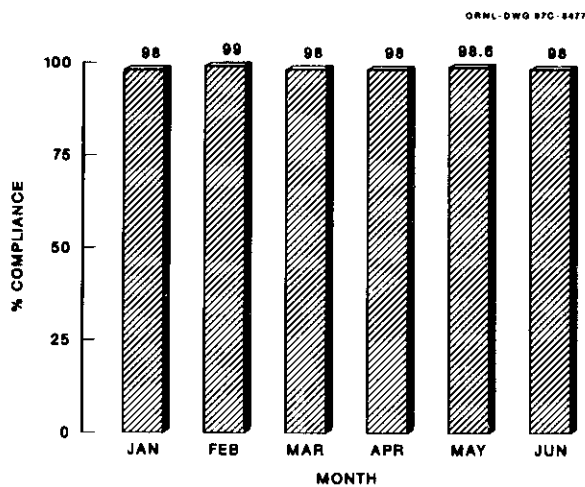


Fig. 5.3.2. Total 1986 NPDES compliance for the Y-12 Plant, January–June.

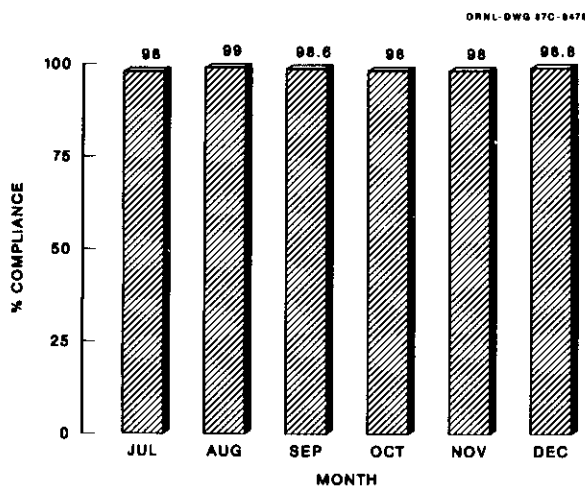


Fig. 5.3.3. Total 1986 NPDES compliance for the Y-12 Plant, July–December.

- **Point Source Outfalls**—These outfalls are discernible, confined, and discrete conveyances from which a process stream is discharged to receiving waters. The effluent must be monitored before it reaches the receiving water or mixes with any other wastewater stream. Point sources at ORNL that are monitored and have compliance limits are listed in Table 5.3.1.

Composite samples are collected by automatic samplers or as grab samples. New monitoring

Table 5.3.1. Point source outfalls at ORNL

NPDES number	Location <sup>a</sup>	M <sup>b</sup>	L <sup>b</sup>
X01	Sewage Treatment Plant		X
X02	Coal Yard Runoff Treatment Facility		X
X03	1500 Area	X <sup>c</sup>	
X04	2000 Area	X <sup>c</sup>	
X06	Ponds (3539 and 3540)	X <sup>c</sup>	
X07	Process Waste Treatment Plant	X <sup>c</sup>	
X08	TRU Ponds	X <sup>c</sup>	
X09	HFIR Ponds	X <sup>c</sup>	
X10	ORR Resin Regeneration Facility	X <sup>c</sup>	
X11	Acid Neutralization Facility	X <sup>c</sup>	
X12	Nonradiological Wastewater Treatment Plant		X <sup>d</sup>

<sup>a</sup>See Fig. 5.3.4.

<sup>b</sup>M = monitoring only, L = concentration or mass limits.

<sup>c</sup>pH is limited at all outfalls.

<sup>d</sup>March 1990 compliance.

stations were installed at X02, X04, X06, X08, X09, X10, and X11. The locations of these NPDES sampling stations are shown in Fig. 5.3.4. The 1986 NPDES compliance for the new Coal Yard Runoff Treatment Facility (X02) is given in Fig. 5.3.5.

- **Ambient Monitoring Stations**—Because of historical data and in order to obtain information on total ORNL discharges before they enter the Clinch River, Melton Branch 1, White Oak Creek and White Oak Dam have been placed on the permit for monitoring purposes only. All three of these ambient stations have newly constructed (1984) weirs and monitoring stations. White Oak Dam has two gates that can be lowered in the event of potentially hazardous releases.
- **Category 1 Outfalls (Storm Drains)**—There are 35 discharge pipes to receiving streams that have been characterized by ORNL and identified in the NPDES permit as storm drains. These outfalls are not contaminated by any known activity and do not discharge through any oil/water separator or other treatment equipment or facility. Limits have been placed on pH, oil and grease, and total suspended solids. Samples are taken from the nearest accessible point before actual discharge or mixing with receiving waters.

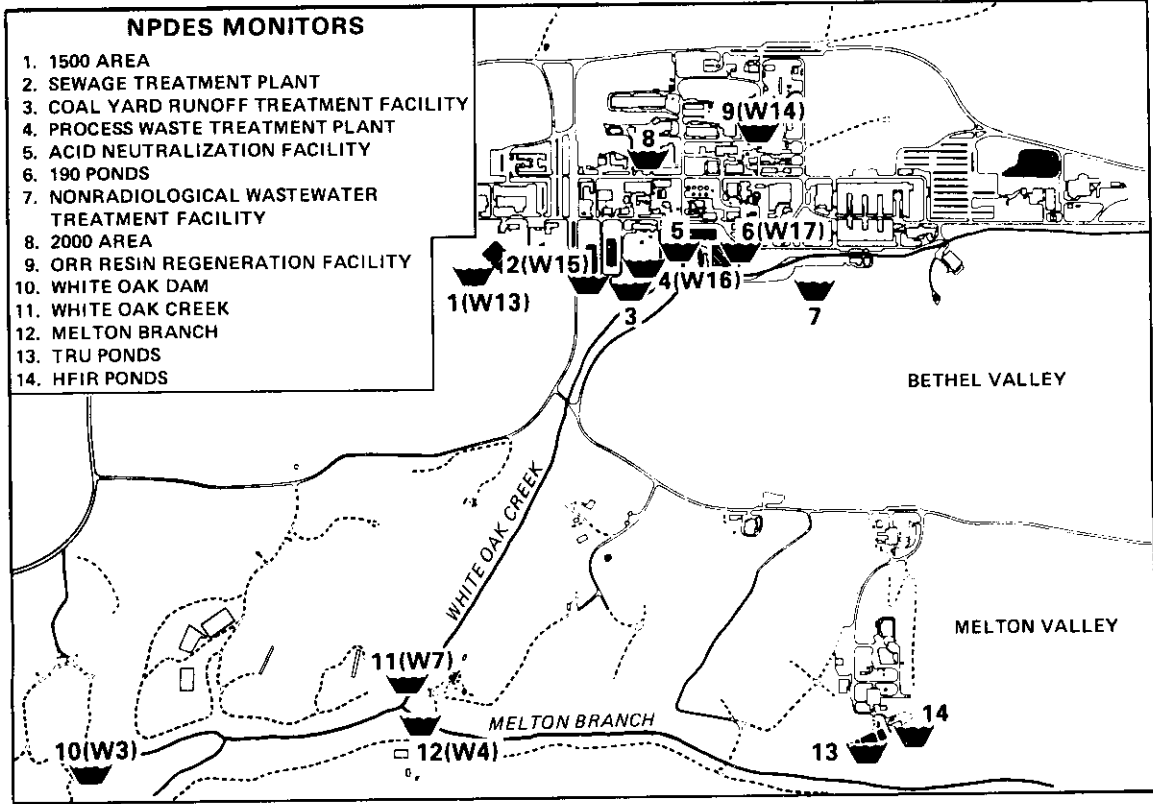


Fig. 5.3.4. Location map of NPDES monitoring points at ORNL.

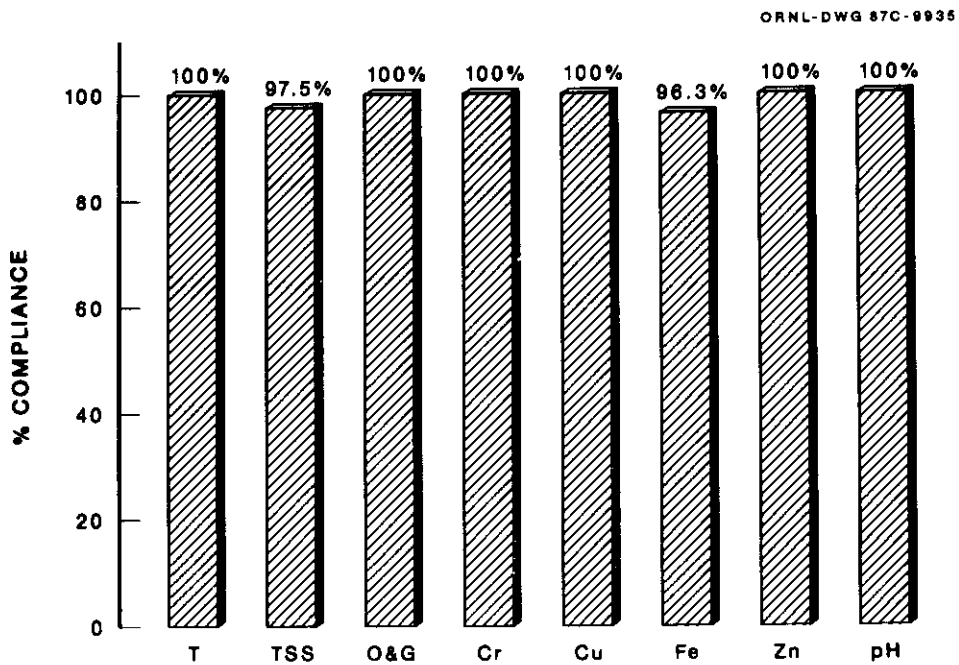


Fig. 5.3.5. NPDES compliance for ORNL Coal Yard Runoff Treatment Facility.

- *Category II Outfalls*—The following discharge pipes have been characterized by ORNL and identified in the NPDES permit as Category II Outfalls: 44 parking lot and roof drains, 8 condensate drains, 7 cooling tower drains, and 2 storage area drains. These outfalls are considered to be contaminated by ORNL activities, but are not discharged through any oil/water separator or other treatment equipment or facility. Limits have been placed on pH, temperature, oil and grease, and total suspended solids.
- *Category III Outfalls (Untreated Process Drains)*—There are 32 discharge pipes that have been characterized by ORNL and identified in the NPDES permit as untreated process drains. These outfalls are actually either Category I or Category II Outfalls, but because of inflow/infiltration, cross-connects, or improper disposal of chemicals, they have become contaminated with pollutants. Further characterization and determination of the source of the pollutants is under way, with the goal of eliminating any untreated process discharge to receiving waters. The only limitation placed on these outfalls is pH.
- *Miscellaneous Source Discharges*—These outfalls have not been assigned serial numbers but are specific to special categories identified by EPA. Limitations have been placed on all miscellaneous source outfalls. Facilities that have been placed in these categories are: 4 cooling towers, 1 boiler (Building 2519), 1 vehicle and equipment cleaning facility (Building 7002), 1 painting and corrosion control facility (Building 7007), 1 vehicle and equipment maintenance facility (Building 7002), 4 photographic laboratories (Buildings 1500, 4500N, 7934, 7601), and 1 firefighter training area (outside Building 2500).
- *Special Monitoring/Management Plans*—In addition, the new permit requires that a number of other plans and programs be implemented: *Mercury Assessment Plan*, *Radiological Monitoring Plan*, *Monitoring Plan for PCBs in the Aquatic Environment*, *Biological Monitoring and Abatement Plan*,

*Best Management Practices Plan*, and the *Toxicity Control and Monitoring Program*.

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 best management practices (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 actions or procedures that eliminate or minimize the potential for release of toxic or hazardous pollutants in significant amounts to surface waters.

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 allow determination of the ecological health of area streams before, during, and after treatment facilities are installed. The TCMP accompanies the BMAP and provides a record of the toxicity of individual point source discharges. The TCMP 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 as well as the Resource Conservation and Recovery Act/Comprehensive Environmental Response, Compensation, and Liability Act (RCRA/CERCLA) remedial action activities.

All total suspended solids and oil and grease noncompliances at Category II outfalls can be attributed to the unusually long periods of dry weather followed by heavy rainfall. Flow from these outfalls is entirely dependent upon rainfall via parking lot drains, and samples must be collected either during or right after a rain event. When there is a lack of rainfall, sufficient

buildup of dirt, dust, oil, etc., occurs to increase the potential for total suspended solids and oil and grease violations.

Total NPDES compliance at ORNL by month is given in Figs. 5.3.6 and 5.3.7.

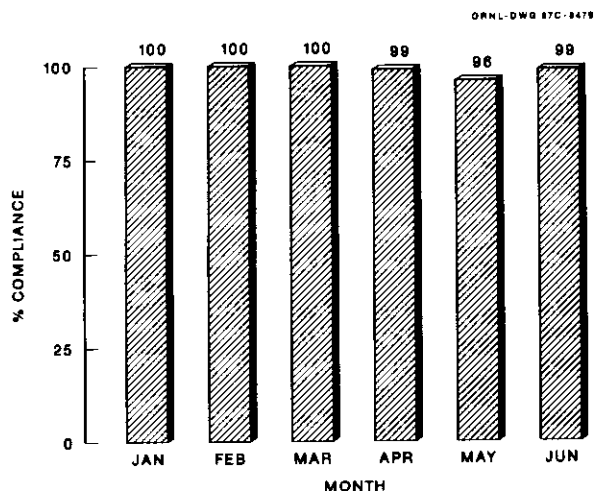


Fig. 5.3.6. Total 1986 NPDES compliance for ORNL, January-June.

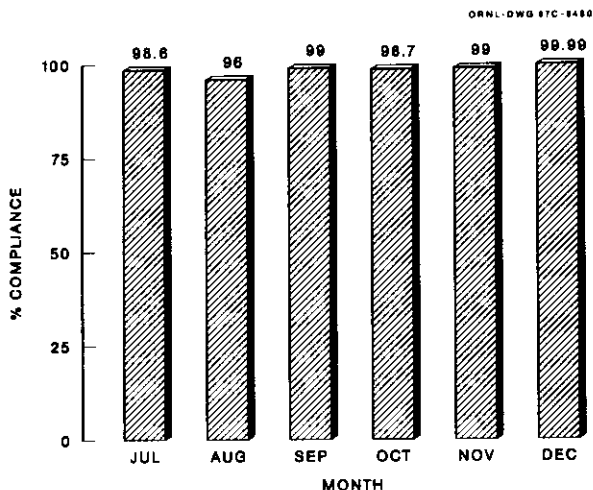


Fig. 5.3.7. Total 1986 NPDES compliance for ORNL, July-December.

### 5.3.3 Oak Ridge Gaseous Diffusion Plant NPDES Permit

ORGDP has seven NPDES discharge locations: K-1700, K-1407-B, K-1203, K-1515-C, K-1007-B, K-901-A, and K-710-A. Six of these locations are monitored. The seventh, K-710-A Powerhouse Sewage Plant, is inactive because of the decrease in mass loading at the site. The locations of these NPDES points are shown in Fig. 5.3.8.

Only the K-1407-B NPDES discharge location is expected to experience changes in the future as a direct result of the closing of the K-1407-B and K-1407-C surface impoundment as mandated by the reauthorized RCRA. The K-1407-B pond has been used primarily for flow equalization and settling of solids from the neutralization activities at K-1407-A. The K-1407-A Neutralization Facility will soon be closed out and the new Central Neutralization Facility (CNF) will become operational.

The outfall of K-1407-B was permitted during recent NPDES permit modifications. When K-1407-B pond is removed from service, the permitted NPDES point will be split to accommodate the two effluent streams from the CNF. One stream will contain small quantities of uranium contamination; the other will contain no radioactive or hazardous constituents.

Total NPDES compliance at ORGDP by month is given in Figs. 5.3.9 and 5.3.10.

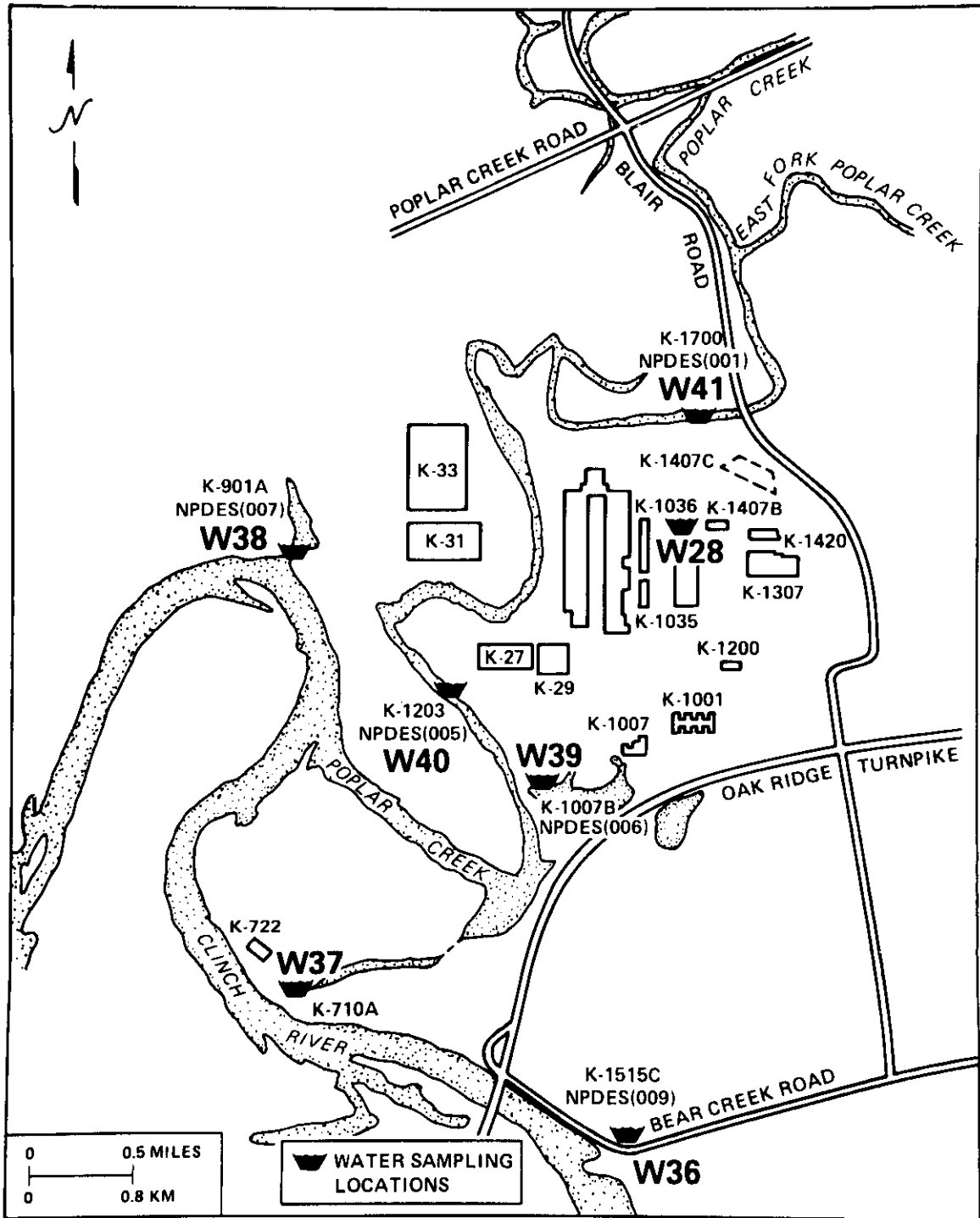


Fig. 5.3.8. Location map of ORGDP NPDES points.

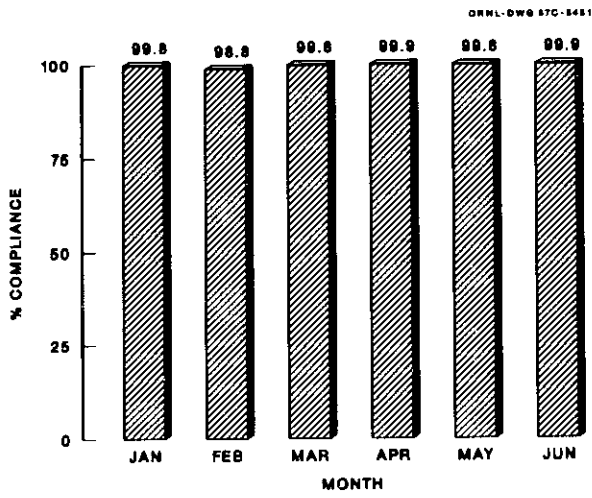


Fig. 5.3.9. Total NPDES compliance for ORGDP, January-June.

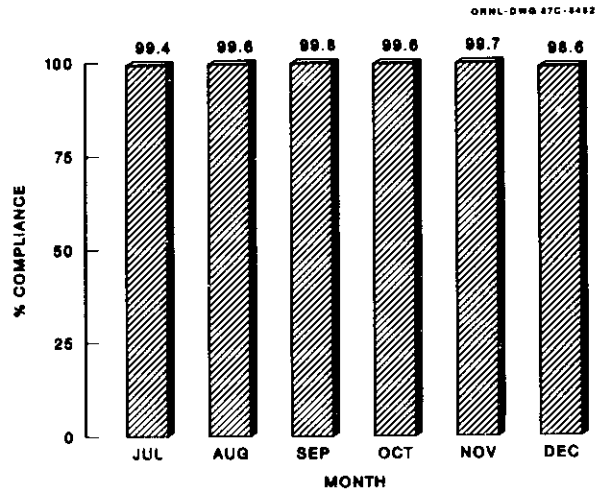


Fig. 5.3.10. Total NPDES compliance for ORGDP, July-December.



## 6. GROUNDWATER

### 6.1 INTRODUCTION

Land-disposed waste materials, whether disposed in landfills, surface impoundments, or other types of land disposal facilities, are subject to various transport processes that may lead to environmental contamination. These transport

processes involve an initial transformation to a more mobile phase, usually by solubilization, volatilization, or a chemical or biochemical reaction to form soluble or gaseous reaction products.

When transport mechanisms are available, as shown in Fig. 6.1.1, the waste materials may

ORNL-DWG 87-8672

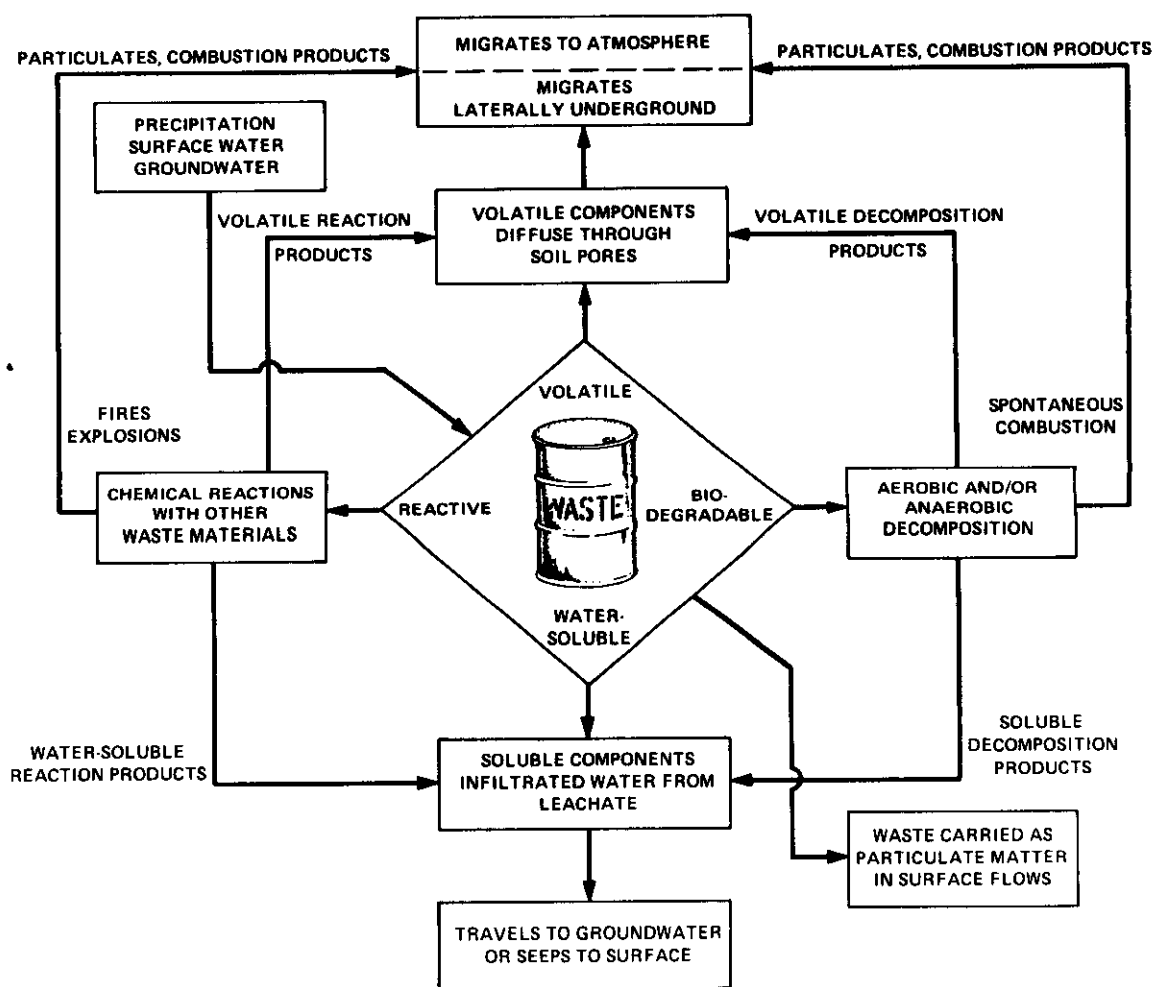


Fig. 6.1.1. Initial transport processes at waste disposal sites.

migrate outside a disposal site and pollute the groundwater, surface water, air, and terrestrial and benthic environments. Water plays an especially important role in the mobilization and transport of waste materials from the disposal site to the environment; therefore, the hydrologic cycle should be well understood as it relates to the geology and topography of a disposal site. Figure 6.1.2 illustrates the flow of water through and around a waste disposal site and the transport of waste constituents to various environmental receptors and presents an overall view of the initial mobilization processes involved in pollutant transport. It can be seen that volatile and water-soluble components are formed from microbial degradation and chemical reactions with other wastes. At times, chemical and biochemical reactions can end in explosions and fires that emit particulates, as well as combustion products, to the atmosphere. Particulates can also be entrained by surface runoff coming into contact with the waste material. The figure illustrates that wastes have the potential to be mobilized in any phase, given the "right" conditions. It is evident that there are many

potential hydraulic pathways a contaminant may follow, depending on site characteristics. For example, leachate may travel downward vertically to contaminate groundwater, or it may travel laterally and emerge as surface seepage, depending on local soil characteristics. It is important to recognize the hydraulic relationship between groundwater and surface water and to realize that either can contaminate the other.

The environmental effects resulting from polluting land disposal sites can be localized or widespread, direct or indirect, apparent or obscure, short term or long term. Figure 6.1.3 illustrates the flow of land-disposed waste contaminants through the environment and to various receptors. Adverse effects of a polluting disposal site may include contamination of a local drinking water well by contaminated leachate entering the aquifer, direct inhalation of waste fumes by nearby workers and residents, or contamination of surface water by a leachate surface seep. On the more obscure side, contamination of an aquatic food chain may occur via biological uptake of settled wastes by benthic (sediment) organisms.

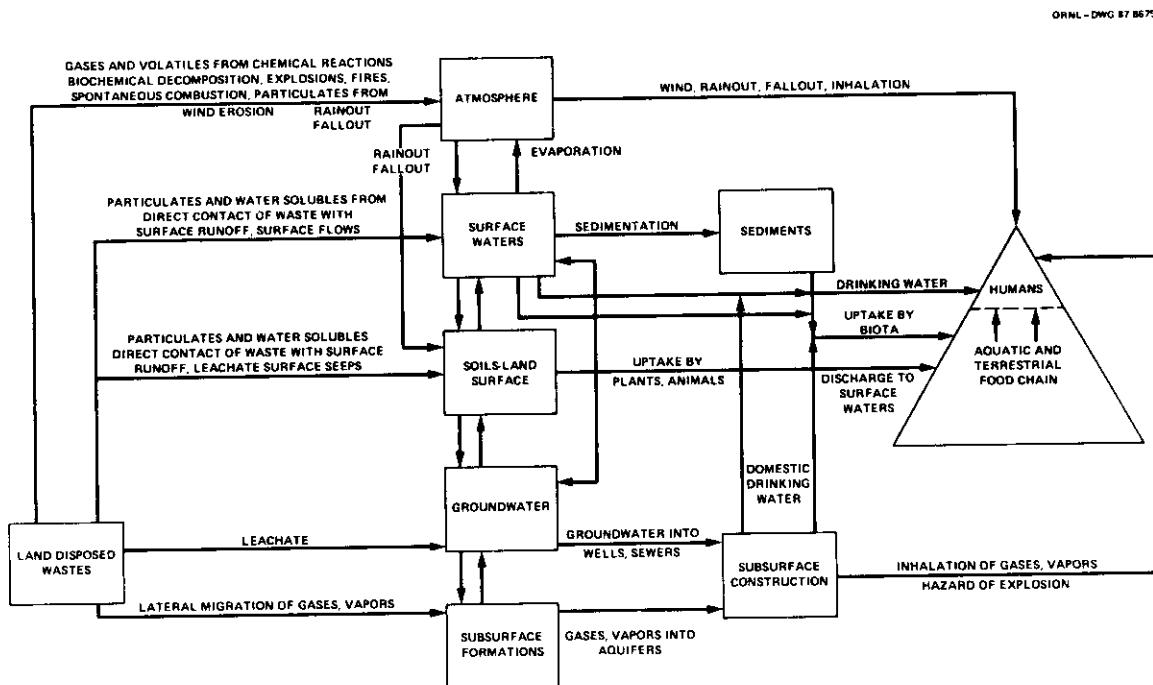


Fig. 6.1.2. Hydrologic pathways for contamination by waste disposal sites.

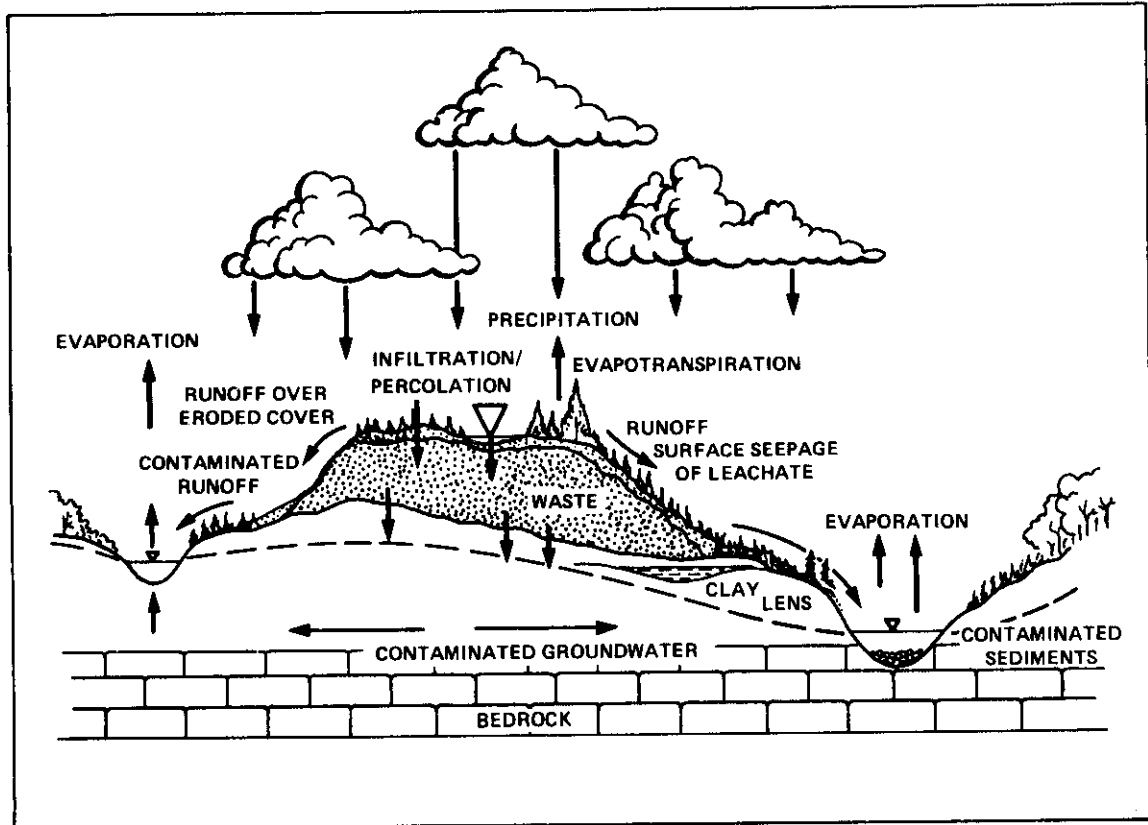


Fig. 6.1.3. Flow of land-disposed waste contaminants through the environment.

The establishment of an effective remedial action plan for a polluting waste disposal site must take into account all of the pathways involved in the transport of contaminants through the environment and to receptors. Remedial actions may be taken on several levels: (1) direct treatment or removal of the land-disposed wastes; (2) prevention of waste migration from the site; and (3) cleanup of affected media (contaminated sediments or sewers).

## 6.2 GROUNDWATER MONITORING

Federal regulations require the owners and operators of hazardous waste facilities to monitor the water in the ground beneath their facilities because solids or liquids placed on or in the ground can be transported by water travelling through soil or rock formations. This groundwater

transport can move chemical or radiological pollutants from one point (e.g., a waste pit) to another (e.g., a lake or stream). Such transport can be very difficult to detect or measure because it may occur many meters underground.

The typical method of monitoring groundwater transport and contamination is to drill a series of wells around a site of concern. Usually, the geology and hydrology of the site are assessed to determine what direction subsurface water would move. Compliance with 40 CFR Pt. 265.91 requires that a minimum of one well is placed upgradient (analogous to upstream) from the site and three are hydraulically downgradient from the site. In that way, the groundwater can be assessed at the upgradient well before it reaches the site, and assays of the downgradient groundwater can be compared with those of the upgradient groundwater to see if significant

changes occur as the groundwater passes through or under the site.

Groundwater monitoring wells in unconsolidated materials or in the upper weathered portions of bedrock are installed with sand filter packs and spiral-wound screens. The screening and well casing material are stainless steel or polyvinyl chloride, depending on the groundwater chemistry anticipated at the site. A schematic drawing of a typical screened well is shown in Fig. 6.2.1.

Groundwater monitoring wells in unweathered bedrock may or may not be installed with a screen. A schematic drawing of a typical open sampling zone groundwater well is shown in Fig. 6.2.2.

Care must be taken during installation of a groundwater monitoring well that the water being sampled is not contaminated by the drilling or sampling processes themselves. Contamination can occur in three ways: by using contaminated drilling tools, by the materials of the well itself, and by the leaking of water through cracks produced in the rock or soil by the drilling process. Such contamination is prevented by using hollow-stem continuous-flight augers or reverse air rotary drills, by steam cleaning all material and equipment that goes down the hole, by controlling the drilling fluid to avoid spreading contaminants, by using surface casings to prevent shallow contaminated groundwater from entering the hole, by sealing the annular space above the filter pack with chemically resistant materials, by capping the well with a metal protective casing with a locking lid, and by following other anticontamination procedures.

Most waste disposal facilities operated for DOE in Oak Ridge have a network of groundwater monitoring wells. Samples are collected from those wells and analyzed on a regular schedule. The data that EPA and TDHE require to be gathered fall into three categories. The first deals with substances that characterize the suitability of the groundwater as drinking water. In this category are determinations of arsenic, barium, cadmium, chromium, fluorine, lead, mercury, nitrates, selenium, silver, endrin, lindane, methoxychlor, toxaphene, 2,4-D,

2,4,5-TP silvex, radium, gross alpha radiation, gross beta radiation, cobalt-60, cesium-137, and total coliform. The second category deals with substances that determine the general quality of surface waters: chlorine, iron, manganese, phenols, sodium, and sulfates. The third category deals with substances that indicate the contamination of groundwater: pH, specific conductance, total organic carbon, and total organic halides. Under the regulations, samples in the last category must be determined in quadruplicate. The expanded well networks will also provide data for improved groundwater flow maps.

### 6.3 OAK RIDGE Y-12 PLANT MONITORING

During 1986, 55 additional groundwater wells were drilled at the Oak Ridge Y-12 Plant. In addition, 4 coreholes and 11 soil borings were taken to shed light on the makeup and structure of the soil and rocks below and around waste sites and to study the hydrology near those sites. These monitoring wells were installed at the Beta-4 Security Pit, the Chestnut Ridge Security Pits, Kerr Hollow Quarry, New Hope Pond, the 9712 Ravine Disposal Site, Rogers Quarry, the Sludge Disposal Basin, the United Nuclear Site, a site south of the BCVWDA, and a site north of the BCVWDA. The locations and arrangements of these monitoring well networks are shown in Figs. 6.3.1 through 6.3.6. Data from these wells should not only indicate the water quality below those sites but also reveal the groundwater flow behavior at those sites. Learning the flow behavior along the crest of Chestnut Ridge is especially important because several of these sites are located there.

### 6.4 ORNL MONITORING

Twenty-two monitoring wells are installed at ORNL at the water quality (RCRA) 3524, 7900, and 3539-40 impoundment areas. The locations of these wells are indicated in Figs. 6.4.1. and 6.4.2.

In addition to these RCRA-quality wells, approximately 250 new piezometer wells were

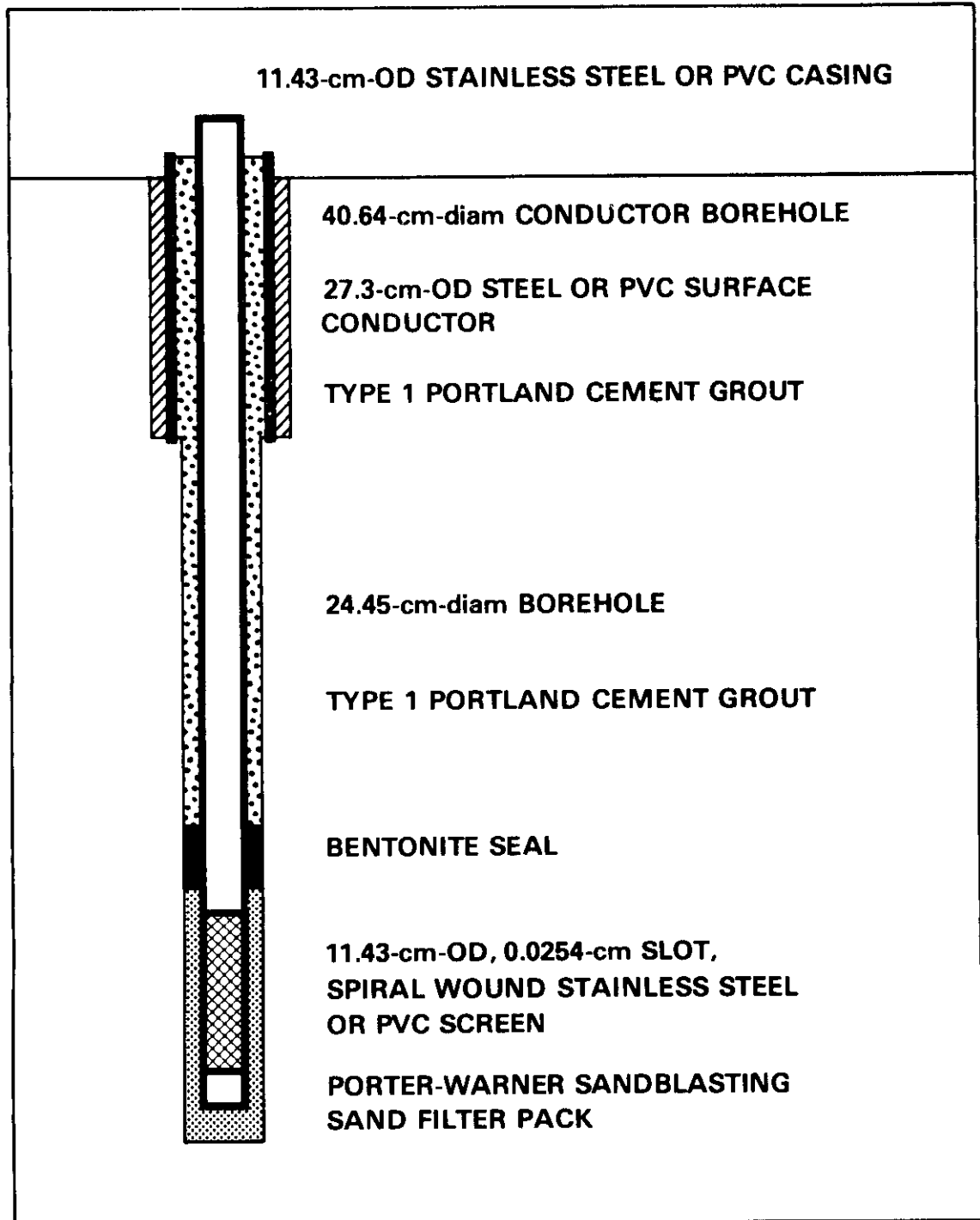


Fig. 6.2.1. Schematic drawing of a typical screened groundwater well.

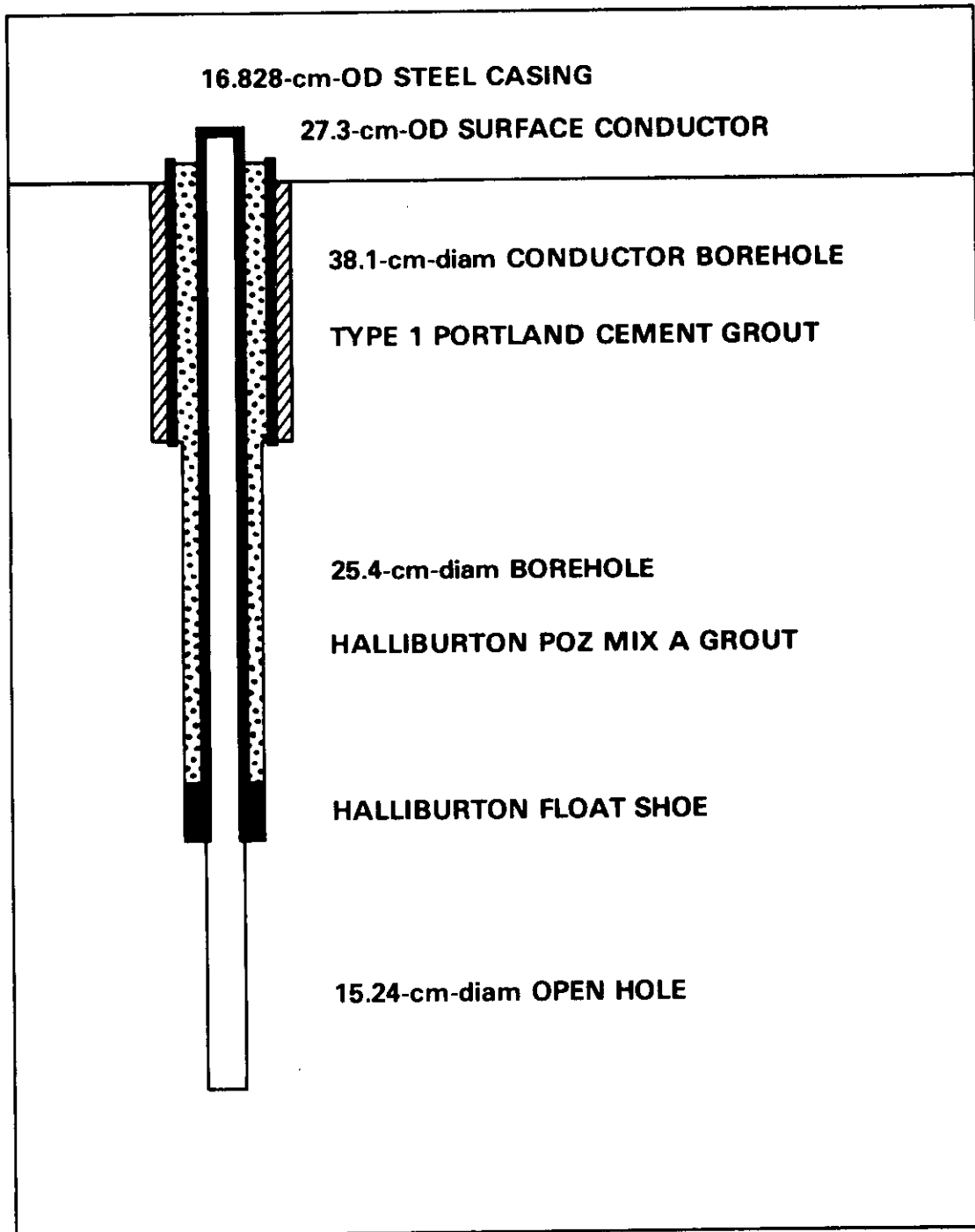


Fig. 6.2.2. Schematic drawing of a typical open groundwater well.

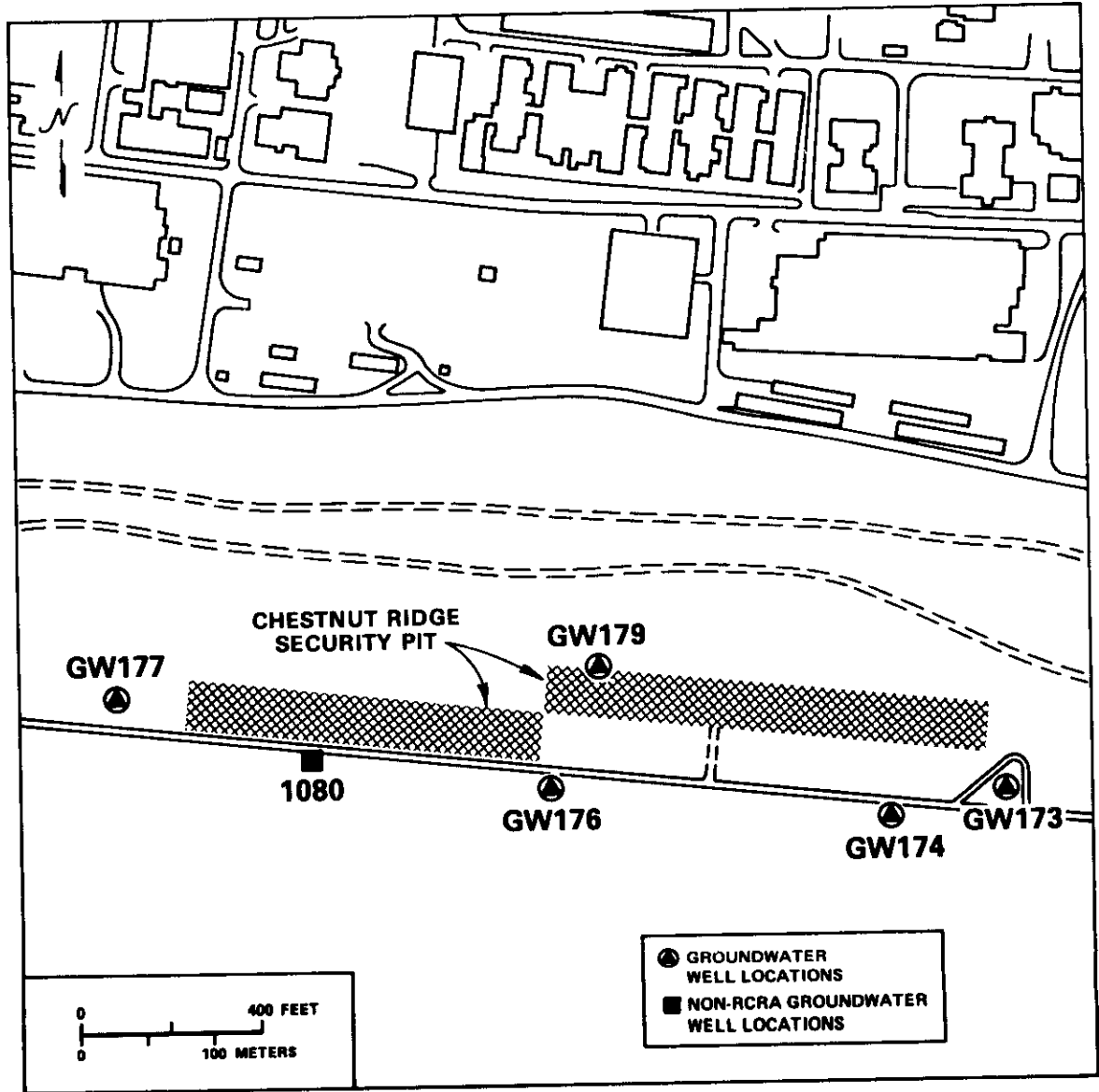


Fig. 6.3.1. Locations of groundwater wells around Chestnut Ridge Security Pits, Y-12 Plant.

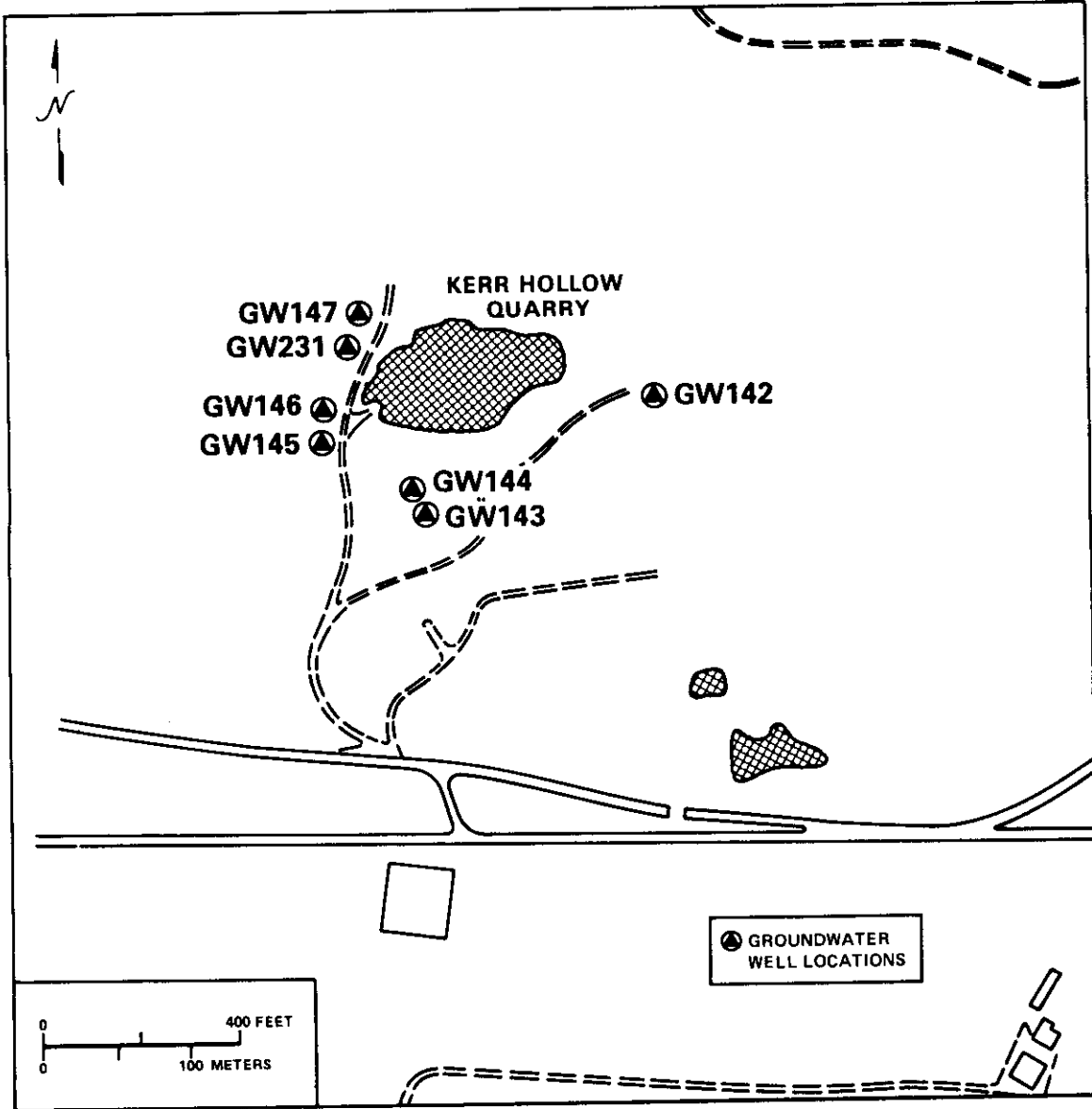


Fig. 6.3.2. Locations of groundwater wells around Kerr Hollow Quarry, Y-12 Plant.



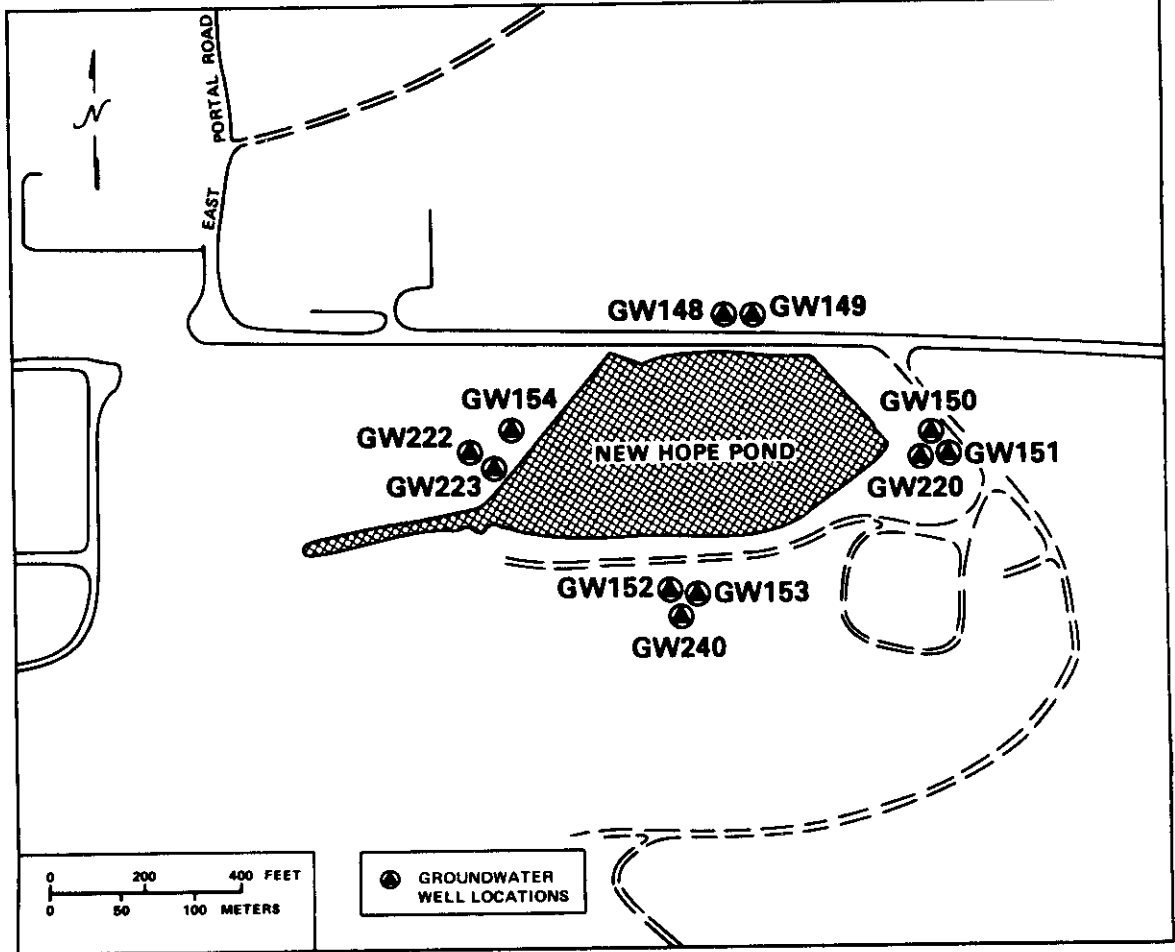


Fig. 6.3.3. Locations of groundwater wells around New Hope Pond, Y-12 Plant.

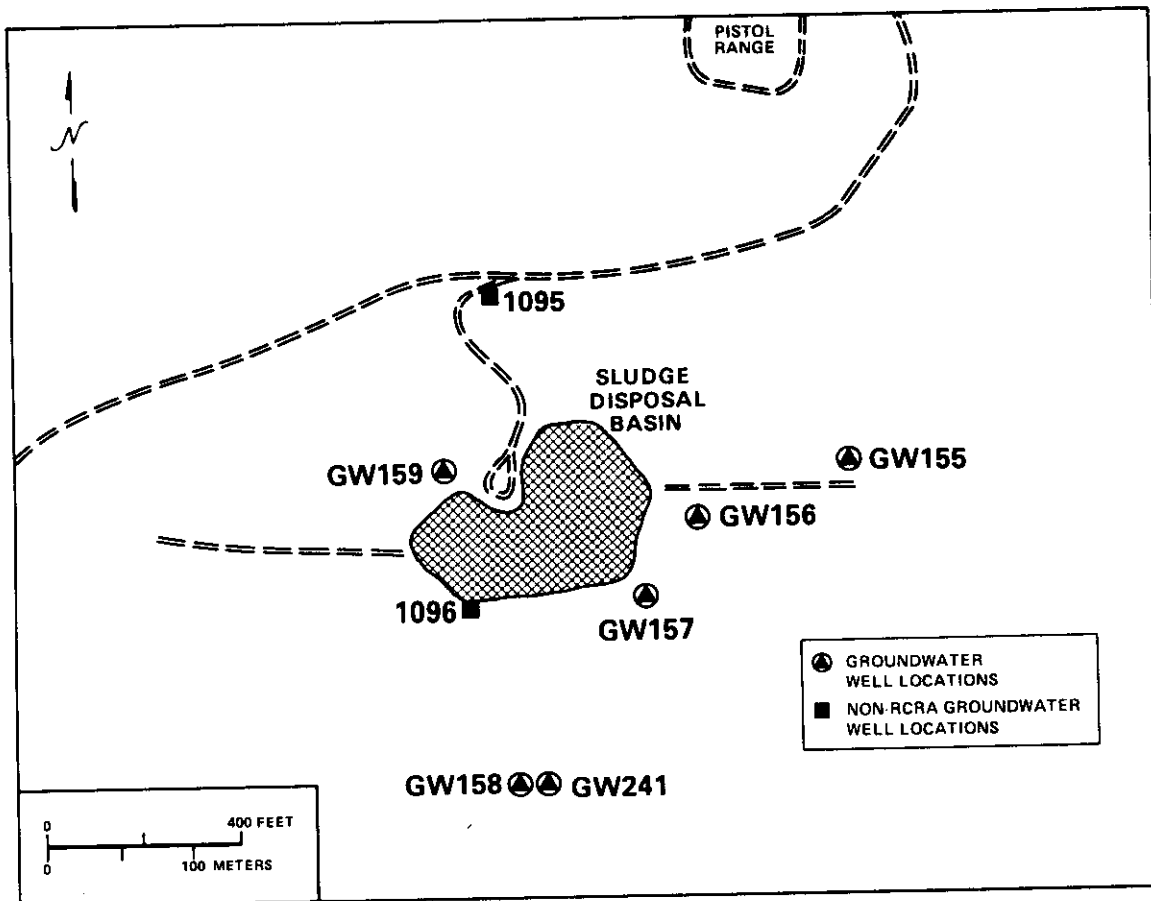


Fig. 6.3.4. Locations of groundwater wells around Sludge Disposal Basin, Y-12 Plant.

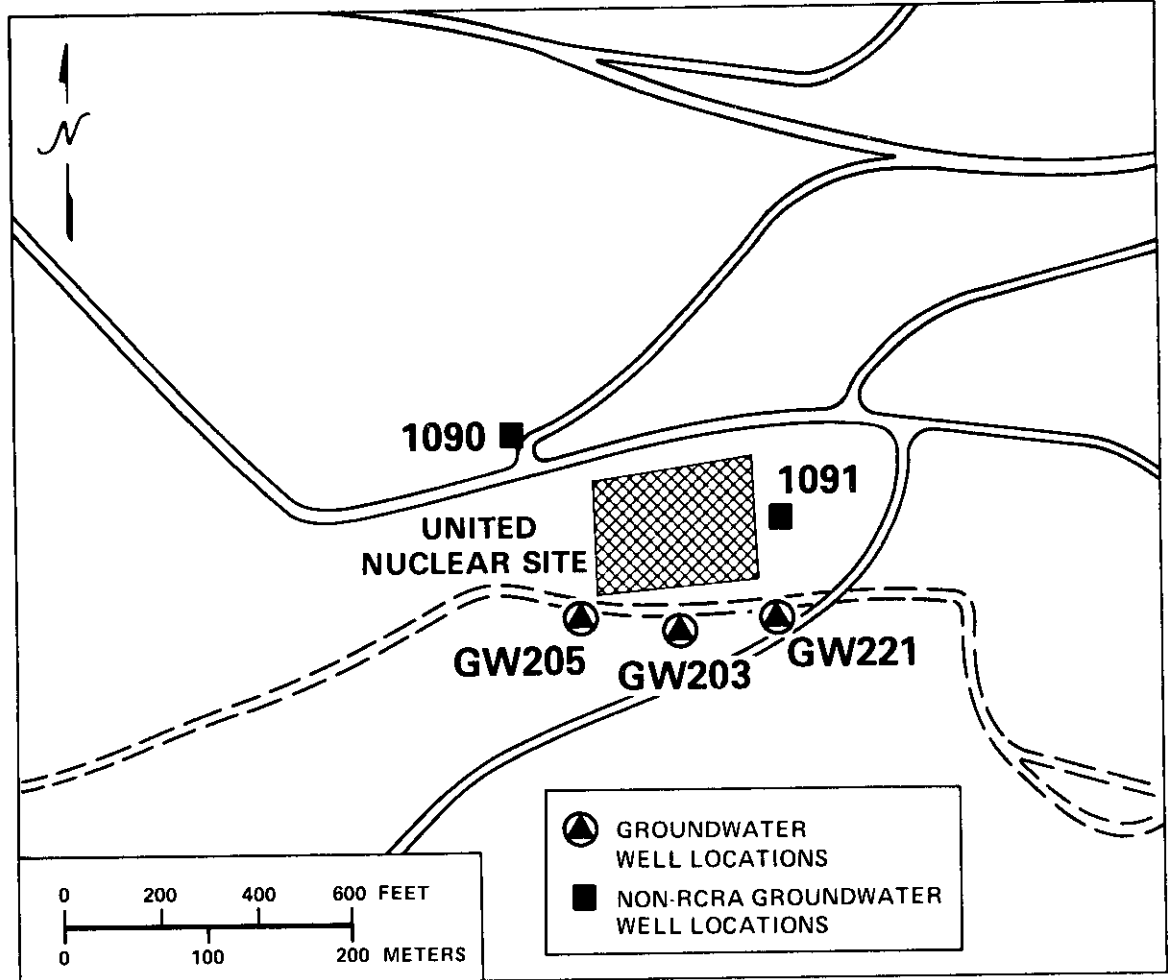


Fig. 6.3.5. Locations of groundwater wells around United Nuclear Site, Y-12 Plant.

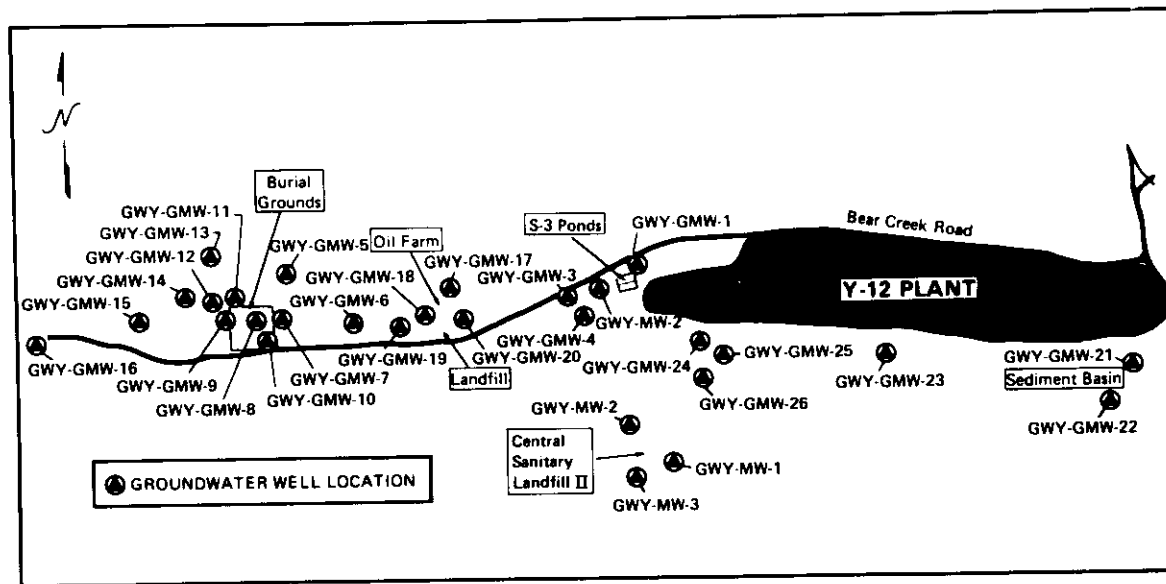


Fig. 6.3.6. Location of groundwater wells near Y-12 Plant waste areas.

installed in 1986 to characterize groundwater flow conditions at ORNL waste disposal sites. Water level and hydraulic test data from these new wells and the several hundred existing wells provide the basis for the planned installation of approximately 260 water quality monitoring wells to be built to RCRA specifications over the next two years. The existing (old construction method) wells are suitable for water level measurements and determination of general water quality parameters, including radionuclides. However, construction materials and methods limit their use and preclude the collection of valid samples for compliance purposes. Most of the older-construction wells (over 300 wells) are located at Solid Waste Storage Areas (SWSA) 4, 5, and 6; Waste Pits 1, 2, 3, and 4; and Waste Trenches 5, 6, and 7. The wells' locations are shown in Figs. 6.4.3 through 6.4.6. Eighteen of these wells were sampled during 1986. The average concentrations of specific radionuclides measured in 1986 appear to be similar to those measured in 1985.

## 6.5 ORGDP MONITORING

A 1985 report by consulting groundwater specialists recommended the investigation of the

groundwater at 13 sites at ORGDP. During consideration of their recommendations, another site was added to the list for such investigation. In 1986, 37 wells were installed at these 13 sites; 17 of these wells were piezometers for monitoring water level, 11 were monitor wells for water quality in unconsolidated material, and 9 were characterization wells in bedrock. The 13 sites at which the wells were installed are indicated on the map of the ORGDP area in Fig. 6.5.1; those sites are the K-1407-A neutralization facility, the K-1407-B holding pond, the K-1407-C retention basin, the K-1232 and K-1413 treatment facilities, the K-1070-A and K-1070-B contaminated burial grounds, the K-1070-C and K-1070-D classified burial grounds, the K-1070-F contractors' burial ground, the K-1099 Blair Road Quarry, the K-770 scrap metal yard, the K-1064-G peninsula storage and burn area, and the K-1085 firehouse burn area. Data from these wells and from other sources indicate that the water table and groundwater flow paths on the ORGDP site are as shown in Fig. 6.5.2.

Monitor wells for obtaining the data needed to meet or exceed the RCRA requirements were installed at the K-1407-B holding pond and the K-1407-C retention basin (see Fig. 6.5.3).

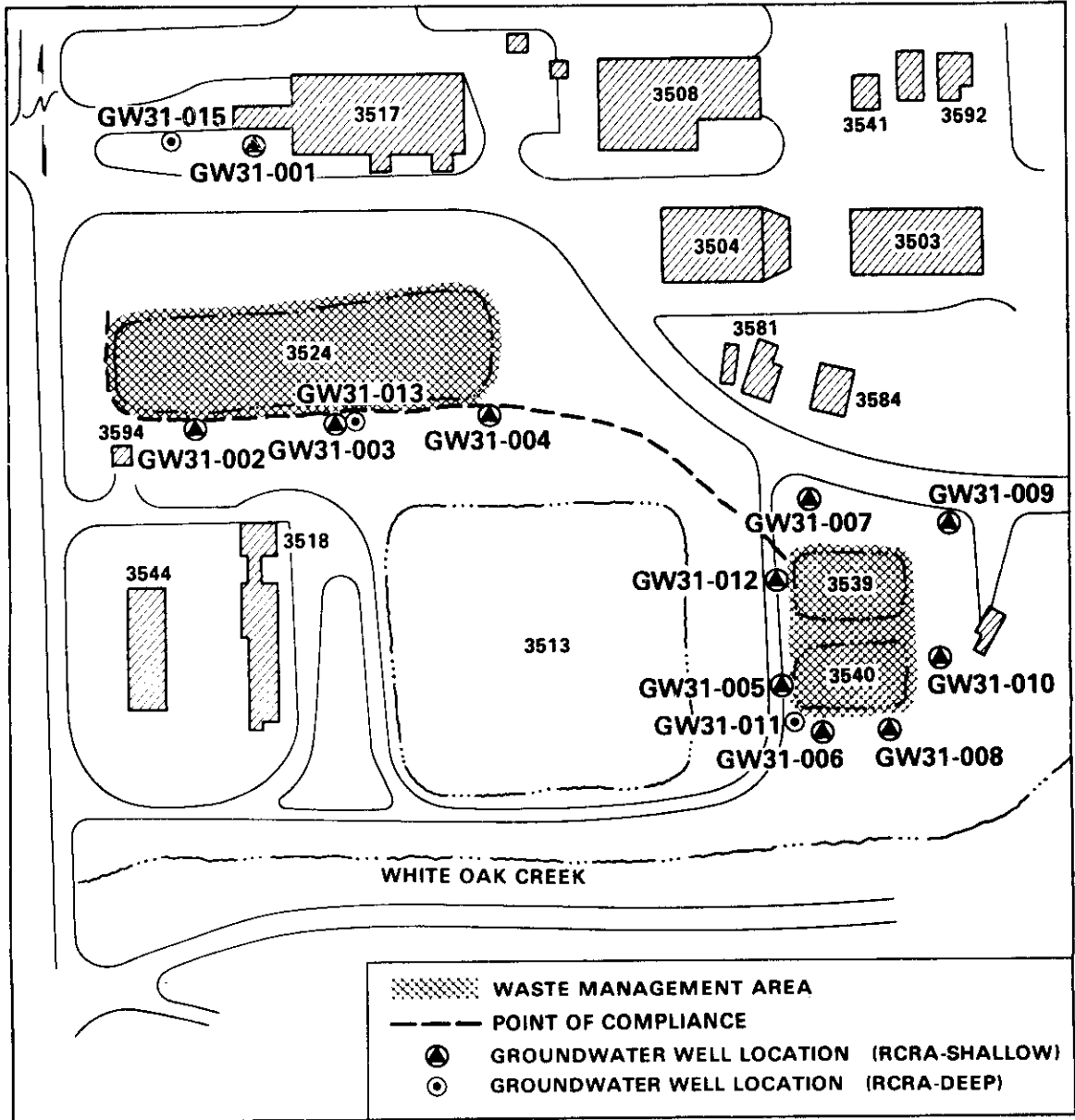


Fig. 6.4.1. Locations of groundwater wells around ponds 3524, 3539, and 3540, ORNL.

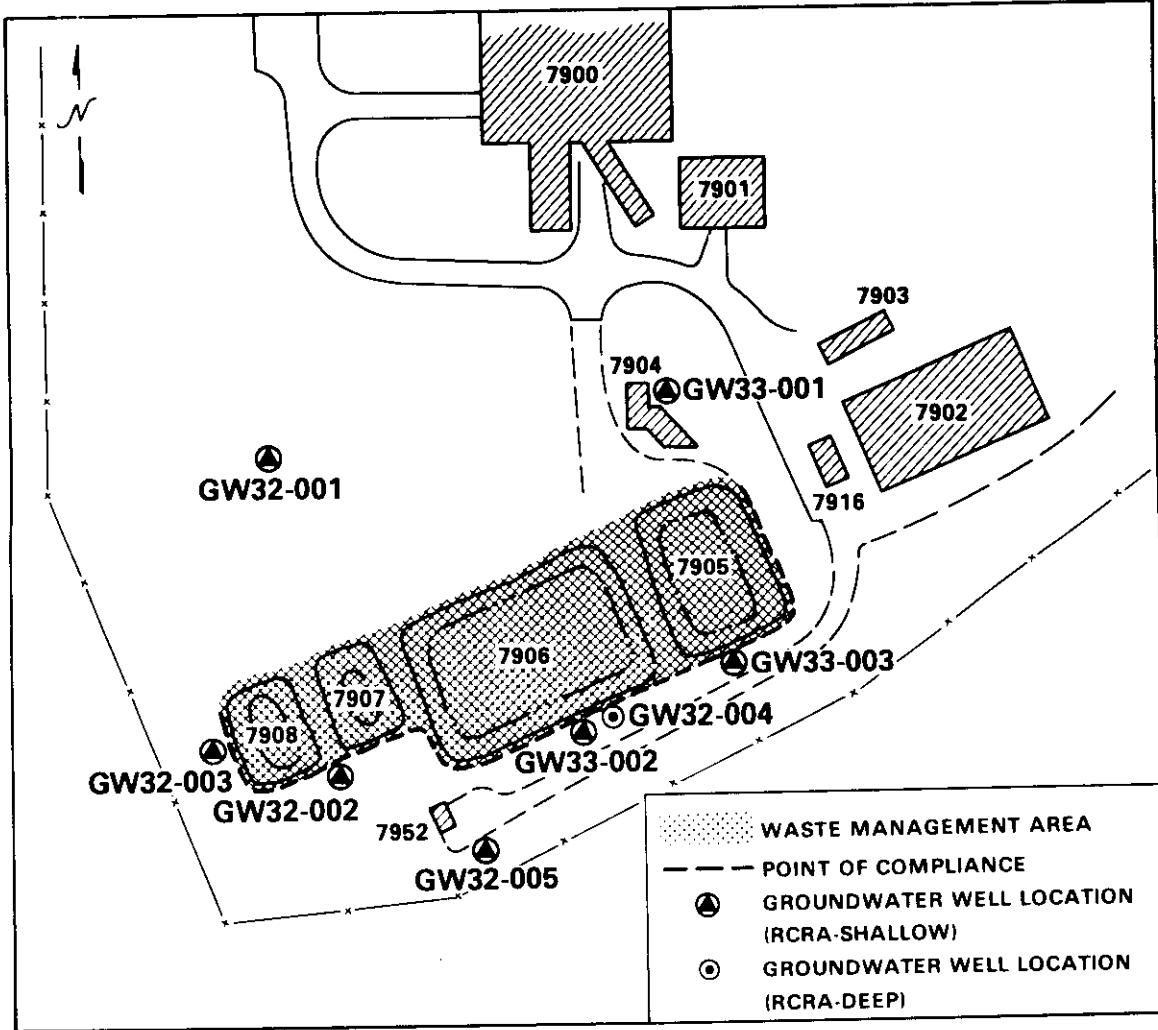


Fig. 6.4.2. Locations of groundwater wells around ponds 7905, 7906, 7907, and 7908, ORNL.

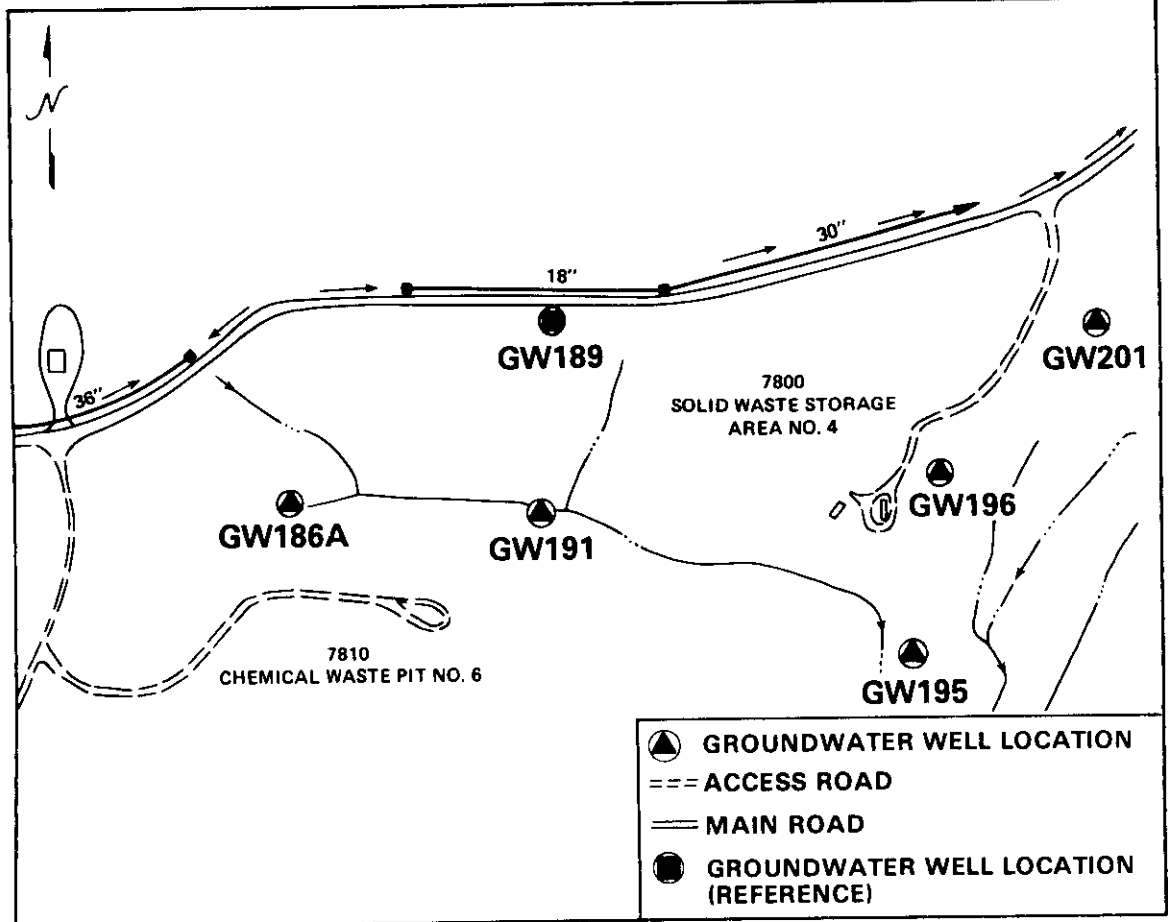


Fig. 6.4.3. Locations of groundwater wells near Solid Waste Storage Area 4, ORNL.

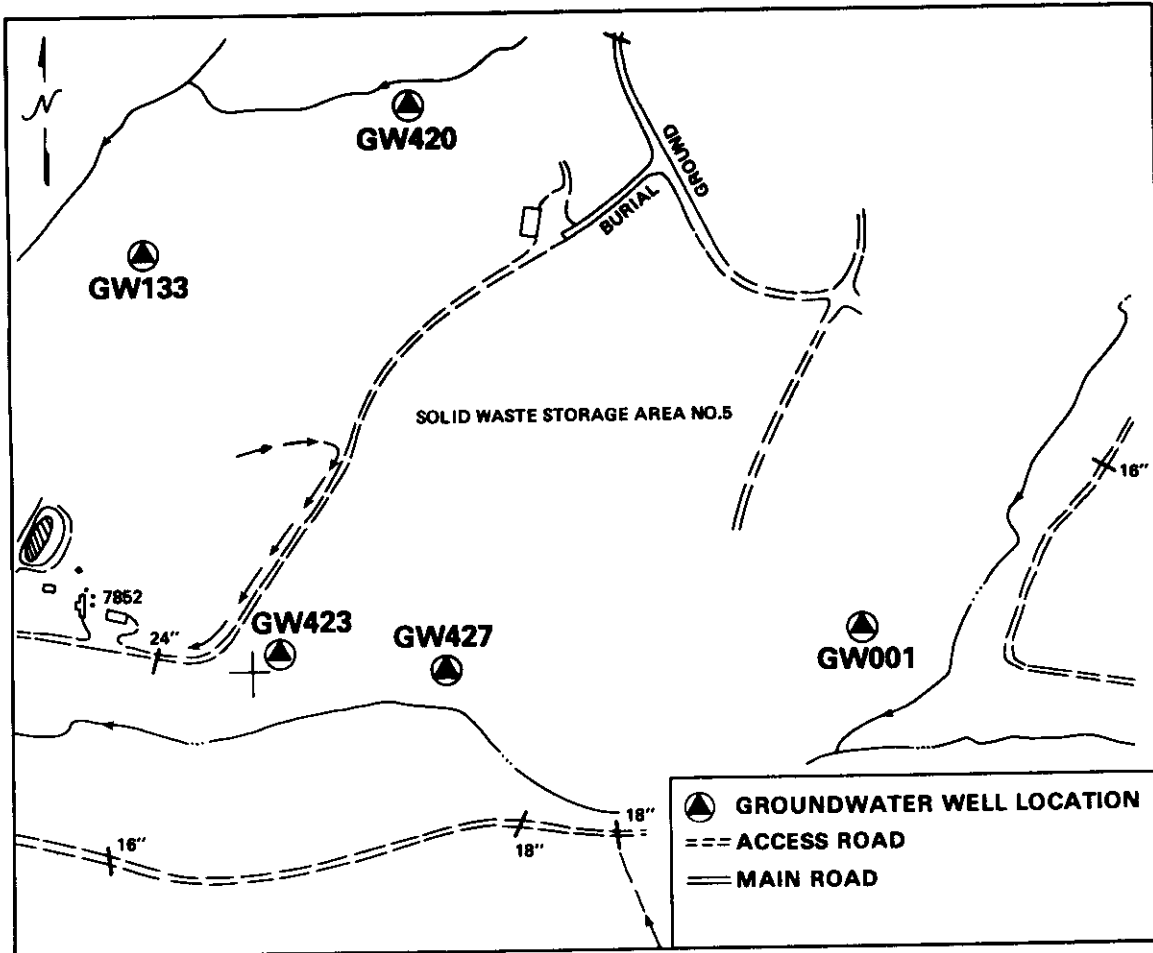


Fig. 6.4.4. Locations of groundwater wells near Solid Waste Storage Area 5, ORNL.



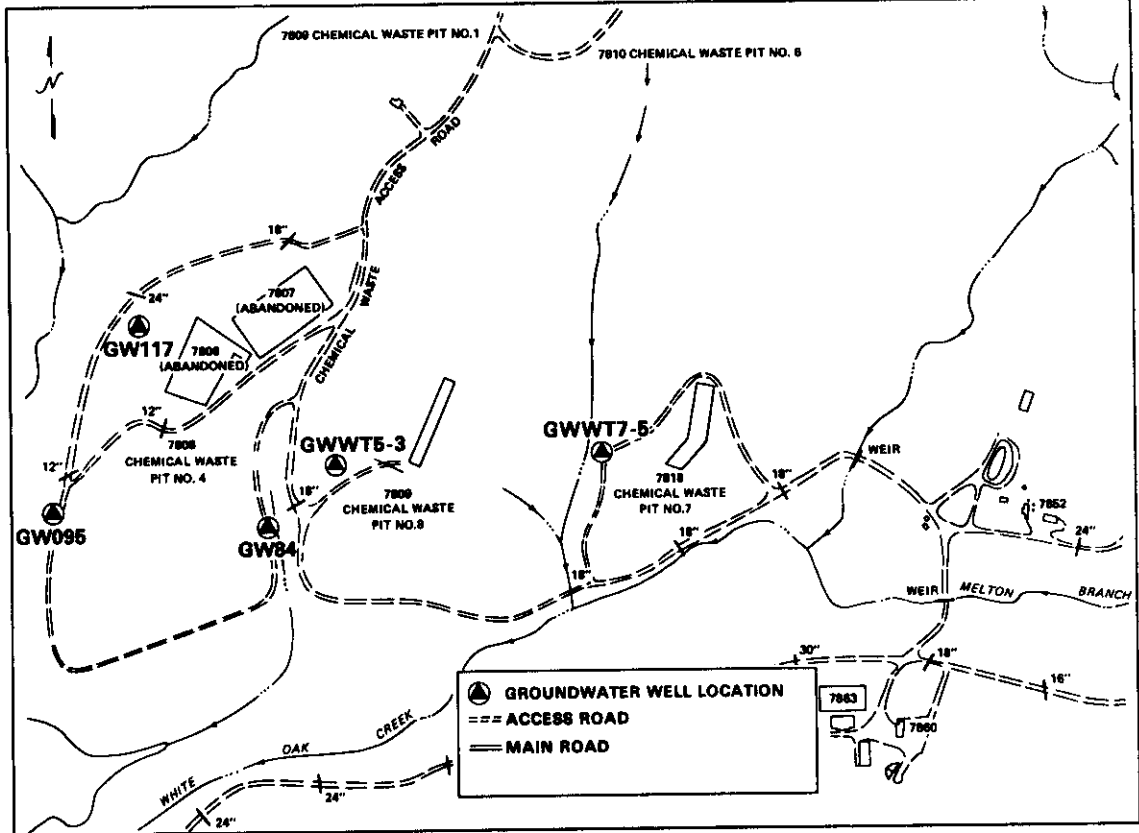


Fig. 6.4.5. Locations of groundwater wells near pits, ORNL.

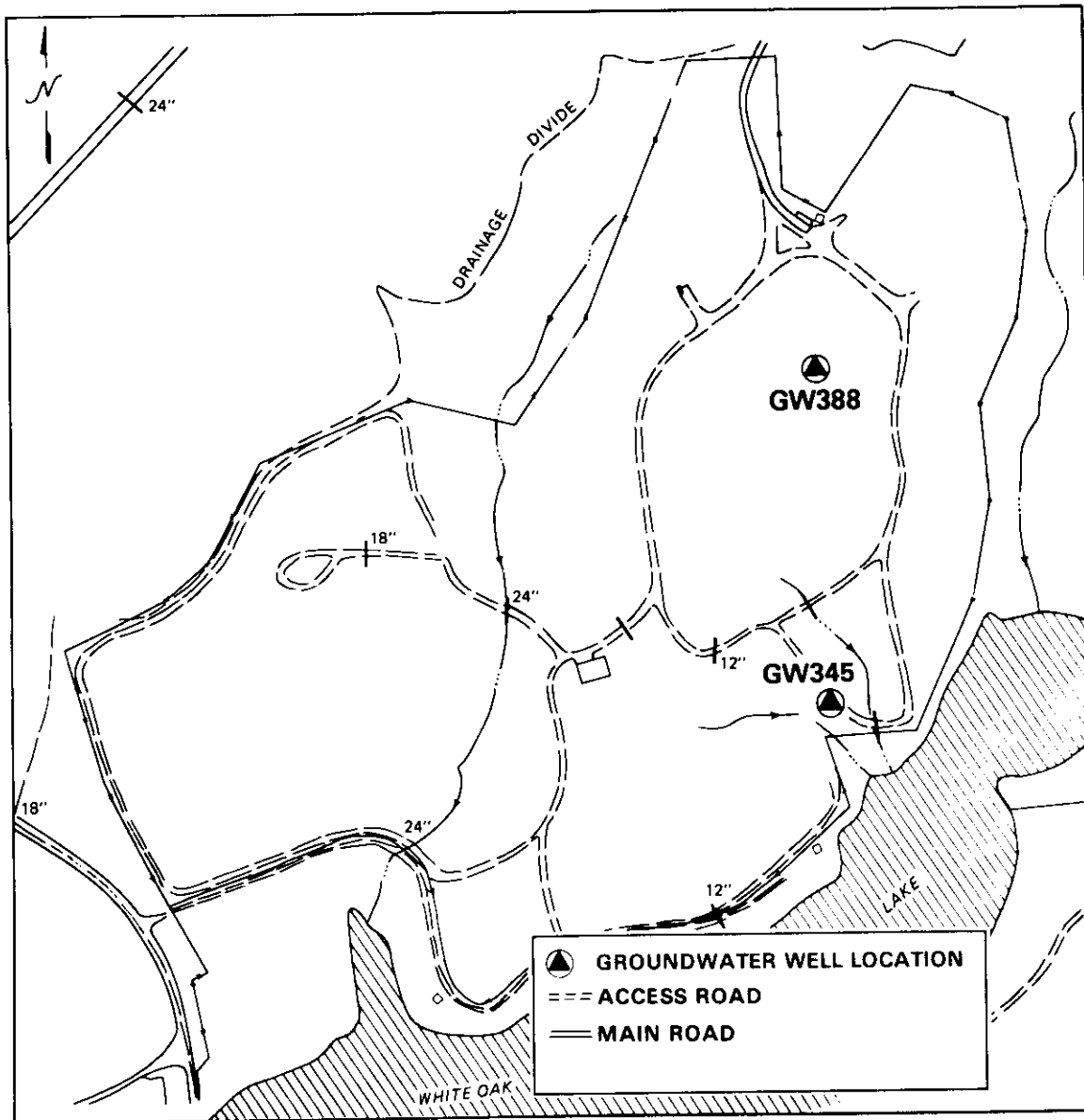


Fig. 6.4.6. Locations of groundwater wells near Solid Waste Storage Area 6, ORNL.

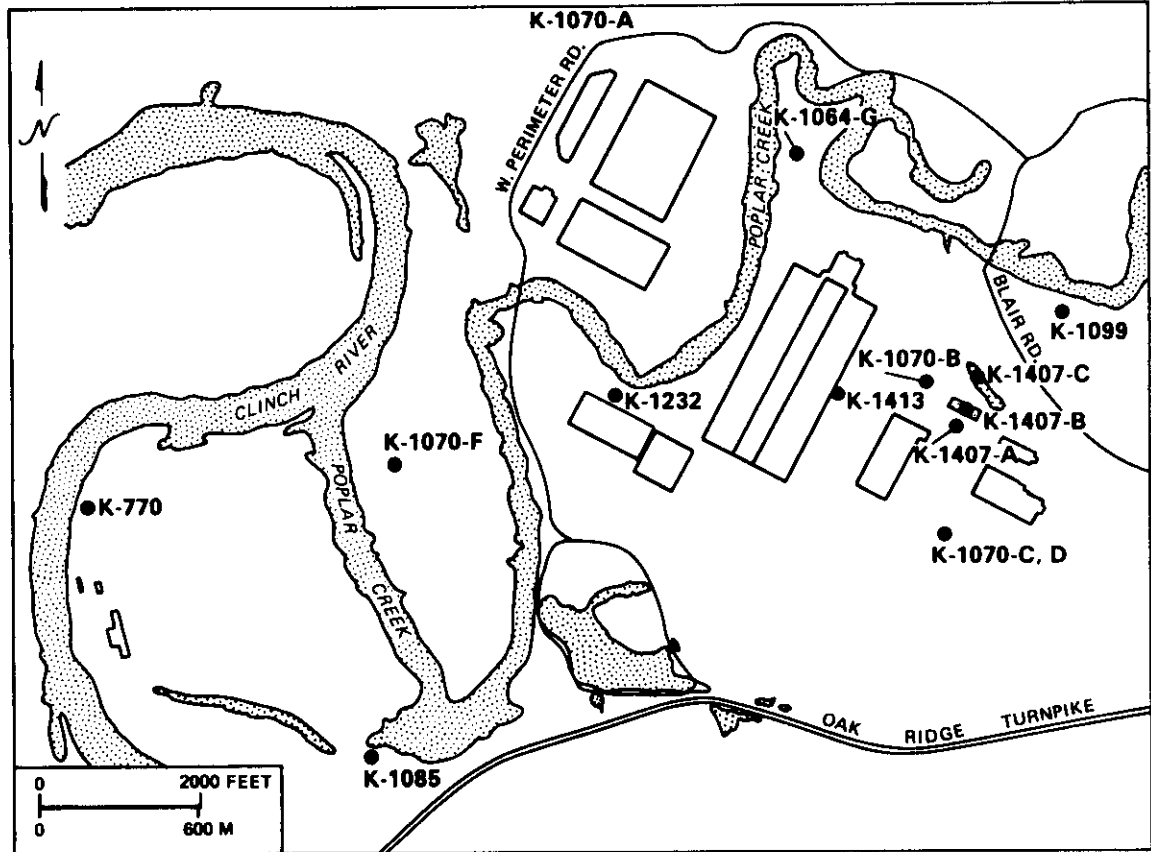


Fig. 6.5.1. Location of the ORGDP waste storage/disposal sites selected for groundwater monitoring.

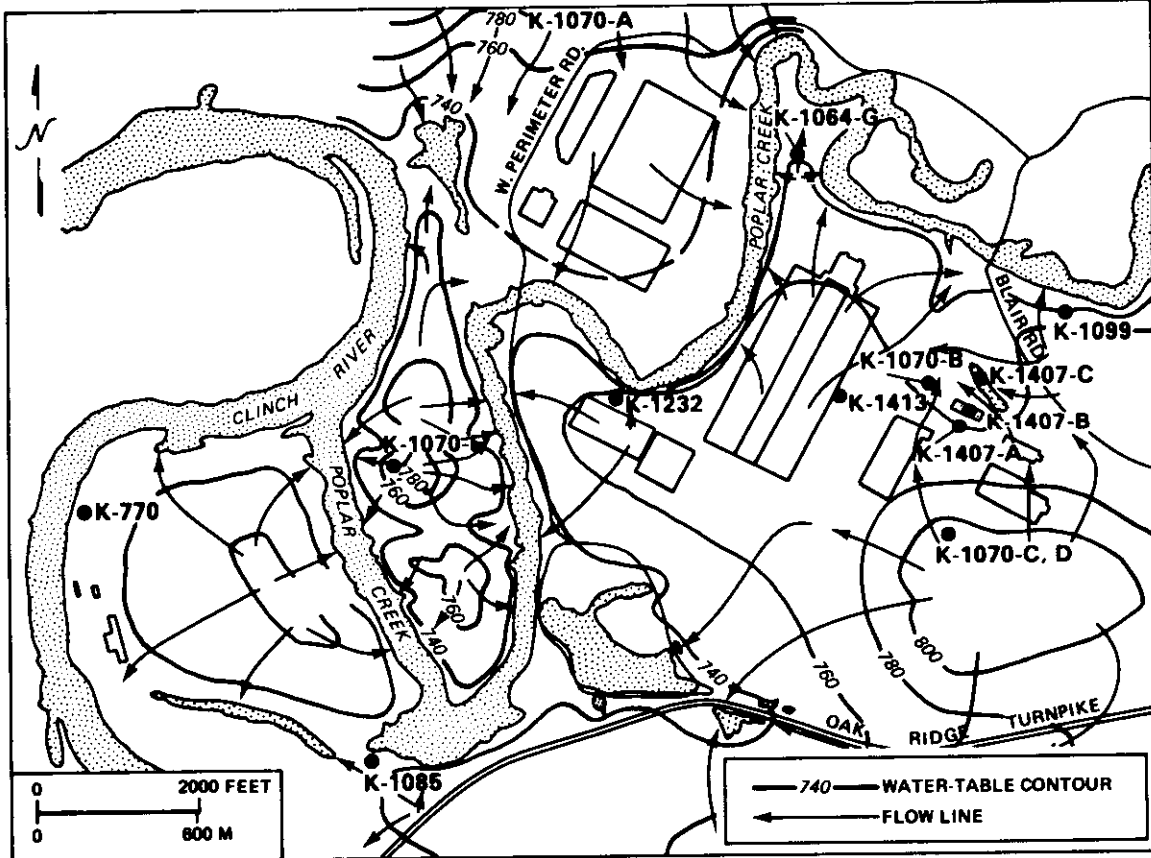


Fig. 6.5.2. Contours on the water table and inferred groundwater flow paths in the ORGDP uppermost aquifer.

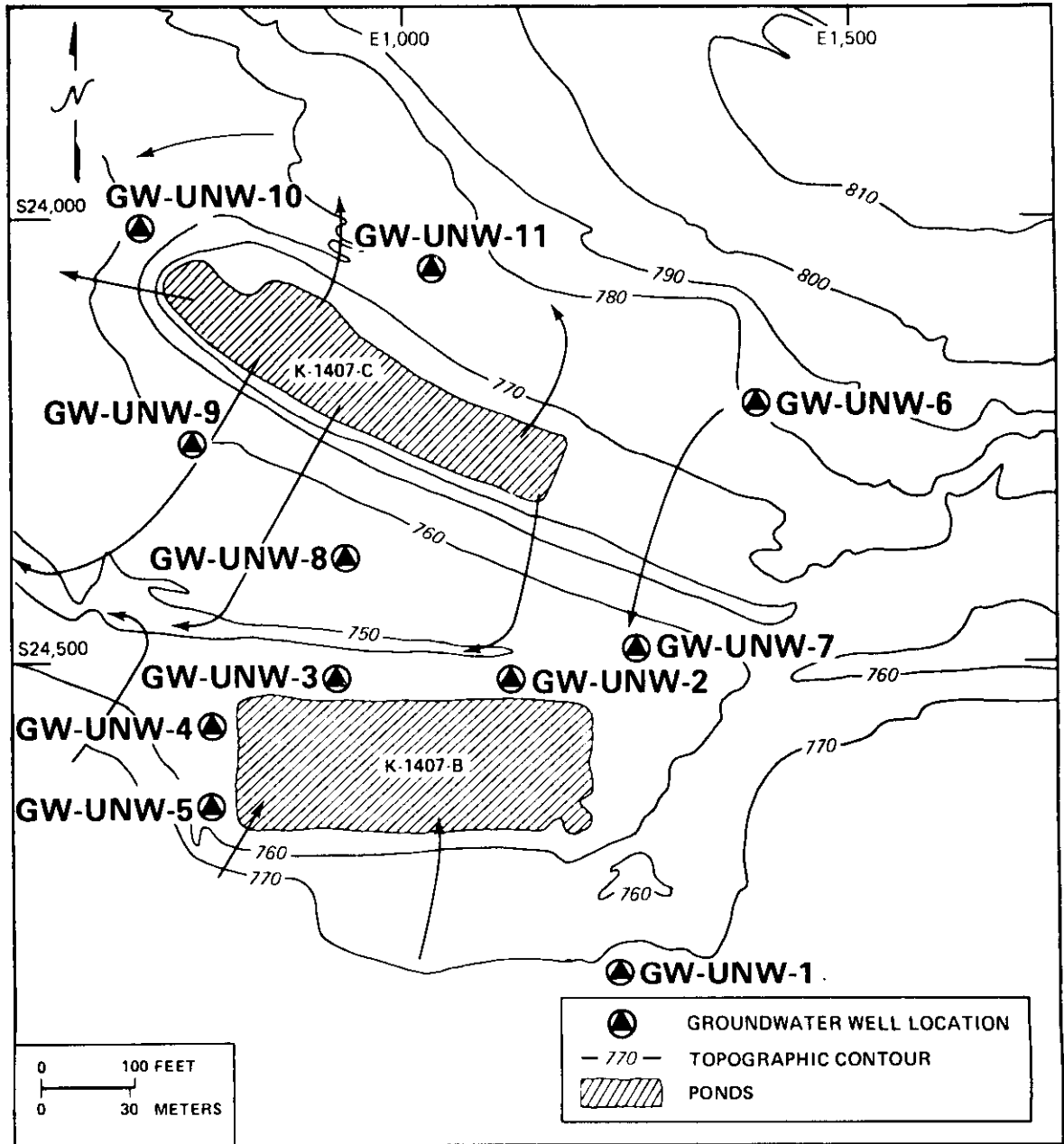


Fig. 6.5.3. Groundwater well locations and groundwater flow paths around the K-1407-B and K-1407-C ponds.

Characterization wells or piezometer wells were installed at all the other sites identified by the consultants or the State of Tennessee, and data have been gathered for those sites. Those data have been analyzed and monitor wells are being installed.

### 6.6 SUMMARY OF GROUNDWATER DATA

During 1986, groundwater samples were collected to meet requirements of TDHE Hazardous Waste Management Regulation 1200-1-11 (TDHE, 1981), the Resource Conservation and Recovery Act (RCRA, 1976), and DOE Orders 5480.1A (1981) and 5480.2 (1983). Wells were monitored quarterly for three sets of parameters—the EPA interim primary drinking water standards, groundwater quality parameters, and parameters indicating groundwater contamination. Statistical presentation of monitoring data collected on RCRA wells in place around facilities that are accorded interim status is required by TDHE regulations (TDHE, 1981). A statistical evaluation of first-year data has been completed by the Oak Ridge Y-12 Plant (Haase, Gillis, and King, 1987).

#### 6.6.1 Oak Ridge Y-12 Plant Data

In November 1986, each of the wells around New Hope Pond, Kerr Hollow Quarry, Chestnut Ridge Security Pits, and Chestnut Ridge Sludge Disposal Basin were certified for groundwater monitoring purposes. At that time, the designations “upgradient” and “downgradient” were based on the topographic relationship of the wells at each site because no water elevation data had been collected before certification (Haase, Gillis, and King, 1987). After a year of data collection, the wells were re-evaluated for gradient using the hydrostatic head measurements obtained throughout the year. After this investigation, designation of well gradient was changed at New Hope Pond, Kerr Hollow Quarry, and Chestnut Ridge Sludge Disposal Basin. Results were compared with EPA drinking

water standards and values exceeding these standards were noted. Those parameters that exceeded standards in 1986 were gross alpha, gross beta, radium, nitrate nitrogen, lead, chromium, arsenic, and mercury (Figs. 6.6.1 through 6.6.6).

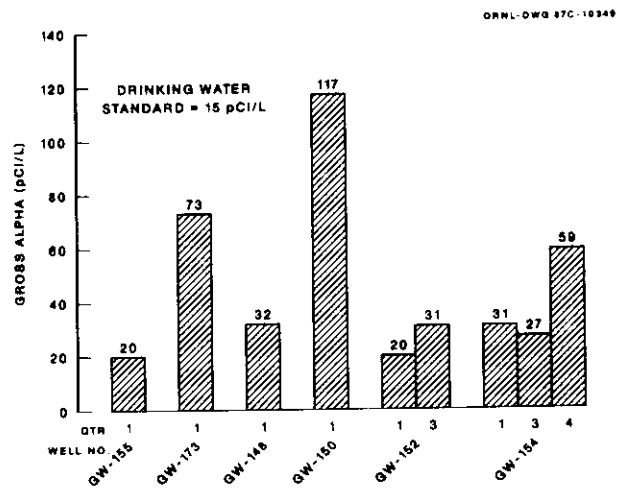


Fig. 6.6.1. Gross alpha concentrations in groundwater wells at the Y-12 Plant that exceeded drinking water standards.

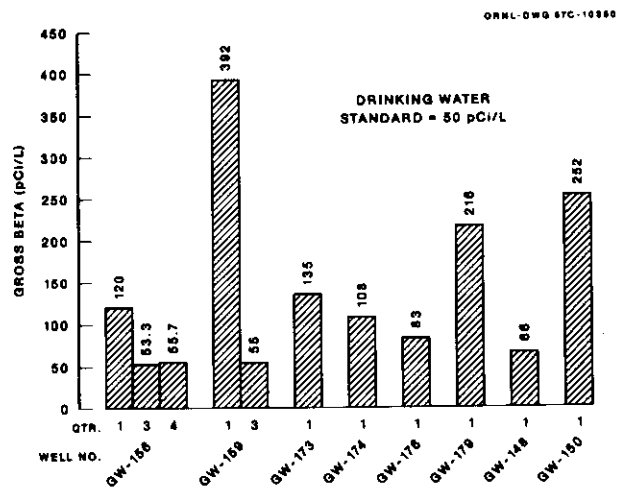


Fig. 6.6.2 Gross beta concentrations in groundwater wells at the Y-12 Plant that exceeded drinking water standards.

#### 6.6.2 Oak Ridge National Laboratory Data

ORNL has a groundwater network consisting of 22 wells located adjacent to 3 impoundment

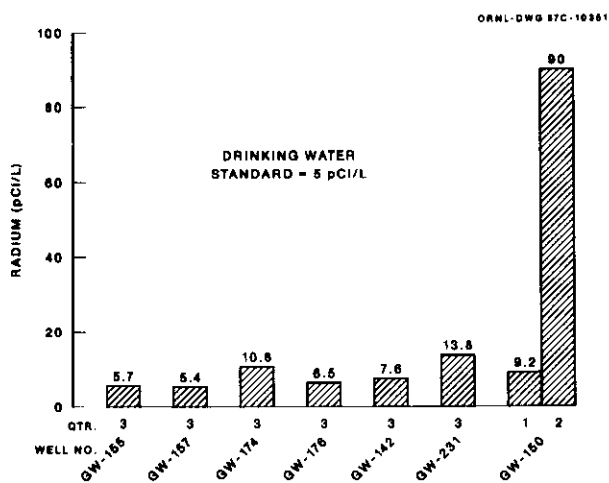


Fig. 6.6.3. Radium concentrations in groundwater wells at the Y-12 Plant that exceeded drinking water standards.

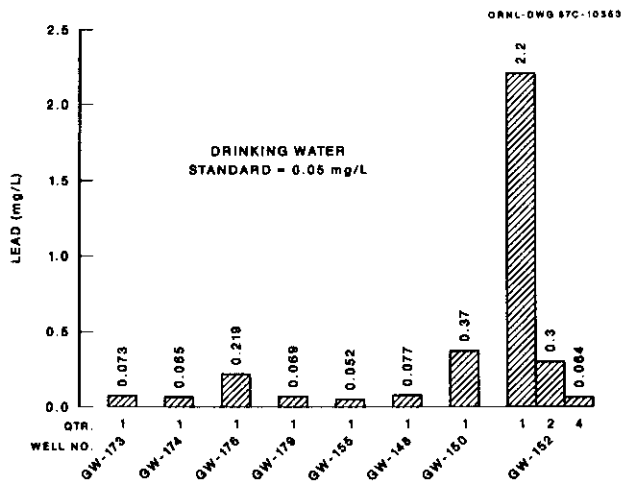


Fig. 6.6.5. Lead concentrations in groundwater wells at the Y-12 Plant that exceeded drinking water standards.

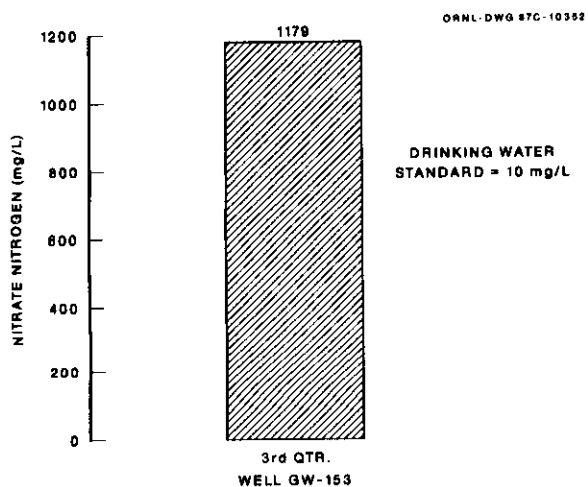


Fig. 6.6.4. Nitrate nitrogen concentrations in groundwater wells at the Y-12 Plant that exceeded drinking water standards.

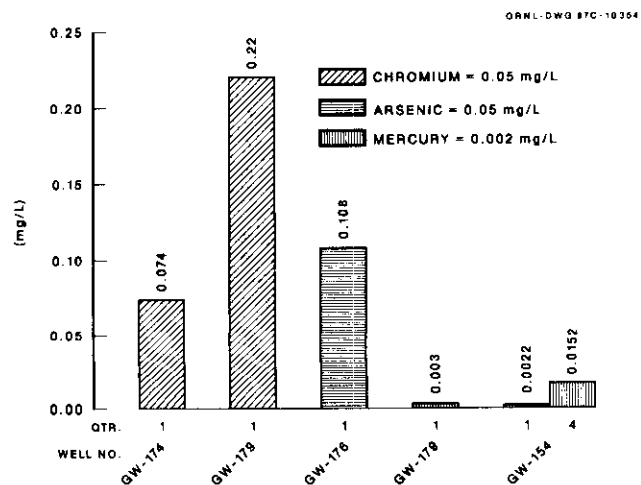


Fig. 6.6.6. Chromium, arsenic, and mercury concentrations in groundwater wells at the Y-12 Plant that exceeded drinking water standards.

areas. During 1986, samples were collected twice from the shallow wells and four times from the deep wells. The samples were analyzed for drinking water, groundwater, and indicator parameters. Results were compared with EPA drinking water standards; parameters whose values exceeded those standards were gross alpha, radium, barium, chromium, NO<sub>3</sub>, and endrin, shown in Figs. 6.6.7 through 6.6.13.

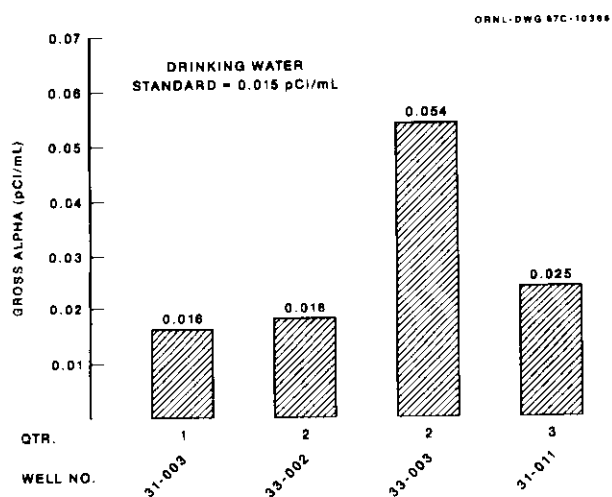


Fig. 6.6.7. Gross alpha concentrations in groundwater wells at ORNL that exceeded drinking water standards.

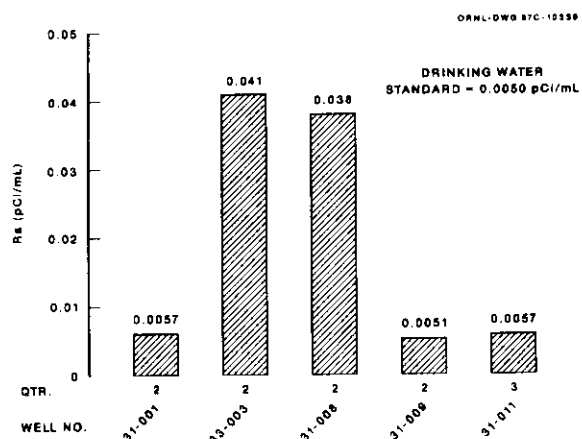


Fig. 6.6.8. Radium concentrations in groundwater wells at ORNL that exceeded drinking water standards.

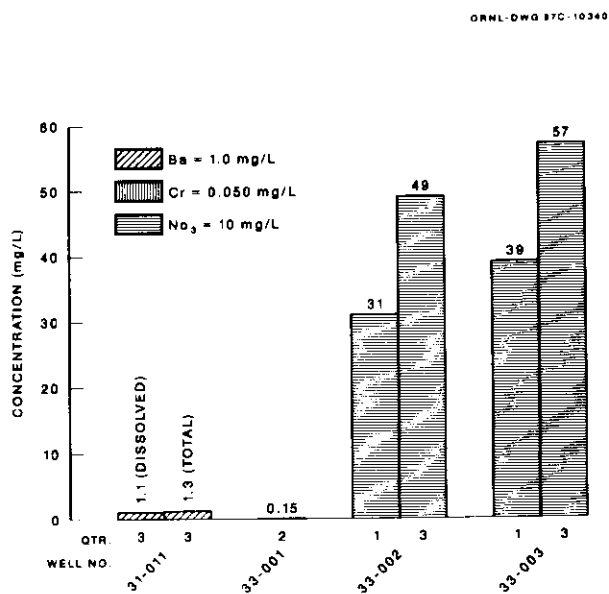


Fig. 6.6.9. Barium, chromium, and NO<sub>3</sub> concentrations in groundwater wells at ORNL that exceeded drinking water standards.

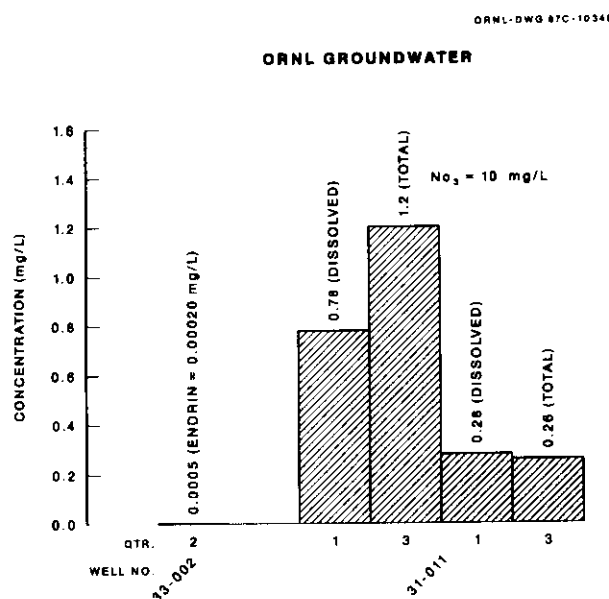


Fig. 6.6.10. Endrin and NO<sub>3</sub> concentrations in groundwater wells at ORNL that exceeded drinking water standards.

### 6.6.3 Oak Ridge Gaseous Diffusion Plant Data

Data collected during the first year at the K-1407-B and the K-1407-C surface impoundments is shown in Vol. 2 (Sect. 6) (Tables 6.2.106



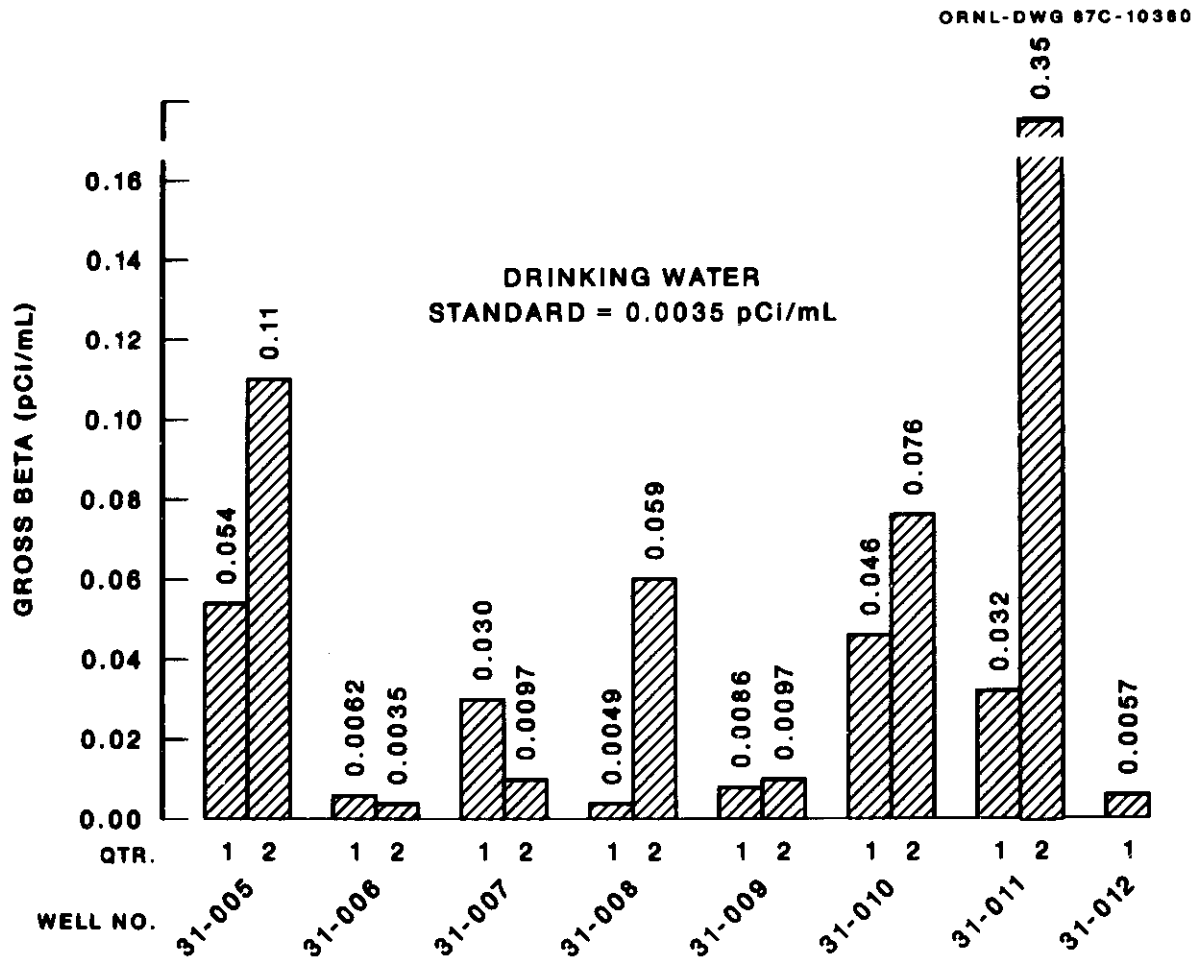


Fig. 6.6.11. Gross beta concentrations in groundwater wells in the 3539-40 area at ORNL that exceeded drinking water standards.

through 6.2.116). These data are in the process of being analyzed using the statistical procedures detailed in the RCRA Groundwater Regulations (40 CFR 264 and 265).

Rather than giving a statistical analysis of the first year, the data are compared to EPA primary interim drinking water standards. The comparison for the ORGDP wells is shown in Figs. 6.6.14 through 6.6.17. During the first year the parameters that exceeded limits established in the standards were cadmium, lead, alpha activity, beta activity, total radium, and total coliform bacteria.

Data collected during the first year of monitoring will be used in the evaluation of future data from the impoundments. These data will be collected semi-annually beginning in April 1987. Parameters collected during the future sampling events will be groundwater quality parameters (chloride, iron, manganese, phenols, sodium, and sulfate) and groundwater contamination indicator parameters (pH, conductivity, total organic carbon, and total organic halogen). Results obtained during these sampling events will be used in the statistical analyses to determine if the units are contributing to

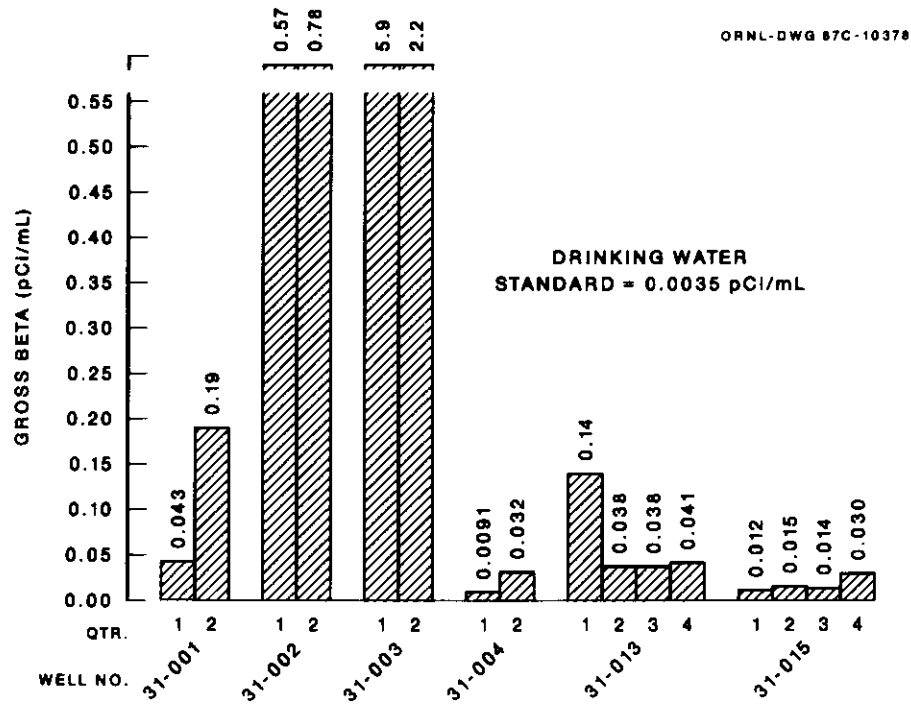


Fig. 6.6.12. Gross beta concentrations in groundwater wells in the 3524 area at ORNL that exceeded drinking water standards.

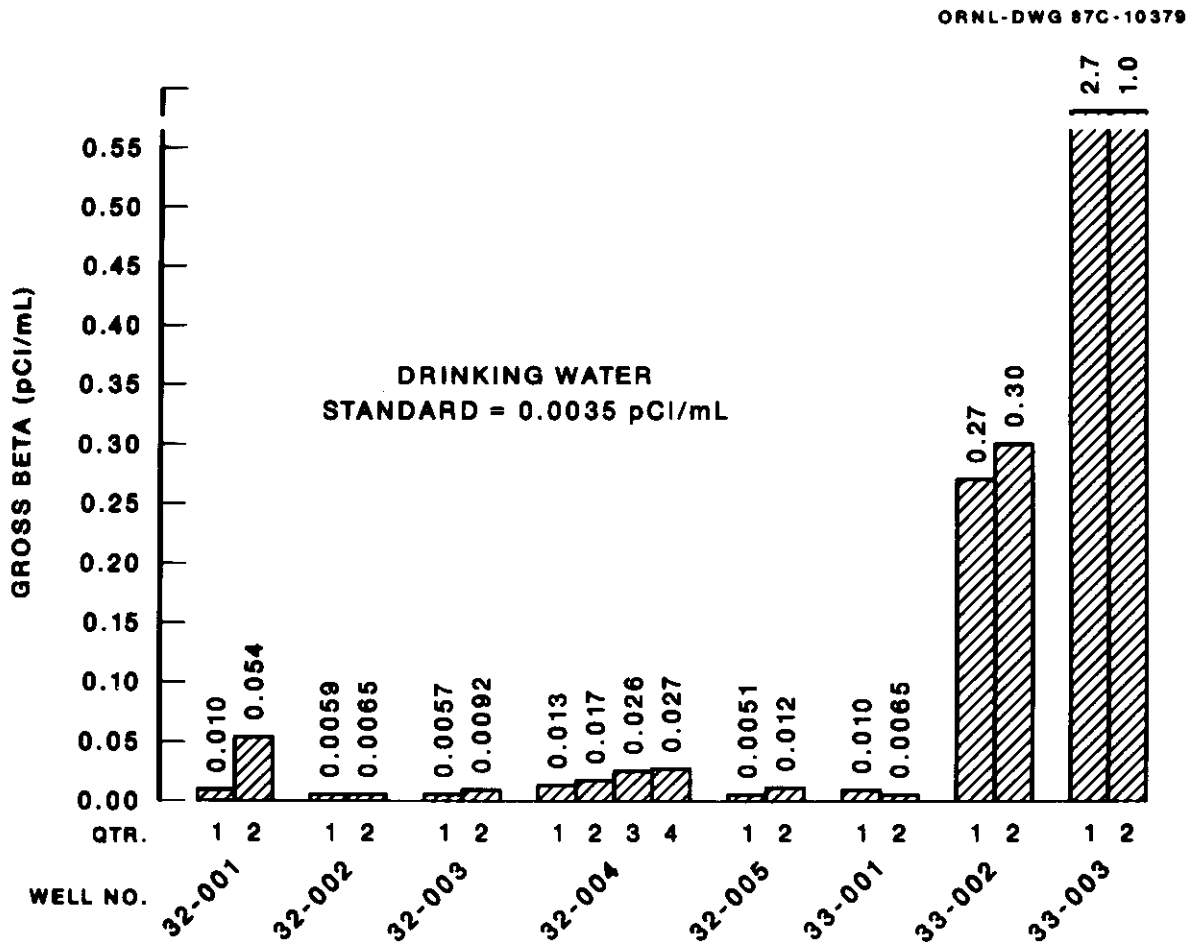


Fig. 6.6.13. Gross beta concentrations in groundwater wells in the 7900 area at ORNL that exceeded drinking water standards.

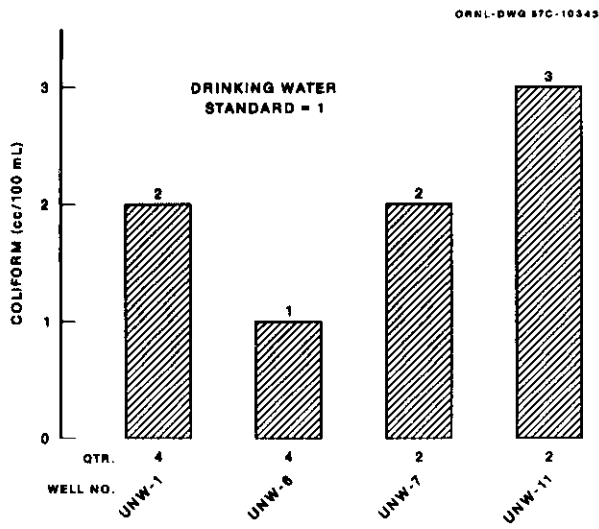


Fig. 6.6.14. Coliform concentrations in groundwater wells at ORGDP that exceeded drinking water standards.

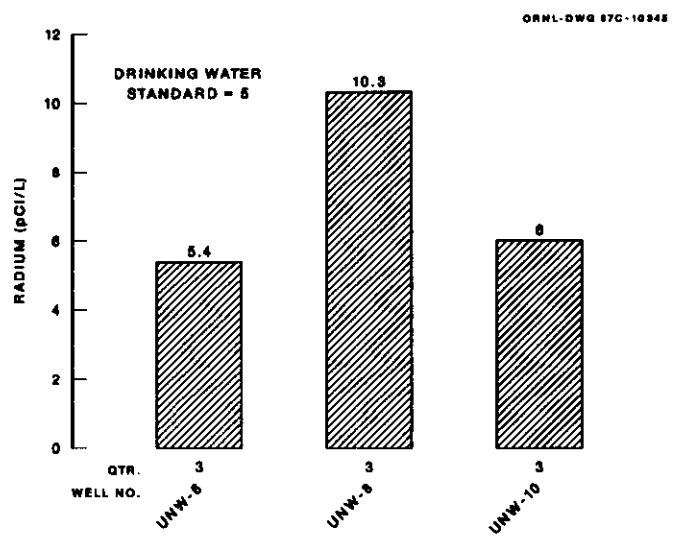


Fig. 6.6.16. Radium concentrations in groundwater wells at ORGDP that exceeded drinking water standards.

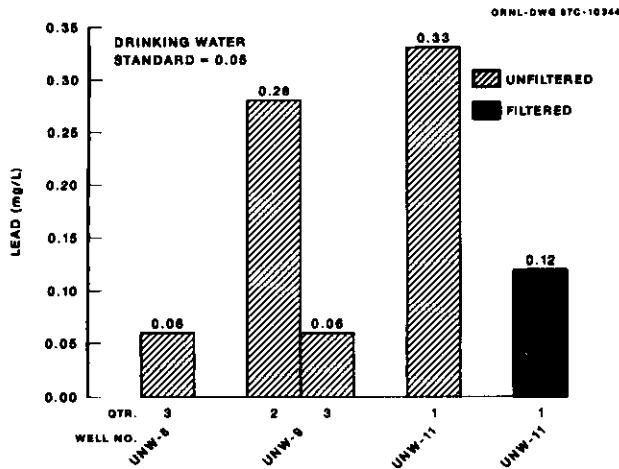


Fig. 6.6.15. Lead concentrations in groundwater wells at ORGDP that exceeded drinking water standards.

groundwater contamination. If such contamination is indicated, further analyses will be conducted, and additional wells will be installed to determine the extent of contaminant migration.

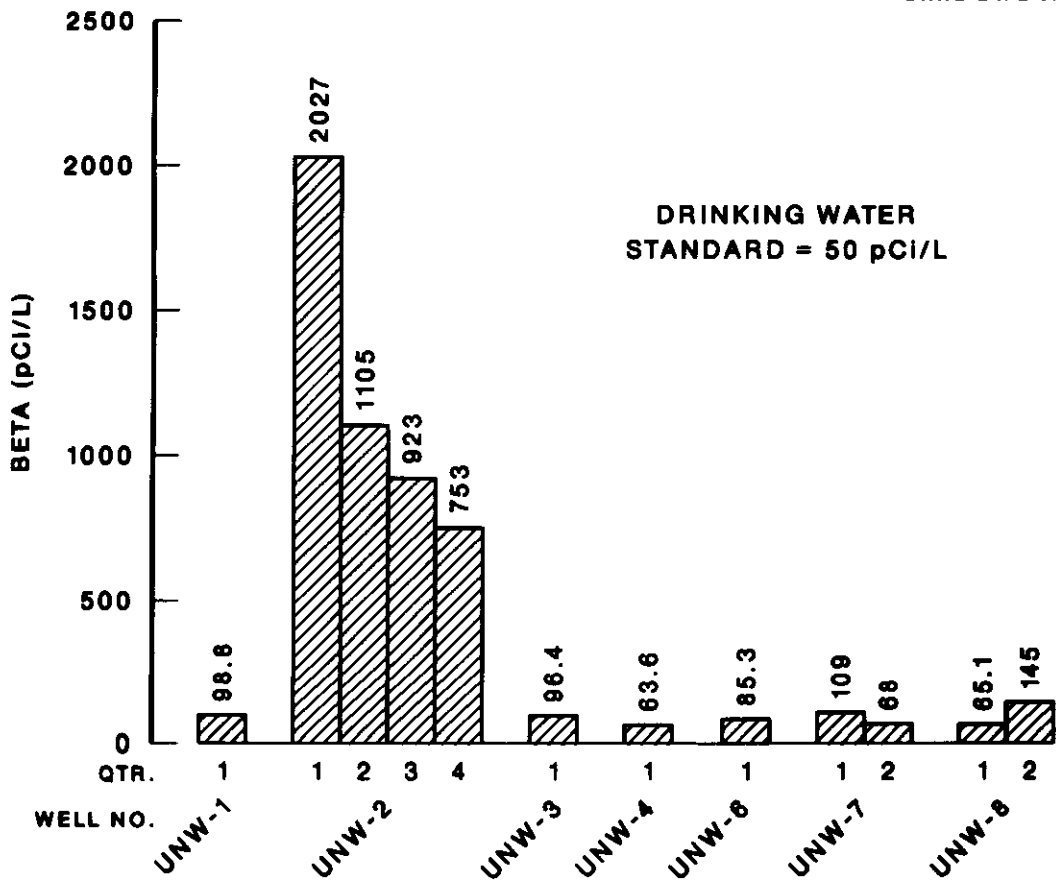


Fig. 6.6.17. Gross beta concentrations in groundwater wells at ORGDP that exceeded drinking water standards.

## 7. EXTERNAL GAMMA RADIATION

External gamma radiation measurements are made to confirm that routine radioactive effluents from the Oak Ridge facilities are not significantly increasing external radiation levels above normal background. Measurements are also made in the relatively small areas accessible to the public where current or past operations could cause radiation levels to be elevated. The monitoring network may also be useful in assessing the impact of unusual occurrences.

Currently there are four groups of stations used for measuring external gamma radiation. The four groups consist of those along the Clinch River (Fig. 7.1), those around the perimeter of ORNL (Fig. 7.2), those that monitor the Oak Ridge Reservation (Fig. 7.3), and those remote from the Reservation (Fig. 7.4). External gamma

radiation measurements are made monthly at the ORNL perimeter and ORR stations T6 and T7, quarterly at sites along the banks of the Clinch River, and semiannually at the remote locations. Measurements at these sites are made using calcium fluoride or lithium fluoride thermoluminescent dosimeters (TLDs). Two or three dosimeters are placed in each container, and the containers are suspended 1 m above the ground. Since April, real-time readings of external gamma radiation levels have been collected at 10-min intervals for all ORR stations except T6 and T7.

Background external gamma exposure rates have two components: cosmic and terrestrial. Figure 7.5 shows the cosmic, terrestrial, and total gamma exposure for several states. The terrestrial

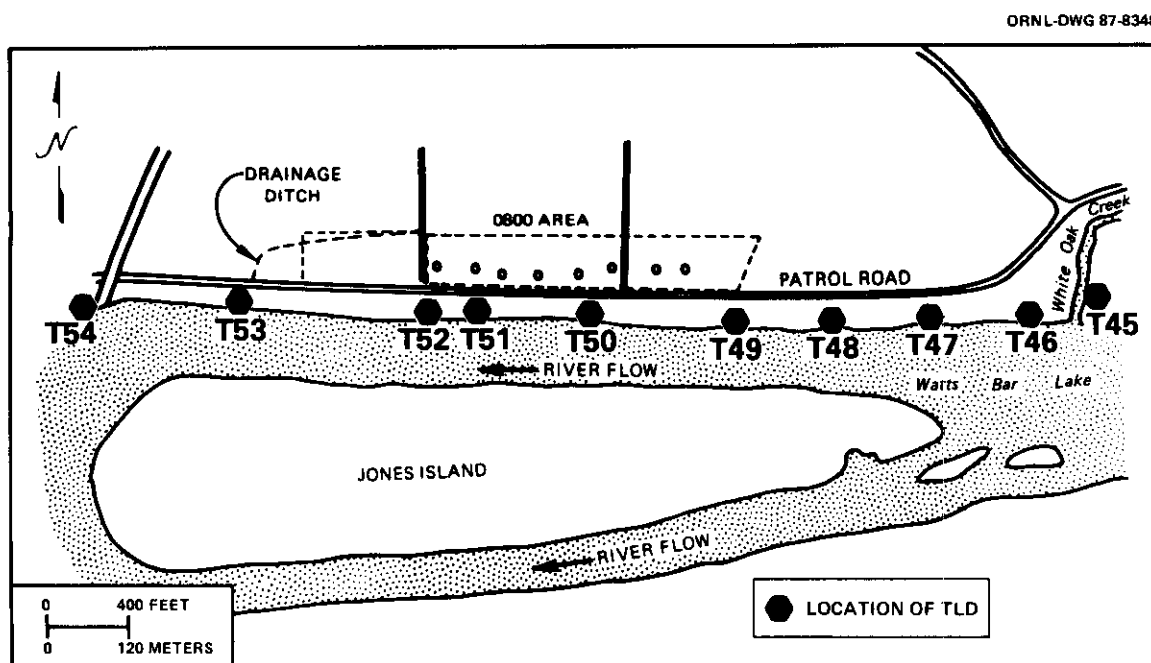


Fig. 7.1. Location map of TLDs along the Clinch River near the experimental  $^{137}\text{Cs}$  plot.

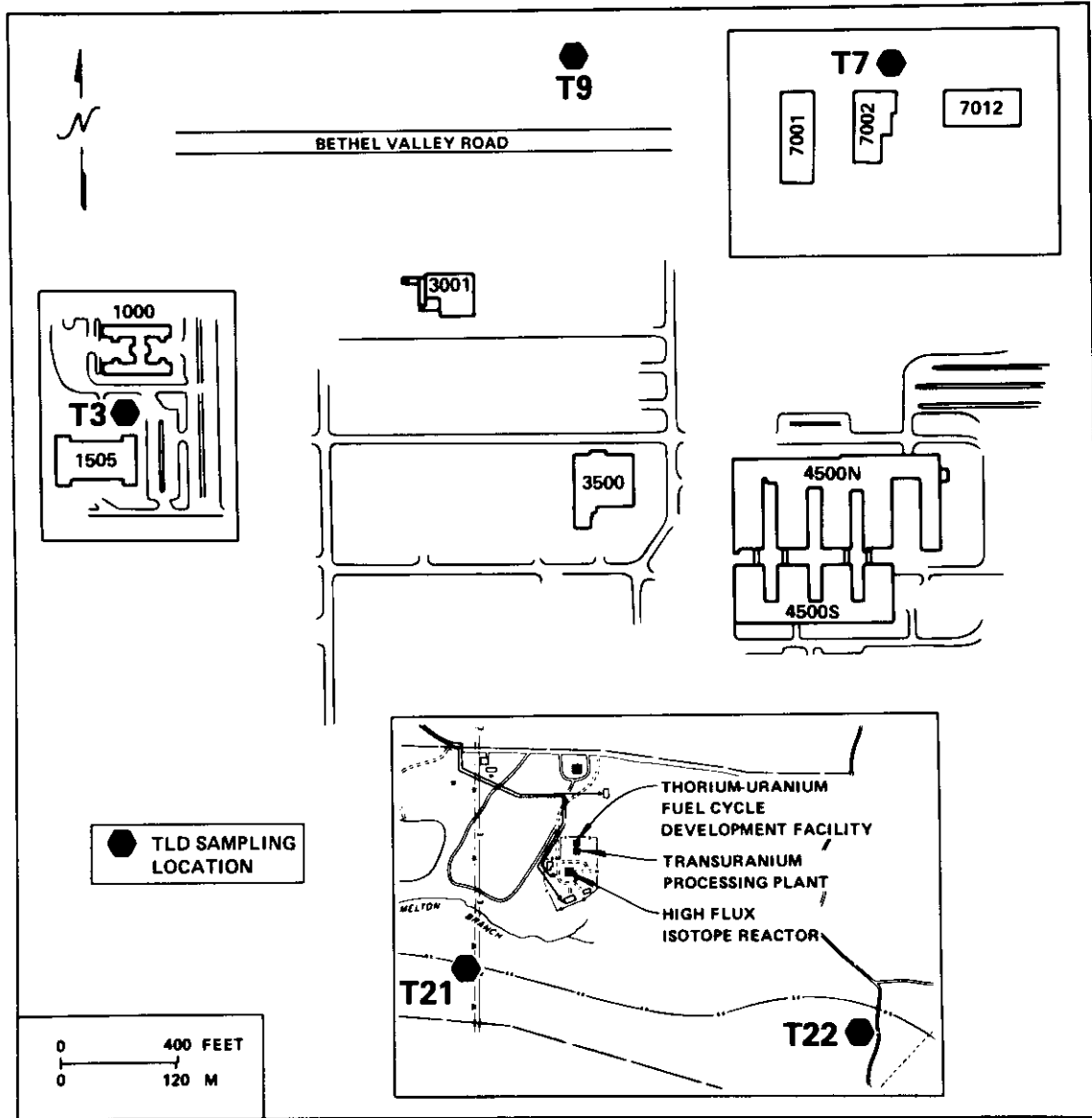


Fig. 7.2. Location map of TLDs around the ORNL perimeter.

gamma exposures for several states are given in Fig. 7.6. Figure 7.7 indicates the average annual external gamma exposure at ORNL, the ORR, remote sites, along the banks of the Clinch River in Tennessee (Fig. 7.1), and in the United States. There were no statistically significant differences

in the average external gamma radiation levels between the ORR and remote stations. The average radiation measurements at the ORNL perimeter stations were statistically higher than either the ORR or the remote stations. Based on the sampling results, external gamma radiation

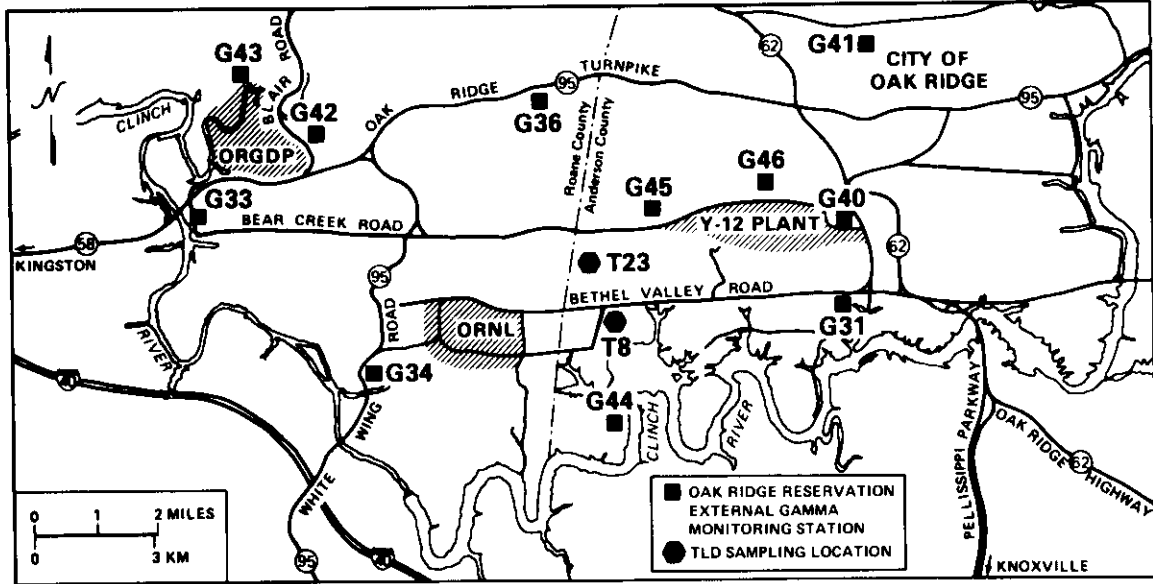


Fig. 7.3. Location map of external gamma radiation monitoring stations on the ORR.

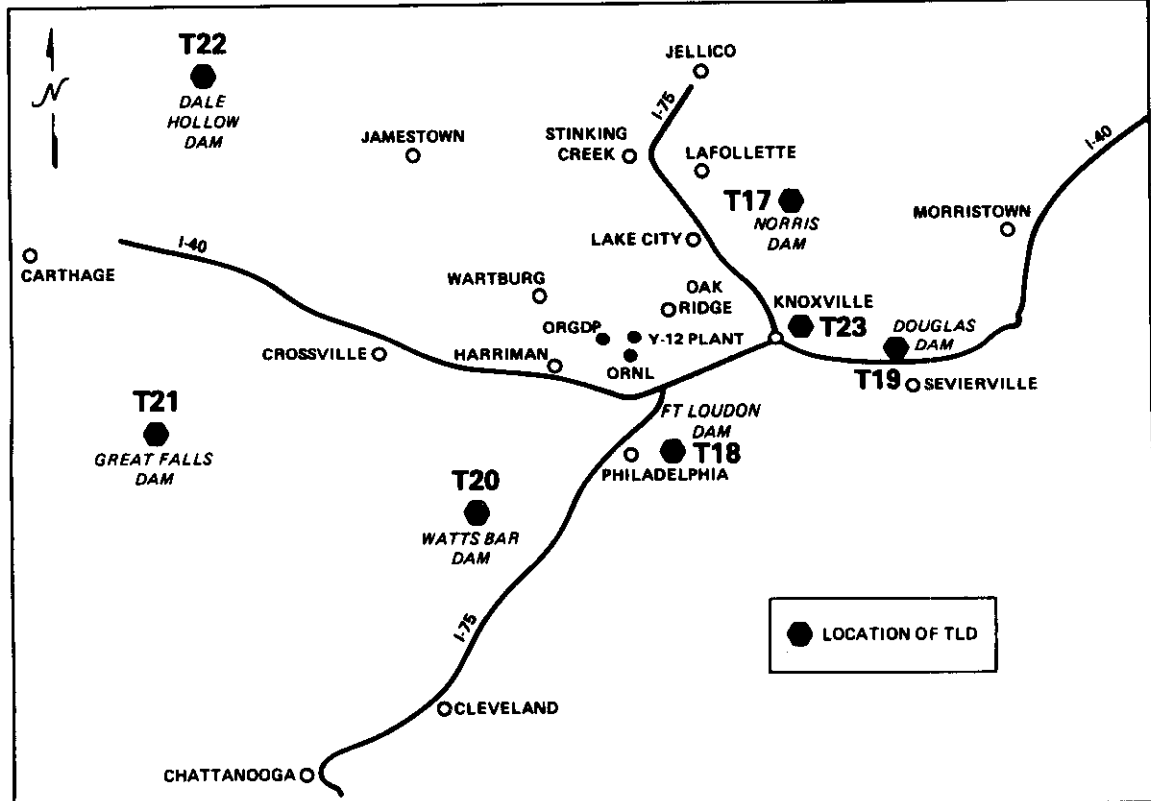


Fig. 7.4. Location map of TLDs at remote locations.

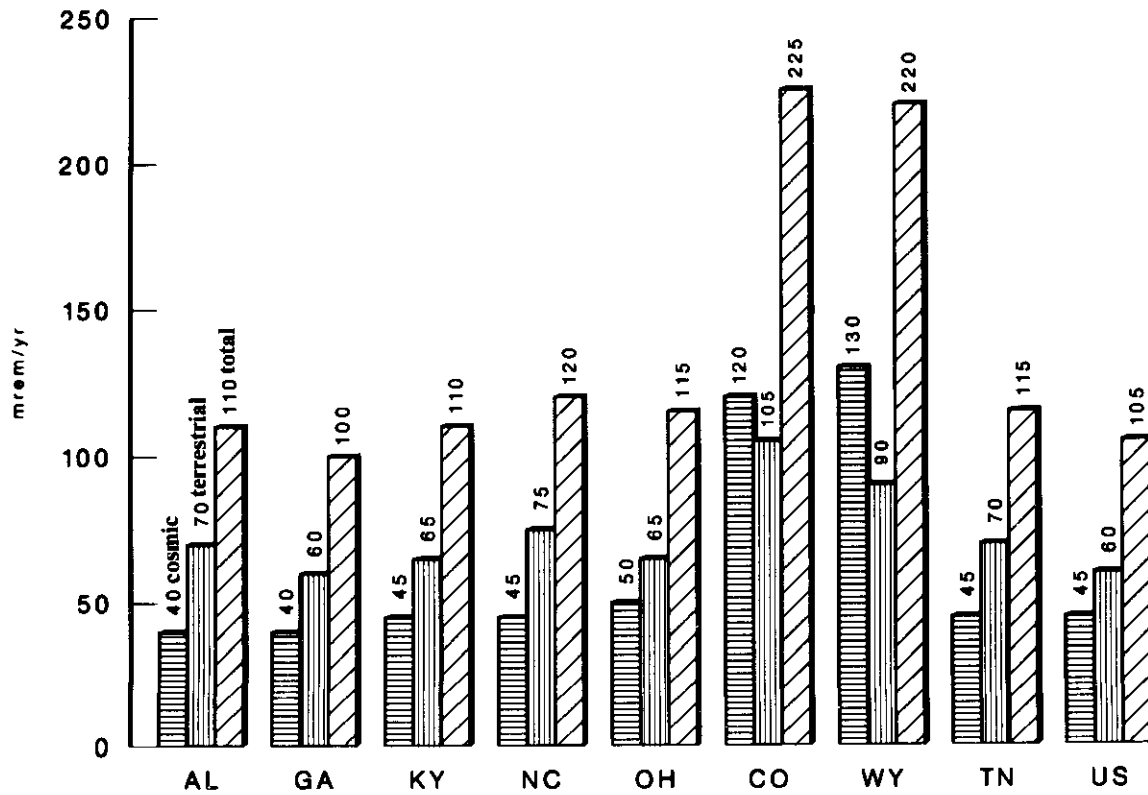


Fig. 7.5. External cosmic, terrestrial, and total gamma exposure.

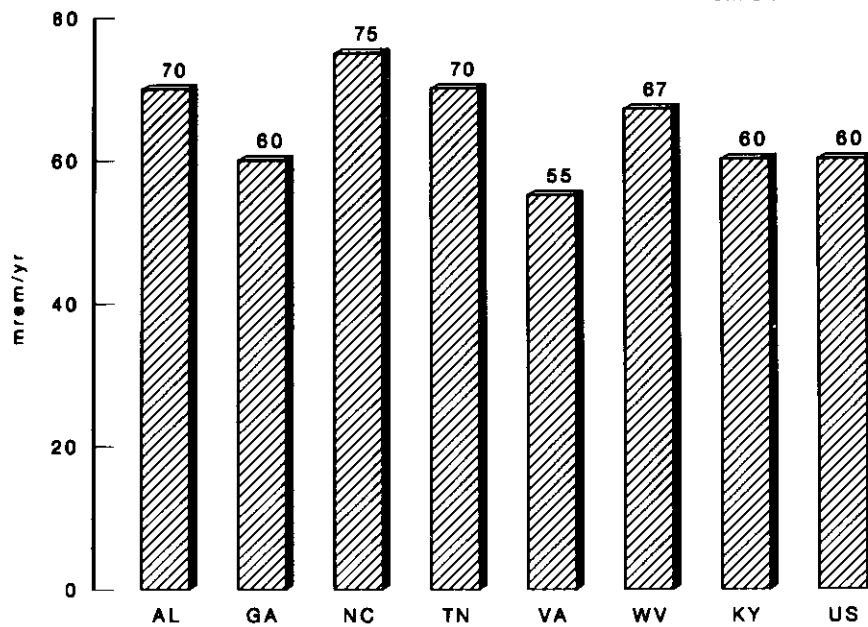


Fig. 7.6. External terrestrial gamma exposure.



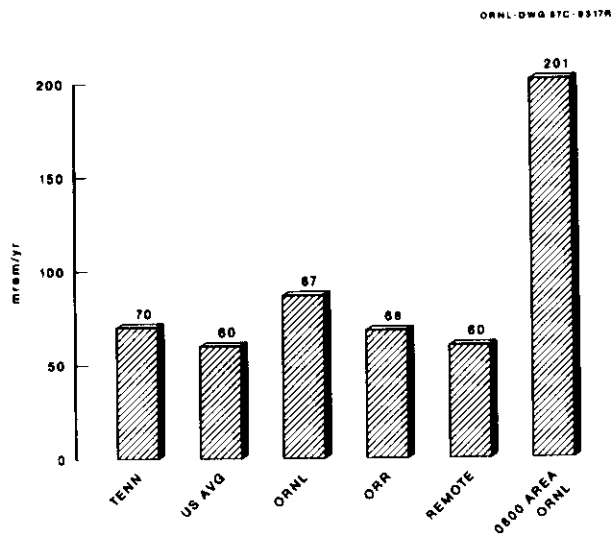


Fig. 7.7. East Tennessee external gamma exposure.

was statistically lower at the ORNL perimeter, the ORR, and the remote stations in 1986 than in 1985. However, comparisons between 1985 and 1986 data are complicated by the fact that ORNL changed to a new TLD system in mid-1986. The new system utilizes a Panasonic

UD702E reader and Panasonic UD804/814 environmental TLD badges. During the changeover to the new system, a Victoreen reader was also utilized for a short time. All readings in 1985 were made using an Eberline reader. The average background level as determined at the remote stations can be subtracted from the measured levels to obtain an estimate of the increase in external radiation levels due to ORR operations.

Measurements along the banks of the Clinch River, from the mouth of White Oak Creek to several hundred meters downstream, are made to evaluate external gamma radiation levels resulting from ORNL effluent releases and "sky shine" from an experimental radioactive cesium plot located near the river bank. The average annual external gamma radiation levels along the Clinch ranged from 14 to 35  $\mu\text{R}/\text{h}$ . Measurements are made at these locations to estimate the maximum exposure to an individual. The average radiation level along the Clinch near the cesium field was 23  $\mu\text{R}/\text{h}$ , which was slightly higher (17  $\mu\text{R}/\text{h}$ ) than during 1985.



## 8. BIOLOGICAL MONITORING

### 8.1 FISH SAMPLING

Radionuclide and chemical pollutants in surface waters can be adsorbed to or incorporated into algae and other foods of fish. These pollutants can also be taken directly from the water. When contaminated foods are eaten by fish, some of the contaminants are retained in the tissue of the fish. Indeed, many pollutants are strongly retained by fish tissues as the fish ingests more and more contaminated food. This process collects and concentrates the pollutants in the body of the fish. The concern here is that such contaminated fish will pose a hazard to the humans (or other animals) that eat them.

To ensure that the fish in the water near and downstream from the ORR installations would not pose a hazard to other wildlife and people, bluegill from three Clinch River locations were collected semiannually for tissue analyses of radionuclides, mercury, and polychlorinated biphenyls (PCBs). One sampling location is above all of the Oak Ridge installations' outfalls; one is at ORNL's discharge point from White Oak Creek to the Clinch River, and one is downstream from the Oak Ridge Y-12 Plant, ORNL, and ORGDP discharges into the Clinch River (see Fig. 8.1.1).

The primary radionuclides of concern from discharges at ORNL are  $^{90}\text{Sr}$  and  $^{137}\text{Cs}$ . Each sampling period, these radionuclides' concentrations were determined on a sample consisting of from 6 to 10 fish.

Mercury and PCBs are of primary concern in discharges from the Oak Ridge Y-12 Plant and ORGDP, and their concentrations were measured in six individual fish from each sampling location. Fish filets were ashed and analyzed by gamma spectroscopy and radiochemical techniques. The results of the analyses are shown in Fig. 8.1.2.

### 8.2 MILK SAMPLING

Radionuclides released to the atmosphere can adsorb to or be incorporated into vegetation that browsing cattle eat. The radionuclides can be passed to a cow's milk, and fresh milk can thus provide a rapid and direct route for the radionuclide to follow to humans. Therefore, raw milk samples were collected every two weeks from six stations located near the Oak Ridge area (Fig. 8.2.1). Other stations remote from the Oak Ridge installations (Fig. 8.2.2) were sampled approximately semiannually. Samples were analyzed by ion exchange and low-level beta counting. After October 15, 1986,  $^{131}\text{I}$  samples were analyzed by gamma spectroscopy. The results are compared with intake guidelines specified by the Federal Radiation Council (FRC) in Fig. 8.2.3.

### 8.3 RADIOACTIVITY STUDIES IN WATERFOWL

To determine whether waterfowl might transport radioactivity off site after feeding at the ORR, qualitative and quantitative determinations were made of radionuclide content of Canada geese residing on three ponds on the ORR and in surrounding communities.

Four geese residing near Pond 3524 at ORNL for about two weeks were tested for radionuclide uptake. Crop contents indicated that the birds had been feeding on root nodules from bottom sediment and on coarse green grass. Analyses of crop, fecal, and tissue samples indicated a high uptake of  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$ , especially by the females (probably because of the birds' physiological processes of storing minerals preparatory for egg laying). The analyses also indicated rapid fecal elimination of the great

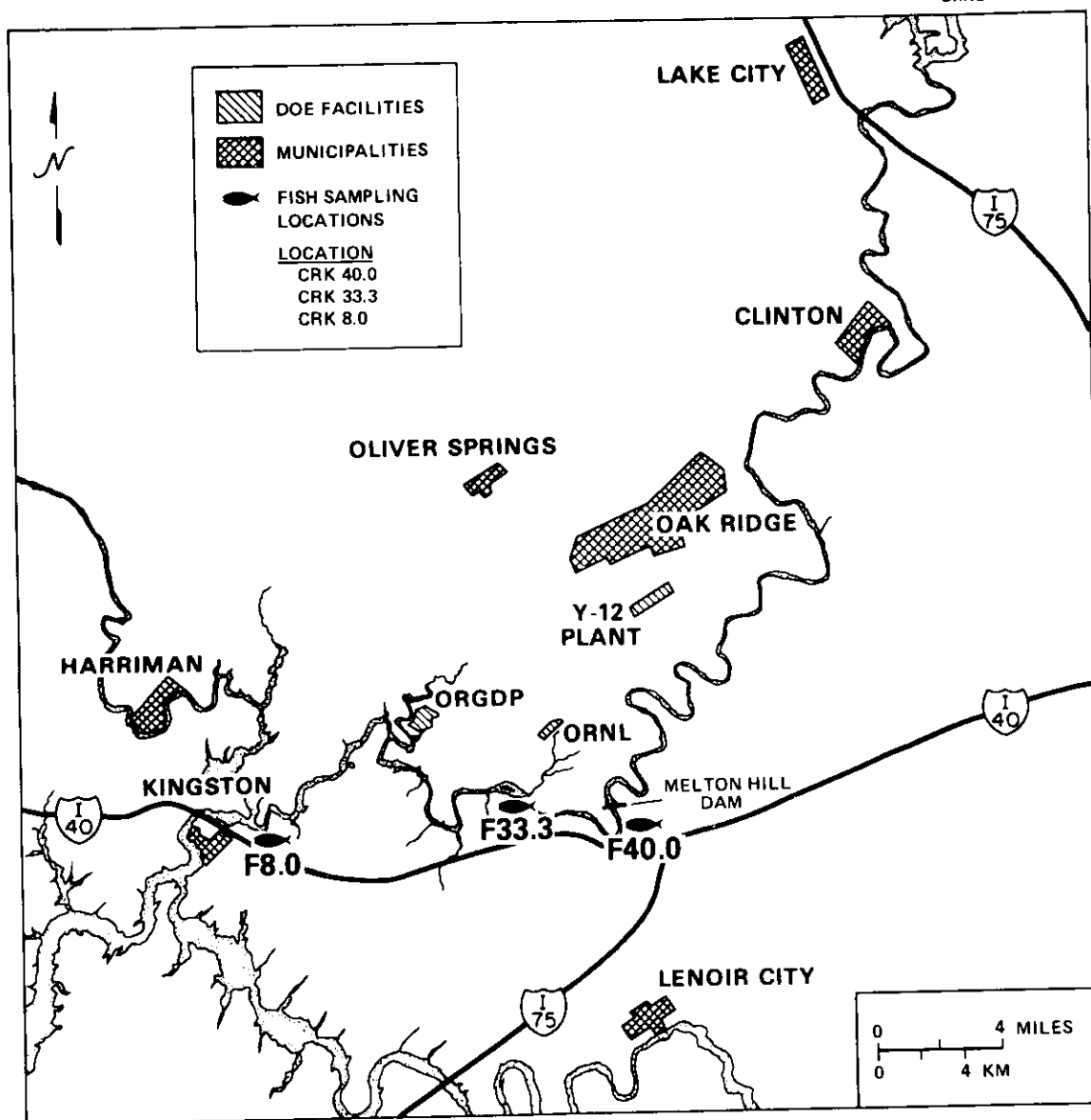


Fig. 8.1.1. 1986 fish sampling locations.

majority of ingested  $^{60}\text{Co}$ ,  $^{152}\text{Eu}$ , and  $^{154}\text{Eu}$ , and measurable uptake and incorporation of  $^{75}\text{Se}$ ,  $^{241}\text{Am}$ ,  $^{95}\text{Zr}$ , and  $^{106}\text{Ru}$ . Strontium-90 can be expected to accumulate in bone but not to any great extent in muscle.

Random samples of geese were taken from the vicinity of both ORGDP and the Oak Ridge Y-12 Plant to provide comparison samples for the Pond 3524 study. Tests showed less-than-detectable amounts of human-made radionuclides

except  $^{90}\text{Sr}$ . Special tests for  $^{90}\text{Sr}$  were performed on the bone and muscle tissues of all these geese. The averaged results of geese on the 3524 and other ORR ponds are compared in Table 8.3.1.

Geese from several locations on Watts Bar, Melton Hill, and Chicamauga reservoirs were analyzed as control samples for the ORR study. Analyses showed only natural radioelement concentrations. Strontium-90 concentrations were similar to the values from the ORR birds.

ORNL-DWG 87C-8878BR2

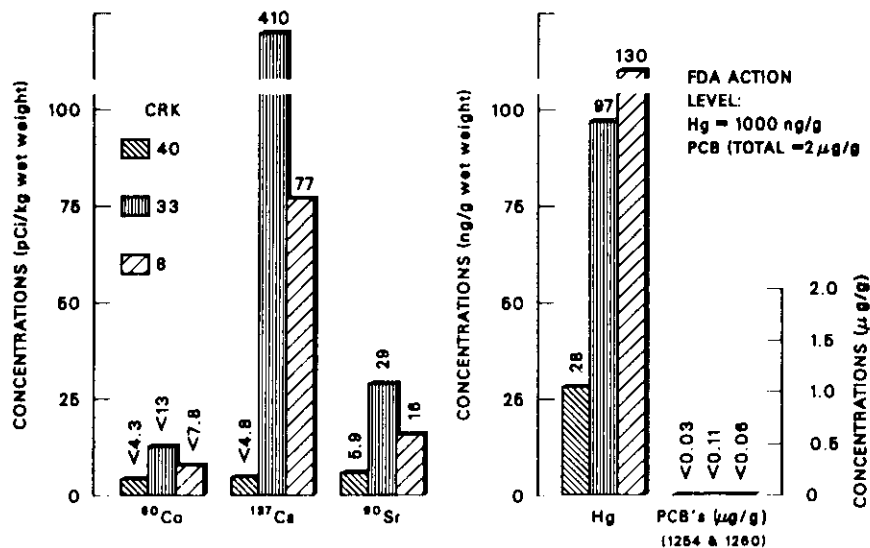


Fig. 8.1.2. Averaged sampling results for radionuclides, mercury, and PCBs in bluegill from the Clinch River.

ORNL-DWG 87-8873

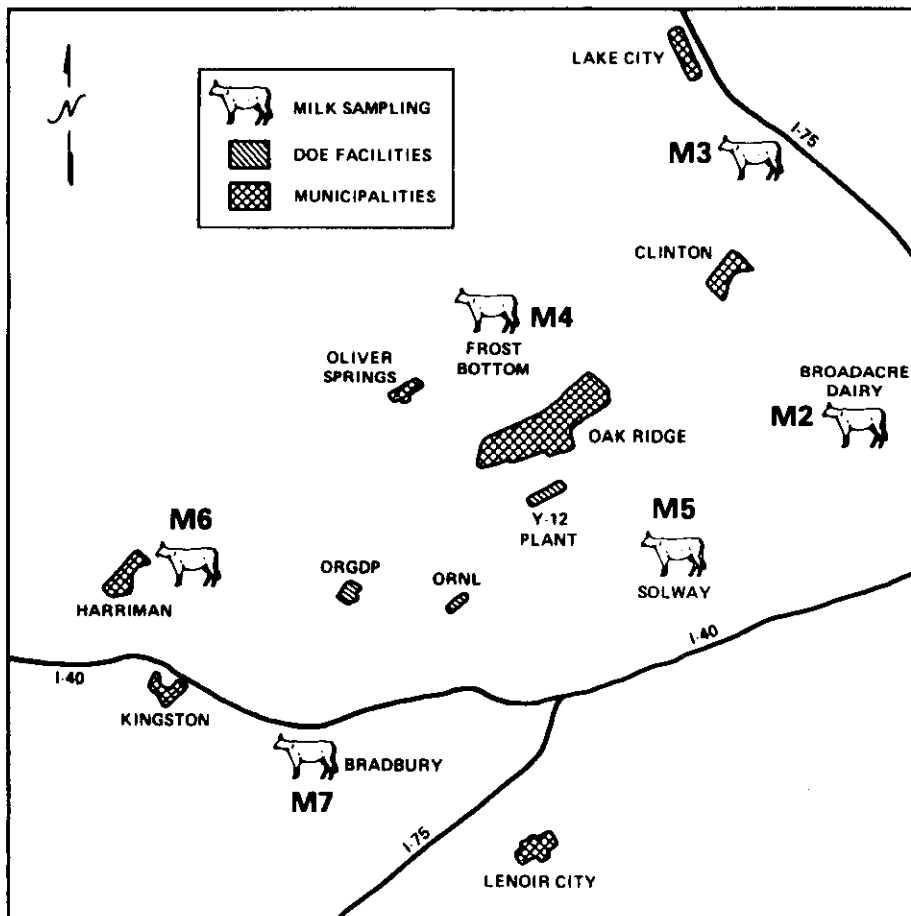


Fig. 8.2.1. Map showing milk sampling stations near the the Oak Ridge area.

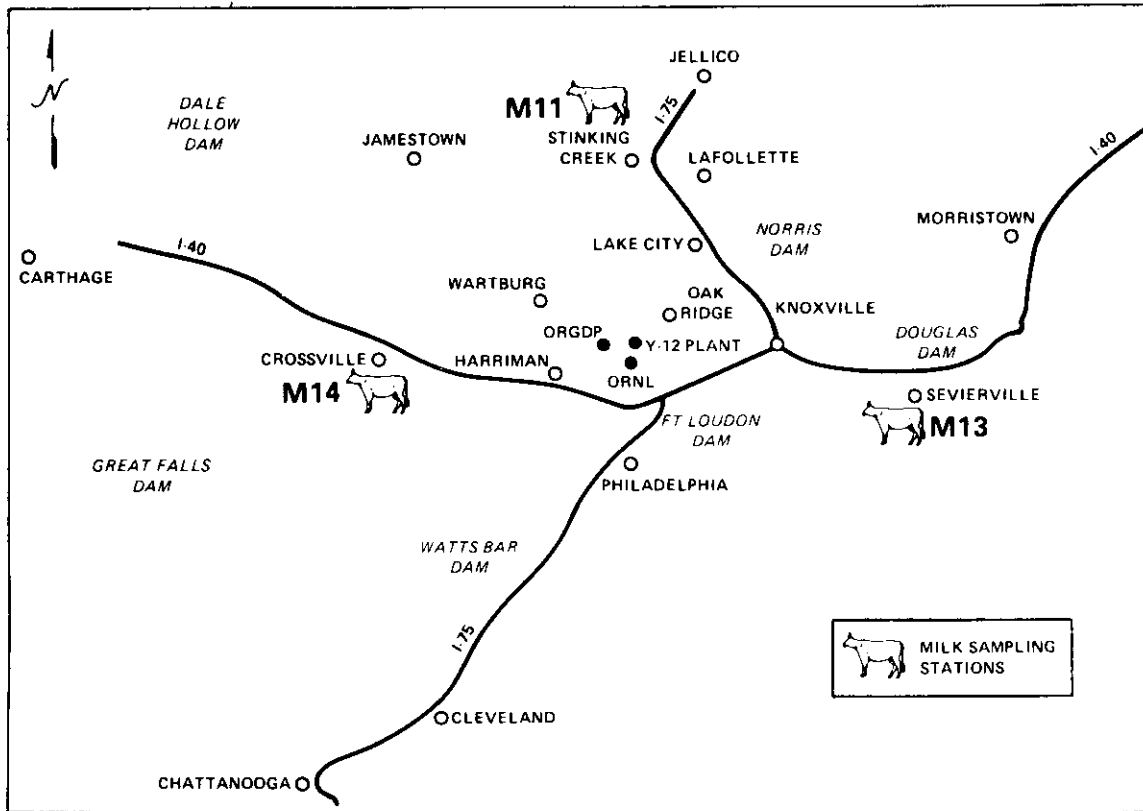


Fig. 8.2.2. Map showing milk sampling stations remote from the Oak Ridge area.

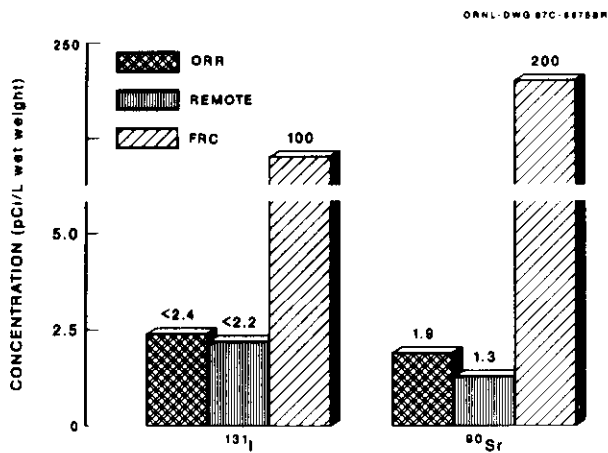


Fig. 8.2.3. Averaged  $^{131}\text{I}$  and  $^{90}\text{Sr}$  concentrations in raw milk obtained near the ORR and remote from ORR compared with the FRC guidelines for milk consumption.

These studies indicate a possibility for radionuclide transport by migratory waterfowl that might take up residence on Pond 3524.

Table 8.3.1. Average  $^{90}\text{Sr}$  concentration in the muscle and bone of Canada geese

	Concentration (pCi/g)	
	Pond 3524	ORR
Muscle	1.8	0.2
Bone	750	0.6

However, the likelihood that geese would be allowed to nest there is very small and the size of this pond will not support many geese. Further studies will be performed on techniques for assessing the possible off-site transport of radionuclides.

### 8.4 DEER

Five weekend hunts for deer were held on the ORR and contiguous lands during the fall of 1986. The harvest totaled 660 deer from the hunt area shown in Fig. 8.4.1. Soft-tissue radionuclide

ORNL-DWG 87-9293A

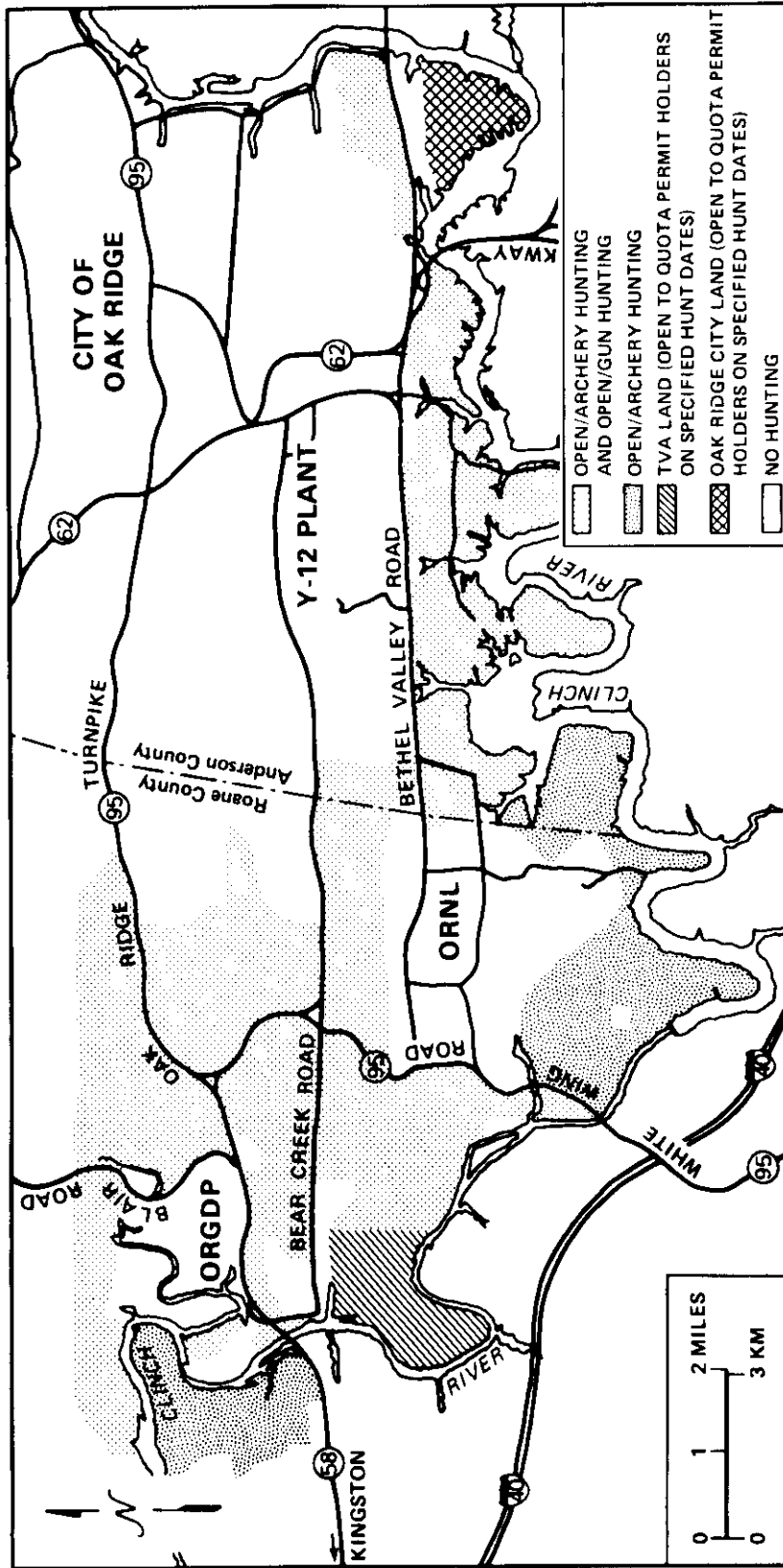


Fig. 8.4.1. 1986 ORR hunt area.

concentrations continued to be low and acceptable for the entire harvest. Cesium-137 concentrations in the liver and/or muscle were determined for each deer by gamma ray spectrometry. More than 90% of the deer had concentrations less than 0.5 pCi/g, and only 1% had concentrations greater than 1 pCi/g. The maximum concentration observed was 1.2 pCi/g.

Strontium-90 concentration in bone was limited to 30 pCi/g. Deer with higher levels were confiscated. Strontium-90 was measured with a scintillation detector applied to a sample of foreleg bone from each animal. Twenty-nine deer

had levels of 30 pCi/g or greater of <sup>90</sup>Sr. This 30 pCi/g was based on the Standard Man model of 3% of <sup>90</sup>Sr in bone or tissue. During the 1986 hunts tissue samples were collected to establish the percentage based on laboratory analysis for the 1987 hunts. Subsequent tests on retained deer showed concentrations of <sup>90</sup>Sr in bone up to 810 pCi/g. Iodine-129 concentrations in the thyroid glands were found to be high in those deer having elevated <sup>90</sup>Sr concentrations in their bones. Most of these deer with increased <sup>90</sup>Sr concentrations were taken in the east and west portions of the ORR and southeast and north of ORGDP.



## 9. VEGETATION, SOIL, AND SEDIMENT SAMPLING

### 9.1 VEGETATION

Radionuclides and chemical pollutants released to water or soil can be taken up by plants through their roots. Materials released to the air can be deposited on plants and absorbed into the plant or remain adhered to the plant surface. In any of these cases, the pollutant can find its way into the animal food chain if the vegetation is eaten by wild or domestic animals. In addition, deposition of pollutants on cultivated fruits or vegetables can introduce them directly into the human food chain.

Even contaminants that remain in the soil can be absorbed by microorganisms, worms, insects, or other creatures. In such cases, the contaminant can be incorporated into the body of the host or it can be metabolized and passed back into the environment in an altered chemical state. Incorporated, it can be passed along the food chain if the host organism is eaten by a predator. Metabolized, it can be absorbed by plants or other organisms that, in turn, can move it through the food chain. Thus, once toxic materials have been deposited in the soil or on vegetation, they can pass through the flesh, eggs, milk, or fruit of animals or plants to the consumers of those animals or plants.

Because vegetation is an excellent collector of pollutants, especially airborne pollutants, vegetation samples can be a good indicator of the occurrence of radioactive or chemical releases. Therefore, vegetation samples have been collected from around the ORR and analyzed for many years.

Grass samples were collected around ORGDP (see Fig. 9.1.1), at the ORNL perimeter locations (Fig. 9.1.2), the ORR locations (Fig. 9.1.3), and at the remote locations (Fig. 9.1.4). At all locations except the remote ones, samples were

collected at 90° angles to the air monitoring station at each site for a total of four samples per location. At the remote stations a single sample was collected near each station. After initial preparation, the samples were analyzed by gamma spectrometry and radiochemical techniques for a wide variety of radionuclides for the samples from the ORNL, ORR, and remote sites. Samples from ORGDP were analyzed for uranium and fluoride. Pine needles were also collected around ORGDP and analyzed for uranium and fluoride.

Because of budgetary priorities, no vegetation sampling was performed around the Oak Ridge Y-12 Plant during 1986. At ORGDP, grass samples were collected twice from 13 areas, and pine needles were also collected at 6 of these sites. The vegetation was analyzed for fluorine and uranium because of the large amounts of uranium hexafluoride used at ORGDP. The highest fluorine concentration found in grass around ORGDP in 1986 was 23.0  $\mu\text{g/g}$ ; the highest uranium concentration found in grass was 10.4  $\mu\text{g/g}$ . In pine needles, the highest concentration of fluorine was 11.8  $\mu\text{g/g}$ , and the highest concentration of uranium was 1.2  $\mu\text{g/g}$ . Most of the observed concentrations were significantly less than these maximum values (usually less than one-tenth). Even so, these maxima are still well below the concentrations that international bodies consider safe. For fluoride, 30  $\mu\text{g/g}$  is considered safe for ingestion by cattle (AIHA, 1964); for uranium, 10.4  $\mu\text{g/g}$  is considered to be within the range of natural background. Figures 9.1.5 through 9.1.11 show concentrations of  $^{238}\text{U}$ ,  $^{90}\text{Sr}$ ,  $^{234}\text{U}$ , fluoride,  $^{235}\text{U}$ , and  $^{137}\text{Cs}$ .

At ORNL, the concentrations of uranium,  $^{137}\text{Cs}$ ,  $^{90}\text{Sr}$ , and plutonium in the grass between the installation's perimeter and the ORR's

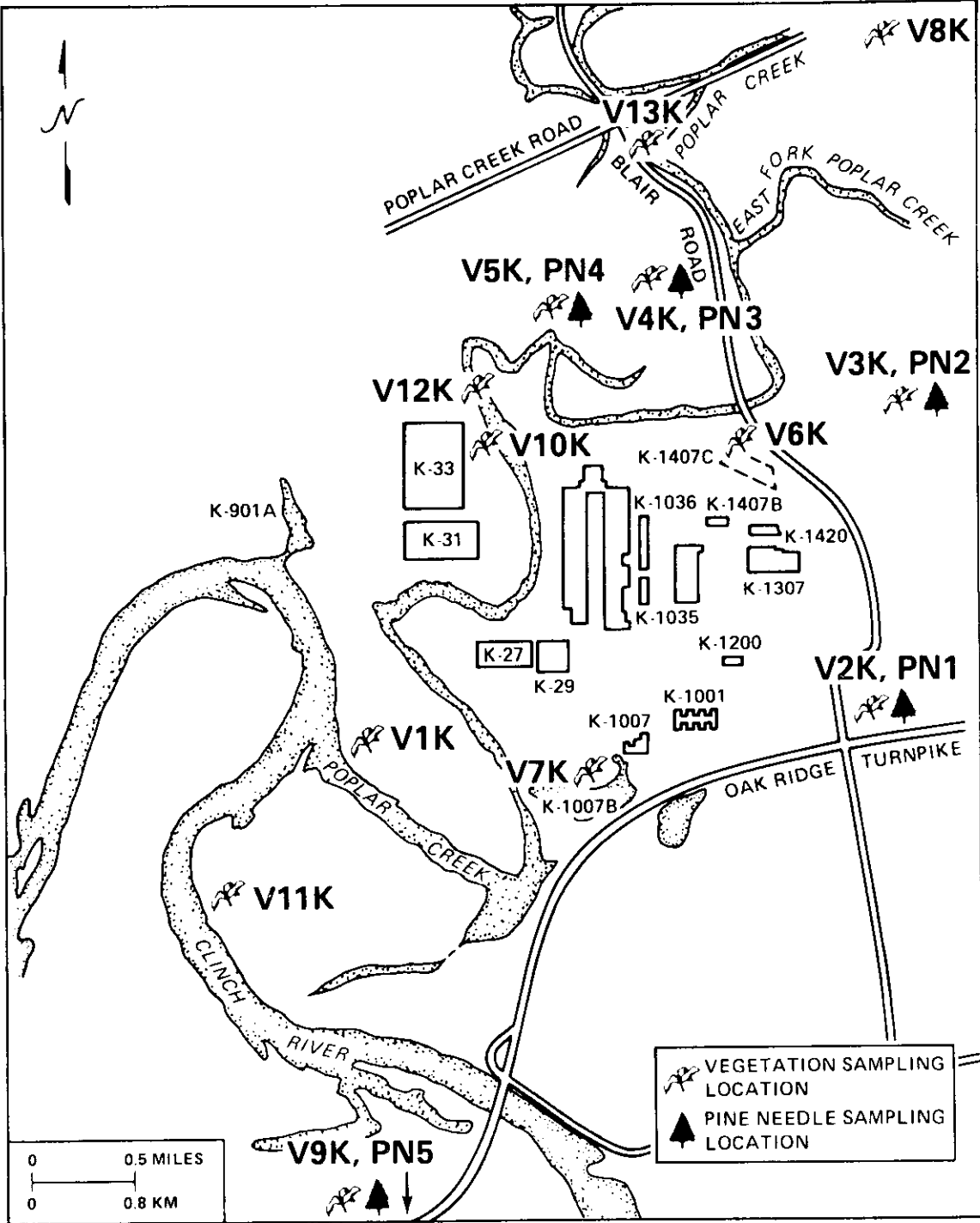


Fig. 9.1.1. Map of ORGDP pine needle and grass sampling locations.

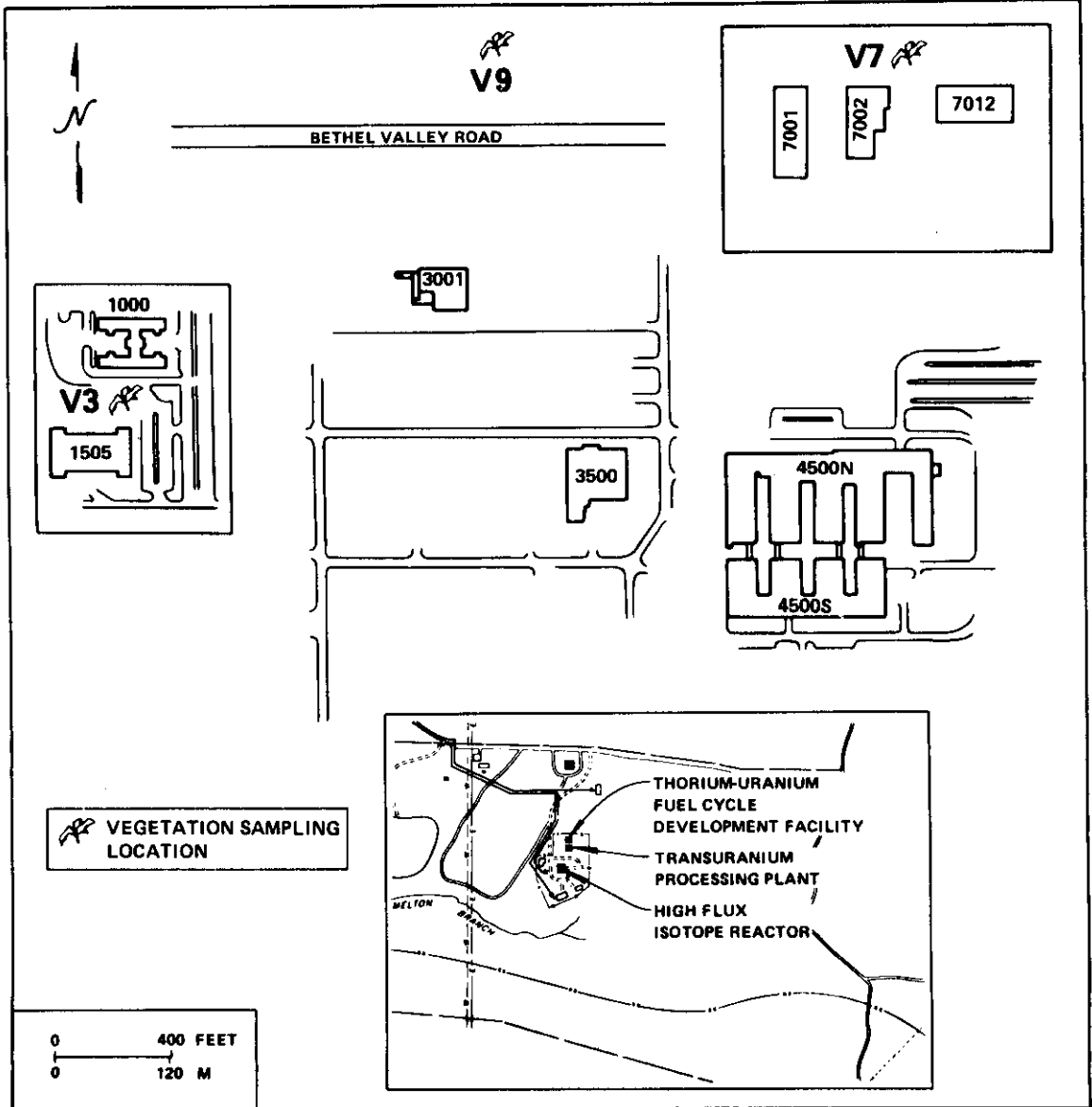


Fig. 9.1.2. Map of ORNL grass sampling locations.

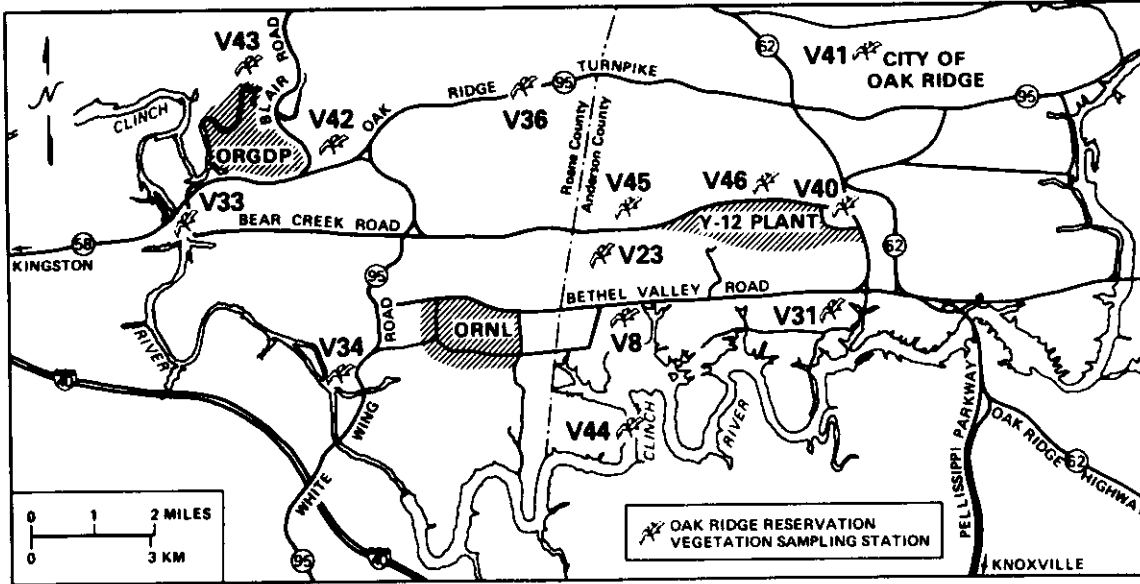


Fig. 9.1.3. Map of ORR grass sampling locations.

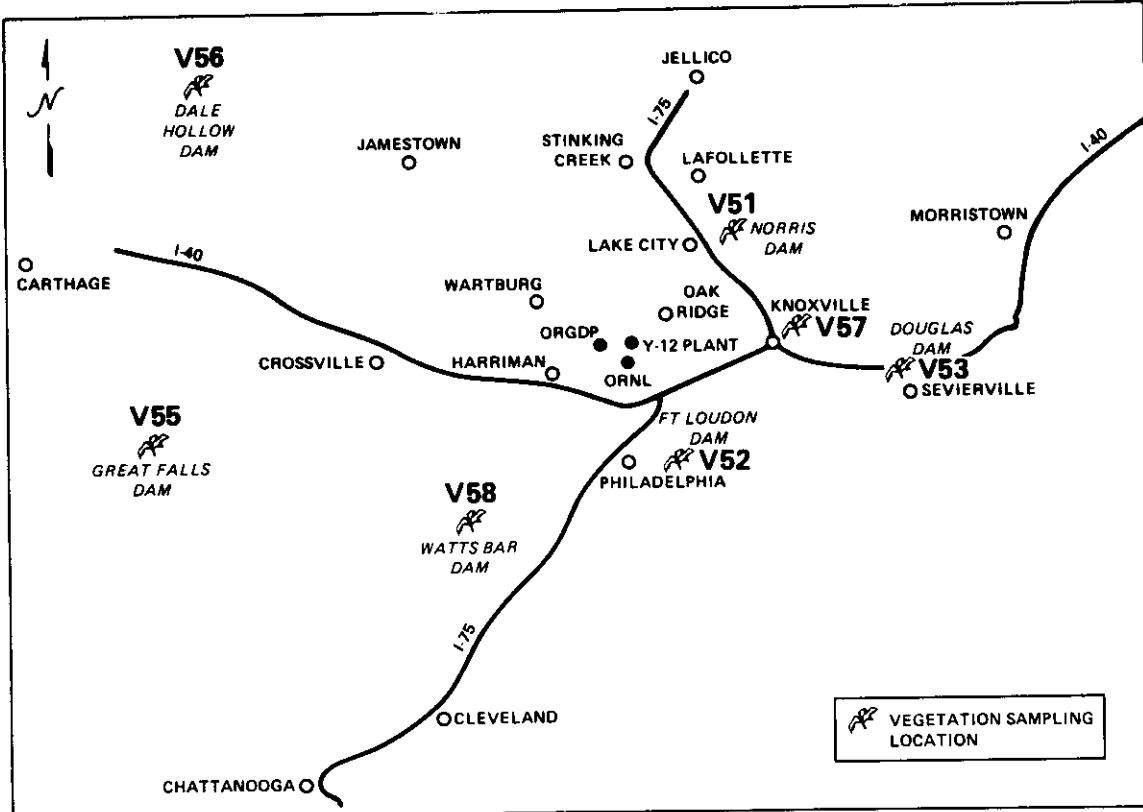


Fig. 9.1.4. Map of remote grass sampling locations.

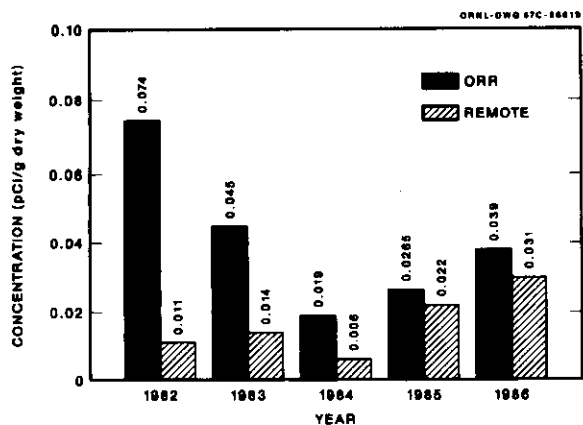


Fig. 9.1.5. Uranium-238 concentrations in grass at ORR and remote locations.

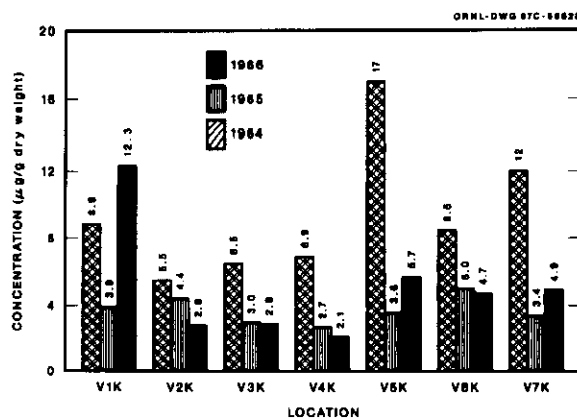


Fig. 9.1.8. Fluoride concentrations in grass at locations V1 through V7.

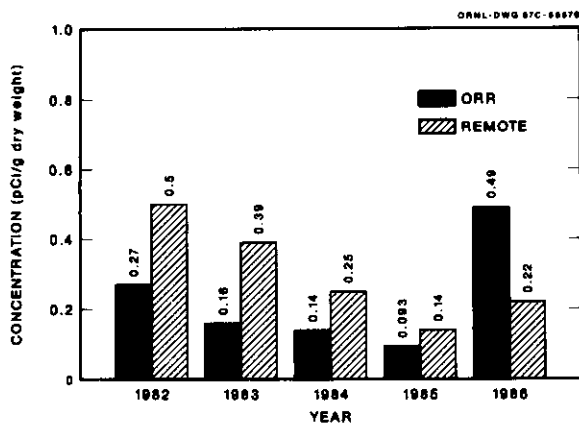


Fig. 9.1.6. Strontium-90 concentrations in grass at ORR and remote locations.

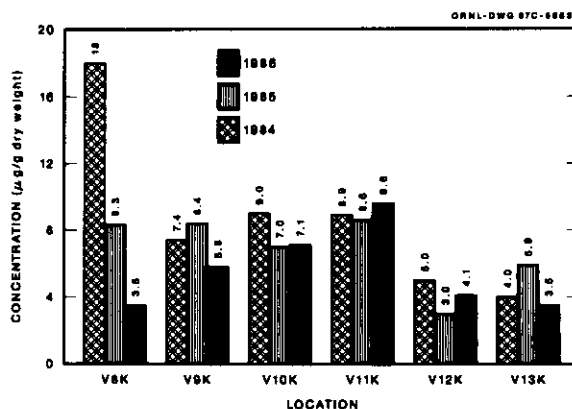


Fig. 9.1.9. Fluoride concentrations in grass at locations V8 through V13.

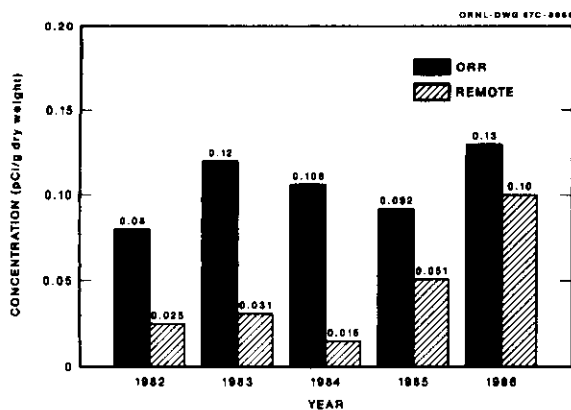


Fig. 9.1.7. Uranium-234 concentrations in grass at ORR and remote locations.

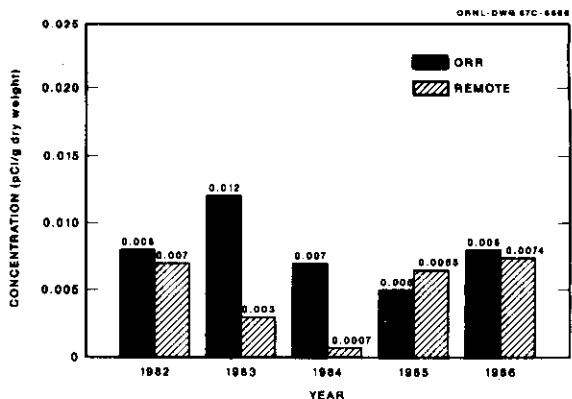


Fig. 9.1.10. Uranium-235 concentrations in grass at ORR and remote locations.

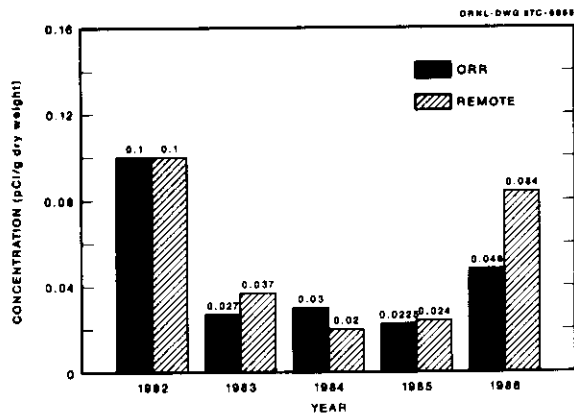


Fig. 9.1.11. Cesium-137 concentrations in grass at ORR and remote locations.

perimeter were checked. In general, the samples taken closer to the installation and directly downwind of it gave the highest concentrations except for uranium and strontium, where the samples taken near the Oak Ridge Y-12 Plant were the highest. In addition to sampling vegetative uptake on the ORR, samples were also taken at remote sites. The highest concentrations recorded on the ORR and at remote sites are shown in Table 9.1.1. The remote sites are so distant from the ORR that contamination from the ORR installations is unlikely. The values for the remote sites are given to allow comparison of the ORR findings with natural occurrences of the nuclides.

Table 9.1.1. Maximum concentrations of radionuclides deposited on vegetation near ORNL and at sites remote from the ORR

Radionuclide	Concentration (pCi/kg dry wt)	
	ORR	Remote sites
Plutonium-238	14	0.3
Plutonium-239	5.4	0.7
Strontium-90	490	460
Uranium-234	700	350
Uranium-235	41	23
Uranium-238	620	130
Cesium-137	52	160

## 9.2. SOIL

### 9.2.1 Soil and Environmental Pathways

Radionuclides that occur in soil can be taken up through the roots of plants and can ultimately find their way into the tissue of animals. In addition to root uptake, direct deposition may occur on plant surfaces. As a result, contaminants may be absorbed by the plants and transferred to the soil upon the death and decay of the plant.

As can be imagined, the environmental pathways by which radioactive materials in soils reach humans can form a complex, interconnected network (e.g., soil → foliage → animals → humans). On the other hand, the most direct pathway to humans is the ingestion of soil by a child.

Guidelines for soil radionuclide concentrations are limited. Where they are available, they are defined as the maximum concentration of a radionuclide in the soil that, if not exceeded, will ensure that dose limits will not be exceeded (DOE, 1983). Source-to-dose conversion factors for individual sites may need to be developed based on site-specific data; however, generic values have been developed. The dose parameter of interest is the dose equivalent to the whole body, tissue, or organ, expressed in millirem.

### 9.2.2 Soil Radionuclide and Fluoride Data on the ORR

Soil samples are collected at 3 locations 4 times a year around ORNL, at 13 locations around ORGDP semiannually, at 13 locations 4 times a year on the Oak Ridge Reservation, and at 7 remote locations 4 times a year.

The ORNL, ORR, and remote soil samples are collected at the same time and from the same plots as are the grass samples. Soil samples are analyzed for atmospheric deposition of radionuclides and fluorides. Fluorometric analysis is used to determine total uranium levels, a fluoride-ion-selective electrode is used to determine fluoride levels, and radiochemical techniques are used to determine  $^{90}\text{Sr}$ ,  $^{137}\text{Cs}$ ,  $^{238}\text{Pu}$ ,  $^{239}\text{Pu}$ , and several isotopes of uranium. The

soil sampling locations are shown in Figs. 9.2.1 through 9.2.4.

For 1986, there were no statistically significant differences in the soil concentrations of  $^{90}\text{Sr}$ ,  $^{137}\text{Cs}$ ,  $^{238}\text{Pu}$ ,  $^{235}\text{U}$ , and  $^{238}\text{U}$  between the ORNL perimeter and the ORR locations. There were significantly higher concentrations of  $^{234}\text{U}$ ,  $^{235}\text{U}$ , and  $^{238}\text{U}$  at the ORR locations as compared with those at remote stations. Uranium concentrations were highest around Oak Ridge Y-12 Plant

stations S40 and S45. Uranium concentrations at ORGDP did not change much from 1985 to 1986 but were generally lower at most sites in 1986 than in 1984. Fluoride concentrations were somewhat higher at some sites in 1986 than in 1985. There were no statistically significant differences in soil concentrations of  $^{238}\text{Pu}$  between ORNL and ORR locations. However,  $^{239}\text{Pu}$  appeared to be higher at ORNL stations than at ORR stations.

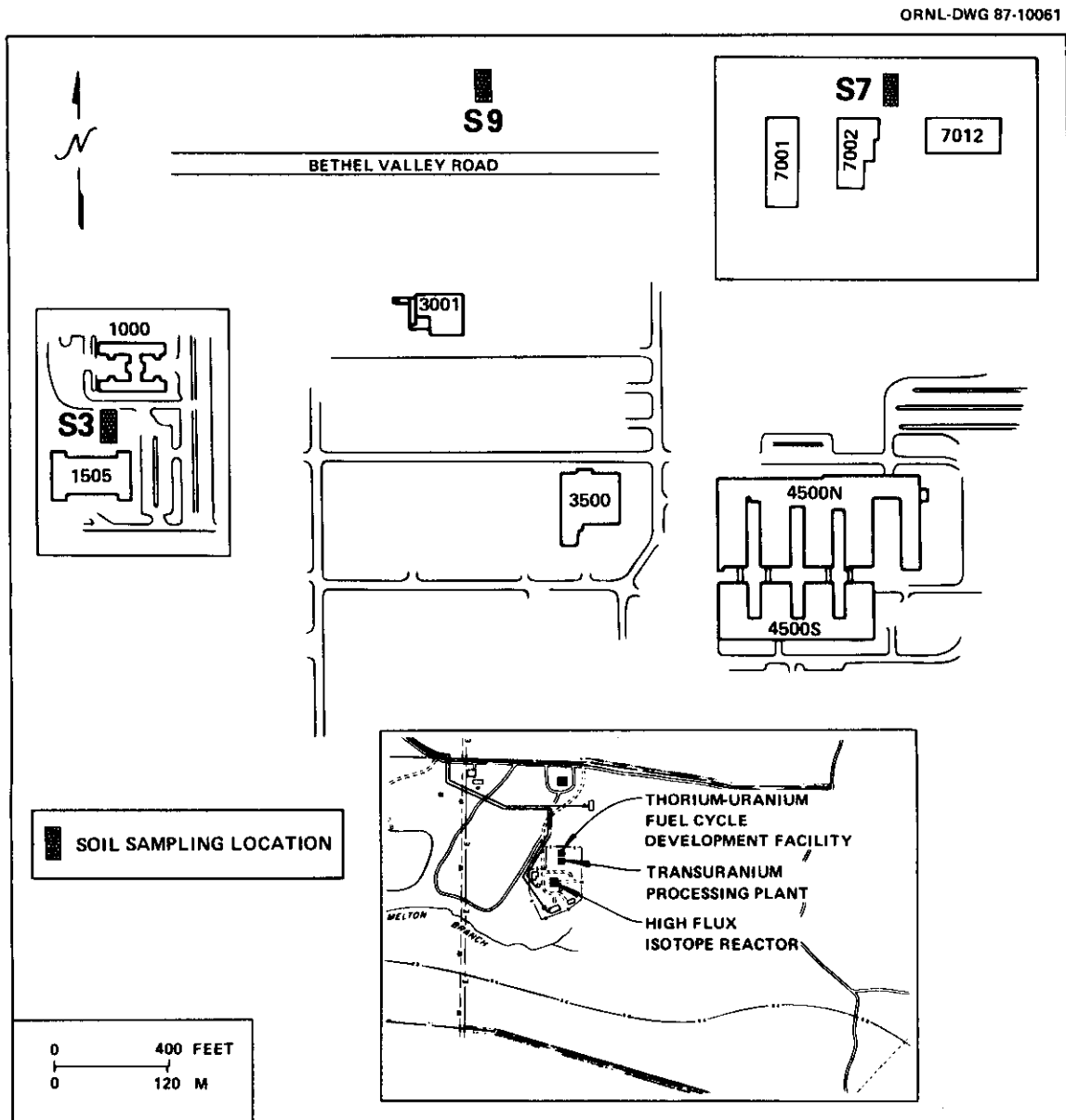


Fig. 9.2.1. Soil sampling locations around ORNL.

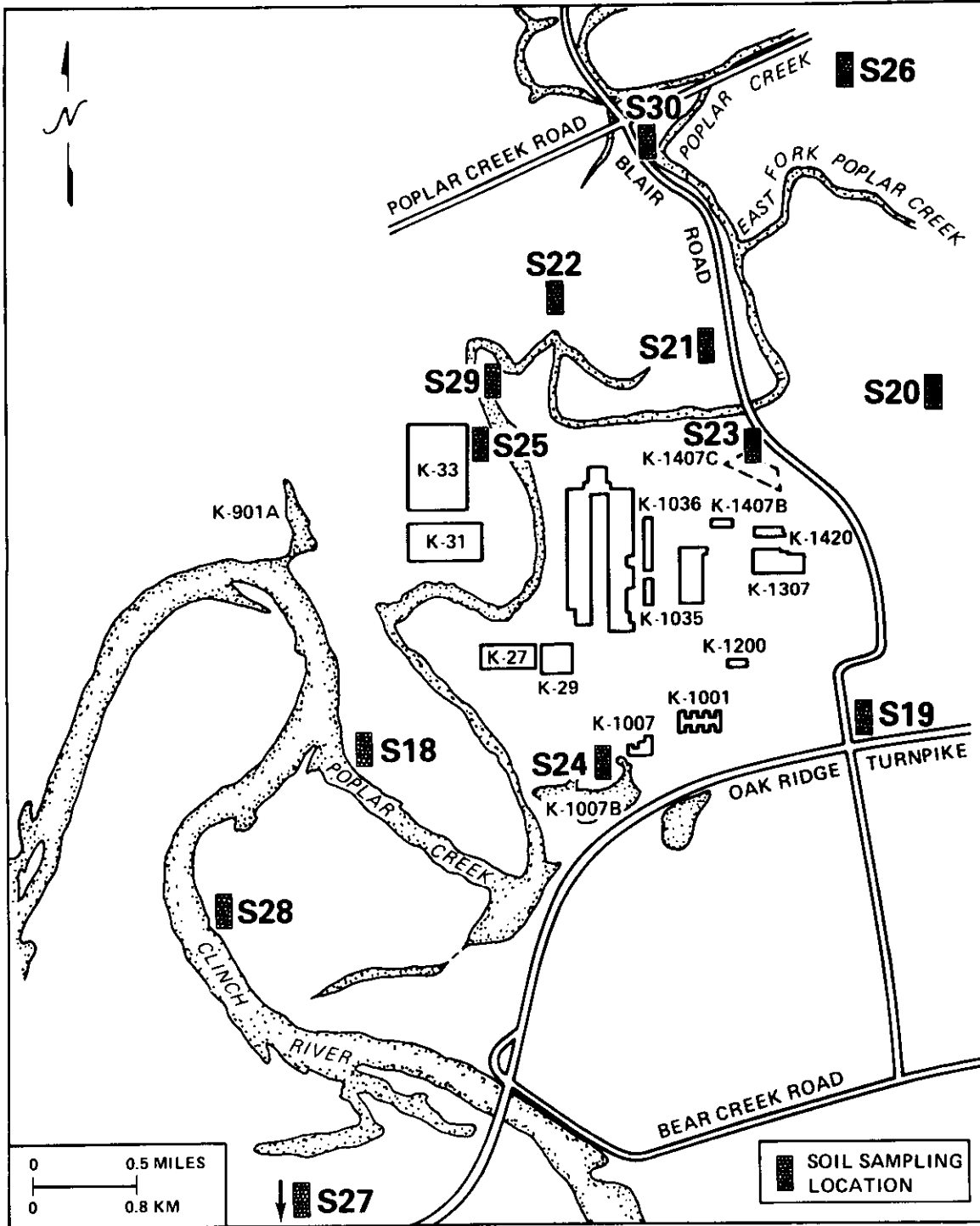


Fig. 9.2.2. Soil sampling locations around ORGDP.



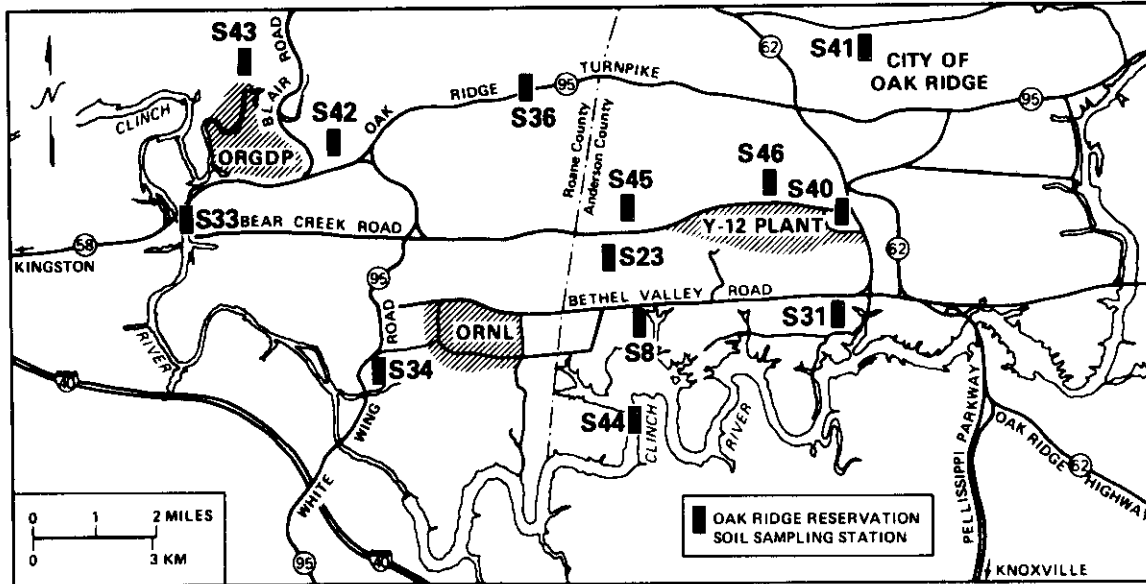


Fig. 9.2.3. Locations of ORR soil sampling areas.

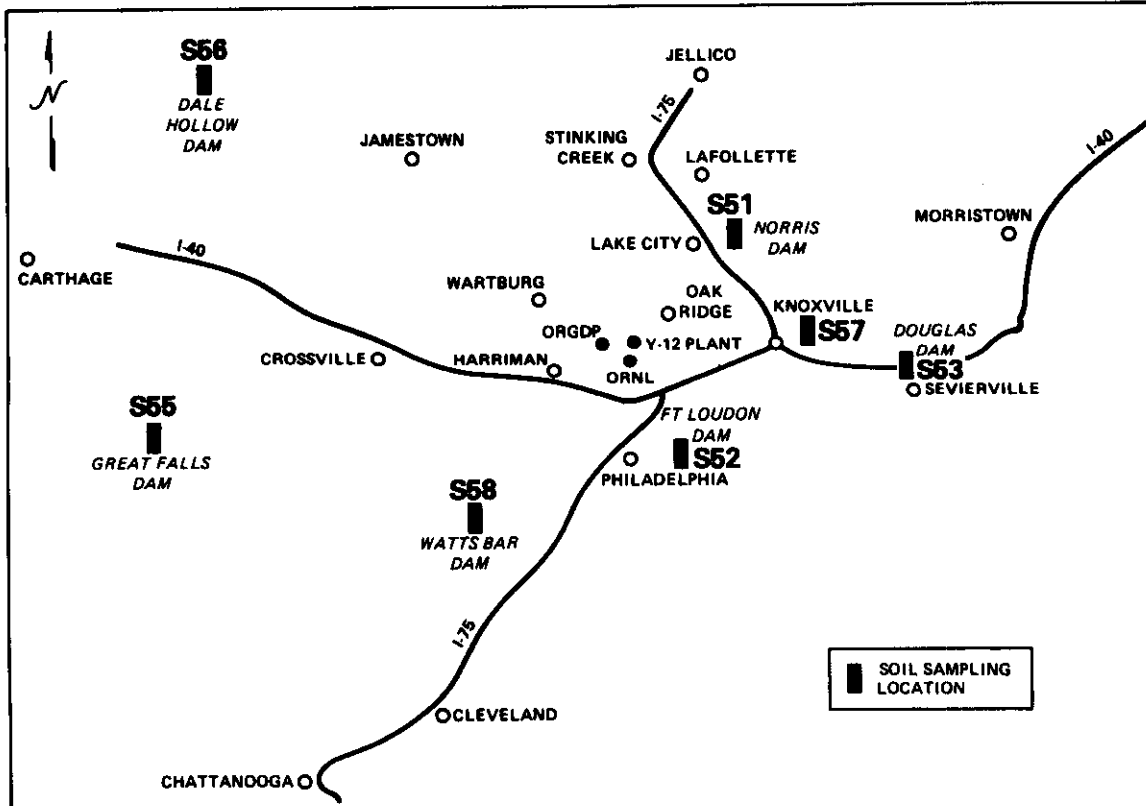


Fig. 9.2.4. Locations of remote soil sampling areas.

The  $^{238}\text{Pu}$  concentrations at most of the remote locations appeared higher during 1986 than they were in 1985. All other radionuclide levels were similar to those of 1985.

Figures 9.2.5 through 9.2.9 compare the average concentrations of  $^{90}\text{Sr}$ ,  $^{137}\text{Cs}$ ,  $^{234}\text{U}$ ,  $^{238}\text{U}$ , and  $^{235}\text{U}$  in soil at ORR locations with those at remote locations. Once again, the remote sites are so distant from the ORR that contamination from the ORR installations is not likely.

Fluoride concentrations in soil around ORGDP are given in Figs. 9.2.10 and 9.2.11; uranium concentrations are given in Figs. 9.2.12 and 9.2.13.

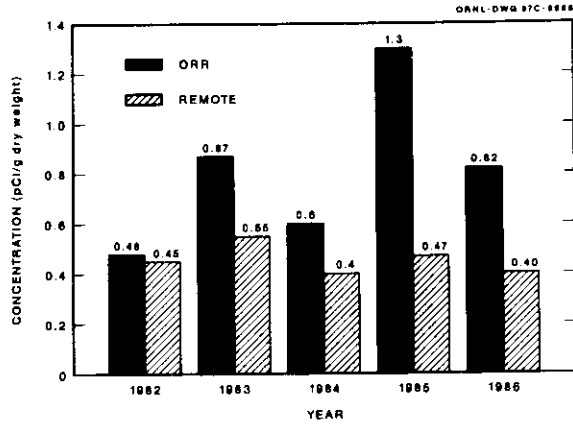


Fig. 9.2.7. Uranium-234 concentrations in soil.

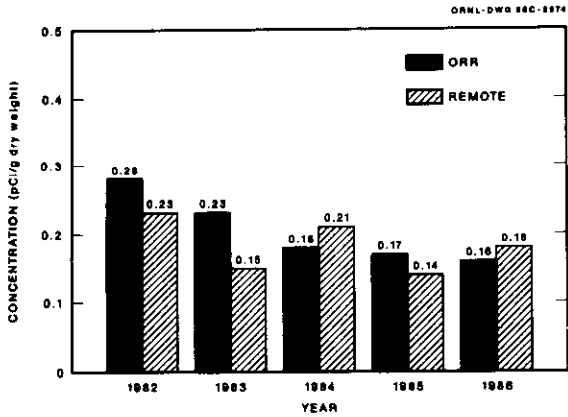


Fig. 9.2.5. Strontium-90 concentrations in soil.

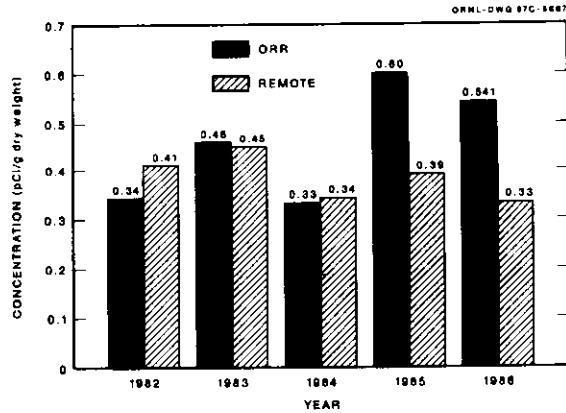


Fig. 9.2.8. Uranium-238 concentrations in soil.

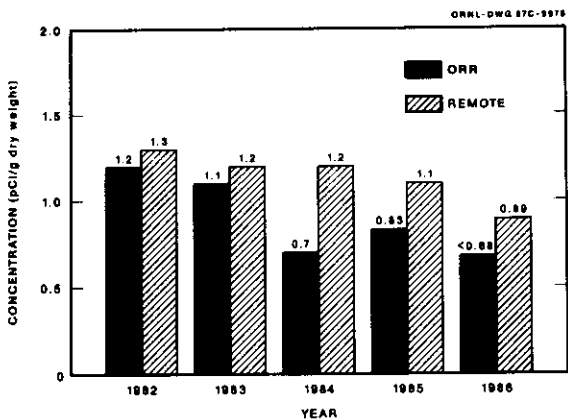


Fig. 9.2.6. Cesium-137 concentrations in soil.

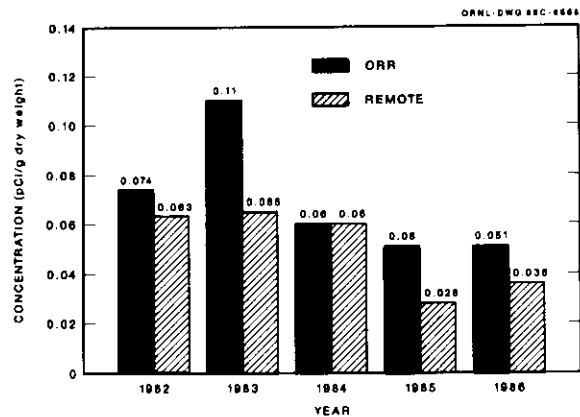


Fig. 9.2.9. Uranium-235 concentrations in soil.

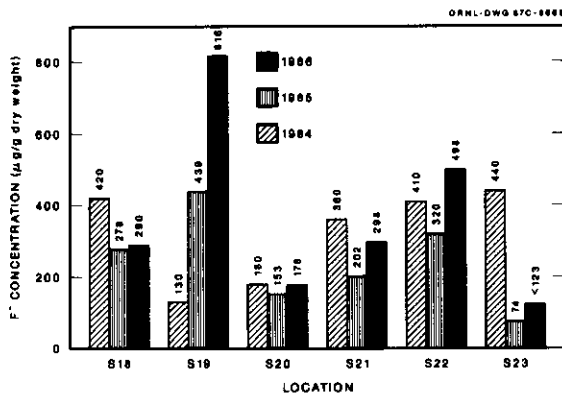


Fig. 9.2.10. Fluoride concentrations in soil (S18 through S23).

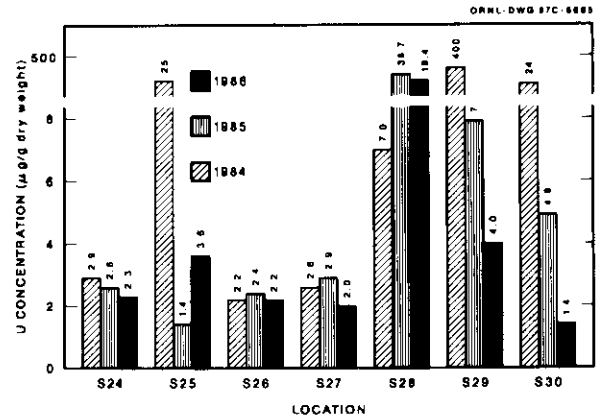


Fig. 9.2.13. Uranium concentrations in soil (S24 through S30).

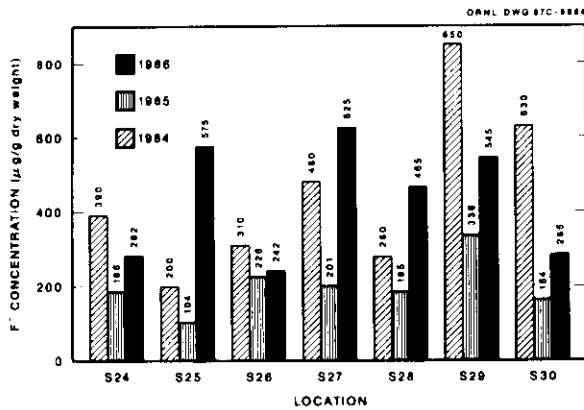


Fig. 9.2.11. Fluoride concentrations in soil (S24 through S30).

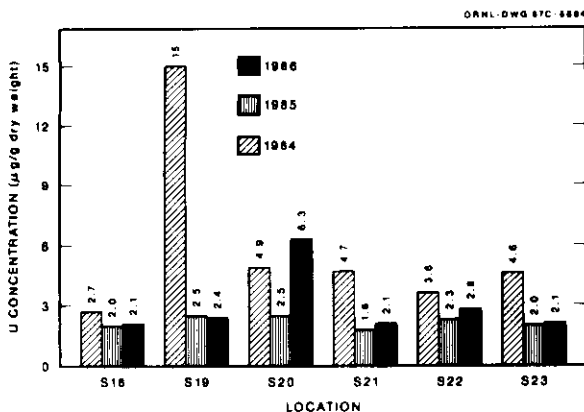


Fig. 9.2.12. Uranium concentrations in soil (S18 through S23).

### 9.3 SEDIMENT

Sediments play a dominant role in aquatic ecology by serving as a repository for radioactive or chemical substances that pass by way of the bottom-feeding biota to the higher trophic levels (Duursma and Gross, 1971). Soluble pollutants introduced into a body of water reach the bottom sediment primarily by adsorption on suspended solids that later deposit on the bottom. The deposited remains of biota that have absorbed pollutants may also be an important source of radioactive and chemical pollutants that enter the food chain. Possible routes (Jinks and Eisenbud, 1972) of trace metals (including uranium) in an aquatic ecosystem are shown in Fig. 9.3.1. The basic components (Eisenbud, 1973) of the aquatic ecosystem are shown in Fig. 9.3.2.

In sediment studies of the Clinch River, the amounts of radioactivity contained by the suspended solids were found to be variable (Parker et al., 1966; Oakes, 1982), which is not surprising considering that the load of solids and particle size varies from place to place in the river and varies with time. The main mechanism of removal of some dissolved matter is ion exchange on sediment surfaces; particulates with good ion exchange properties, such as most clay minerals, act as efficient scavengers and may serve to purify the water of the more readily

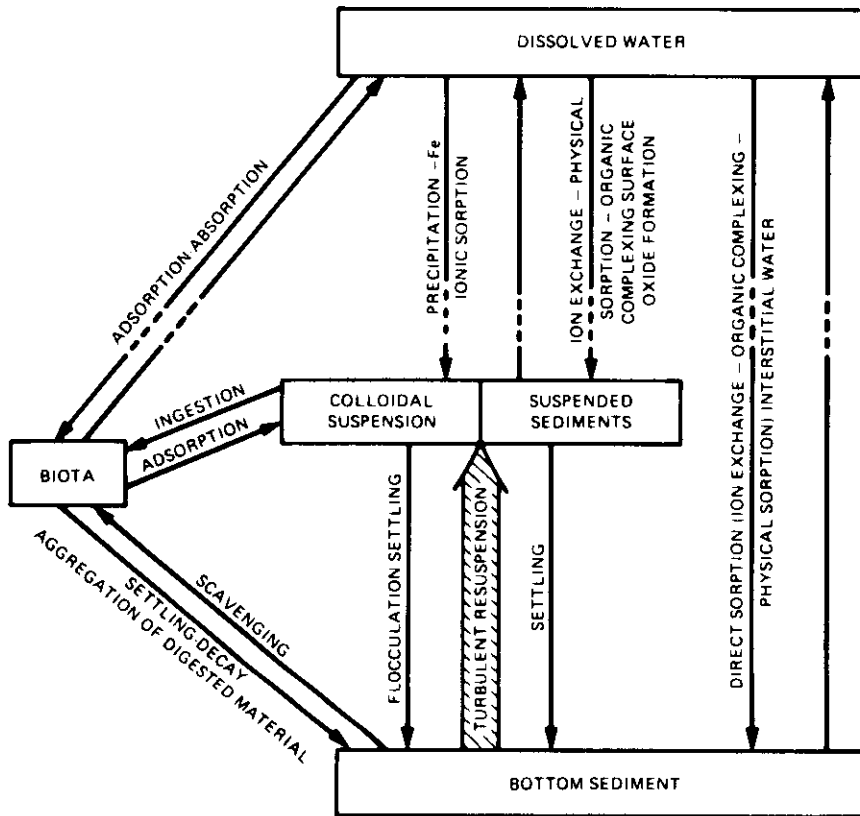


Fig. 9.3.1. Possible routes of trace metals in an aquatic ecosystem.

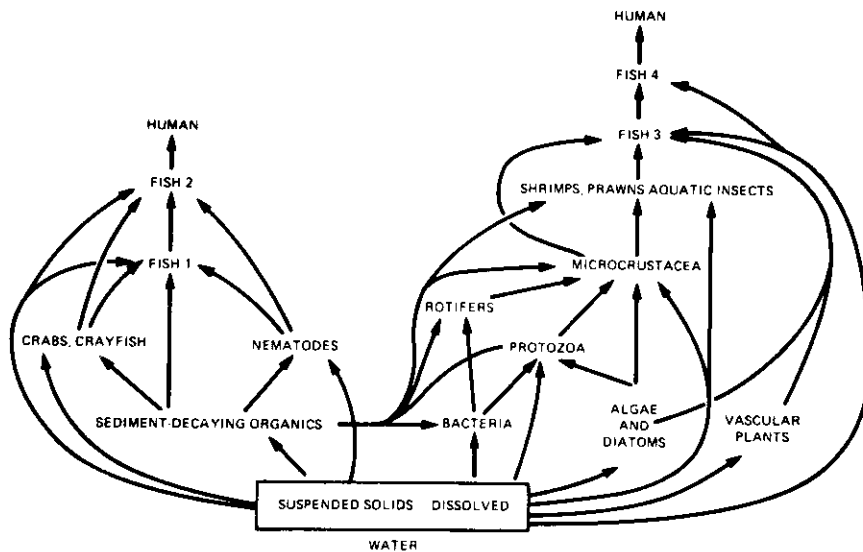


Fig. 9.3.2. Basic components of the aquatic ecosystem.

adsorbed ions (Duursma and Gross, 1971). These ion exchange properties apply to  $^{90}\text{Sr}$  and a few other contaminants. For most other contaminants, other processes are involved.

A sediment sampling program has been carried out at ORGDP since 1975 to determine the concentrations of metals in the sediment of Poplar Creek and the Clinch River. Eight sampling stations, all of which can be affected by the effluents from the three major ORR installations, have been established. The locations of the sampling stations are shown in Fig. 9.3.3. Samples are collected semiannually and analyzed by atomic absorption, inductively coupled plasma, and other methods.

Average concentrations of metals at the eight sampling stations during 1984, 1985, and 1986 are compared in Figs. 9.3.4 through 9.3.9.

The concentrations of metals in stream sediments generally exceeded background levels of the same metals in remote streams (streams unaffected by the installations' operations). Background data are given in Table 9.3.1. For mercury and lead, the highest concentrations

occurred in East Fork Poplar Creek. For most of the other metals, the highest concentrations occurred in the creek close to or above ORGDP. Concentrations of nickel and copper were higher in 1986 than they were in 1985 and 1984, and concentrations of zinc were lower. The reasons for these changes are unknown. Concentrations in sediments can vary widely with time and place, so temporal and spatial trends must be regarded cautiously.

There are some known discharges of aluminum from the ORR installations; concentrations in sediment at these locations are given in Fig. 9.3.8. Considering the apparent decrease in aluminum at nearly every site since 1983, the validity and/or variability of the sampling process may be involved. Sample analysis (degree of dissolution) may also be involved, as may instrumental settings to correct for spectral interference.

In addition to regularly scheduled sediment samplings, about 180 coordinated sediment samples and 3 sediment cores were taken in the waters around ORGDP and analyzed.

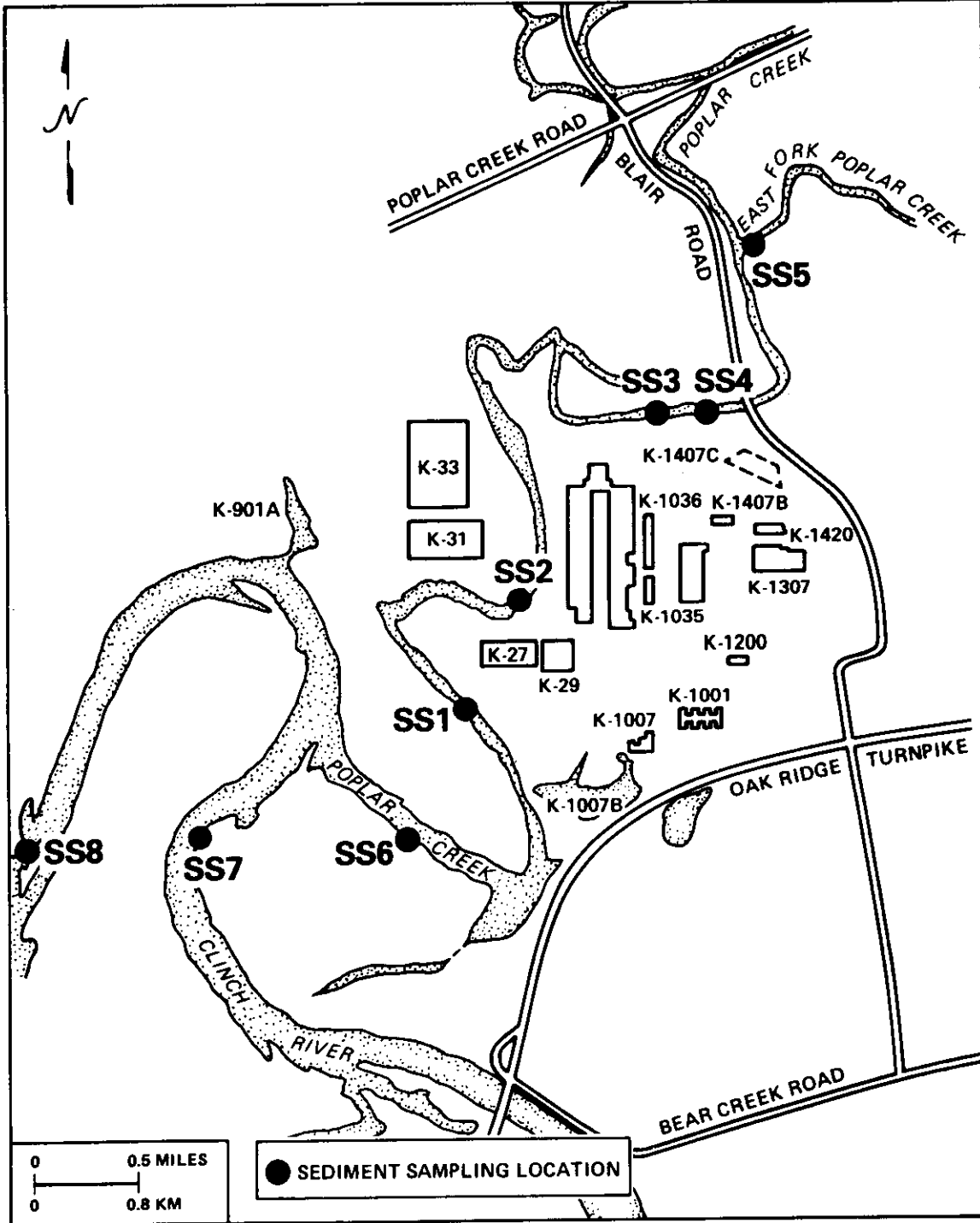


Fig. 9.3.3. Stream sediment sampling locations at ORGDP.

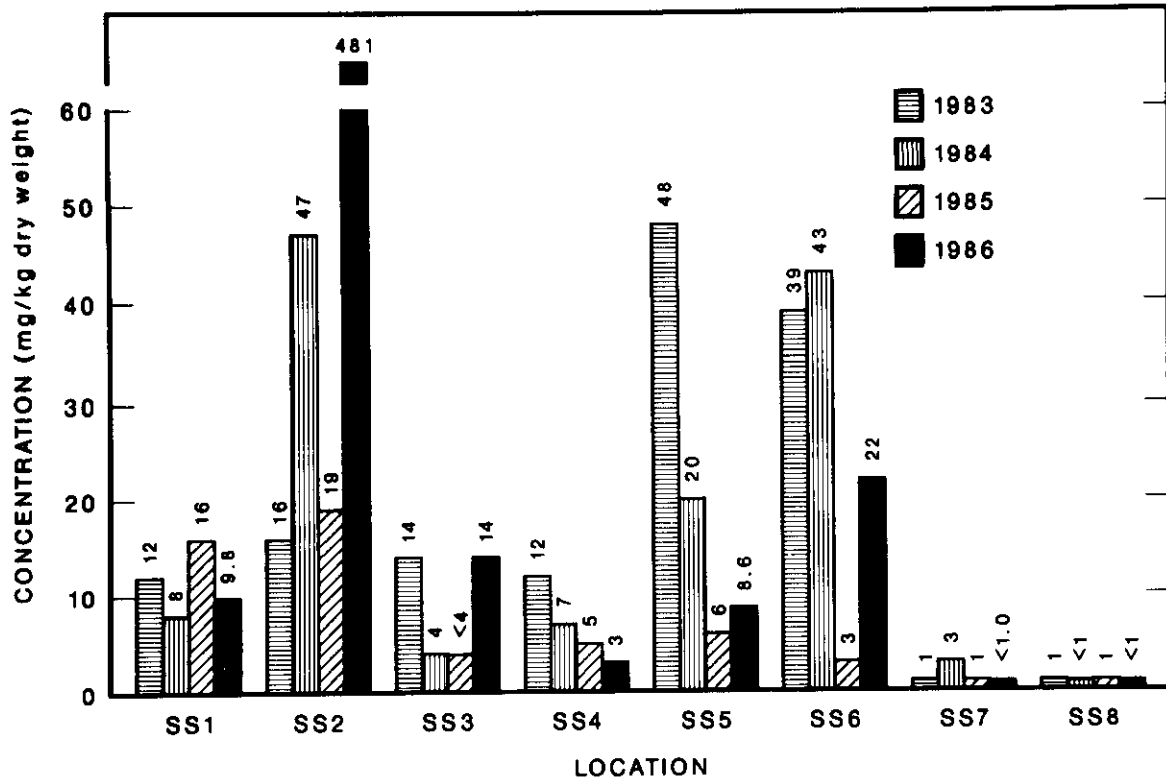


Fig. 9.3.4. Average mercury concentrations in sediment.

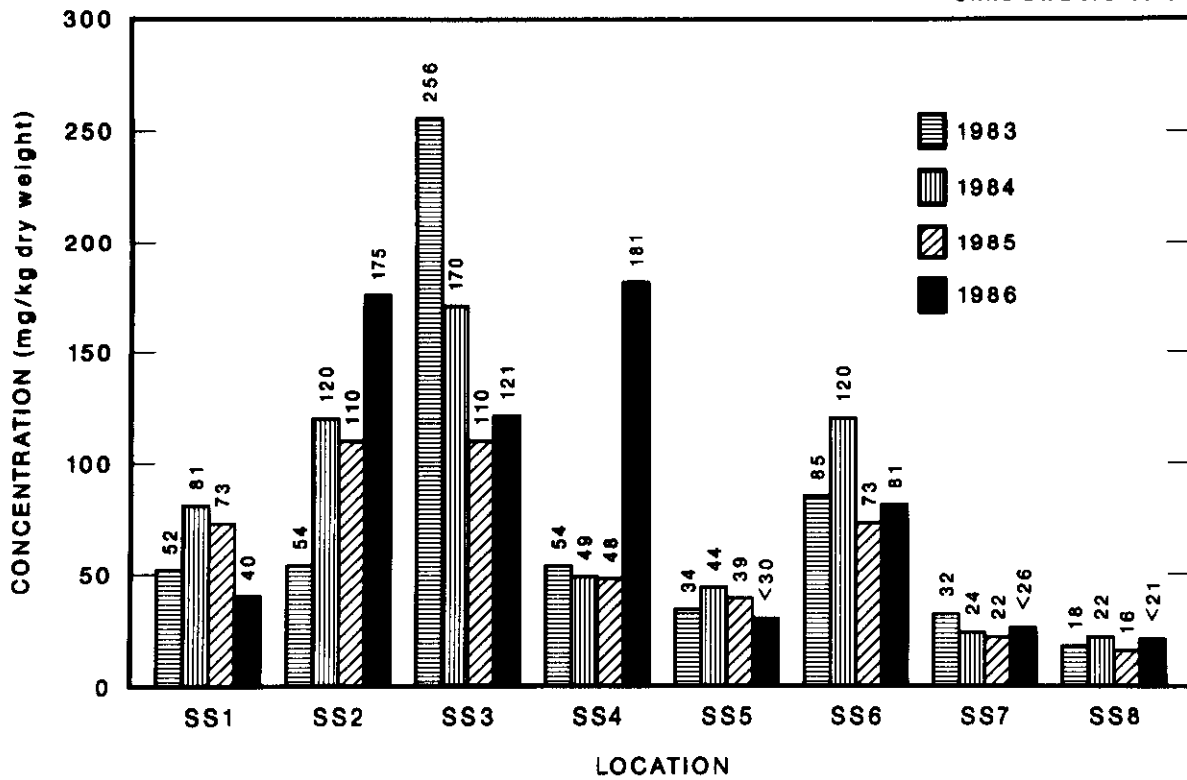


Fig. 9.3.5. Average nickel concentrations in sediment.

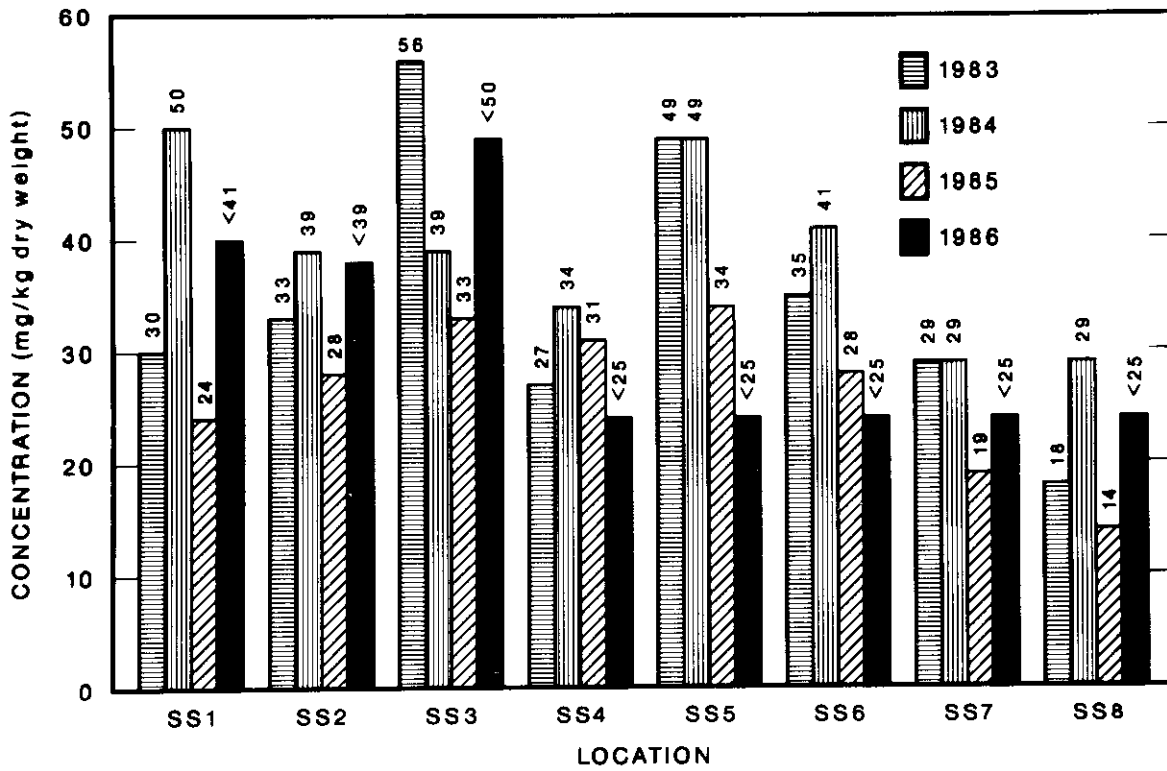


Fig. 9.3.6. Average lead concentrations in sediment.

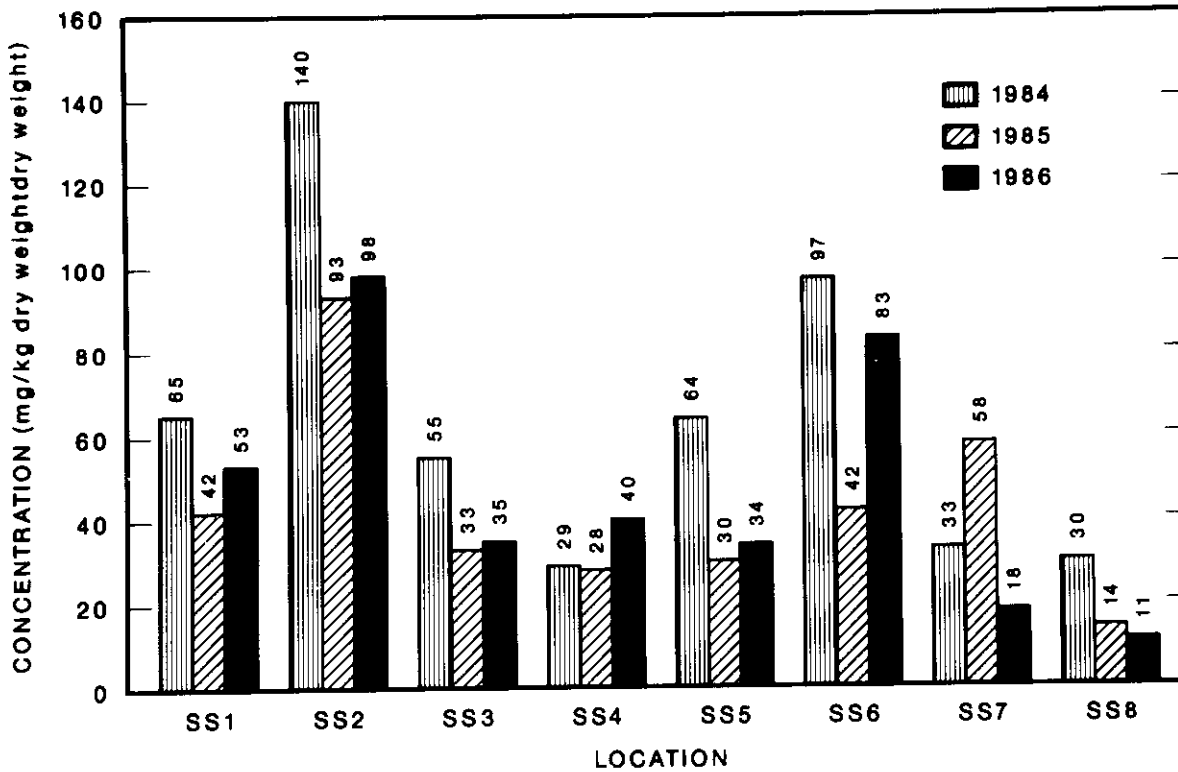


Fig. 9.3.7. Average chromium concentrations in sediment.



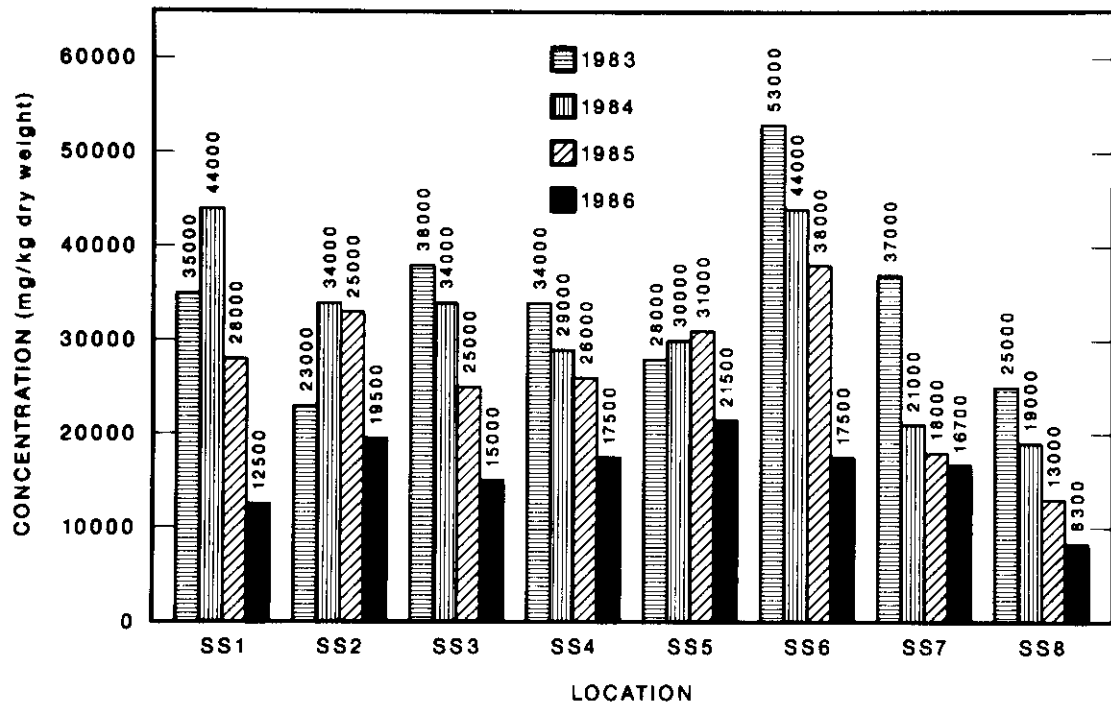


Fig. 9.3.8. Average aluminum concentrations in sediment.

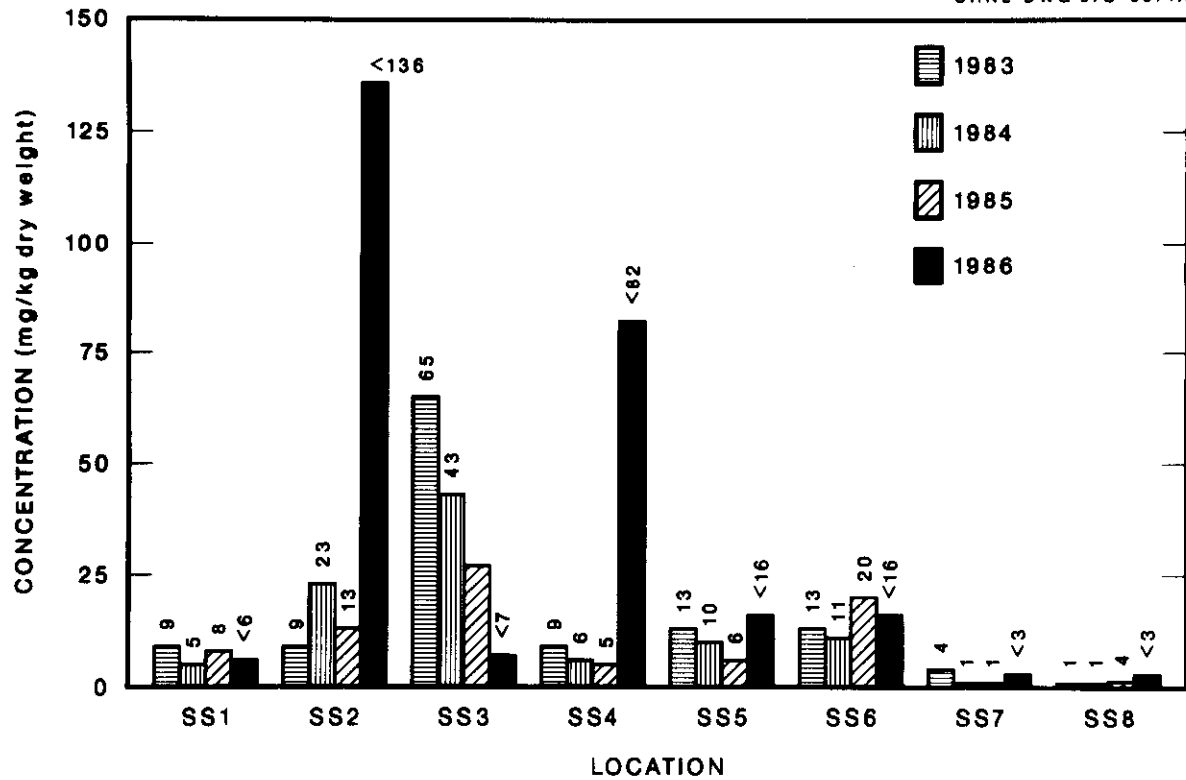


Fig. 9.3.9. Average uranium concentrations in sediment.

**Table 9.3.1. Criteria and selected data for chemical parameters in sediment and soil  
Instream Contaminant Study—Task 5**

Parameter <sup>a</sup> (ppm)	Proposed Virginia criteria <sup>b</sup>	Average Earth's crust <sup>c</sup>	Mean concentrations of upper Tennessee River <sup>d</sup>	Mean concentrations of tributary streams to upper Tennessee River <sup>e</sup>	Mean concentrations of Clinch River <sup>f</sup>
Mercury	0.3	0.5	1.00 (<0.05–4.3)	0.25 (<0.05–0.98)	0.16 <sup>g</sup> (<0.05–0.51)
Arsenic	ND <sup>h</sup>	ND	12.00 (7.4–17.5)	12.20 (2.0–56.0)	8.70 (2.0–16.0)
Cadmium	ND	0.2	5.50 (0.4–12.0)	1.80 (<0.4–11.0)	1.40 (<0.4–3.7)
Chromium	ND	200.0	48.00 (14.0–86.0)	19.70 (5.0–46.0)	19.30 (6.3–44.7)
Lead	ND	16.0	59.70 (<10.0–99.0)	47.90 (<3.0–300.0)	31.60 (13.1–72.0)
Nickel	ND	100.0	33.60 (5.8–57.0)	22.40 (<3.3–70.0)	30.00 (16.0–70.0)
Silver	ND	ND	2.50 (0.5–5.0)	1.30 (0.4–2.1)	1.60 (1.3–2.0)
Zirconium	ND	ND	ND	ND	ND

Source: Oak Ridge Task Force, 1986. *Instream Contaminant Study—Task 5: Summary Report*, Tennessee Valley Authority, Office of Natural Resources and Economic Development.

<sup>a</sup>Concentrations given in mg/kg (ppm), dry weight, range in parentheses.

<sup>b</sup>State of Virginia proposed regulation for total mercury in freshwater river sediment.

<sup>c</sup>Y. M. Goldschmidt. Courtesy A. Muir, editor, and Clarendon Press, Oxford, publishers of *Geochemistry*, average abundance of trace elements in the crust of the earth.

<sup>d</sup>Average concentrations in river sediment for reach from Nickajack Dam to confluence of the Holston and French Broad Rivers, TRMs 427 to 652; 24 sampling locations—1970 to 1983, TVA STORET data.

<sup>e</sup>Average concentrations in river sediment for streams tributary to the Tennessee River between miles 424 and 652; 43 sampling locations—1970 to 1981, TVA STORET data.

<sup>f</sup>Average concentrations in Clinch River sediment above Melton Hill Dam, CRM 23.2; 12 sampling locations—1970 to 1981, TVA STORET data.

<sup>g</sup>Seven of twelve samples below detection limits.

<sup>h</sup>ND = no data.

## 10. SUMMARY OF ENVIRONMENTAL SURVEILLANCE AND MONITORING OF THE OAK RIDGE COMMUNITY

### 10.1 HISTORICAL PERSPECTIVE

Wastewater discharges from the Oak Ridge Y-12 Plant into EFPC have contaminated the floodplain with materials such as mercury, uranium, thorium, chromium, zinc, and various inorganic and organic compounds. Unwittingly, these floodplain soils and creek sediments were then used throughout the community as topsoil.

In 1983, a sampling program was started to determine whether soil, vegetables, or well water in the community were contaminated and to define the extent of contamination. Also in that year an interagency Oak Ridge Task Force (ORTF) was assembled to collect toxicological and environmental data with which to evaluate the potential long-term public health impact of the residual contamination and costs versus benefits of remedial measures. The organization of that task force is shown in Fig. 10.1.1.

### 10.2 CURRENT ACTIVITIES

During 1986, sampling of private property in Oak Ridge and the EFPC floodplain continued. In addition, sampling was expanded to include surrounding communities.

#### 10.2.1 Oak Ridge Community Sampling

During 1986 sampling of private properties in the Oak Ridge Community continued. Oak Ridge was broken into sampling areas as shown in Fig. 10.2.1.

Properties surrounding a contaminated salvage yard on Fairbanks Road were sampled. This study is still in progress.

Samples were collected from seven properties within and adjacent to the EFPC floodplain, where fill material was used to raise the surface

elevation. In one case, the fill material was contaminated with mercury. In a separate case, soil mercury concentration for the sandbars where EFPC crosses under the Oak Ridge Turnpike near Illinois Avenue ranged from 0.02 to 4300 mg/kg, with 176 samples exceeding the state guideline.

At the sandbars at the bridge where EFPC flows under the Oak Ridge Turnpike near Jefferson Avenue, 44 of the 45 samples exceeded the state interim guideline.

The USGS shallow groundwater site at the YWCA was sampled to determine the vertical distribution of mercury in the soil. No samples exceeded the state interim guideline.

Previous sampling had demonstrated that contamination was present in the Robertsville Junior High School athletic field, which was subsequently covered with clean soil. To determine whether the covered contamination had migrated to the surface, surface samples were taken and boreholes were installed. Only one soil sample exceeded the state mercury guideline, and that sample was collected 8–15 inches below the surface at the depth of the original contamination.

In the Scarboro area, soil mercury concentration ranged from 0.03 to 21 ppm. At a private-residence garden where contaminated soil might have been brought in as a soil amendment, seven samples exceeded the state guideline.

West End Water Treatment Plant soil mercury concentrations ranged from 0.03 to 2500 ppm, and 136 samples exceeded the state interim guideline.

Samples collected from the Oak Ridge Civic Center property ranged from 0.05 to 0.35 ppm mercury.

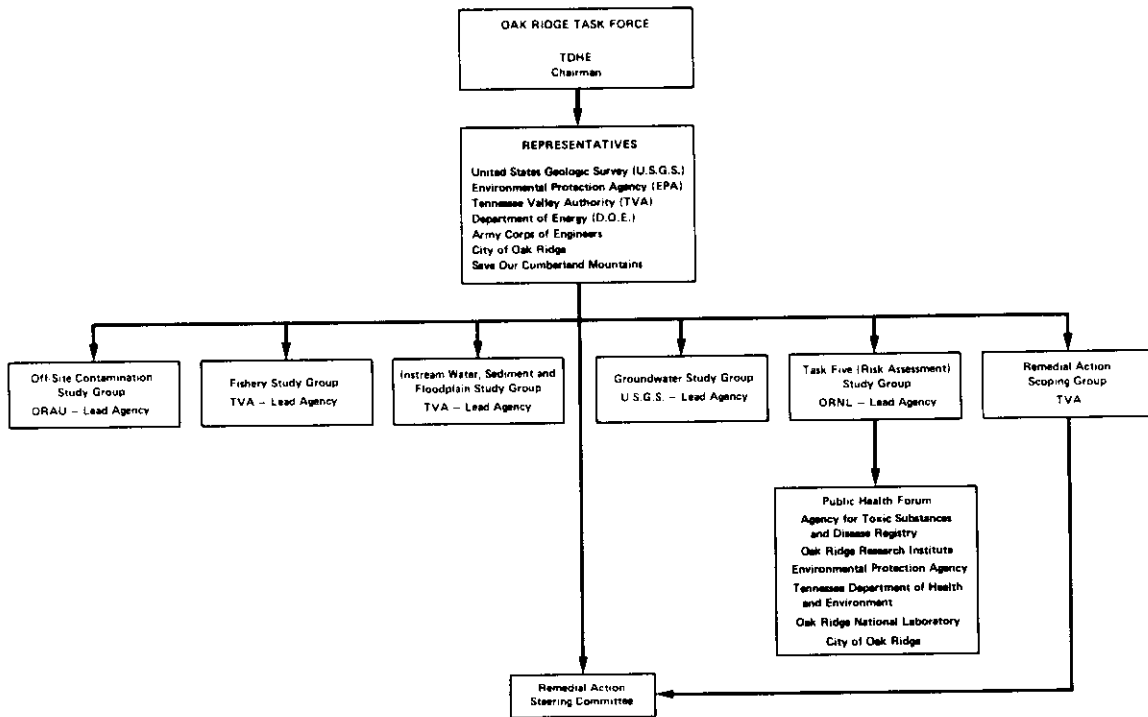


Fig. 10.1.1. Organization of the Oak Ridge Task Force.

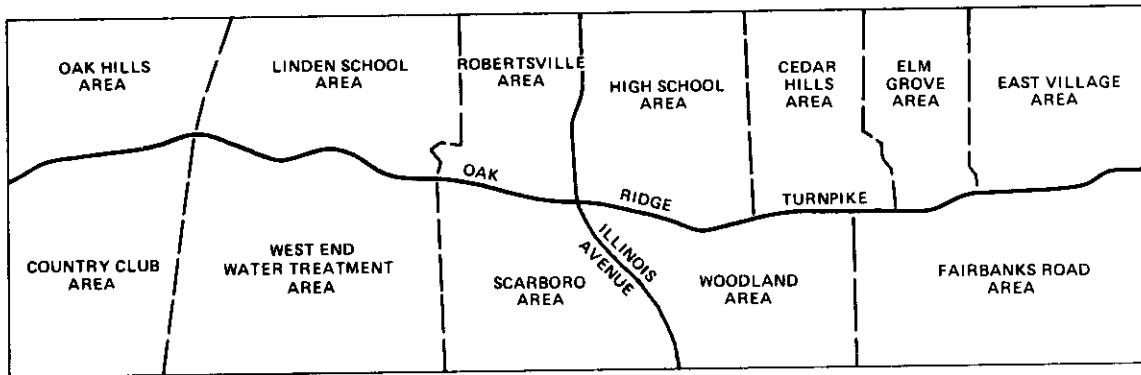


Fig. 10.2.1. Private property areas in the Oak Ridge community.

**10.2.2 East Fork Poplar Creek Floodplain Studies**

Samples were collected from the EFPC floodplain to characterize the contaminants released from the Oak Ridge Y-12 Plant. Two distinct areas, designated Reach 2 and Reach 4 in Fig. 10.2.2, have higher contamination than the rest of the creek. Figure 10.2.3 shows that the

majority of the higher levels of contamination are <70 cm from the surface. These areas have been targeted for investigations for remedial action.

**10.2.3 Terrestrial Food Chain Studies**

Paired soil and plant samples were collected in the EFPC floodplain to estimate the transfer of

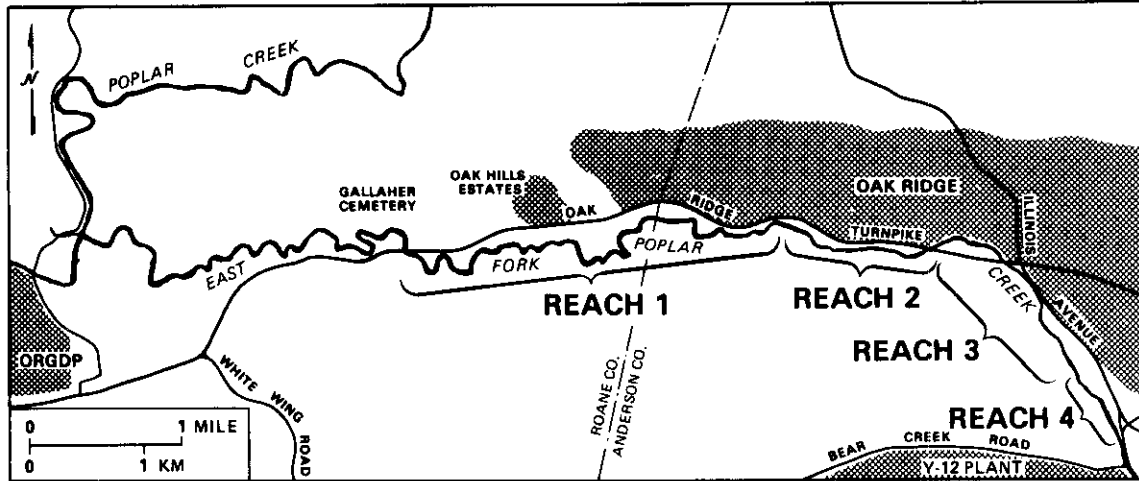


Fig. 10.2.2. EFPC and its subdivisions.

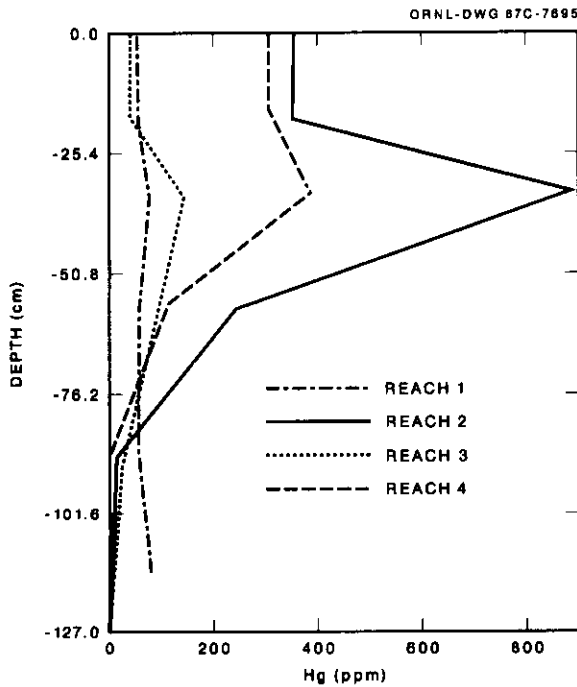


Fig. 10.2.3. Levels of contamination and depth of contamination at four locations (reaches) of EFPC.

contaminants from the soil to various parts of the plant. In addition, white-tailed deer were selected for observation, because they are actually consumed by humans and because their uptake of contaminants is similar to that of domestic

livestock. Deer killed by car collisions in the vicinity of East Fork Poplar Creek are checked for ingestion and incorporation of contaminants. This investigation is currently under way.

#### 10.2.4 Oak Ridge Water Treatment Plant

Samples of sewage sludge were collected from water treatment plants in Oak Ridge, Knoxville, and Lenoir City for comparison. Analysis showed seemingly high levels of barium, cadmium, chromium, copper, lead, mercury, selenium, silver, uranium, and zinc in the Oak Ridge sludge. It also showed high levels (relative to those for Oak Ridge sludge) of arsenic and thorium in the Knoxville sludge and high levels (relative to those for Knoxville sludge) of lead, mercury, selenium, uranium, and zinc in the Lenoir City sludge. That these concentrations should be considered "elevated" and of concern, however, is premature because of the absence of standards or a sound, statistical evaluation of what typical levels should be.

#### 10.2.5 Cooperative Studies

At the request of the Oak Ridge Task Force, the USGS initiated a shallow groundwater study below the EFPC floodplain to determine whether any of the contamination in the soils on the floodplain has migrated into the groundwater.

Thirteen shallow wells were placed in the floodplain, and two background shallow wells were placed in an uncontaminated location at the Civic Center. Two additional wells were established in Knoxville to serve as urban "background" wells. All wells are now in place, and data are being collected.

DOE has contracted with Advanced Sciences Incorporated (ASI) to develop a Remedial Alternatives Engineering Evaluation for the EFPC areas with the highest levels of contamination.

#### **10.2.6 Sampling in Surrounding Communities**

Several residents in the Harriman/Kingston area expressed concern that DOE activities would result in contamination of their well water supplies and requested sampling of their groundwater. Sampling was performed for them, and results showed contamination well below the regulatory limits for all components of concern.

## 11. SUMMARY OF POTENTIAL RADIATION AND CHEMICAL DOSE TO THE PUBLIC

### 11.1 INTRODUCTION

The DOE installations on the ORR emit effluents, some of which are radioactive and some of which are chemically reactive. The amounts of these effluents that the general public might be exposed to are measured directly. For instance, if water that originated on the ORR mixes with that used as a public water supply, it is sampled at the intake of the water plant to measure exactly any contaminants that might be in it. These measurements are used to estimate the magnitude of hazard that the contaminant poses. The estimates are compared with the data, standards, and recommendations of federal agencies and international organizations.

### 11.2 RADIATION DOSES FROM AIRBORNE RELEASES

Radioactive gaseous effluents are discharged from several locations in each of the DOE installations in Oak Ridge. These effluents may contain not only radioactive gases but also radioactive particulates, which then settle out of the air and deposit on the soil, vegetation, buildings, and anything else downwind. People can be exposed to these effluents in four ways: ingestion (by eating plants on which the particulates have settled), inhalation (by breathing the air in which the radioactive gases or particulates are present), contact (by touching something on which the particles have settled), and ground surface (by walking near a contaminated surface).

The hazards associated with these airborne effluents are largely proportional to the concentrations of them to which people are

exposed. Radioactive material deposited in the body by inhalation or ingestion stays there until it is removed by metabolic processes or until it decays away. In radioactive decay, energy is released, and that energy absorbed can harm or destroy nearby cells and tissues. If the concentration of pollutant to which a person is exposed is very small, the amount available for absorption is reduced, and, once absorbed, the chances of its doing significant damage to the body are also lessened. Higher concentrations can lead to increased absorption and increased damage to the body and its organs. Certain materials, however, seek out specific organs or tissues in the body. Strontium, for example, seeks out bone because of its chemical similarity to the calcium found in bones. As a result of this tendency to seek out a specific organ any of these materials that are absorbed by the body will concentrate in these preferred sites, thus increasing the possibility of damage to that portion of the body.

Meteorologic conditions are continuously measured and recorded at each installation. The release and meteorologic data can be used to determine how the effluent mixes with the atmosphere, where it travels, how it is diluted, and where it is deposited. Once the dispersal is calculated, population data and conversion factors can be used to calculate the maximum and average doses of these materials that people are subjected to.

The whole-body dose accounts for absorbed substances that distribute themselves more or less uniformly throughout the body. The effective dose takes into account the total risk associated with the exposure for all tissues involved; this in view of the fact that some tissues may be

selectively targeted by a pollutant and others ignored. Each of these dosages can be calculated as a 50-year committed effective dose equivalent. The 50-year committed effective dose equivalent calculation takes into account the fact that the polluting material may reside in a person's body for a long time. It therefore calculates the risk associated with exposure to the material for 50 years. This dose calculation can account for all four types of exposure: inhalation, ingestion, air immersion, and ground surface.

Once the calculational methods are set, the concerns about personal safety can be framed by two questions: What is the maximum dosage any person might receive? And how much exposure is visited upon the population as a whole?

It happens that the closest residents to the ORR installations are exposed to the highest concentrations of airborne effluents. Therefore, the 50-year whole-body and effective doses were calculated for the resident nearest each of the three installations. The calculated dosages are shown in Table 11.1.1. The total exposure (50-year committed effective dose equivalent) of the entire population within 80 km of each of the installations was also calculated. The results of those calculations are shown in Table 11.1.2. These calculations used the actual meteorologic and measured or estimated data recorded for each of the installations during 1986. Moreover, the effluent-release data were expressed in terms that would give the worst possible effects.

The cumulative whole-body dose from all three installations for an individual is shown in Table 11.1.1 to be 0.5 millirem. This value can be

**Table 11.1.1. Calculated doses to the nearest resident from the 1986 airborne releases of the three Oak Ridge DOE installations**

Installation	Whole-body dose (millirem)	Effective dose (millirem)
Y-12 Plant	0.00026	2.0
ORNL	0.5	0.5
ORGDP	0.000000023	0.000027
Maximum	0.5+	2.0+

**Table 11.1.2. 50-year committed effective dose equivalent to the population within 80 km of any DOE Oak Ridge installation**

Installation	Dose (person-rem)
Y-12 Plant	28
ORNL	16.5
ORGDP	0.0009
Maximum	<45

compared with the regulatory limit set for such exposures by the National Emission Standards for Hazardous Air Pollutants. It is 25 millirems. Thus, the worst calculated exposure to an individual from the radioactive atmospheric effluents from the three Oak Ridge DOE installations is far below the limit set by the national standard.

The 50-year dose commitment of the entire population living within 80 km of the Oak Ridge installations can be compared with the dose commitment that that population would receive in 50 years even if no such installations existed. Such a dose would result from the natural radioactivity of the soil and rocks and from the radiation of the sun and other cosmic sources.

### 11.3 SUMMARY OF EFFECTIVE AND SELECTED ORGAN DOSES AND FIVE-YEAR TRENDS

The effective and critical organ dose equivalents for the inhalation pathway for 1982 through 1986 are shown in Figs. 11.3.1 and 11.3.2, respectively. The effective and critical organ dose equivalents from consumption of milk for 1982 through 1986 are given in Figs. 11.3.3 and 11.3.4, respectively. The effective and critical organ dose equivalents for ingestion of fish for 1982 through 1986 are given in Figs. 11.3.5 and 11.3.6, respectively. Effective and critical organ dose equivalents for drinking water at Kingston, Tenn., for 1982 through 1986 are given in Figs. 11.3.7 and 11.3.8, respectively. Direct radiation doses for 1982 through 1986 are shown in Fig. 11.3.9.



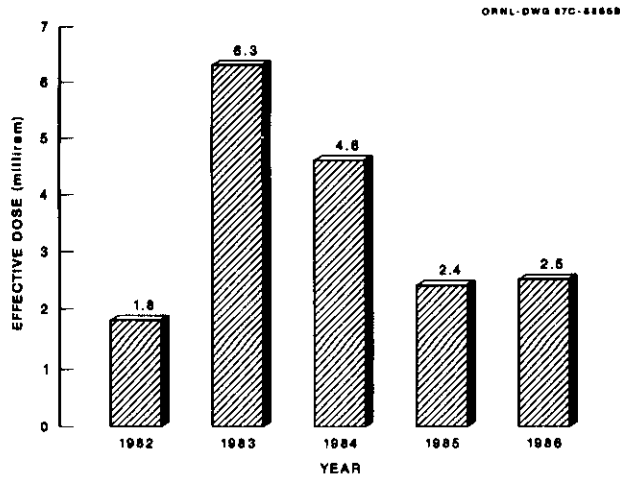


Fig. 11.3.1. Effective dose from inhalation pathway.

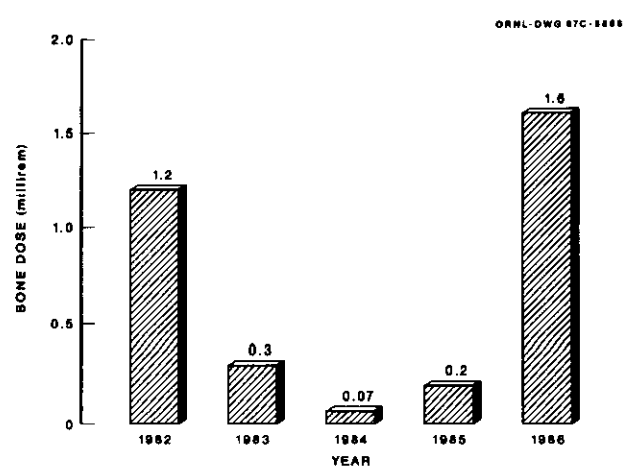


Fig. 11.3.4. Thyroid dose from milk consumption.

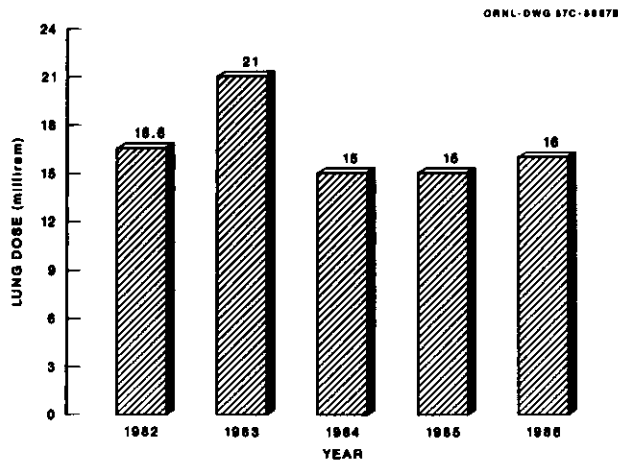


Fig. 11.3.2. Lung organ dose from inhalation pathway.

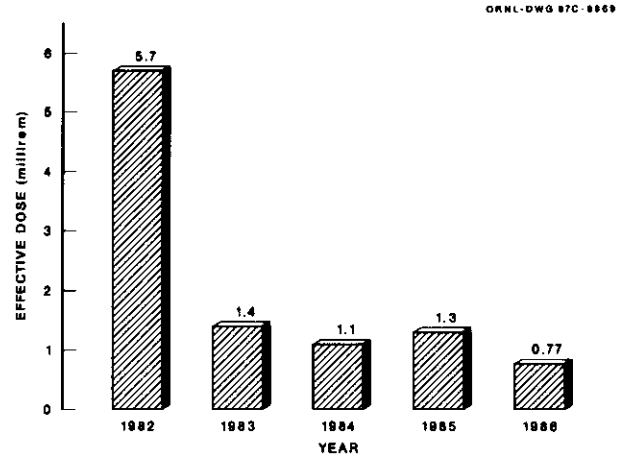


Fig. 11.3.5. Effective dose from ingestion of fish.

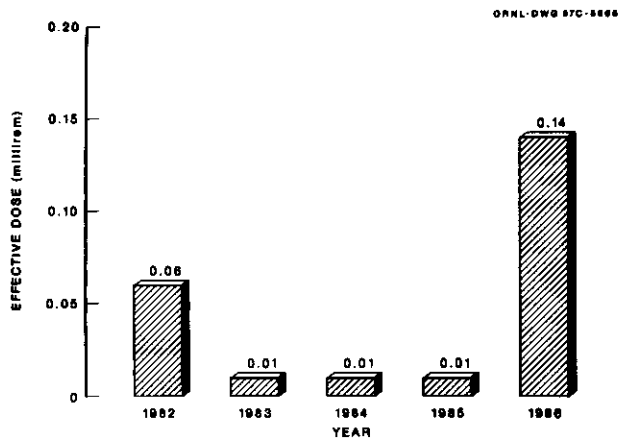


Fig. 11.3.3. Effective dose from milk consumption.

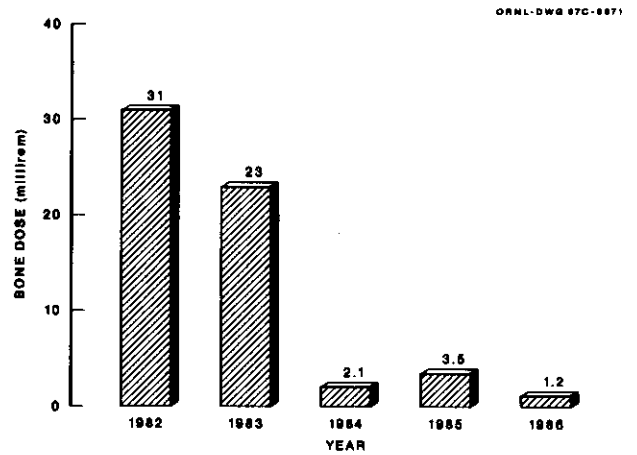


Fig. 11.3.6. Endosteal bone dose from fish ingestion.

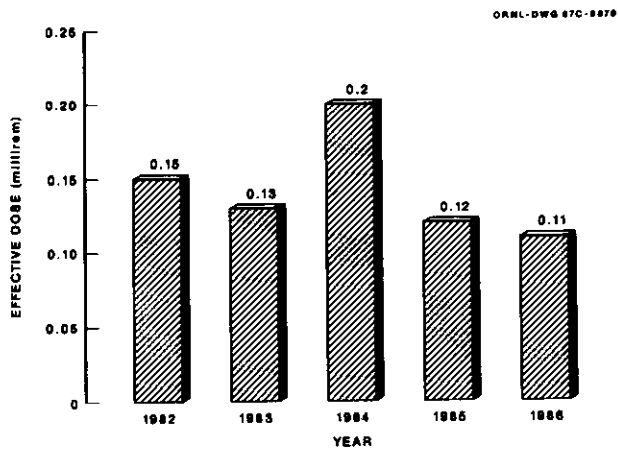


Fig. 11.3.7. Effective dose from water (Kingston) consumption.

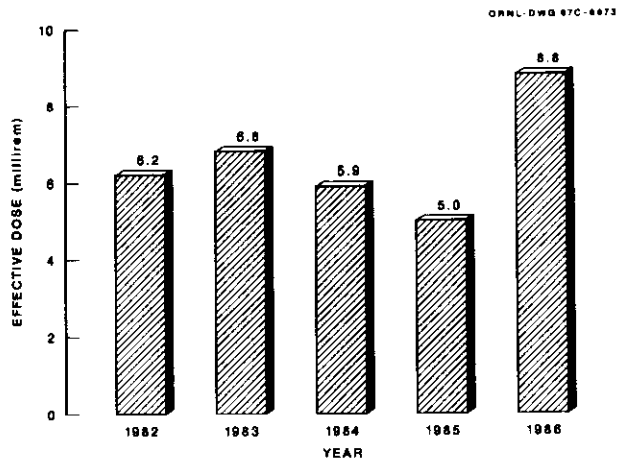


Fig. 11.3.9. Whole-body doses from direct radiation.

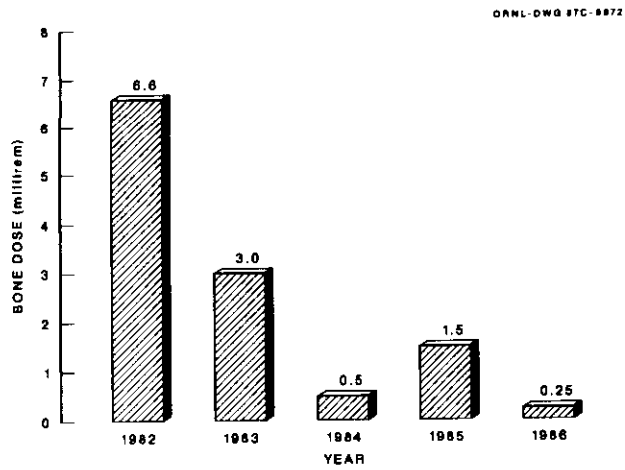


Fig. 11.3.8. Stomach wall dose from water (Kingston) consumption.

## 12. SPECIAL STUDIES, UNUSUAL OCCURRENCES, REVIEWS, AND AUDITS

### 12.1 SPECIAL STUDIES

#### 12.1.1 K-1501 Steam Plant Opacity Compliance

On December 18, 1985, a quality assurance task team was appointed to review the opacity noncompliance problems at the ORGDP K-1501 steam plant and make recommendations that would bring the plant into 100% compliance with Tennessee air emission standards. The team was made up of representatives from the Utilities, Environmental Management, Engineering, Process Support, and Maintenance organizations. When two electrostatic precipitators were installed in 1978, the plant was in compliance until numerous problems were experienced. Although each of the problems was corrected individually and overcome to some extent, the result had been a less-than-consistent compliance record. As a result of the shutdown of the gaseous diffusion process, a 25% reduction in the ORGDP steam demand occurred in early FY 1986. Base-loading natural gas and the efforts of the task team to improve compliance during coal firing resulted in a 70% reduction in noncompliances in FY 1986. The team reviewed six alternatives and recommended the installation of two 18,000-kg/h wood-fired boilers as the most economical compliance option.

#### 12.1.2 Biological Monitoring and Abatement Program for Mitchell Creek at ORGDP

On September 15, 1986, a modified NPDES permit was issued for ORGDP. As specified in Part III (L) of the permit, a plan for biological monitoring of Mitchell Branch (K-1700 stream) shall be submitted to EPA and TDHE within 90 days of the effective date of the permit modifications. The Biological Monitoring and

Abatement Program (BMAP) was developed to meet this requirement.

The proposed program will be conducted for the duration of the modified NPDES permit; it is based on preliminary discussions held on October 14-15, 1986, between staff of ORNL and ORGDP, EPA, and TDHE. Because the composition of existing effluent streams entering Mitchell Branch will be altered shortly after the modified NPDES permit is issued, baseline (pre-operational) conditions in Mitchell Branch may exist only for the next few months. Consequently, preliminary sampling of the benthic invertebrate and fish populations was initiated in August and September 1986, respectively.

The overall strategy of the BMAP is to use the results obtained in the initial characterization studies to define the scope of future monitoring efforts. Such efforts may require more intensive sampling than initially proposed in some areas (e.g., additional toxicity testing if initial results indicate poor survival or growth) and a reduction in sampling intensity in others (e.g., reduction in benthic invertebrate sampling frequency from monthly to bimonthly or quarterly after the first year). By using the results of previous monitoring efforts to define the needs and short-term goals of future studies, an effective, integrated monitoring program can be developed to assess the impacts of ORGDP operations on the ecological integrity of Mitchell Branch.

#### 12.1.3 Study of the Level and Extent of PCB Contamination in Bear Creek Valley: Status Report

To determine the scope and extent of PCB contamination in Bear Creek Valley, approximately 400 soil and sediment samples

were collected and analyzed at the ORGDP analytical laboratory during 1986. Objectives of the sampling program were (1) to confirm conclusions of earlier analytical data, where available; (2) to determine PCB distributions in areas that had not previously been investigated; and (3) to provide boundaries of the linear and vertical extent of contamination likely to require remediation. Areas investigated included the Oil Landfarm, areas of visible oil seepage in the BCVWDA; the bottoms and environs of the Oil Retention Ponds; and channels and floodplains of tributaries draining the BCVWDA.

Approximately 200 samples were collected in a stratified random sampling design from the Oil Landfarm. PCB levels ranged up to approximately 60 mg/kg. Several areas visually contaminated with oil and grease exceeded the proposed action limit of 25 mg/kg. Generally, contamination above 2 mg/kg was restricted to the upper 15 cm.

Results of sampling and analysis from the BCVWDA have been presented in a draft report. At the four areas of visible oil seepage, PCB levels ranged from <1 mg/kg at a seepage area north of the walk-in pits in BG-C to 550 mg/kg in a seep on the northwest corner of BG-A (north). Levels in the stream channel between this seep and Oil Retention Pond 1 remained above 250 mg/kg. In Pond 1, PCBs ranged up to 880 mg/kg in cores taken from the bottom sediments. Contamination above 25 mg/kg extended to a maximum depth of 66 cm. In the Tributary 7 floodplain downstream from Pond 1, concentrations as high as 570 mg/kg were detected, apparently due to past deposition of contaminated sediments.

Levels in Tributary 8, which drains BG-C and -D, were elevated above 25 mg/kg at the confluence with Bear Creek, possibly as a result of inputs from two visible seeps on the south side of BG-C. Tributary 6 sediments downstream from Oil Pond 2 did not contain PCB levels above 25 mg/kg, although sediments around Pond 2 contained PCBs as high as 170 mg/kg.

Based on PCB profiles, the total volume of soil and sediment in the Oil Retention Ponds and tributaries contaminated above the proposed

25-mg/kg action limit was estimated at 1400 m<sup>3</sup>. The volume of the seep on Tributary 7 that exceeds this limit was estimated as an additional 90-450 m<sup>3</sup>.

#### 12.1.4 Investigations of Coal Ash Disposal Operations at the Oak Ridge Y-12 Plant

The Oak Ridge Y-12 Plant disposes of coal ash from its steam production operations in a slurry form through a filled ash retention impoundment on the southern slope of Chestnut Ridge, through the emergency spillway of the impoundment dam, and into McCoy Branch. McCoy Branch then flows into Rogers Quarry, where ash solids and sluice water are separated by sedimentation. In 1986 the State of Tennessee and EPA requested that the Oak Ridge Y-12 Plant characterize the discharge of ash slurry to McCoy Branch. In addition, the Oak Ridge Y-12 Plant requested that a limnological investigation be conducted by ORNL to determine the nature of pH variations in the effluent from Rogers Quarry.

The results of the ash slurry characterization indicated that ash sluice water entering McCoy Branch below the emergency spillway is typical of raw ash sluice water generated at many coal-fired power plants. The filled ash retention impoundment is providing little or no treatment to remove suspended ash or to attenuate large fluctuations in the concentrations of other pollutants. A spring located immediately below the dam showed evidence of groundwater inputs of ash-derived pollutants (e.g., sulfate) but also provided additional alkalinity to buffer the somewhat acidic reaction of Oak Ridge Y-12 Plant fly ash. Nonetheless, the flow of the receiving stream (McCoy Branch) is so small (10% of the ash sluice water flow) that it is incapable of providing appreciable dilution of the ash sluice water. No removal of suspended ash solids occurs until the ash sluice water enters Rogers Quarry. Rogers Quarry, with a water volume estimated at 1000 million liters and an average daily inflow (including ash sluice water) of about 3.8 million liters, provides a very effective settling basin for suspended ash solids.

The discharge from the quarry is currently

permitted under the NPDES and has nearly always been in compliance with the permit. The exceptions have consistently involved pH and prompted the limnological investigation of the quarry completed in 1986. Historical records of pH measurements in the effluent from Rogers Quarry show a consistent pattern of excursions above pH 8.5 (the NPDES upper limit value) during warmer months of the year. Water quality measurements throughout the entire water depth of the quarry in 1985 and 1986 showed that pH values above 8.5 were restricted to the upper few meters of the water column and that algal biomass (as indicated by chlorophyll-a measurements) was high in surface waters. A laboratory study of Oak Ridge Y-12 Plant coal ash showed that ash being sluiced to Rogers Quarry is somewhat acidic (pH <7) in character and reduces the acid neutralizing capacity (ANC), but not the pH, of quarry influent water. The reduced ANC of quarry influent water appears to increase the sensitivity of quarry surface waters to photosynthesis-driven pH fluctuations and permits pH to increase above the NPDES limit value when algae are growing rapidly in quarry surface water. However, water quality measurements in Lamberts Quarry, which is located north of the Oak Ridge Turnpike at the west of Oak Ridge and which receives no wastes, has also exhibited elevated pH values (up to pH 8.5) at water depths associated with increased algal abundance.

Results of the limnological investigation clearly implicated high algal growth in Rogers Quarry as the cause of occasional pH excursions above the NPDES limit value of 8.5. Algal blooms in the quarry appear to be related to excessive concentrations of soluble phosphorus that occur in Rogers Quarry but not in Lamberts Quarry. The source of the excessive concentrations of soluble phosphorus is unknown at present, but leaching from the coal ash that is sluiced to Rogers Quarry is strongly suspected. Alternative remedial actions (1) to reduce the pH excursions in the short term and (2) to eliminate ash discharge to McCoy Branch and Rogers Quarry in the long term are currently being evaluated.

### 12.1.5 Results of East Fork Poplar Creek Floodplain Sampling for RCRA Testing

High concentrations of mercury, uranium, and certain other contaminants have been measured in floodplain deposits of EFPC. A major environmental issue to be resolved by the Oak Ridge Task Force and DOE concerns how these and similar historical deposits should be handled to ensure protection of human health, fish, and wildlife. Central to this issue is the degree of environmental mobility, bioavailability, and toxicity of the contaminants in these deposits. These factors are being addressed by the Task Force and others. In 1986 the Task Force requested application of the EPA's RCRA extraction procedure (EP) to selected floodplain deposits for the purpose of comparing results with RCRA maximum allowable concentration limits (MCL). The EP entails the extraction of 100 g of waste in 2 L of water held at pH 5.0 with acetic acid for 24 h. Concentrations of eight metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) and several herbicides and pesticides in the resulting leachate are then compared with standards promulgated under RCRA. Wastes that yield leachate concentrations exceeding the MCL for any listed contaminant are classified as toxic, and therefore hazardous, under the RCRA.

The selection of EFPC floodplain sampling localities for EP testing was biased toward sites with the highest observed levels of contamination under the assumption that sites with lower levels would not yield concentrations in the EP test higher than sites with the highest concentrations of contaminants. Locations for sampling were selected by determining where in the EFPC floodplain the maximum concentrations (mg/kg) of each metal on the RCRA list had been observed by the sampling and analysis program of Oak Ridge Associated Universities. Although the maximum concentrations of each metal did not occur in the same sample, or even at the same site, they did occur in two general areas of the EFPC floodplain: the reach between EFPC km 21.57 and 22.70 and the reach between km 16.42

and 18.24. These two areas represent, respectively, the extensive floodplains behind the National Oceanic and Atmospheric Administration/Atmospheric Turbulence and Diffusion Laboratory (NOAA/ATDL) facility on Illinois Avenue and adjacent to the Oak Ridge Turnpike between Jefferson Avenue and Louisiana Avenue.

Samples for EP testing were collected by excavating a shallow pit at six locations identified previously (ORAU data) as exhibiting the highest metal concentrations. To confirm the presence of expected high concentrations of mercury, cadmium, and other contaminants in the samples collected for EP testing, a homogeneous subsample was analyzed for the total content of each RCRA metal. The EP test was performed on each sample in accordance with EPA Method 1310.

Results of the EP testing are summarized in Table 12.1.1 along with the maximum total soil concentrations observed for the eight metals. The data for total metal concentrations indicate that the six samples were quite representative of the highest concentrations of contaminants observed earlier by ORAU. None of the samples yielded EP leachate concentrations of any contaminant

that approached or exceeded RCRA MCL values. The highest leachate concentration of mercury (0.021 mg/L) occurred in the sample containing the highest total mercury concentration (3100 mg/kg), but the leachate value was only 10% of the RCRA MCL and represented only 1.4% of the total mercury in the sample. Other contaminants that appeared in the EP leachates in measurable amounts included barium, cadmium, and lead, but none of these exceeded 10% of the MCL. These results indicate that the EFPC floodplain deposits would not be classified as hazardous under RCRA.

#### 12.1.6 Oak Ridge Y-12 Plant Stack Radiological Monitoring Project

In October 1985, the Oak Ridge Y-12 Plant initiated a major project to significantly upgrade its radiological stack monitoring capabilities from approximately 85 exhaust stacks serving areas where enriched or depleted uranium is processed. Significant progress was realized in the stack radiological monitoring project throughout 1986 as project design gave way to actual construction and startup of new emissions sampling and monitoring equipment.

**Table 12.1.1 Summary of RCRA extraction procedure results for EFPC floodplain deposits**

	Maximum total content (mg/kg)	RCRA MCL (mg/L)	Maximum EP value (mg/L)	MCL (%)
Arsenic	20	5.0	<0.005	<0.1
Barium	2900	100	2.4	2.4
Cadmium	48	1.0	0.088	8.8
Chromium	115	5.0	<0.01	<0.2
Lead	2600	5.0	0.375	7.5
Mercury	3100	0.2	0.021	10.
Selenium	<15	1.0	<0.005	<0.5
Silver	32	5.0	<0.01	<0.2
2,4-D <sup>a</sup>		10.	<0.002	<0.02
Endrin		0.02	<0.0001	<0.5
Lindane		0.4	<0.00002	<0.005
Methoxychlor		10.	<0.00008	<0.0008
Silvex		1.0	<0.0002	<0.02
Toxaphene		0.5	<0.002	<0.4

<sup>a</sup>Samples were not analyzed for total content of pesticides and herbicides.

The Oak Ridge Y-12 Plant has historically operated a large number of exhaust ventilation systems that serve areas where enriched or depleted uranium is processed. Emission control equipment is employed on the majority of these exhaust systems to ensure that emissions are minimized. A number of projects are under way or planned to provide additional emission controls to reduce emissions to ALARA levels. However, only those exhaust systems that serve major Oak Ridge Y-12 Plant processing operations have been routinely sampled in the past. The purpose of the Stack Radiological Monitoring Project was to provide an appropriate and consistent level of emissions monitoring capability from all Oak Ridge Y-12 Plant uranium processing exhaust stacks to demonstrate compliance with recently promulgated NESHAP regulations for radionuclides.

The strategy employed was to upgrade all uranium processing exhaust stacks to meet accepted EPA criteria for particulate stack sampling (40 CFR Pt. 60, Appendix A, Method 1). Permanent stack sampling access platforms were constructed at prescribed locations to facilitate emissions sampling. The stack upgrade project involved the construction of new exhaust stacks at numerous locations throughout the installation. To accurately characterize emissions from the newly modified stacks, the stack sampling services of the ORGDP Systems and Equipment Technology Department were contracted to the Oak Ridge Y-12 Plant. Approximately 75 EPA Method 5 stack samples were conducted on the uranium processing exhaust stacks in 1986 and approximately 50 additional stack samples were taken to determine particulate size distribution of the stack emissions.

In addition to upgrading the uranium processing exhaust stacks to facilitate periodic stack sampling, the Stack Radiological Monitoring Project also completed installation of new continuous emissions sampling equipment on all radiological stacks in late 1986. While the periodic EPA-approved stack samples are intended to accurately quantify or "benchmark" the normal emission rate, the continuous sampler

is intended to measure the stacks' relative emission rates and ensure that benchmarked levels are not significantly exceeded.

While the primary emphasis of the Oak Ridge Y-12 Plant effort was to upgrade emission monitoring facilities to allow demonstration of compliance with new EPA NESHAP regulations, efforts were also directed toward utilizing the monitoring system for risk reduction purposes. By periodically replacing the stack sampler filter papers for routine laboratory analysis, the relative stack emission rate can be determined. Statistical control limits can be employed to ensure that stack emissions have not significantly increased over expected levels. On the majority of the stacks, the use of control limits applied to routine stack sampling laboratory analysis is an acceptable and appropriate level of reducing the risk of a significant emission release. However, the Oak Ridge Y-12 Plant does operate a number of exhaust stacks that provide ventilation to large uranium processing areas. On these stacks, a higher level of risk reduction against accidental releases was desired. Therefore, the continuous stack sampling system was modified by installing a "real-time" radiation detector next to the sampler filter assembly. The radiation detector is designed to continuously monitor the accumulation rate of the uranium on the sample filter paper and to alert the operating department of any significant uranium emissions increase (which could potentially occur as a result of failure of emission control equipment, fire, etc.). Although the real-time stack monitors have limited operating history at the Oak Ridge Y-12 Plant, their use to minimize risk associated with potential accidental airborne releases is intended to accent the overall radiological stack monitoring program. Efforts will continue in 1987 to assess the ability to accurately monitor the Oak Ridge Y-12 Plant stacks on a real-time basis and collect accurate emissions data from all radiological exhaust stacks.

#### **12.1.7 Radiological Air Monitoring Strategy at the Oak Ridge Y-12 Plant**

In February 1985, EPA promulgated standards for radionuclides in the Federal Register final

NESHAP regulations. The new NESHAP regulations not only established maximum allowable dose limits for airborne radioactivity released from DOE federal installations, but also set forth provisions requiring each facility to demonstrate its compliance status to EPA. Each DOE installation is now required to quantify and defend estimates of airborne radioactivity to regulatory agencies under Section 112 of the Clean Air Act.

The Oak Ridge Y-12 Plant, like many other DOE facilities, has several hundred point sources of exhaust air from production equipment and process areas. Approximately 85 of these exhausts are potential sources of airborne radioactivity and are potentially regulated under provisions of the new EPA NESHAP regulations.

Continuous real-time monitoring of radiological exhaust stacks is an important part of efforts under way at the Oak Ridge Y-12 Plant to reassure the public and the regulators that emissions are being controlled. Real-time radiation stack monitors can be used to detect emission excursions that may result from process upsets or other unusual conditions (e.g., failure of emission control equipment). Immediate corrective actions can be initiated, and a potential significant release of radioactive material may be prevented.

In practice, the real-time radiological monitoring of production area exhaust stacks proves difficult. The presence of highly variable concentrations of naturally occurring radon and radon daughter products can result in an excessive number of false alarms or an unacceptably high monitor detection sensitivity. The presence of dirt, oils, and corrosive acid fumes common to many production exhaust streams also presents significant technical challenges that must be considered in design.

#### **12.1.8 Stack Monitor Evaluations at the Oak Ridge Y-12 Plant**

Uranium particulate detection is to be monitored using a thin (0.1-cm-thick) sodium iodide scintillator. The sensitivity of the detector allows detection of X rays from 6 to 60 keV.

Enriched uranium is of primary concern because of the 1%  $^{234}\text{U}$  present. This isotope emits L-shell X rays in the 10- to 20-keV energy band. Radon daughters show activity in the 40- to 60-keV band. Filter papers of collected enriched uranium have been counted, as have radon-contaminated papers. A factor correcting for radon contamination of the uranium window has been generated for preventing radon activity from mistakenly causing false alarms.

#### **12.1.9 Oak Ridge Y-12 Plant Airborne Mercury Monitoring Program**

During 1986 the Oak Ridge Y-12 Plant initiated an on-site airborne (ambient) mercury monitoring program. This program has been established to provide a historical database 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 coal at the steam plant, and fugitive exhaust from Building 9201-4, a former lithium isotope separation facility that is contaminated with mercury.

With the assistance of the ORNL, the Oak Ridge Y-12 Plant has established four ambient mercury sampling stations. Sampling locations include ambient air stations A62 and A68 on the east and west ends of the site and two mobile stations near Building 9201-4 and the steam plant. Four additional mercury sampling stations are planned in 1987. Airborne mercury is collected by pulling ambient air through a Teflon filter followed by a flow-limiting orifice and a charcoal sampling tube. Particulate mercury is collected for 28 days on the Teflon filter, and mercury vapor is collected for 7 days in the charcoal absorber. The flow-limiting orifice is used to restrict air flow to less than 1000 mL/min.

Mercury collected on the filters and charcoal absorbers is analyzed by cold vapor atomic absorption spectrophotometry after digestion in nitric-perchloric acid. Average air concentration during the period of sample collection is



calculated by dividing the total quantity of mercury collected on the charcoal and filter by the total volume (uncorrected for STP) of air sampled.

Table 12.1.2 shows the maximum, minimum, and average concentrations of airborne mercury at the four sampling locations in 1986. The results indicated that on-site airborne (ambient) mercury concentrations are well below the EPA NESHAP guideline for mercury in ambient air of  $1 \mu\text{g}/\text{m}^3$  (30-day average) 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 four sites. Concentrations of particulate mercury measured since September 1986 have been less than  $0.001 \mu\text{g}/\text{m}^3$ .

**Table 12.1.2. 1986 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. A62 (east end of plant)	7/18-12/30	0.058	0.003	0.011
Ambient No. A68 (west end of plant)	8/12-12/30	0.034	0.002	0.017
Building 9404-13 (SW of Building 9201-4)	7/15-12/30	0.200	0.033	0.110
Building 9805-1 (SE of Building 9201-4)	9/23-12/30	0.140	0.026	0.071

#### 12.1.10 Oak Ridge Y-12 Plant Surface Characterization Project

The Oak Ridge Y-12 Plant Surface Characterization Project was initiated in late 1985 and completed in 1986. 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, it was decided also to analyze the soil samples for mercury.

Mercury was selected because of its use in years past, its persistence in the Oak Ridge Y-12 Plant environment, and the area source nature of the mercury entering East Fork Poplar Creek. 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 database 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. These analyses are expected to be complete and the database management system operational by late spring 1987.

The survey discovered some  $^{137}\text{Cs}$  contamination on the railroad tracks outside the fence near Scarboro Road. Further investigation found additional  $^{137}\text{Cs}$  contamination on the railroad spurs to the east of Scarboro Road. Because  $^{137}\text{Cs}$  is not used in the Oak Ridge Y-12 Plant, DOE contracted with ORAU to assess the level of contamination and its impact.

#### 12.1.11 Investigation of Heavy Metal Wastes at the Oak Ridge Y-12 Plant

In June 1986, an investigation was initiated to determine whether solid waste disposal facilities at the Oak Ridge Y-12 Plant improperly received

hazardous waste. A preliminary study of lead waste management and disposition indicated that small quantities of lead metal machine turnings had been disposed of in BCVWDA after the installation gave up interim status under RCRA (November 1985). Loss of the ability to manage RCRA wastes (i.e., interim status) resulted from the decision not to file closure plans or a Part B permit application for the burial grounds by November 9, 1985; it was anticipated that the installation would not receive hazardous wastes for disposal. Subsequent efforts were undertaken to identify additional heavy metal wastes (arsenic, barium, cadmium, chromium, mercury, selenium, and silver) that were disposed in the following noninterim status facilities: BCVWDA, Centralized Sanitary Landfill II, and Chestnut Ridge Security Pits; and to determine whether the disposals of suspect wastes were in compliance with Tennessee solid and hazardous waste regulations.

Thirteen suspect solid waste streams were identified and generators ceased disposal of these suspect wastes until a RCRA hazard determination was complete. A multiphased sampling and analysis program was implemented to determine whether the wastes were hazardous. All 13 suspect streams were evaluated. Test results reveal that 8 of the 13 streams were characteristically hazardous. The volumes of all waste streams confirmed to be hazardous are minimal when compared with the total volume of wastes disposed in the facilities. The hazardous wastes are now being managed properly. Groundwater monitoring results do not reveal any heavy metal contamination adjacent to the facilities that received the wastes. A final report of the investigation and its results will be published in the near future.

#### **12.1.12 East Fork Poplar Creek Area Source Pollution Assessment**

An area source pollution assessment and control plan for EFPC is currently being prepared by Camp Dresser and McKee, Inc. The purpose of the plan is to develop a sampling program to identify and locate non-point-source discharges to

EFPC. As a part of this evaluation, 15 automatic water quality monitoring stations are being installed to sample storm sewers and EFPC flows.

Non-point-source pollution results when precipitation runoff or groundwater flows over or through contaminated surfaces. Pollutants of concern include uranium, mercury, PCBs, nutrients, solids, and heavy metals. A preliminary sampling program was conducted in the fall of 1986 to define background or "dry weather" water quality. The comprehensive sampling program, which will last approximately 12 months, will also include water quality and quantity sampling during storm events ("wet weather"). By comparing "wet weather" and "dry weather" water quality, the sources and impacts of non-point-source pollution can be evaluated and appropriate control measure taken if needed. Results of the sampling program will be evaluated and control measures, if necessary, will be developed for further implementation.

#### **12.1.13 S-3 Ponds TSP Sampling**

As the liquid in the S-3 Ponds was treated and discharged under the NPDES permit, the area began to dry, and concerns were expressed over potential air contamination and health effects from sludge dust becoming airborne. To investigate whether dry material in the ponds was becoming airborne, two high-volume particulate samplers were stationed at the east and west sides of the four-pond site. Total suspended particulates (TSP) were measured along with  $^{99}\text{Tc}$ ,  $^{90}\text{Sr}$ ,  $^{230}\text{Th}$ ,  $^{234}\text{Th}$ , and Zr. These parameters were selected as probable constituents of the S-3 Ponds sludge.

The sampling schedule was set for 24 hours every 3 days and began on January 23, 1986. Although data are currently being assessed by various organizations, a preliminary review indicates a definite reduction in particulates and in all other parameters throughout the year. These reductions coincide with the grass seeding of the site and stabilization of the sludges. As a result of the preliminary review, the sampling schedule has been reduced to 24 hour every 6 days to coincide with the two regular TSP samplers at the Oak Ridge Y-12 Plant.

#### **12.1.14 Investigation of Subsurface Mercury at the Oak Ridge Y-12 Plant**

An investigation of the fate of spills and leaks of elemental mercury that occurred in the past at the Oak Ridge Y-12 Plant has been carried out through a multiphased well installation and soil boring program. The overall program resulted in the installation of a 43-well monitoring network and the analysis of 430 soil/mud and 113 groundwater samples for mercury content. Results of mercury analyses of soils and fill indicate that high concentrations (up to 1% by weight) of mercury occur in the shallow soil and fill at several sites within the installation, but the estimated total quantity located (~3150 kg) represents only about 2% of the amount estimated to have been lost to the ground. Additional quantities of mercury may exist in the extensive cavity system underlying much of the installation. Estimates are based on analysis and known solubility of mercury in water compared with knowledge of spills, leaks, and soil contaminant levels. Results of mercury analyses of groundwater indicated that mercury does not appear to be moving in significant quantities in an aqueous phase; the highest soluble concentrations found (~1 µg/L) were limited to three wells. The analyses of the groundwater samples from the total well network for other chemical constituents revealed the presence of several contaminant plumes within the installation, including sulfates from a large coal pile, nitrates from liquid waste disposal operations, and chlorides from several sources, as well as general increases of electrical conductance (an inorganic pollutant indicator) and alkalinity.

#### **12.1.15 Oak Ridge Y-12 Plant Waste Minimization Strategy**

The 1984 amendments to the Resource Conservation and Recovery Act mandate that waste minimization be a major element of hazardous waste management. In addition, the costs for waste treatment, storage, and disposal are high and will increase as environmental regulations become more stringent. Thus, waste

reduction and elimination must be an integral part of industries' waste management programs. Unlike traditional approaches, waste minimization focuses on controlling waste at the beginning of production instead of at the end. This approach includes (1) substituting nonhazardous process materials for hazardous ones, (2) recycling or reusing waste effluents, (3) segregating nonhazardous from hazardous or radioactive waste, and (4) modifying processes to generate less, or less-toxic, waste.

An effective waste minimization program must provide the appropriate incentives for generators to reduce their waste and provide the necessary support mechanisms to identify opportunities for waste minimization. This approach consists of four major program elements: (1) promotional campaign, (2) process evaluation for waste minimization opportunities, (3) waste generation tracking system, and (4) information exchange network.

#### **12.1.16 ORNL's Environmental ALARA Program**

The ORNL environmental ALARA program is an installation-wide effort applicable to each person, project, activity, and operation at ORNL. It is implemented at all stages of an ORNL project from initial planning to final decommissioning. A wide range of methods are used for implementing the program.

At the planning stage of a proposed project or activity, an environmental review is conducted and the review is documented at one of three levels: as an Action Description Memorandum, Activities Description Memorandum, or Environmental ALARA Memorandum. Details of the review process, decision criteria for determining the level of documentation, and mechanisms for effectively handling hundreds of projects are given in this presentation. The means for disseminating environmental ALARA information, for tracking projects, for maintaining auditable computer files, and for ensuring compliance are discussed. Sources of conflict are examined, methods that have been used for settling disputes are elaborated on, and some foreseeable problems are addressed.

### **12.1.17 Uranium Detection in and Source Separation of Oak Ridge Y-12 Plant Solid Wastes**

Calibration of the new Oak Ridge Y-12 Plant Trash Monitoring Station has been concluded and the facility placed in operation. Statistical analysis of the data obtained from the calibration studies indicates that the lower level of detection is 120 g with a  $\pm 70$ -g variability for depleted uranium at the 95% confidence level.

The facility is being used to monitor uranium contamination in solid waste collected in steel dumpsters. In addition, it has been used to "spot check" dumpsters from ORNL for the presence of cesium contamination.

In the absence of regulatory guidelines to define a below regulatory concern quantity of radioactivity, the Oak Ridge Y-12 Plant is following guidelines for the on-site burial of solid waste based on current operating limitations at the Trash Monitoring Station. Out of approximately 200 dumpster stations within the installation, approximately 20 have been found to be consistently contaminated. These dumpster stations and the generators contributing to them are the current target of the Oak Ridge Y-12 Plant's waste segregation efforts.

A pilot test program has been initiated at the Oak Ridge Y-12 Plant to determine the effectiveness of administrative control in the source separation of uranium-contaminated trash from sanitary trash. Dumpsters and trash collection containers have been designated in test areas, and waste dumpsters are being monitored to determine the effectiveness of this method of source separation. This program is currently being refined and expanded to other production buildings.

### **12.1.18 Oak Ridge Y-12 Plant Steam Plant Waste Minimization**

Methods to minimize chemical consumption, operating costs, and waste generation of the Oak Ridge Y-12 Plant steam plant were evaluated. Pilot-scale studies and modeling of process options are emphasized. Implementation of recommendations will allow estimated reductions

of 85% in chemical consumption, 90% in boiler blowdown, 6% in water consumption, 3% in coal consumption, and 50 to 90% in waste generation. The estimated return on investment is 35%. No dollar value was placed on improved environmental compliance.

The proposed process uses electro dialysis to remove 70 to 90% of the dissolved solids. Residual cations are removed by ion exchange. Next, a strong base ion exchange resin removes silica. This allows substantial reductions in boiler blowdown and in the consequent loss of heat and water. Electro dialysis reduces the chemical loading to the resin enough to make silica removal cost effective.

Finally, the plant's demineralized water system is to be supplied entirely from electro dialysis product. Currently, the system is fed half with untreated water and half with steam condensate. The recommended change will improve the quality of demineralizer feed water while allowing more recovered steam condensate to be recycled to the boiler.

### **12.1.19 Water Conservation Plan for the Oak Ridge Reservation**

The Water Conservation Plan for the ORR is part of the site development study required by DOE Order 4300.1A to ensure that maximum benefit is derived from water resources and that they are protected. The plan includes the ORR water balance, options for maximizing the efficiency of water usage, plans for the improvement and protection of water quality, and measures to curtail water usage in the event of prolonged drought.

The ORR water balance includes the water supply and wastewater discharge. There are several potential options for minimizing water use at the ORR installations: controlling water line leakages, recycling effluents, reducing once-through cooling, and installing flow meters for accurate accountability of water use. In the event of prolonged drought, water usage and wastewater discharge could be restricted. Curtailment measures range from elimination of water usage at nonessential facilities to the

extreme case of supplying water for fire protection purposes only, which would result in installation shutdown. The curtailment of waste stream discharges would require a detailed review of each discharge stream.

Water quality can be affected by discharges from the three installations and by groundwater transport of pollutants from burial grounds and landfills. The plan is to improve water quality through adequate characterization of effluents and wastes so that appropriate treatment, storage, disposal, or remedial action programs can be implemented.

#### **12.1.20 Uranium in Oil**

Machine coolant waste containing oil-perchloroethylene-PCB is currently being stored in four 18,950-L tanks on the south side of the Oak Ridge Y-12 Plant. The coolant also contains low levels of enriched uranium that must be removed before the coolant can be incinerated and disposed.

Preliminary tests showed that the uranium could not be removed by submicron filtration but could be processed to less than 0.01  $\mu\text{g/g}$  uranium by extraction with sulfuric acid.

A critically safe uranium extraction facility has been built using a 15.24-cm glass column. Sulfuric acid is the stationary phase, and the coolant flows continuously. Production data show that coolant flow rates of 0.5–1.0 L/min can be processed to less than 0.1  $\mu\text{g/g}$  uranium. The performance of the system is limited by phase separation and not by extraction coefficient, thereby allowing an extended acid life.

Plans are to install another column to increase the production capability to about 2 L/min. The contents of the tanks will be processed and stored in clean tank trucks for shipment to ORGDP.

#### **12.1.21 West End Treatment Facility: Sludge Recycle Potential**

Construction of the West End Treatment Facility (WETF) was completed in 1986, and it will soon be brought on line to treat nitrate-bearing aqueous waste streams generated at the Oak Ridge Y-12 Plant. Many of these waste

streams are acidic and are currently neutralized with lime [ $\text{Ca}(\text{OH})_2$ ] before they are biologically denitrified. During biodenitrification the nitrate is converted to nitrogen, and the by-product carbon dioxide reacts with the calcium present to form calcium carbonate. This calcium carbonate makes up about half of the sludge volume generated at the WETF, with the remainder being made up of various heavy metal hydroxides.

The sludges generated at the WETF are planned to be stored in 1.9 million-liter, above-ground tanks until a long-term solution for the mixed wastes can be identified. In the interest of minimizing interim storage requirements as well as long-term disposal costs, the potential of recycling the calcium carbonate generated in the tanks for use as a head-end neutralization medium was investigated.

#### **12.1.22 Evaluation of Carbon Sources for Biodegradation of Concentrated Nitrate Wastewater Generated at the Oak Ridge Y-12 Plant**

The Oak Ridge Y-12 Plant West Tank Farm, a biodegradation treatment facility, currently treats concentrated nitrate wastewater (3–5% nitrate) generated at the Oak Ridge Y-12 Plant. The facility primarily consists of 1.9 million-liter tanks equipped with mixers that are used as batch suspended growth reactors. Acetic acid neutralized with hydrated lime (calcium acetate) is used as the carbon source for the biodegradation process. However, partly because of the amount of lime required to neutralize the acetic acid, substantial amounts of sludge are produced that will require dewatering and disposal, possibly at a hazardous waste disposal facility. Such costly handling and disposal justifies consideration of alternative carbon source feed materials that will reduce sludge production.

A laboratory study of the denitrification process is in progress to determine and compare denitrification rates and sludge production of batch reactors fed with calcium acetate, methanol, and sucrose. The study involves using laboratory-scale reactors approximately 40 L in

volume for modeling the bionitrification process at the West Tank Farm. A composite of actual wastewater that is treated by the West Tank Farm is treated in the laboratory-scale reactors.

#### 12.1.23 The ORNL Remedial Action Program

The ORNL Remedial Action Program (RAP) was established in 1985 to provide comprehensive management of all inactive contaminated sites under ORNL control. Over 140 sites are now included in the program, ranging in complexity from inactive burial grounds and experimental reactors to individual waste storage tanks or process ponds. The sites are being collectively managed to ensure adequate consideration of site interactions and long-term decommissioning/closure alternatives. Program implementation is being focused in six principal areas: (1) preliminary assessment/site investigation of all RAP sites; (2) maintenance, surveillance, and corrective actions for sites requiring routine controls; (3) remedial investigation/feasibility studies (RI/FS) for specific site assessment; (4) technology demonstrations for potential remedial action techniques; (5) program strategy development, with primary emphasis on closure criteria; and (6) site decommissioning/closure for the Metal Recovery Facility and Fission Product Development Laboratory.

The most significant development in the RAP over the past year was the reorientation of the program from a CERCLA focus to that of regulation under the 3004(u) provision of RCRA. As part of that reorientation, an accelerated RI/FS effort is now under way, with plans to use a major subcontractor for the majority of that work. Other major activities conducted in FY 1986 include initiation of a comprehensive groundwater well installation program; implementation of characterization efforts at SWSA 6, White Oak Creek/Lake, and the hydrofracture facilities; and demonstration of in situ grouting and vitrification techniques for corrective applications.

#### 12.1.24 Witherspoon, Inc., Cleanup Project

The overall objective of this project was to assist Witherspoon, Inc., in the removal of

contaminated material at a site in Knoxville. The material consisted of metal, drums of dirt, and contaminated dirt under the metal and drums. The DOE, after agreeing with the state to accept the material, instructed Energy Systems to take the lead role in coordinating metal removal directly with Witherspoon, Inc. Personnel from ORGDP coordinated the project, which was divided into three phases: metal removal and storage at ORGDP; drum sampling, removal, and storage at ORGDP; and contaminated dirt removal and storage. Phase I has been completed. Originally, Phase I was estimated to involve 75 tons of metal and take 3 days to complete. This evolved into 329 tons and 4 weeks to complete. Factors leading to this underestimation were inadequate metal-handling equipment available at Witherspoon, underestimation of the amount of contaminated material because of insufficient surveying, and the subsequent discovery of substantial amounts of asbestos and yellow cake.

#### 12.1.25 Precipitation of Heavy Metals by a Mixed Culture Containing Sulfate-Reducing Bacteria

Sulfate-reducing bacteria are ubiquitous soil organisms that play a role in the natural cycling of sulfur by sulfate respiration, which reduces sulfate to sulfide. However, when sulfate is limiting and heavy metal ions are present, these organisms can methylate the metal ions, which may be used for assessment of heavy metal contamination. Sulfate reducers are unable to grow in the presence of oxygen. However, a natural mixture of a sulfate reducer and *Citrobacter* has been isolated in which the growth of *Citrobacter* removes oxygen from the microenvironment, making it possible for the sulfate-reducing organism to metabolize sulfate to sulfide. Growth of the sulfate-reducing mixed culture in media contaminated with heavy metals such as mercury, cadmium, or lead causes precipitation of those metals. The precipitate is not closely associated with the cells. The organisms are resistant to the toxic effects of heavy metals and will grow and precipitate mercury at initial concentrations of at least 100 ppm. Bacterial sulfate reduction might be used in

waste treatment to remove dissolved toxic heavy metals, or it might be effective in contaminated soils. Amendment of contaminated soils with appropriate nutrients to enhance sulfate respiration could both immobilize metals by precipitation and also inhibit the formation of soluble, toxic organometal complexes such as methyl mercury.

#### **12.1.26 Characterization of Bacterial Strains Isolated from Soil Contaminated with Industrial Pollutants**

Because of their rapid growth rate and diversity of enzymatic profiles, microorganisms are able to adapt quickly to a variety of adverse environmental conditions. It is possible, therefore, that strains of bacteria that are resistant to specific industrial pollutants can be isolated, cultivated, and utilized to help control the spread of environmental contaminants. Four strains isolated from soil sampled near an industrial plant in Oak Ridge, Tennessee, were supplied by Oak Ridge Research Institute. This study initiates the characterization of these strains for a number of growth parameters. Limited morphological and biochemical characterization has enabled us to describe various complex and chemically defined media suitable for laboratory cultivation of these strains. We have determined from the rate of accumulation of RNA and protein versus growth rate that these strains exhibit balanced growth. The adjustment of the rate of RNA and protein accumulation to growth rate indicates that these strains have maintained a mechanism for the global control of macromolecular control to certain small, unidentified nucleotide phosphates.

It is hoped that these data will aid in assessing the ecological impact of environmental contaminants and will suggest approaches to biological control.

#### **12.1.27 Integrated Testing for Environmental Facilities**

Testing is required to verify that a facility has been constructed according to design and that it is capable of accomplishing its particular mission.

Four phases of testing have been defined: vendor, installation, preoperational, and operational. Integrated testing delineates the scope of each phase and the responsibilities of the contractor, the engineering organization, and the operating organization of each phase. The specifications of vendor and installation testing (including definition of test procedures and pass/fail criteria) and development of preoperational and operational test plans and procedures are also formalized.

The implementation phase of the testing includes the sequential order in which various engineering disciplines must proceed with their testing; scheduling; manpower coordination between engineering, operations, and maintenance organizations; the need for establishment of a dedicated checkout coordinator; and development of a system for tracking the progress of the testing and preparation of punchlists.

#### **12.1.28 Developmental Checkout Plan for the Oak Ridge Y-12 Plant Uranium Chip Oxidation Facility**

A flash fire occurred during startup testing of the Uranium Chip Oxidation Facility at the Oak Ridge Y-12 Plant. Operations at the facility were halted, and a detailed safety review was made. Recommendations from the safety review led to equipment modifications. A developmental test plan was required to prove the new equipment design and to set upper operating parameters.

#### **12.1.29 Successful RCRA Closure at ORGDP**

Past practices at the Oak Ridge Gaseous Diffusion Plant for handling hazardous waste materials called for their storage within the K-1070-D1, -D2, and -D3 drum storage dikes. These areas were used for the staging, sampling, and storage of 208-L drums of waste solvents and oil. Upon completion of the K-1425 waste oil/hazardous waste/PCB storage facility, the use of the drum storage dikes was discontinued. A closure plan was submitted to the state to propose the proper method for closing the diked areas. This proposal included the removal of the hazardous waste inventory followed by an

extensive soil sampling survey and methods for closing the areas. The plan was approved May 12, 1986. The analysis results showed that there were no RCRA-hazardous constituents in the soil, so no excavation was required. The areas were backfilled with dirt, contoured, compacted, graded, and seeded to provide proper drainage and erosion control. Upon completion of these items, a state-registered professional engineer certified that the areas were closed in accordance with the state-approved closure plan. DOE must now certify the closure and submit it to the Commissioner of the TDHE and the Regional Administrator of the EPA. This is the first DOE-Oak Ridge Operations closure plan to be approved and completed under the RCRA rules governing hazardous waste management facilities in Tennessee.

#### **12.1.30 Screening of Mercury, PCBs, and Volatile Organics in Soils To Be Excavated for Construction of PIDAS at the Oak Ridge Y-12 Plant**

There is a need to develop analytical screening capabilities for a variety of chemical pollutants in soil and groundwater. Screening methods can provide rapid, low-cost measurements of selected chemical pollutants in comparison with standard EPA methods. The near-real-time field measurement capabilities of some coarse screening techniques are particularly useful for worker protection and applications requiring rapid assessment of pollutant concentration and spread. The installation of a perimeter intrusion, detection, and alarm system (PIDAS) at the Oak Ridge Y-12 Plant has provided such an opportunity for screening of mercury, PCBs, and volatile organic compounds (VOCs) in soil to be excavated during construction of PIDAS. The sampling plan for the PIDAS route attempts to account for lateral and vertical displacement of mercury, PCBs, and VOCs in soils. Substantial uncertainty exists concerning the degree of mixing of surface soils because of earlier construction and the number, location, and age of chemical spills. The project goals are to (1) provide an assessment of pollutant concentrations along the PIDAS route and (2) alert PIDAS officials to areas of significant contamination.

#### **12.1.31 Utilization of the Toxic Substances Control Act Incinerator at ORGDP**

After a schedule extension to accommodate EPA concerns with the RCRA Part B permit submission for the TSCA Incinerator at ORGDP, routine processing of materials from ORO installations should begin in the second quarter of FY 1988. Waste feed acceptance criteria are based on system and effluent treatment design. The present waste feed characterization includes types of waste, inventories, and generation rates at the ORO installations. Finally, additional work is planned to optimize system utilization within the constraints of available storage, regulatory time limits on retention, and management directives.

#### **12.1.32 Upgrade of the Process Waste Treatment Plant at Oak Ridge National Laboratory**

Process wastewater that is slightly contaminated with  $^{90}\text{Sr}$  and  $^{137}\text{Cs}$  has been routinely treated at ORNL by a filtration/ion exchange process using a strong acid cation resin. The resin becomes loaded with  $\text{Ca}^{2+}$  after a throughput of 400 bed volumes (BV) and is regenerated by elution with 2.7 M  $\text{HNO}_3$ , which is concentrated by evaporation and transferred into the ORNL LLW system for disposal. New regulations for disposal of LLW have recently prompted ORNL to upgrade these facilities and reduce the volume of LLW generated.

A wide variety of more efficient chemical precipitation techniques (needed to remove Ca and Mg ions, which compete with the radionuclides for adsorption sites on IX materials) and 17 ion exchange materials were tested in laboratory-scale screening tests. Based on these results, three process flowsheets have been developed for pilot- and full-scale testing. A plant-scale water softening unit has been installed in the existing treatment plant upstream of the columns, which extended the column life to 700–12,300 BV (mean of 3,300 BV). A treatment process in which process water is passed through a series of columns containing a chabazite type of zeolite to remove cesium and/or strontium is being tested at full and pilot scales. The loaded zeolites will be dewatered, transferred to a



disposal container, and stored for permanent disposal. This treatment process has the potential of being a simple method of concentrating radionuclides into a nonhazardous solid waste form.

Plant performance is also being improved by upgrading the existing equipment and operating procedures. An ion exchange pilot facility has been used to determine maximum loading capacities of the resins and to optimize the regeneration cycle. On-line monitoring and control systems have been installed to monitor for water hardness, total organic carbon, potassium, pH, and radioactivity.

#### **12.1.33 Waste Management Database**

A waste management database was created at ORGDP to provide a tracking system and inventories of waste generated for treatment, storage, or disposal. The system is used to track all waste-handling activities. The database attributes include generator information, description of waste, radioactive isotopes and concentrations, EPA identification number, hazardous constituents, amount of material, Department of Transportation shipping name, material category, storage location and date, and disposal location and date.

This database system will aid in the preparation of routine reports such as the annual report to TDHE and the monthly waste generation report.

The database will also provide specific information for management of the types and quantities of waste material generated for disposal. The information that management receives from this system should generate additional support in the waste minimization efforts.

#### **12.1.34 Using QA Tools To Ensure Waste Management Compliance**

The success of radioactive waste management programs is a critical factor in the operation of nuclear facilities. ORNL uses many formal QA techniques to carry out its waste management activities: QA plans, training programs, nondestructive examination, control of

nonconformances, audits, and certification package preparation. The QA methods are one means of ensuring compliance with program requirements such as federal, state, and facility regulations, orders, procedures, and waste acceptance criteria. The fundamental goals at ORNL are achievement of technical performance and careful documentation of that performance. These goals are not achieved solely through the efforts of the line organization; rather, they are achieved through the work and cooperation of numerous individuals from waste-generating and waste-managing organizations, engineering, QA, and environmental management.

#### **12.1.35 NESHAP Compliance Strategy for TSCA Incinerator**

In February 1985, EPA established radionuclides as hazardous air pollutants under the NESHAP regulations. Energy Systems became subject to the reporting requirements of NESHAP. At present, all reporting requirements are submitted to DOE, which submits the appropriate information to EPA, Washington, and EPA, Region IV. ORGDP, Energy Systems' central environmental staff, and DOE were involved with EPA, Region IV, in developing a NESHAP construction air discharge permit application for the ORGDP K-1435 TSCA Incinerator. Since that time, ORGDP has submitted one additional construction air permit application for NESHAP requirements. Using guidance from EPA, Region IV, DOE, and Energy Systems' central staff, ORGDP has established a protocol for NESHAP construction submission. This includes a format that details the following.

- Technical information describing the proposed nature, size, design, operating design capacity, and method of operation of the source, including a description of any equipment to be used for control of emissions. Such technical information includes supporting calculations.
- Radiation doses to maximally exposed persons off site and to the nearest resident determined by modeling using AIRDOS-EPA and radionuclide emissions from each facility permitted and collectively for the entire point.

### 12.1.36 Evaluation of the Sensidyne Toxic Gas Sensor for HF Vapor

In uranium feed material processing facilities operated by DOE, large quantities of uranium hexafluoride (UF<sub>6</sub>) are converted to uranium tetrafluoride (UF<sub>4</sub>), with hydrogen fluoride being formed as a by-product. Leakage or rupture of cylinders containing UF<sub>6</sub> can result in the formation of toxic HF aerosol (such as occurred recently at the Sequoyah Fuels Facility at Gore, Oklahoma). Sensitive, alarmable, real-time monitors for HF vapor could be important safety devices at such facilities. In support of the restart of the Westinghouse Materials Company of Ohio operations at Fernald, Ohio, the use of an electrochemical sensor for HF is being evaluated.

The HF alert unit is manufactured by Sensidyne, Inc., Largo, Florida. Acidic vapors diffusing through a thin, porous membrane into an internal electrolyte solution produce a galvanic response proportional to the partial pressure of the gas. Response is rapid as observed by exposure of the detector to 3 ppm of HF actuated an alarm threshold set at 2 ppm within 1 min or less. Response to higher concentrations is more rapid; in an experimental release of UF<sub>6</sub> into an enclosed volume, producing less than 40 ppm HF hydrolysis product, an alarm signal was actuated within 12 s.

The chief obstacle in using these devices as ambient air monitors is the difficulty in obtaining a reliable calibration with use of the highly reactive and nonideal gas, HF. A compatible calibration flow cell that interfaces with a commercial portable permeation tube apparatus (Kin-Tek Laboratories, Texas City, Texas) to safely transport known trace levels of HF vapor to the sensor is available.

### 12.1.37 Effluent Toxicity Testing at the Oak Ridge Y-12 Plant

In compliance with the Oak Ridge Y-12 Plant and ORNL NPDES permits and the CWA, our laboratory uses aquatic organisms to determine the toxicity of various effluents. These tests can identify toxic effluents and help control toxic

discharges to surface waters. The toxicity testing laboratory currently conducts tests to comply with such requirements as those of the Toxicity Control and Monitoring Program and the Biological Monitoring and Abatement Program. The tests can also effectively troubleshoot operational procedures that may contribute to the toxicity of the effluent.

One of the intentions of the regulators is to develop test systems that can be used to measure potential environmental impact from point-source discharges. Although this approach overcomes some of the disadvantages associated with traditional chemical analyses, a number of uncertainties relevant to the test methods and necessary assumptions make interpretation of the data very difficult. Obviously, numerous physical, chemical, and biological reactions modify the original composition of the effluent in the real world. An additional example includes the use of 7-day static renewal tests for evaluating the toxicity of periodic batch discharges. In this test, organisms are exposed to potentially toxic agents over an entire 7-day period. In the actual environment, however, the organisms may be exposed to potentially toxic agents for only a few hours. The Oak Ridge Y-12 Plant's NPDES permit stipulates that toxicity tests are to be used to determine if specific effluents discharged to EFPC upstream from New Hope Pond (NHP) are likely to contribute to chronically toxic conditions in EFPC downstream from NHP. The tests that are used compare actual toxicity of an effluent to its expected instream waste concentration, based on the stream's anticipated lowest 3-day flow with an expected return time of once per 20 years (the  ${}_3Q_{20}$  flow). This comparison includes an uncertainty factor but assumes that no losses in effluent toxicity occur as the effluent moves from the point of discharge to the outfall of NHP. The validity of this assumption remains open to question for many toxicants. In August and September, for example, water entering NHP was clearly toxic to *Ceriodaphnia*, while water exiting NHP was not. The pond also elevates the pH of the water seasonally and exports large quantities of coarse particulate organic matter to invertebrates and

decomposers in the upper reaches of EFPC. Understanding what goes on in NHP, then, is likely to have important implications both for interpreting results of toxicity tests of effluents (i.e., the Oak Ridge Y-12 Plant Toxicity Control and Monitoring Plan) and for studies downstream (the Oak Ridge Y-12 Plant EFPC Biological Monitoring and Abatement Plan).

#### 12.1.38 Effects of Biomonitoring Requirements on the Operation of a Wastewater Treatment Facility

Nitrate-containing wastewater is treated at the Oak Ridge Y-12 Plant in one of six  $1.9 \times 10^6$ -L tanks. Each tanker of wastewater is neutralized, if necessary, and placed in one of the tanks. After a tank is filled, acetate is added as the organic carbon source, and the wastewater is bionitrified to destroy the nitrate ions. Suspended solids are then allowed to settle and the decant water is processed through a precipitation/flocculation treatment before it is discharged.

A small batch of decant water was processed through the treatment facility in July 1986 and extensively sampled. The discharge water easily met all of the NPDES chemical requirements, but biomonitoring tests using the water flea *Ceriodaphnia dubia/affinis* showed that the water was marginally toxic. Laboratory studies were initiated to study treatment variations that would make the water less toxic. It was found that increasing the pH during precipitation would significantly reduce the toxicity of the discharge water. Further studies are in progress to better identify the cause of the toxicity problem.

#### 12.1.39 Removal of Mercury from Water

The removal of heavy metals to ppb levels is required by the water discharge permits for the Oak Ridge Y-12 Plant. A treatment process was developed to remove mercury from contaminated waters within the installation. Seven hundred fifty-eight thousand liters from three distinct sources were treated. Important parameters and operating conditions were determined in laboratory-scale studies. The mobile wastewater

treatment trailers were used for pilot-scale studies and for processing the contaminated waters. The trailers are equipped with pH adjustment tanks, a reactor clarifier, filters, ion exchange columns, storage tanks, pumps, and process monitoring equipment. The treatment process used prefiltration with a coarsely woven filter cloth, followed by chemical coprecipitation. The coprecipitation step included adjustment to a pH of 2 with sulfuric acid, the addition of iron sulfates as flocculants, and adjustment to a pH of 6 with lime slurry. Sodium sulfide was also added. The water was allowed to settle in a reactor clarifier and was then filtered. Next, it was treated with a chemically modified ion exchange resin and filtered through filters having a nominal pore size of  $1 \mu\text{m}$ . This treatment process was transferred to production and routinely reduced the mercury levels of the contaminated waters to  $<2$  ppb.

#### 12.1.40 Uptake of Radioactive Strontium by Sporulating Bacteria: Possible Development of Spores for Removing $^{90}\text{Sr}$ from Wastewater

Bacterial sporulation is associated with the synthesis of an organic acid (i.e., dipicolinic acid) and the uptake of calcium. The uptake and retention of calcium has been correlated to the chelation of this cation by dipicolinic acid. Other cations, such as strontium, have been shown to accumulate in sporulating bacteria, presumably as a result of chelation with dipicolinic acid. The fact that sporulating bacteria accumulate strontium provides an opportunity to explore the development of a biological waste treatment system for removing radioactive strontium ( $^{90}\text{Sr}$ ) from wastewater. *Bacillus megaterium*, isolated from  $^{90}\text{Sr}$ -contaminated soil, was used in all studies. Five-milliliter cultures were grown to sporulation for 18 h at  $32^\circ\text{C}$  in Schaeffer's medium in the presence or absence of  $^{90}\text{Sr}$ . Accumulation of  $^{90}\text{Sr}$  was determined by filtering 1-mL aliquots of culture through 0.45- $\mu\text{m}$  filters and radiochemically counting the filter immersed in scintillation fluid. All experiments were performed using three 5-mL cultures per test

(i.e., per counted and experimented) and four filtered 1-mL aliquots of culture. The removal of  $^{90}\text{Sr}$  from the culture medium was complete at concentrations ranging from  $1 \times 10^{-12}$  M to  $1 \times 10^{-4}$  M. At concentrations of  $1 \times 10^{-3}$  M, strontium removal from the medium was 20% to 50%. The removal of  $^{90}\text{Sr}$  was not affected by calcium, zinc, iron, cadmium, or lead at concentrations of  $1 \times 10^{-8}$  M to  $1 \times 10^{-6}$  M. However, when calcium was increased to  $1 \times 10^{-3}$  M, strontium removal was significantly reduced to 50%. The release of  $^{90}\text{Sr}$  from germinating spores and the uptake of  $^{90}\text{Sr}$  by spores (18-h incubation) were 20% and 70%, respectively. We have estimated that the maximum uptake of  $^{90}\text{Sr}$  per sporulating cell is approximately 0.18 pg per cell. This information is being tested in large batch cultures (i.e., 1.5 to 4 L) containing strontium. Results from these latter studies will provide the necessary information for determining the application of this system for treating  $^{90}\text{Sr}$ -contaminated wastewater.

#### 12.1.41 Continuous Automated Wastewater Analyzer

Oak Ridge National Laboratory generates highly variable process wastewaters because of the diverse nature of activities contributing wastes. Trace metals in wastewater must be determined before treatment and final discharge. To gain some reasonable knowledge of average and peak amounts of specific trace metals in the combined drainage system, continuous monitoring is essential. Impetus for the development of on-line analyzers at ORNL came from the need to know the trace metal concentrations that a new treatment plant will have to accommodate. In this case, all metals of concern (Ag, Cd, Cr, Cu, Fe, Ni, Pb, and Zn) can be analyzed at the parts-per-billion level using voltametric methods. However, no on-line devices have previously existed for continuously obtaining these measurements. We have developed a system to achieve this goal and have recently placed the first system into operation, analyzing wastewaters from the 4500 complex at a confluence point.

The on-line metals monitoring system functions as a remotely located, real-time analyzer for criteria trace metals by polarographic means. The system may be used for waste stream characterization or for control of waste treatment plant operation. Six trace metals, (Cd, Cr, Cu, Ni, Pb, and Zn) are routinely measured, and Ag and Fe could be monitored with additional apparatus.

The basic equipment, available commercially, consists of an EG&G Princeton Applied Research Corp. (PARC) Model 384B polarographic analyzer and two PARC Model 309 automatic voltametric electrodes. Two Masterflex peristaltic pumps for sample and buffer delivery, a pump activator circuit boards, and an Apple IIe microcomputer were added to this equipment. The resulting system is capable of continuous automated analysis (15-min cycle time) of a flowing wastewater stream for the six metals listed above.

#### 12.1.42 Soil Conservation Plan for the Oak Ridge Reservation

Soils on the ORR are diverse and represent a cross section of the Great Appalachian Valley of Tennessee that is situated between the Cumberland Mountains to the north and the Great Smokies and Unaka Mountains to the south. Geologic materials range from sandstones, siltstones, claystones, and mudstones to carbonate rocks. These geologic materials chemically weather to form distinctive kinds of soils. Each kind of soil has certain inherent properties that affect its use. Knowledge of these properties is important in the conservation and management of Reservation soils. Soil conservation does not imply preserving soils in a pristine state but rather using both soils and land within their capabilities without degradation. If each major soil on the Reservation is to be used in accordance with this principle, the relevant properties of each soil, from the surface down to hard rock, must be known and quantified. Data from each soil, along with the spatial distribution of soils on the Reservation, become the soils database and part of the Reservation's natural resource database.

Planning and management of the Reservation's soil and lands also involves water quality, both surface and subsurface. Natural soils have a great but finite capacity to filter and purify water as it infiltrates and percolates downward to the permanent water table. This filtration and purification capacity of the soil is largely a result of its biotic activity and the ability of clay minerals to absorb and retain. Most biotic activity is located in the upper one to two meters of the soil. Unfortunately, most waste materials are buried below this depth in what has been called the "no man's land," or that zone between the soil horizons of the soil scientist and hard rock of the geologist. The great volume of this particular soil zone is scarcely understood regarding its chemical, physical and mineralogical properties, or even its capacities for retention, filtration, and purification of the waste materials that are now being buried in it. This soil zone can also be termed the last great frontier of basic research in the earth sciences. Expanding the database of this soil zone has, or should have, a high priority. Soil scientists, geologists, and hydrologists must all work closely together to accomplish this task.

Efforts are under way to learn more of deeper soil properties, water flow pathways, and other important parameters for successful computer modeling and for predicting problems or hazards if a particular site is used or proposed to be used for the burial of waste (e.g., SWSA 6, SWSA 7, West Chestnut Ridge site, BVCWDA, and future sites yet to be designated). A soil survey of Bear Creek Valley that is currently under way will facilitate planning of future activities on this part of the Reservation. Plans are in progress to map the Melton Valley part of the Reservation that lies within Roane County. These soil surveys and soil characterization data will greatly facilitate site selection for waste disposal.

#### **12.1.43 Monitoring Plan for Characterization of White Oak Creek/White Oak Lake Watershed**

ORNL is located in the White Oak Creek (WOC) watershed, which drains an approximately 16.8-km<sup>2</sup> area to the Clinch River.

The waters of WOC are impounded by White Oak Dam at its intersection with White Wing Road (State Route 95) 1 km upstream from the Clinch River. The resulting White Oak Lake (WOL) is a 9.8-ha (24.2-acre), shallow impoundment whose water level is controlled by a vertical sluice gate that remains in a fixed position during normal operations.

In addition to natural drainage, the WOC watershed has received treated and untreated effluents from ORNL activities since 1943. Controlled releases include those from the Process Waste Treatment Plant, the Sewage Treatment Plant, and a variety of process waste holding ponds scattered throughout the ORNL complex. WOC also receives effluent from non-point sources such as solid waste storage areas and liquid and solid low-level waste pits and trenches through both surface and groundwater flow. Sediments within the watershed have sorbed the released chemical and radioactive contaminants and have subsequently accumulated in the floodplain and WOL bed. Under high flow conditions, these sediments can be carried through the dam and thus become a source of contaminant discharges to the Clinch River.

As a federally owned facility, ORNL is required to comply with all existing federal, state, and local environmental regulations regarding waste management (solid, liquid, and gaseous). Final EPA rules published July 15, 1985, incorporated changes in the RCRA of 1976 resulting from the passage of the Hazardous and Solid Waste Amendments of 1984 including a new section, 3004(u), requiring that any facility permit issued after November 8, 1984, include planned corrective actions for all continuing releases of hazardous waste or constituents from any disposal unit at the facility, regardless of when the waste was placed.

#### **12.1.44 Fiscal Year 1985 Groundwater Investigation Drilling Program at the Oak Ridge Y-12 Plant**

Groundwater investigation drilling operations at ten formerly or currently used waste disposal sites in the Oak Ridge Y-12 Plant vicinity were

completed during the period August 15, 1985, through December 20, 1985. Sites investigated were the Beta-4 Security Pit, the Chestnut Ridge Security Pits, Kerr Hollow Quarry, New Hope Pond, the Ravine Disposal Site (Bldg. 9712), Rogers Quarry, the Sludge Disposal Basin, the United Nuclear Site, a site on Chestnut Ridge south of the BCVWDA, and a site on Pine Ridge north of the BCVWDA. A total of 4 coreholes, 11 soil borings, and 55 groundwater investigation wells were completed.

The objective of the drilling program was to characterize the geology and hydrology of the sites investigated so that an effective monitor well network could be designed and installed. The basic approach followed at each of the sites investigated was first to identify the major features of subsurface geology and then to install the necessary boreholes to investigate the hydrogeologic significance of such features.

Initially, a corehole or relatively deep borehole was drilled at an updip location to determine the general components of the subsurface geology. Study of drill core, cuttings, and geophysical logs from this initial borehole allowed geohydrologically significant targets to be identified. Targets identified for investigation during the second stage of drilling at a specific site include (1) the top of the water table, (2) the interface between the base of soil and the top of weathered bedrock, (3) base of weathering in the bedrock, (4) cavity zones near the base of weathering in the top of bedrock, (5) zones of high porosity in the unweathered bedrock, and (6) fractures or fractured zones within the unweathered bedrock. After the investigatory phase was completed, groundwater investigation wells were installed to provide additional subsurface geological data and to provide data on hydrostatic heads and water quality for the shallow flow regime in soils and upper weathered bedrock zone and deep flow regimes within the bedrock below the zone of significant weathering.

#### **12.1.45 Regulatory Reference Book for Hazardous Wastes**

This reference book on hazardous waste law and regulation was compiled by the Hazardous

Waste Remedial Actions Program (HAZWRAP) in support of DOE's Office of Defense Waste and Transportation Management. The document represents an update of the original *Regulatory Reference Book for Hazardous Wastes* (DOE/HWP-7), which was issued in early 1985.

Since the compilation of the first edition of the book, drastic changes in the regulatory picture for hazardous wastes have occurred. In late 1984, Congress passed the Hazardous and Solid Waste Amendments, which greatly strengthened the RCRA and made it much more highly directive. These amendments, and the new regulations implementing them, have produced more complicated and tougher RCRA requirements and have greatly expanded the regulated community. In addition, the reauthorization process for CERCLA, though still incomplete at this time, is also likely to result in significant changes in the Superfund program. The contents of this revised reference book have been updated to provide the most current forms of the statutes and regulations.

#### **12.1.46 Database Management for the Remedial Action Program at Oak Ridge National Laboratory**

The ORNL Remedial Action Program was established in 1985 to provide appropriate corrective measures at areas contaminated with radioactive and/or hazardous chemical wastes. To achieve this goal, numerous and varied studies are being conducted to characterize the waste disposal sites, which will result in the collection of an unprecedented amount of data for the ORNL site. To manage such data effectively and efficiently, a computerized database is being developed. The database provides a unified repository for all data generated within the Remedial Action Program to allow for necessary storage, manipulation, analyses, assessment, display, and report generation.

Database management for the Remedial Action Program is documented by (1) defining the organization of the data management staff and the services provided; (2) describing the design of the database, including its management system,

organization, and applications; (3) providing examples of the current and anticipated tasks; and (4) discussing quality assurance measures implemented to control the accuracy of the data entries and the security of the data.

#### **12.1.47 Sampling of Oak Ridge Sludge Land Farming Site**

The DOE Oak Ridge Operations office and the City of Oak Ridge negotiated the land placement of treated sludge from a new city sewage treatment plant on the ORR. Deposition on this site was begun in November 1983. In March 1984, it was learned that some of the deposited sludge was contaminated with various radionuclides. The site was then extensively sampled and the source of the radioactivity was located and halted. Disposal of nonradioactive material has continued since that time. It was believed that the site had reached its maximum capacity, and a followup survey was initiated to determine if there were any environmental impacts to the placement of the sludge on the ORR.

During the summer of 1986, soil, sediment, and water samples were collected at several locations on the Oak Ridge Sludge Land Farming Site (hereafter referred to as the McCoy site), at control locations, and at the Clark Center Recreation Area to determine if these areas were contaminated and if discharge from the site was contaminating the Clinch River. Samples were analyzed for a variety of metals, organics, and radionuclides.

Results from surface water samples indicated that there were no statistically significant differences in concentrations of any of the parameters between the upstream and downstream locations. Based on these results, there appears to be no downstream contamination of surface waters resulting from runoff from the site.

Twelve water samples were collected for fecal coliform from three locations in the Clark Center Recreation Area: the cover, the boat dock area, and the swimming area. None of the individual samples nor the geometric mean from an area in

Clark Center exceeded the water quality limit for fecal coliform in bathing waters.

Groundwater was collected from one upgradient and two downgradient wells for an initial characterization. Of the 81 parameters analyzed in the samples, only 30 were above the detection limit. A review of the data indicated that for approximately half of the parameters detected, higher concentrations were measured in the upgradient well. The other half were higher in one or both of the two downgradient wells.

Soil samples were collected from three ridges and a control location within the McCoy site. In general, the concentrations of chemicals were lowest in soils from the control location, and it appeared that most of the contaminants had washed down from the slopes of the ridges to the bottom.

Single sediment samples were collected from a spring and creek running through the McCoy site and from McCoy Branch and the Clark Center Recreation Area. Samples were sieved into three particle size fractions ( $> 1$  mm, 0.1 to 1 mm, and  $< 0.1$  mm). Each fraction was analyzed for metals and anions. A slurried fraction of the original sample was also analyzed for volatile organics. These data will be used as a baseline for future sampling efforts. In general, in all sediment fractions, the highest concentrations of inorganics occurred in sediments from McCoy Branch, which could be caused by disposal of ash in Rogers Quarry. The lowest concentrations in the smallest fraction were in sediments from Clark Center Recreation Area, and the lowest concentrations in the other fractions were from the upstream locations.

#### **12.1.48 Reconnaissance of Surficial Geology, Regolith Thickness, and Configuration of the Bedrock Surface in Bear Creek and Union Valleys**

Field investigations and interpretive studies conducted in the Oak Ridge area during the past several decades have contributed to the geologic information for Bear Creek and Union valleys. The majority of these studies were undertaken in response to needs for site-specific information,

and the studies did not attempt to generalize the information for an interpretation of the geology of Bear Creek and Union valleys as whole.

To provide such information, a preliminary interpretation of the lithology, thickness of regolith, and configuration of the bedrock surface underlying Bear Creek and Union valleys was made based on geological and geophysical data from boreholes and cores in Bear Creek Valley and on the related work of other investigators. Analysis of drillers' logs and lithologic logs and comparison of these data with a topographic map indicated that topography and depth of weathering are interdependent and are ultimately controlled by lithology. Topographic patterns were, therefore, used to extend localized geologic data to a larger scale. Generalized maps of surficial geology, thickness of regolith, and configuration of the bedrock surface in Bear Creek and Union valleys were constructed based on an extrapolation of site-specific data from previous investigations. This extrapolation of information was based on the determination of trends in lithology, topography, and weathering characteristics. The maps may not be accurate locally; some averaging of data was required to establish patterns in areas where no data were available. The maps were constructed for use in defining the groundwater flow system and for indicating areas for which additional field data are needed.

#### **12.1.49 Streamflow and Specific Conductance Data for Bear Creek**

To describe the regional groundwater flow system and to evaluate the extent of any effects on groundwater resulting from activities at the Oak Ridge Y-12 Plant, discharge and specific conductance of streams in the Bear Creek watershed were measured August 13, 1985, by the USGS. These measurements were made during low baseflow conditions to describe the interaction of the stream system with groundwater.

Stream flow was measured at 87 sites along Bear Creek and its tributaries. Values ranged from 0 to 0.03 m<sup>3</sup>/s. Flow in the stream system

was assumed to be largely from groundwater discharge rather than from surface runoff. Flow decreased in a downstream direction in several channel reaches; some reaches were dry.

The discharge of Bear Creek is measured at a continuous-record station at Highway 95 by the USGS. A discharge graph of Bear Creek for August 7-14, 1985, shows antecedent stream flow recession and indicates stable stream flow conditions for measurements on August 13.

Specific conductance, measured at 107 sites along Bear Creek and its tributaries, ranged from 225 to 7600  $\mu$ Sv/cm at 25°C. Specific conductance was measured to help detect locations of groundwater discharge to Bear Creek and to distinguish between re-emergence of channel flow and natural spring flow.

#### **12.1.50 Pilot Survey of Mercury Levels in Oak Ridge**

Between 1953 and 1977 an estimated 484,000 to 1,034,000 kg of mercury was discharged into East Fork Poplar Creek, which traverses the City of Oak Ridge, from operations at the Oak Ridge Y-12 Plant. TDHE was concerned about the potential health risk from human exposure to mercury-contaminated soil and possibly contaminated fish. In June-July 1984, that agency and the Centers for Disease Control conducted a pilot study to document human body levels of mercury and to determine whether exposure to mercury-contaminated soils or consumption of fish presumed to be contaminated with mercury constituted an immediate health risk to the Oak Ridge population. Histories of exposure to mercury-contaminated soil and/or fish were collected on 2627 residents and city workers. Urine-mercury concentrations were measured for the 79 of the sample population with the highest exposure to soil and for the 99 of those with the lowest exposure. Hair-mercury concentrations were measured for 11 people with a history of eating locally caught fish and for 46 with no history of ingestion. Adjusted mean urine-mercury concentrations and mean hair-mercury concentrations were not significantly different between presumably exposed and



unexposed populations. It is unlikely that residents and city workers now exposed to contaminated soil are at risk for developing significantly higher mercury levels than unexposed populations. Urine- and hair-mercury concentrations were below levels associated with known health effects.

The report issued by the TDHE and the Centers for Disease Control recommended that the citizens of Oak Ridge should be informed of the low probability of harmful health effects from mercury as a result of current community exposure to mercury-contaminated soil and sediment and that, because of the lack of absolutely conclusive evidence, the fish ban along EFPC should continue until the final results of fisheries studies being conducted by the Oak Ridge Task Force have been completed.

#### **12.1.51 Environmental Data Package for ORNL SWSA 4, Intermediate-Level Liquid-Waste Transfer Line, and Liquid-Waste Pilot Pit**

The ORNL Remedial Action Program has determined through its review of past environmental studies that SWSA 4 continually releases radioactivity to White oak Creek and therefore requires site stabilization and remedial actions. This study assembled the available historical and environmental data on the SWSA 4 waste area grouping (WAG), which includes the 9.3-ha SWSA 4 site, the adjacent abandoned intermediate-level liquid waste transfer line, and the experimental pilot pit area. The rationale for grouping these three waste management units into the SWSA 4 WAG is the fact that they lie in the same hydrologic unit and share a common tributary to White Oak Creek.

The results of this compilation demonstrate that, although a considerable number of studies have been carried out in SWSA 4, water quality wells and continued monitoring and reporting of hydrologic data are still needed. These needs will become even more critical as remedial measures for the site are considered.

#### **12.1.52 Large-Scale Leaching of Low-Level Radioactive Wastes**

To evaluate potential releases from low-level radioactive wastes disposed of in a proposed central waste disposal facility, a large-scale leaching of low-level radioactive wastes was conducted with 208- and 314-L drums containing radioactive wastes produced at ORNL and ORGDP. Ten 208-L drums containing low-level transuranic (TRU) wastes and four 314-L overpack drums containing compacted drums from a Westinghouse-Hittman drum compaction demonstration were leached with potable drinking water in a manner that simulated the flooded conditions of a shallow-land burial site. The TRU drums selected contained less than 100 nCi/g of transuranics and less than 5 mR/h gamma radiation at the surface of the drum. Only one of the ten drums produced a leachate that contained detectable levels of alpha activity over a 27-d leaching period. Concentrations ranged from 0.05 to 0.32 nCi. Concentrations of inorganic and organic constituents in the drum leachates were also monitored. Maximum cadmium concentrations in the leachates of all ten TRU drums were equal to or, in many cases, in excess of the National Interim Primary Drinking Water Standard. However, cadmium concentrations were factors of ten below the maximum limit established by the RCRA extraction procedure leach test (1 mg/L). The major organic constituent detected in the TRU leachates was phenol, at concentrations of 1 to 2 mg/L in leachates from two of the ten drums. Other organic compounds detected in TRU leachates were phthalates, bromodichloromethane, chlorodibromomethane, chloroform, and chlorinated ethanes and ethenes. Maximum concentrations of these organic compounds were quite low, usually on the order of 0.05 to 0.5 mg/L, indicating that shallow-land disposal of these materials probably would not contaminate groundwater supplies with hazardous organic chemicals.

Only one of the overpacked drums produced leachates containing detectable concentrations of

$^{137}\text{Cs}$ ,  $^{60}\text{Co}$ , or  $^{90}\text{Sr}$  (concentrations ranging from 0.035 nCi of  $^{90}\text{Sr}$  to 0.81 nCi of  $^{137}\text{Cs}$ ) during 20 days of leaching. Another showed detectable levels of  $^{90}\text{Sr}$  (1.11 to 7.4 pCi/L), and another showed detectable levels of alpha activity (up to 1.85 pCi/L) in their leachates. Leachates from these drums were analyzed for volatile organic compounds. Leachate collected from one of these drums contained 1,1,1-trichloroethane and/or 1,2-dichloroethane in excess of 0.3 mg/L. Leachates from one of the other four overpacked drums contained from 0.05 to 0.1 mg/L of tetrachloroethene. Concentrations of volatile organic compounds decreased rapidly on continued leaching, indicating that disposing of these low-level radioactive wastes in a shallow-land burial site probably would not contaminate the groundwater.

#### **12.1.53 Sediment Contamination in Streams Surrounding the Oak Ridge Gaseous Diffusion Plant**

A survey of sediments in the streams surrounding ORGDP was conducted in 1985 and 1986 to identify sites from which pollutants have historically entered or may currently be entering the surface water. Specifically, this study identified areas surrounding the site where contaminant levels are high enough to indicate the possible presence of a contamination source (e.g., seepage from a surface impoundment).

Approximately 180 surface-sediment grab samples and three sediment cores were collected in the Clinch River-Poplar Creek system and several ponds, discharge pipes, and ephemeral streams on the site. Every effort was made to obtain samples of recently deposited material so that the results would indicate current conditions. The presence of  $^7\text{Be}$  (a naturally occurring, 53-d half-life radionuclide) was used to indicate whether the samples were of recent origin.

The samples were screened for metals with inductively coupled plasma spectroscopy, for PCBs with gas chromatography, and for other organics with gas chromatography-mass spectrometry. The samples were also analyzed for gamma-emitting radioisotopes.

Data from this study indicate that Hg,  $^{137}\text{Cs}$ , and  $^{60}\text{Co}$  in the sediments originate from sources other than ORGDP. Other sources also contribute uranium and miscellaneous organic contamination of the sediment of surrounding waterways. Within ORGDP the K-1700 stream, K-901-A chromate pond, K-710-A powerhouse, and K-1007-B pond appear to be the major sources of contamination. Principal contaminants detected in these areas were U, Cr, Ni, Cu, Ag, and PCBs.

#### **12.1.54 Field Evaluation of a Cement-Bentonite Grout and a Chlorosulfonated Polyethylene Fabric Liner in Hydrologically Isolating Low-Level Radioactive Solid Waste**

In 1981, field experiments were initiated at ORNL to demonstrate and evaluate two modifications to shallow land burial of low-level radioactive wastes as currently practiced. The two modifications selected were trench grouting with a Portland cement-bentonite clay mixture and trench lining with an impermeable Hypalon fabric. The experiments were conducted with nine 28-m<sup>3</sup> experimental trenches containing compacted low-level waste from ORNL.

Advantages of the grout treatment were thought to include (1) the ability of the grout to "fix" the waste and associated radionuclides within the confines of the trench, (2) the tendency of the grout to impede water flow through the waste trenches, and (3) the structural strength of the grout supporting the trench soil cover and preventing future trench cover subsidence. Advantages of the lining operation were thought to include (1) the relative low cost associated with lining the four sides, top, and bottom of a trench, (2) the complete hydrologic isolation of waste contained in a watertight liner, and (3) the availability of lining materials and their common use in the field of hazardous waste disposal and storage.

After approximately two years of laboratory and field testing designed to evaluate the performance of the grouted and lined trenches, groundwater monitoring has shown that standing

water is present in all nine experimental trenches (both treated and untreated). However, depth of water and water level fluctuation patterns differed according to trench treatment and were minimal in the case of the grouted trenches. Both water pump-in and water pump-out tests conducted on the lined trenches showed that the original goal of watertight liners was not achieved and that water was entering and leaving these trenches with each precipitation event. Water entering the grouted trenches was inhibited by the cement-bentonite grout backfill, as reflected in the lower values of hydraulic conductivities that were measured in these trenches compared with those in control (untreated) trenches. In examining engineering properties of the grout and liner material, it was found that no significant change in liner tensile strength or liner puncture resistance was observed in the initial 15 months of a liner aging study, indicating that there were no short-term changes in these engineering properties with field weathering. Cover subsidence has not occurred over the grouted or control trenches, while two of the lined trenches have settled 7 to 10 cm (2 to 3% of the trench depth) in the first two years. Based on these treatment evaluation tests, the cement-bentonite grouted trenches appear to offer the highest level of water protection compared with the fabric-lined and control trenches.

#### **12.1.55 Characterization of the Homogeneous Reactor Experiment No. 2 Impoundment**

A characterization study was conducted on a radioactive waste impoundment for the Homogeneous Reactor Experiment No. 2 (HRE) at ORNL to provide information for its proper disposition. The impoundment was excavated in clay soil and weathered sedimentary rock of the Conasauga Group and received low-level radioactive wastes from 1957 until 1963. In 1970, the pond was backfilled with clay soil, and the impoundment capped with asphaltic concrete, but no wastes were removed.

The mixed soil fill and sediment, approximately 4.8 m deep, were sampled by soil-boring methods. The samples were analyzed to determine if the material would classify as a hazardous waste

under RCRA. The impoundment is not regulated under RCRA because it was a land disposal unit and received no wastes after November 19, 1980. However, if the soil and sediment mixture contained RCRA-defined hazardous waste, it would be subject to CERCLA. Chemical analyses indicate that the sampled material does not contain hazardous chemical constituents above the levels permitted by RCRA regulations. The sediment was found to contain an estimated radioactivity inventory of approximately 70 Ci of  $^{90}\text{Sr}$  and 16 Ci of  $^{137}\text{Cs}$ .

Four wells for monitoring the groundwater were constructed around the perimeter of the impoundment to depths ranging from 7.6 to 9.1 m. Sampling and analyses of the groundwater will be used to determine the effect of the impoundment on the groundwater quality. Preliminary results indicate that radioactivity (gross beta resulting predominantly from  $^{90}\text{Sr}$ ) of the groundwater exceeds limits allowed by RCRA regulations.

#### **12.1.56 Characterization of the Near-Surface Radionuclide Contamination Associated with the Bathtub Effect at SWSA 4, ORNL**

If wastes are buried where the zone of saturation is close to the ground surface, such as in the humid southeastern United States, continuous contact may exist between the buried waste and the groundwater. Even in cases where the saturated zone is deeper, occasional contact may occur as the water table fluctuates. Surface water may also be a potential source of problems. During storm events, precipitation and surface runoff may collect in surface depressions and infiltrate directly into the trenches containing the buried wastes, or perched water table zones may contribute via lateral inflow. If the percolation rate for water leaving a trench is slower than the inflow rate, water will accumulate in the trench and may eventually overflow. Not considering the overflow, the water collected in the trench can result in migration of the wastes. This general pattern of trench inundation is referred to as the bathtub effect.

This study evaluated a shallow, low-level waste disposal site, SWSA 4 located at ORNL, to

determine the vertical and lateral distribution of radionuclide contamination that has apparently resulted from the bathtub effect. Earlier work had identified SWSA 4 as a significant source of  $^{90}\text{Sr}$  contamination to White Oak Creek and a recent surface-water diversion had successfully reduced  $^{90}\text{Sr}$  releases by almost 50%.

A surface survey of the low-elevation portion of the burial ground was conducted to identify areas where the bathtub effect had resulted in surface contamination. With this initial survey as a guide, 15 soil cores, each approximately 3 m deep, were taken (1) to determine the depth to which contamination had spread and (2) to help identify any contamination plumes. Results showed that two areas of surface radionuclide contamination exist, one located between the western end of the SWSA 4 tributary and the edge of the burial ground, the other located just north of the tributary below the central paved runoff channel. In addition, some downward migration of the solutes has occurred. However, the penetration depth for  $^{90}\text{Sr}$  seems to be generally less than 2.7 m.

#### **12.1.57 Groundwater Monitoring for Selected Waste Handling Facilities at ORGDP**

Groundwater characteristics at 29 waste handling sites at ORGDP were evaluated to determine if any of these sites provide a potential for contamination of groundwater. Thirteen of the sites were determined by the original study to require further evaluation. The TDHE suggested that one additional site be included, bringing the number of sites studied to 14. Thirty-seven test holes were drilled in the vicinity of those sites, 28 in the unconsolidated rock residuum and alluvium that comprise the uppermost aquifer and 9 in the bedrock.

Geologic and hydrologic data collected during the drilling and testing of the wells were used in the characterization of the hydrogeology at each of the sites. Groundwater in the area is derived from local precipitation that infiltrates the uppermost aquifer and, in some areas, moves into underlying bedrock aquifers. Groundwater flows from areas of recharge, downgradient, along

relatively short and shallow flow paths toward areas of discharge. Discharge from both the surficial and bedrock aquifers is to the banks and bottoms of the Clinch River and Poplar Creek.

Rate of groundwater flow in the surficial aquifer is very slow, on the order of  $10^{-4}$  ft/day, due to the low permeability of the unconsolidated aquifer material and the low gradients in the area. Movement of groundwater through fractures and solution conduits in some of the carbonate bedrock aquifers, on the other hand, is quite rapid, even where gradients are not particularly steep. Conclusions derived from study of that data guided the development of a network of monitor wells and determined the planned locations of those wells. Twenty-four unconsolidated and 18 bedrock compliance monitor wells were proposed and installed at 7 sites. The resulting monitor well network provides hydrologic and water quality data; determines the presence, concentration, and extent of pollutants; and meets current state and federal regulations for groundwater monitoring.

#### **12.1.58 Characterization of SWSA 6**

SWSA 6 is the only low-level radioactive waste shallow land burial facility at ORNL. To ensure that it would comply with proposed governmental guidance, it was necessary to establish whether sufficient data on the geology, hydrology, soils, and climatology exist and to develop plans to obtain any additional information required.

Routine operation of SWSA 6 was initiated in 1973, and it is estimated that more than 30,000  $\text{m}^3$  of low-level waste containing more than 250,000 Ci of radioactivity has been buried there. Both low- and high-activity-level wastes have been buried in trenches and auger holes at the site. It is possible that before 1980, wastes were buried that would be considered hazardous wastes under the RCRA. Since SWSA 6 was sited prior to enactment of current disposal regulations, a detailed site survey of the geologic and hydrologic properties was not performed before wastes were buried.

This soil survey and the subsequent characterization study, integrated with ongoing

geologic, geochemical, geophysical, and hydrologic investigations, will allow for better pathways analysis and performance assessment of SWSA 6.

In addition, DOE requires that an accurate documentation system be established that addresses both trench location and contents for shallow-land burial of low-level radioactive wastes. As part of this documentation system, a photographic and descriptive geologic study of low-level waste trenches opened in SWSA 6 has been initiated. In this study, trenches were excavated, geologically described, and photographed before being filled and closed. Each trench is briefly described using a standardized data sheet followed by photographs of the trench walls.

#### **12.1.59 Characteristics of the 3513 Impoundment**

Oak Ridge National Laboratory has established a remedial action program for areas where past research, development, and waste management activities resulted in residual contamination of facilities or the environment. As part of this program, the characterization of the waste holding basin (3513 impoundment) was planned and carried out.

During the planning phase, earlier studies of the concentrations and distributions of radionuclides in the resident aquatic biota and nearby terrestrial plants were reviewed along with available data on contaminant movement to groundwater. The actions needed to model the transport and dose pathways of hazardous substances from the site were also identified.

The pond sediment was sampled and analyzed to determine if it would classify as a hazardous waste under RCRA. Total inventories of chemical elements in the waste were also determined. The impoundment is not regulated under RCRA because it was a land disposal unit and ceased receiving waste before November 19, 1980. However, it appears that the sediment would be classified as hazardous under those regulations because mercury concentrations in the RCRA extraction procedure toxicity test were about ten times higher than is permitted. The sediment

waste had previously been determined to be contaminated by a radioactivity inventory of approximately 156 Ci, consisting primarily of  $^{137}\text{Cs}$  (130 Ci),  $^{60}\text{Co}$  (1 Ci),  $^{90}\text{Sr}$  (20 Ci), and  $^{239}\text{Pu}$  (3 Ci).

Five wells for monitoring the groundwater were constructed around the perimeter of the impoundment at depths ranging from 2.7 to 7.6 m. All of the wells, except one of the two upgradient wells, extend at least 0.3 m into bedrock. Sampling and analyses of the groundwater will be used to determine the effect of the impoundment on groundwater quality. Preliminary results indicate that radioactivity (gross beta resulting predominantly from  $^{90}\text{Sr}$ ) of the groundwater exceeds limits allowed by RCRA regulations. Low levels (0.0001 mg/L) of PCBs were also detected in the groundwater.

The study recommended that, if the waste is solidified in place, remedial actions will have to be taken to isolate the solidified material from the groundwater in both the surrounding clay overburden and underlying limestone bedrock. It also noted that the proposal to separate the pond into smaller workable segments by driving sheet piling into the clay may need to be modified because in some parts of the pond the clay layer is insufficient to anchor the piling.

#### **12.1.60 Resource Information and Site Analysis for Planning on the Oak Ridge Reservation**

A survey and study of the resources of the ORR was conducted as part of the Resource Management Plan for the ORR. This effort reviewed and summarized natural features (geology, soils, hydrology, meteorology, flora, etc.) of the area, its facilities (buildings, utility systems, transportation systems, etc.), population, and other resources (wildlife, culture, forest, parks, etc.). This information was compiled, organized, described, and illustrated for use in planning any changes in land use, zoning, or site development on the ORR. The study noted that extreme care must be taken in the evaluation of future use or disposition of available land and that the feasibility of renewing certain properties

(recycling lands formerly used by functions and programs that have ended) is very real, given the age, condition, and obsolescence of some facilities.

#### **12.1.61 Characterization of the Old Hydrofracture Facility Impoundment**

ORNL has established a remedial action program for areas where past research, development, and waste management activities have resulted in residual contamination of facilities or the environment. As part of this program, characterization of the contamination of the Old Hydrofracture Facility (OHF) was planned and carried out.

During the planning phase, extant documentation of site contamination was reviewed, and the actions needed to confirm the extent of contamination within the facility were identified. The major tasks required were measurement of radionuclides and potentially hazardous chemicals contained in the five underground waste storage tanks at the facility and determination of the lateral and vertical contamination caused by seepage of waste from the impoundment.

The OHF was used for the permanent disposal of liquid radioactive waste in impermeable shale formations at depths ranging from about 230 to 300 m from 1964 to 1979. The liquid waste was blended into a pumpable grout by mixing it with cement and special clays used to immobilize radionuclides against groundwater transport.

The pond sediment was sampled and analyzed to determine whether it would classify as a hazardous waste under RCRA. The impoundment is not regulated under RCRA because it was a land disposal unit and ceased receiving waste prior to November 19, 1980. However, if the sediment contained RCRA-defined hazardous waste, it would be subject to CERCLA. Chemical analyses indicate that the sediment/waste does not contain hazardous chemical constituents above levels permitted by RCRA regulations. The sediment was found to contain an estimated radioactivity inventory of approximately 260 Ci, consisting primarily of  $^{137}\text{Cs}$  (60 Ci),  $^{90}\text{Sr}$  (190 Ci),  $^{60}\text{Co}$  (0.3 Ci), and  $^{238}\text{U}$  (0.3 Ci).

Four wells for monitoring the groundwater were constructed around the perimeter of the impoundment to depths ranging from 5.8 to 7.9 m. Sampling and analyses of the groundwater will be used to determine the effect of the impoundment on the groundwater quality. Preliminary results indicate that radioactivity (gross beta resulting from  $^{90}\text{Sr}$  and tritium) of the groundwater exceeds limits allowed by RCRA regulations. Low levels (0.0001 mg/L) of PCBs were also detected in the groundwater.

#### **12.1.62 Inventory of ORR Groundwater Wells**

Over 1000 wells have been drilled on the ORR during its 40-year history. However, the wells were drilled at different times for different purposes, and the resulting information was recorded in many different databases. As a result, it is difficult to locate a specific set of data or to present a comprehensive picture of the overall extent of the hydrogeologic information that is available. Consequently, the objectives of an ongoing inventory are (1) to document the approximate number of wells and the types of information on file or being gathered according to project or functional location within the ORR, (2) to describe the multiplicity of databases currently in use, (3) to discuss the need for a unified database system, and (4) to present candidate criteria for such a system.

Personal communications with groundwater investigators and results from a well information questionnaire show that approximately 1400 wells divided into 5 main functional locations can be accounted for. However, the numbers of wells are only estimates. In some cases, responses to questionnaires overlapped, so judgment was used to adjust total numbers of wells to avoid probable duplication. The count was made during early January 1986, and more wells have been and will be drilled in ongoing programs. No attempt is made here to estimate the number of wells that will be drilled in the near future.

The data reported do not include all the wells on the ORR, for even a casual inspection of waste sites shows deteriorated corrugated iron well casings that were probably abandoned years ago. Therefore, the summary statistics should not

be interpreted or reproduced in any way that implies rigorous accuracy. Nevertheless, these data do show the immensity of the information base that is available if data from all of the groundwater activities are brought together.

Plans are under way for the generation of a Reservation-wide map (at the S-16 grid scale) of well locations as part of a document on land use planning being prepared by Energy Systems. This information will be useful, but maps are needed to show quantitative information such as detailed geologic units or depths of screened intervals. This activity will be part of a region-wide groundwater monitoring and characterization plan.

Information on groundwater levels, flowpaths, and spatial and temporal trends in water quality on an ORR-wide basis is fragmented among diverse reports, studies, projects, and databases. There is no comprehensive picture of ORR groundwater quality or of the geological and geochemical factors that determine groundwater movement and quality. The crucial step in developing that picture is a unified, centralized system for storing and reporting groundwater data.

The recommendations resulting from this study are as follows.

- Work should begin immediately to assemble a well inventory database.
- Planning should begin for a well information system, which should be funded as an Energy Systems activity. A lead group for implementing the system should be identified, and the group should be given sufficient authority to require that individual investigators provide access to basic information.
- Efforts should be started to develop a consensus among groups that use groundwater data, directly and indirectly, as to the desirability and advisability of developing an advanced, centralized database system. Implementing such a system would be considerably more costly than implementing a well inventory or well information system.
- Database capabilities with the USGS need to be further explored. Implementation of a sophisticated database system would entail considerable costs. Among other things, Energy Systems should provide a staff member with responsibility for assisting investigators with small projects who have problems related to entering and processing data.
- Interactive programs for transforming coordinate points among the different geographical coordinate systems should be made available. The Computing and Telecommunications Division should undertake this task with direction from engineering staff members who have had recent experience with transforming the coordinate systems.
- An integrated ORR-wide groundwater characterization and monitoring plan should be developed.

#### **12.1.63 Geotechnical and Hydrological Evaluation of Oak Ridge Y-12 Plant Coal Ash Pond Dam**

The Geotechnical and Hydrological Evaluation project involved geotechnical, geohydrological, and hydrological evaluation of the ash pond dam, located on McCoy Branch Watershed at the Oak Ridge Y-12 Plant. The earthen dam was constructed in 1955 to provide a storage basin for coal ash slurry generated by the steam plant. The area is now almost completely filled with sediment. Ash slurry currently flows across the ash pond, through an emergency spillway, and directly into McCoy Branch, which flows into Rogers Quarry farther downstream. The coal ash consists of bottom ash and fly ash.

Vegetation varies from slight to heavy across all portions of the dam and ash pond. The downstream slope of the dam is approximately 2.5(H):1(V). The fly ash basin is relatively flat. The embankment material consists of clayey silt soils of moderate to high plasticity and medium to stiff strength. The fly ash fill is very soft and has intermittently formed "sinks" that later refill with additional slurry discharge. A thin layer of medium strength virgin soil underlies the fill

material. The basement rock is a competent dolomitic limestone. Groundwater levels are high in the fly ash basin area and drop off rapidly below the dam. There is evidence of considerable erosion in the spillway.

The dam and abutments appear to be in safe condition with respect to failure caused by slope instability, internal erosion (piping), or foundation failure. The embankment is in good condition and has undergone no softening or other detrimental changes that were detectable by a normal subsurface investigation.

The dam is susceptible to overtopping as a result of inadequate spillway capacity. Hydrological analyses indicate that the dam could be overtopped even during a 1-h storm, and that continued fly ash deposition would further reduce the present minimal reservoir storage capacity.

It is recommended that the dam crest be stripped and raised to elevation 956.0 (approximately 0.61 m) by adding a small amount of compacted fill. The upstream dam slope exposed above the fly ash should be protected from wave action by a thin layer of shot rock fill. Minor eroded areas on the embankment or abutment slopes should be backfilled and planted.

The spillway should be regraded, enlarged, and stabilized to minimize erosion. The old underdrain system exiting beneath the embankment should be exposed and provided with controlled ditching. The abandoned overflow pipe through the embankment should be inspected and/or plugged and sealed with grout. Trees on the dam slope and crest and in the impoundment within 30.48 m of the crest should be removed, the stumps and root systems dug out and, where accessible, the excavations backfilled with compacted clay.

A continuing maintenance and monitoring program as per guidelines provided by the state and federal regulatory agencies should be considered. Several settlement points should be installed on the crest and monitored semiannually along with the previously installed monitor wells and inclinometers.

Reclamation of the site to eliminate impoundment is a viable alternative, pending economic evaluation. This process would involve

placement of soil cover over the sediments and diversion of runoff and slurry discharge operations around the site.

#### **12.1.64 Preliminary Seepage Residual Study by Water Balance Method for Rogers Quarry**

The purpose of the preliminary seepage residual study was to conduct an investigation of water balance on the Rogers Quarry impoundment using available hydrological data. Rogers Quarry is used for disposal of coal ash slurry from the Oak Ridge Y-12 Steam Plant. Coal ash from the steam plant is pumped as a slurry to the crest of Chestnut Ridge and flows by gravity through a filled ash retention impoundment, over the emergency spillway of the impoundment dam, and into McCoy Branch. McCoy Branch then flows into Rogers Quarry, where ash solids are deposited. McCoy Branch has a 142.3-ha (358-acre) drainage area above the quarry and includes the area covered by the filled ash retention impoundment.

Data are available in the water balance equation for McCoy Branch flows at the MBK 0.94 station (located below the dam), precipitation, evaporation, outflow from the quarry, and change in storage of the quarry pool. The unknown term in the water balance equation is the groundwater seepage residual, along with systematic and random errors associated with the measurement of each of the input terms. A 50-day study was conducted (April 2 through May 21, 1986) to obtain the net seepage residual for that period.

Between the MBK 0.94 station and the quarry, these springs have been identified as significant contributors to the McCoy Branch base flow into the quarry. The flow was volumetrically measured at these lower springs once to obtain a rough estimate of their contribution, which was 0.0014 m<sup>3</sup>/s. This raised the base flow into the quarry to 0.0054 m<sup>3</sup>/s. In addition, several saturated areas in the floodplain between the dam and the quarry may contribute a significant amount of diffused seepage to the branch flow.

For the time period studied, net seepage appears to be flowing into the quarry. The following table summarizes the results of this



analysis. The table presents the results using the measured lower spring flows ( $0.0014 \text{ m}^3/\text{s}$ ) and an assumed higher spring flow ( $0.0028 \text{ m}^3/\text{s}$ ). This table indicates that accurate determination of the unmeasured base flow in McCoy Branch is critical for an accurate determination of net seepage residual.

Although the positive net seepage residual indicates flow into the quarry during the study period, one should be careful not to infer any long-term trends. A long-term study of two years should be conducted before a more accurate and representative seepage term can be produced.

#### Summary of Results

Residuals	Seepage residuals		50-day total (mg)	Average daily residual <sup>a</sup> ( $\text{m}^3/\text{s}$ )
	April (mg)	May (mg)		
Measured lower spring base flow = $0.0014 \text{ m}^3/\text{s}$	2.47	1.47	3.94	0.0034
Assumed higher spring base flow = $0.0028 \text{ m}^3/\text{s}$	1.53	0.79	2.32	0.0020

<sup>a</sup>A positive seepage residual indicates seepage into the quarry.

#### 12.1.65 Proposed Groundwater Monitoring Plans for Kerr Hollow and Rogers Quarries

The Oak Ridge Y-12 Plant abandoned the Kerr Hollow and Rogers quarries for waste disposal. A RCRA Part A application has been submitted to EPA for Kerr Hollow, and NPDES permits have been granted for discharges from both sites. In accordance with the document, *Fact Sheet: Application for National Pollutant Discharge Elimination System Permit to Discharge Treated Water to U.S. Waters*, a monitoring plan for the two quarries must be submitted to EPA and TDHE to demonstrate the protection of groundwater and surface water quality.

In January 1985, Energy Systems retained Geraghty and Miller, Inc., to prepare

groundwater monitoring plans to satisfy NPDES permit requirements for Roger Quarry and to satisfy requirements of Section 265 of RCRA and the NPDES permit for Kerr Hollow Quarry. Requirements for monitor well location set forth in RCRA Section 264 were also incorporated into the network design at Kerr Hollow Quarry.

Kerr Hollow and Rogers quarries are located on the north side of Bethel Valley Road. Kerr Hollow Quarry is  $\sim 1.61 \text{ km}$  southeast of Oak Ridge Y-12 Plant and  $\sim 0.8 \text{ km}$  west of the intersection of Scarboro Road and Bethel Valley Road. Rogers Quarry is  $\sim 1.61 \text{ km}$  south of the Oak Ridge Y-12 Plant and  $\sim 2.4 \text{ km}$  west of the intersection of Scarboro Road and Bethel Valley Road. Wastewater from both quarries discharges into Clinch River tributaries.

#### 12.1.66 Characterization of Oak Ridge Y-12 Plant Coal Ash Discharge to McCoy Branch

The Oak Ridge Y-12 Plant disposes of coal ash from steam plant operations in a slurry form through a filled-ash retention impoundment, to the emergency spillway of the impoundment dam, and into McCoy Branch, which flows into Rogers Quarry where the ash solids and sluice water are separated by sedimentation. The State of Tennessee and EPA have expressed concern about the ash disposal system. In response to those concerns, Oak Ridge Y-12 Plant has undertaken several investigations of the ash disposal system including (1) chemical characterization of the ash sluice discharge and surface receiving water (McCoy Branch), (2) a geotechnical evaluation and hydrologic study of the filled-ash retention impoundment and dam in the headwaters of McCoy Branch, and (3) an investigation of the groundwater in the vicinity of Rogers Quarry. The report documents investigation of the coal ash sluicing system and surface receiving stream conducted March through May 1986.

The purposes of the investigation were (1) to obtain analytical chemical and hydrologic data necessary to characterize the coal ash sluice discharge to McCoy Branch and (2) to characterize chemicals in McCoy Branch. Pursuant to the first objective, samples of ash sluice water were collected at the discharge point

(emergency spillway) to McCoy Branch and, for comparison, at selected other points. Pursuant to the second objective, water samples were collected at several sites on McCoy Branch in the absence of ash sluicing and at the outlet for the effluent from Rogers Quarry.

Sluicing of both fly ash and bottom ash is intermittent, the frequency and duration being determined by boiler load, which varies seasonally. In a typical ash sluice cycle, bottom ash is sluiced first, followed immediately by fly ash. As is typical of most pulverized coal furnaces, about 20% of the ash produced is bottom ash. Tramp iron (pyrite) and other material rejected by the coal pulverizers are collected dry and hauled to a landfill.

#### **12.1.67 Phase IV Monitor Well Drilling Program in the Bear Creek Valley Waste Disposal Area**

In March 1984, Geraghty and Miller, Inc., was retained to design remedial action alternatives for surface water and groundwater contamination in the BCVWDA. The entire BCVWDA, located west of DOE's Oak Ridge Y-12 Plant, consists of three principal waste-disposal sites: the S-3 Ponds, the Oil Landfarm (which includes the Sanitary Landfill), and the BCVWDA. A key component of the investigation was to install a network of monitor wells at the disposal sites.

Following review of the hydrogeologic and water quality data from previous drilling and sampling programs (Phases I and II) at the waste disposal sites, Geraghty and Miller recommended installing additional monitor wells as Phases III and IV. The well location and design were chosen primarily to provide data on contaminant plume migration down dip and across strike and to define vertical groundwater flow components. Twenty-two wells were installed in the fall of 1984 (Phase III); construction details and hydrogeologic and water quality interpretations are given in Geraghty and Miller reports.

Sixteen wells were installed as Phase IV in spring, summer, and fall 1985. The report includes well construction details and summarizes geologic and hydrologic observations made during

Phase IV. Hydrogeologic evaluations and interpretations were made and presented to Energy Systems in 1986.

The recommendations resulting from this study are as follows.

- Work should begin immediately to assemble a well inventory database.
- Planning should begin for a well information system, which should be funded as an Energy Systems activity. A lead group for implementing the system should be identified, and the group should be given sufficient authority to require that individual investigators provide access to basic information.
- Efforts should be started to develop a consensus among groups that use groundwater data, directly and indirectly, as to the desirability and advisability of developing an advanced, centralized database system. Implementing such a system would be considerably more costly than implementing a well inventory or well information system.
- Database capabilities with the USGS need to be further explored. Implementation of a sophisticated database system would entail considerable costs. Among other things, Energy Systems should provide a staff member with responsibility for assisting investigators with small projects who have problems related to entering and processing data.
- Interactive programs for transforming coordinate points among the different geological coordinate systems should be made available. The Computing and Telecommunications Division should undertake this task with direction from engineering staff members who have had recent experience with transforming the coordinate system.
- An integrated ORR-wide groundwater characterization and monitoring plan should be developed.

## 12.2 UNUSUAL OCCURRENCES

### 12.2.1 Fish Kill on East Fork Poplar Creek

Between November 21 and December 5, 1986, approximately 1140 stoneroller fish were found dead over a 1.6-km reach of East Fork Poplar Creek downstream of New Hope Pond. An investigation was begun immediately upon discovery of the first dead fish on November 21 by members of ORNL's Environmental Sciences Division and the U.S. Fish and Wildlife Service. The cause of the deaths was found to be a bacterial infection (*Aeromonas hydrophila*). These bacteria present no threat to human health. The outbreak of the disease is triggered by stress, which can be caused by electroshocking, overcrowding, temperature changes, or pollutants. The source of the stress was not discovered.

### 12.2.2 Sulfuric Acid Spill at the Oak Ridge Y-12 Plant

On September 26, 1986, approximately 2275 L of concentrated sulfuric acid was spilled when a valve failure resulted in the overflow of an 1895-L storage tank inside a process building. Approximately 1895 L of the acid was contained in a dike. The other 380 L overflowed the dike and entered a storm drain leading to East Fork Poplar Creek. The first accessible location on the creek inside the boundary of the Oak Ridge Y-12 Plant was monitored continuously until pH readings returned to normal. The lowest pH detected at this point was 1.5.

Spill response personnel intercepted the acid plume at a point upstream of the influent of New Hope Pond and neutralized the acid by adding approximately 270 kg of lime over a 1-h time period. The pH and conductivity readings at the outlet of New Hope Pond were monitored continuously, and a biologist was called to check for impacts downstream. No off-site impacts were observed, and no drop in pH at the outlet of New Hope Pond was observed.

### 12.2.3 Sodium Hydroxide Solution Spill at the Oak Ridge Y-12 Plant

On October 27, 1986, a high-pH alarm at the inlet of New Hope Pond was received at the Oak

Ridge Y-12 Plant Shift Superintendent's Office. Investigation of the source of the alarm revealed that approximately 1990 L of sodium hydroxide solution had leaked into a storm drain leading to East Fork Poplar Creek. The cause of the leak was a ruptured valve on a storage tank. The pH at the outlet of New Hope Pond was monitored continuously. A rise in pH was noted, but readings never approached the NPDES discharge limit of 10.0 for the outlet of New Hope Pond. No off-site effects were observed.

### 12.2.4 WC-10 Tank Farm Radioactive Liquid Waste Storage Area (ORNL)

On two occasions during 1986, the WC-10 Tank Farm storage area was the source of elevated <sup>60</sup>Co releases into White Oak Creek through the Process Waste Treatment Plant. On one of these occasions, the gates of White Oak Dam were closed for a few days while efforts were made to minimize the amount of <sup>60</sup>Co being released.

The problem at WC-10 was related primarily to the effects of rapidly fluctuating groundwater level on the water level and radionuclide content in the WC-10 dry well.

Currently, efforts are being made to identify the problems associated with the WC-10 Tank Farm and to plan for the correction of these problems.

### 12.2.5 Fish Kills in the ORNL Area

During 1986, four fish kills were discovered by ORNL personnel. Two of these occurred during May in Melton Branch and involved approximately 50 minnows and 9 bluegill. These mortalities were believed to have been related to the draining of wastes from a silver recovery operation to a holding pond in the HFIR area and then to the Melton Branch stream. These wastes are now being collected and tested to determine their final disposition.

The third fish kill occurred in early July when two dead carp were discovered in White Oak Lake above the dam. No cause of death was identified, although low dissolved oxygen levels were suspected. In this case, however, the dissolved oxygen problems were believed to be natural rather than man-induced. Low flow

conditions resulting from a long dry period contributed to the depressed dissolved oxygen level.

In late September, three dead minnows were found in White Oak Creek following a chilled water line leak that released several thousand liters of a 5% ethylene glycol-water mixture into the creek. The fish mortality was believed to have resulted from abnormally low dissolved oxygen levels created by high oxygen demands put on the stream system by a sewage-like bacterial "bloom." The bacteria were apparently responding to the sudden introduction into the stream of a large amount of nutrient (the ethylene glycol-water mixture). The leaking pipe was repaired and aeration of a short stretch of the creek relieved some of the stress on the fish population. No dead fish were found after aeration of the creek was begun.

#### 12.2.6 Miscellaneous ORNL Spills

During 1986, ORNL had a total of 109 spills and/or releases of various types of materials. Each of these was investigated by staff members of the Department of Environmental Management to determine environmental impact and to provide input for reducing any harmful effects and assisting with cleanup efforts. Cleanup activities were conducted by staff members of the Hazardous Waste Operating Group. All cleanup materials were disposed of according to proper ORNL procedures.

ORNL instituted a new spill reporting system in 1986. Each spill is now reported to various levels of ORNL management and DOE officials as soon as possible after the spill through an electronic mail system, and updates are provided as necessary. The reporting system has resulted in an increased spill awareness by ORNL staff members. Many of the reported spills were of very small quantities, such as half a liter of gasoline.

Upon review of the data, it can be determined that a majority of the spills are related to petroleum products, and efforts are under way to enhance spill prevention in the future. These

activities include more monitoring and inspection of construction activities where these types of spills most often occur. When potential problems are found, prompt action is taken to reduce the spill potential.

## 12.3 REVIEWS AND AUDITS

### 12.3.1 General Accounting Office's Assessment of Environmental Issues at DOE Defense Facilities Including the Oak Ridge Y-12 Plant

At the request of a Senate Subcommittee, the General Accounting Office identified key environmental issues at nine DOE defense facilities and evaluated the status of DOE's efforts to strengthen its environmental, safety, and health oversight programs. The Oak Ridge Y-12 Plant was one of the facilities under review.

GAO's review of nine DOE defense facilities identified a number of significant environmental issues:

- Eight facilities have groundwater contaminated with radioactive and/or hazardous substances to high levels.
- Six facilities have soil contamination in unexpected areas, including off-site locations.
- Four facilities are not in full compliance with the Clean Water Act.
- All nine facilities are significantly changing their waste disposal practices to obtain a permit under the Resource Conservation and Recovery Act.

**Groundwater contamination.** The GAO report stated that Oak Ridge Y-12 Plant groundwater was contaminated with solvents, nitrates, mercury, arsenic, and chromium.

- Solvents have been detected over 1000 times greater than proposed drinking water standards.
- Nitrate concentrations have been reported at levels 1000 times the drinking water standards.

- Mercury has been detected at levels 500 times the drinking water standards.
- Arsenic has been detected at levels 60 times the drinking water standards.
- Chromium has been detected at levels over 30 times the drinking water standards.

**Soil contamination.** The GAO report stated that large amounts of mercury used at the Oak Ridge Y-12 Plant were lost to the environment during the late 1950s and early 1960s. (DOE has estimated that over two million pounds of mercury used at the Oak Ridge Y-12 Plant is unaccounted for, and about 35 percent (0.7 million pounds) may have been lost to the environment.) As a result, a creek bed and its floodplain became contaminated with the mercury. Elevated levels of mercury were also found in the Clinch River. To complicate matters, in the early 1980s, dirt was taken from the floodplain and used in and around the neighboring City of Oak Ridge as topsoil in the construction of a civic center and water sewer system.

DOE, through soil monitoring programs, has found that some locations in the creek bed and its floodplain contained levels of mercury thousands of times the normal levels. Readings as high as 2000 ppm were recorded, according to DOE officials. DOE also found that the soil used at the Civic Center and water sewer system had contamination levels that were, in some instances, over 500 ppm. To protect human health, the State of Tennessee in 1983 issued a guideline level for mercury in soil of 12 ppm.

In response to the situation, DOE has taken a number of steps, including

- on-site projects to reduce mercury migration off site,
- a cleanup project at the Civic Center to reduce the level of mercury in the soil,
- an extensive program to monitor known contaminated soil locations and identify others, and

- the establishment of an interagency task force (including representatives from DOE, EPA, the State of Tennessee, the City of Oak Ridge, and TVA) to oversee DOE actions and recommend new actions.

**Compliance with the Clean Water Act.** EPA issued the Oak Ridge Y-12 Plant a new NPDES permit in May 1985 as a result of negotiations between DOE, Tennessee, and EPA. The permit contains a compliance schedule aimed at resolving the following major problem areas:

- the runoff from a coal pile at the facility into a nearby creek,
- the elimination and/or treatment of waste discharged from numerous pipes at the facility, and
- eliminating the leakage of various pollutants from disposal areas into a nearby creek.

To correct these problems, numerous facilities are to be built, including a steam plant wastewater treatment facility, a sanitary wastewater treatment facility, and treatment facilities for handling process waste (e.g., nitrate, uranium, etc.) directly from the Oak Ridge Y-12 Plant. Projects to reduce leakage from disposal areas will also be undertaken. DOE estimates that it will cost over \$50 million to bring the installation into full compliance with its NPDES permit by 1990.

**Hazardous waste disposal.** This report states that DOE and its predecessor agencies have been generating radioactive and hazardous waste for over 40 years. The management, storage, and disposal of this waste has been regulated, for the most part, by the generators (DOE and its predecessor agencies). DOE Order 5480.2, dated December 13, 1982, established procedures for regulating hazardous waste at its facilities and requires its facilities, to the extent practicable, to follow regulations issued by EPA pursuant to RCRA. DOE also required that mixed waste—waste containing both radioactive and hazardous material—be managed under a degree of protection equivalent to that afforded by EPA regulations for hazardous material.

In 1984 DOE's self-regulation of all its waste ended when a U.S. District Court in Tennessee ruled that nonradioactive waste produced by DOE was not exempt from RCRA. While this case involved only one facility, DOE extended the ruling to all its defense facilities, thus making them subject to EPA regulations under RCRA. Under RCRA, each DOE facility must have a permit to generate, store, and dispose of hazardous waste. In order for DOE to acquire permits for its facilities, it has changed and is changing its waste disposal practices.

To comply with the Oak Ridge Y-12 Plant Part B permit, submitted in November 1985, existing disposal areas that handle hazardous waste will be closed. Hazardous waste will be sent to a commercial disposal operation. DOE plans to treat some mixed waste to make it nonhazardous and then dispose of it as radioactive waste. Other mixed waste will be stored and/or treated. DOE has not specified a disposal plan for this waste.

### **12.3.2 Review of Experience and Improved Techniques in Radiological Environmental Monitoring at Major DOE Low-Level Waste Disposal Sites**

The primary purpose of this DOE review, completed in 1986, was to provide a concise summary of routine radiological environmental surveillance programs conducted at major active DOE solid LLW disposal sites. The DOE disposal sites at which monitoring programs were reviewed include those located at Hanford, Idaho National Engineering Laboratory (INEL), Nevada Test Site (NTS), Los Alamos National Laboratory (LANL), Oak Ridge National Laboratory (ORNL), and Savannah River Plant (SRP).

Areas of environmental monitoring reviewed in this program included air monitoring for particulates and gases, monitoring of surface water runoff, surface water bodies, groundwater, monitoring of surface soils and the vadose zone, and monitoring of ambient and penetrating radiation. The review was limited to activities conducted for the purpose of monitoring disposal site performance and includes DOE Reservation

boundary monitoring activities only if those activities are also intended to serve the purpose of monitoring an LLW disposal site.

Use of the term "site" will apply primarily to the entire DOE site or reservation. The term "LLW site" will be used to designate that area within the boundaries of the solid LLW disposal site.

A second purpose of this review was to provide information on recently developed techniques utilized in or applicable to routine environmental monitoring of LLW disposal sites. Techniques presently in use at LLW sites which were not described in the Low-Level Radioactive Waste Management Handbook Series, *Environmental Monitoring for Low-Level Waste Disposal Sites* (DOE/LLW-13 Tg) (1983), are described. This monitoring handbook provides generic guidance for site-specific application on design of environmental monitoring programs, monitoring systems and programs, statistical considerations, sampling and measurement techniques, quality assurance, and data interpretation and presentation. Information presented in the environmental monitoring handbook was not reiterated in this program review.

A third purpose of the work on which this program was based was to provide a forum for DOE contractor personnel responsible for environmental monitoring to identify needed improvements in monitoring capabilities.

Chapter III, Section 3.e, of DOE Order 5820.2, "Radioactive Waste Management," requires that field organizations develop procedures for new and existing LLW disposal sites which address "an environmental monitoring program having documented procedures and access to sampling and analytical equipment." An environmental monitoring program is necessary to determine if an LLW disposal site is performing as expected and is in compliance with standards or regulations.

In general, LLW site environmental monitoring programs are designed to monitor particular radionuclides associated with operations at that site and environmental media and pathways of importance at each site. Because each monitoring program is tailored to the specific needs of each

individual site, across-the-board comparisons between programs are inappropriate. The intent of the review report is to present and summarize information on the environmental monitoring programs at major LLW disposal sites, and not to evaluate or compare programs.

Routine environmental surveillance is conducted at major LLW disposal sites at various levels of effort for specific environmental media.

In summary, all sites implement a routine monitoring program for penetrating radiation. Four sites (INEL, NTS, LANL, and SRP) monitor particulates in air specifically at LLW disposal sites. Hanford monitors particulates at LLW sites in conjunction with monitoring of other site operations. Particulates are monitored on a Reservation-wide network at ORNL. Gases are monitored specifically at active LLW sites operated at NTS, LANL, and SRP. Groundwater is monitored specifically at LLW sites at INEL, LANL, and SRP, in conjunction with other operations at Hanford and as part of a Reservation-wide program at NTS and ORNL. Surface water is monitored at INEL, LANL, and SRP LLW sites. Surface soil is sampled and analyzed on a routine basis at INEL and LANL. Routine monitoring of the vadose zone is conducted at the INEL and SRP.

In general, most routine monitoring activities are based on documented procedures. Laboratories utilized for analysis of monitoring program samples institute internal quality assurance programs and participate in external quality assurance programs. As an additional check on laboratory performance, some environmental monitoring programs (INEL, Hanford) submit blind quality control samples (i.e., known standards or blanks or replicate samples). At all sites, control sampling locations (locations which monitor all influencing factors except the LLW site) are included in the sampling design.

In some cases (INEL, LANL), further quality assurance is conducted or related to sampling design, such as the collection of replicate samples in the field.

Five of six sites have incorporated some level of computerization into the environmental monitoring programs, ranging from maintenance

of computerized databases to enhanced graphics and data interpretation capabilities. Real-time reporting of results was noted only for site effluent monitoring and is not used in monitoring LLW disposal sites.

In most cases, modeling and performance assessment are the responsibility of organizations other than routine environmental monitoring personnel.

Other than the addition of nonradiological (hazardous) monitoring parameters to routine surveillance programs, no major changes in these programs were identified by monitoring personnel. Alterations to the monitoring program, in the way of equipment changes, revised sampling design, etc., appear to be instituted on an as-needed basis. At some sites (e.g., INEL), regularly scheduled peer reviews have been utilized to update monitoring programs. However, none are planned in the near future.

The most often-repeated needs identified by environmental monitoring personnel at the major DOE LLW disposal sites were administrative, rather than technical, in nature. These included:

- Determining applicability of regulations, especially pertaining to radioactive mixed waste.
- Determining how to apply regulations, especially pertaining to radioactive mixed waste.
- Maintaining sufficient manpower to conduct routine monitoring programs and respond to additional DOE requests.

Some technical needs were identified by environmental monitoring personnel:

- More reliable pH and dissolved oxygen recorders for monitoring flowing surface water.
- A satisfactory technique for in-field filtration of small volumes of surface water containing large amounts of sediments.
- Standardized and reliable sampling equipment for monitoring particulates in air.
- Increased numbers of sampling locations and/or replicate samplers.

- Completion and calibration of a tritium distillation system that eliminates the possibility of cross-contamination of samples.
- Improvements in sensitivity and response time of surface radiation survey equipment.
- Improved geophysical monitoring techniques for determining trench location and contents.
- Field testing of existing techniques for vadose zone monitoring.

Work is already being done to meet most of these needs, generally by those identifying them. This review is documented in *Experience and Improved Techniques in Radiological Environmental Monitoring at Major DOE Low-Level Waste Disposal Sites*, DOE/LLW-S4T, September 1986.



## 13. SUMMARY OF QUALITY ASSURANCE

Quality assurance is a demand placed on every step of the entire environmental surveillance effort, and each contributor to the total is responsible for the quality of that contribution. This surveillance program, developed and evolved over many years of such activity, can be roughly divided into three major efforts: sampling of the environment, analysis of the samples, and treatment and interpretation of the results.

### 13.1 SAMPLING QUALITY ASSURANCE

From the point of conception of any sampling project, quality assurance plays a role. Each monitoring or sampling organization plans the project, sets objectives, identifies responsibilities, and selects the appropriate sampling instruments or devices in accord with use and cleaning practices recommended by the American Society for Testing and Materials (ASTM), EPA, or other authorities. The number of samples, the location of sampling sites, and the time for sampling (taking into account weather factors or operations schedules) must all be decided. The rationale for these decisions and others is the responsibility of the sampling organizations. Sampling plans and field documentation are conducted as appropriate. Chain-of-custody documentation is prepared from the point of sampling, and the samples are properly protected as they are placed in the hands of the analytical laboratory personnel.

### 13.2 ANALYTICAL QUALITY ASSURANCE

Receiving the samples from the sampling group or the sample transporter, the laboratory sample

custodian assumes responsibility for the proper protection and handling of the samples. Using guidance from the EPA, the laboratories document the steps in the handling, analysis, and approval of results. All analytical procedures are documented; EPA-approved methods are used when they are available. These procedures, with traceability to EPA methods, are presented in Vol. 2, Sect. 12.3. The quality control programs that support the analytical activities are discussed in detail in Vol. 2, Sect. 12, which includes a variety of examples of participation in external quality control programs.

### 13.3 TREATMENT AND INTERPRETATION OF RESULTS

This activity is the responsibility of the environmental management organizations. As shown in both Vols. 1 and 2, the amount of data in these programs can become staggering. Of course, the task for each project or each monitoring program is compartmentalized to maintain responsible control. With the major objectives of protection of the public and the environment, the data are promptly reviewed as soon as they are available to establish regulatory compliance and to determine whether remedial action is needed. Periodically the data are reviewed for overall interpretation and, where relevant, interprogram relationships. The documentation of the overall effort in periodic publications such as this report serves as a resource for future activity.



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**APPENDIX**

**FOLD-OUT MAPS OF MONITORING AND  
SAMPLING LOCATIONS**

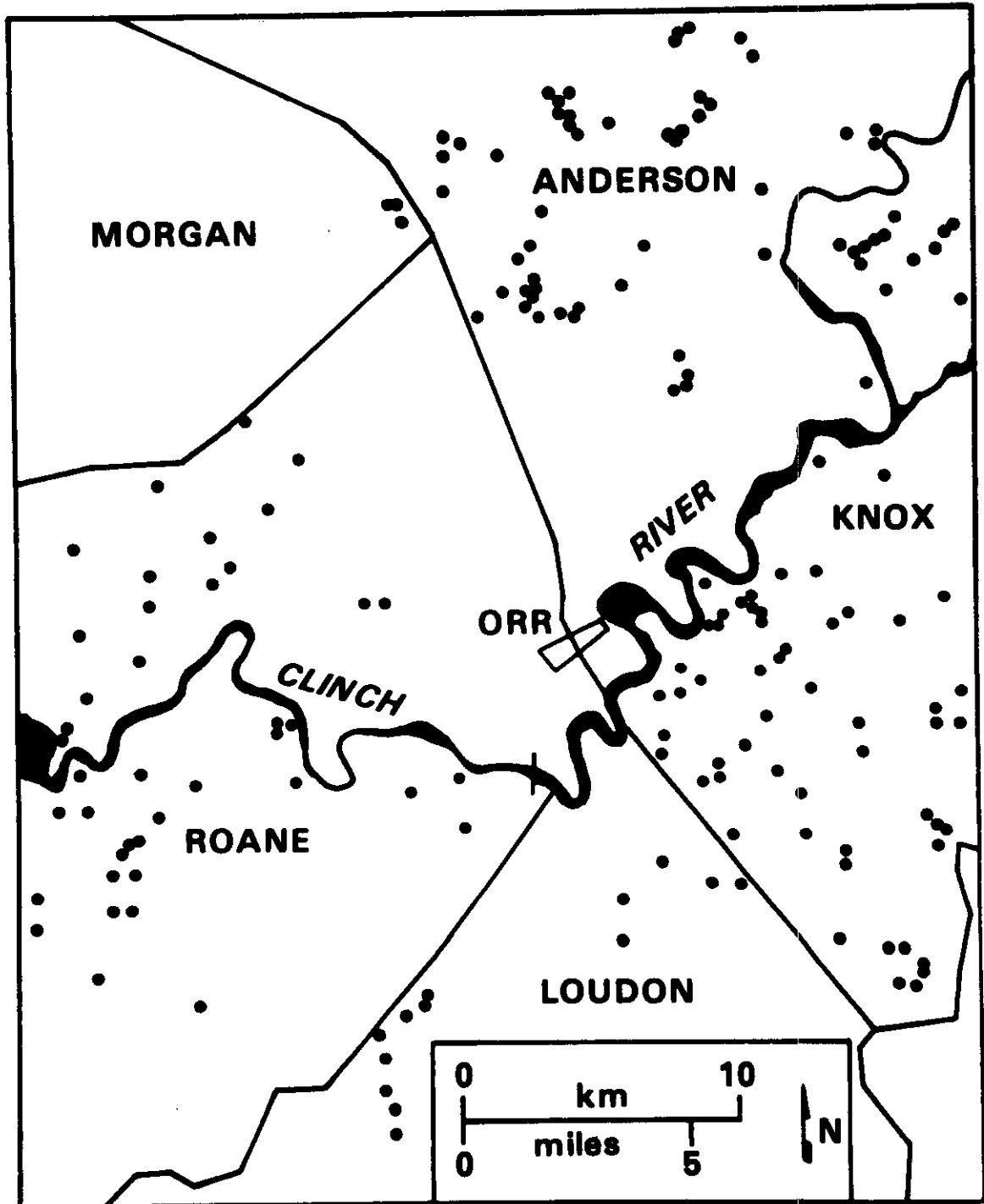


Fig. A.1.5.2. Locations of water wells in the Oak Ridge vicinity.



ORNL DWG 87-8356

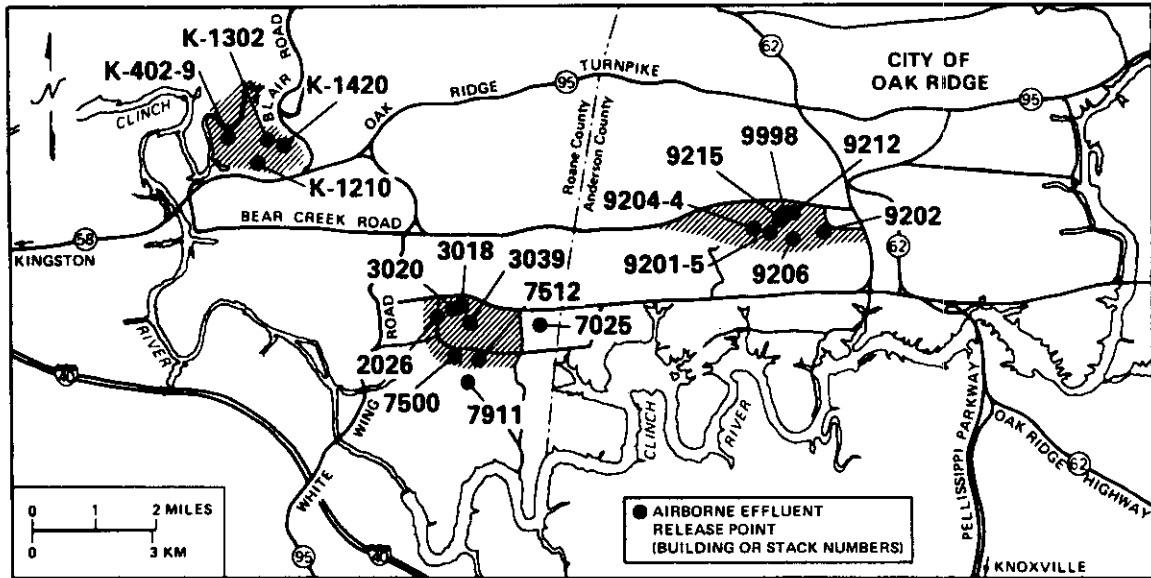


Fig. A.4.1.1. Location of radioactive airborne effluent release points on the ORR.

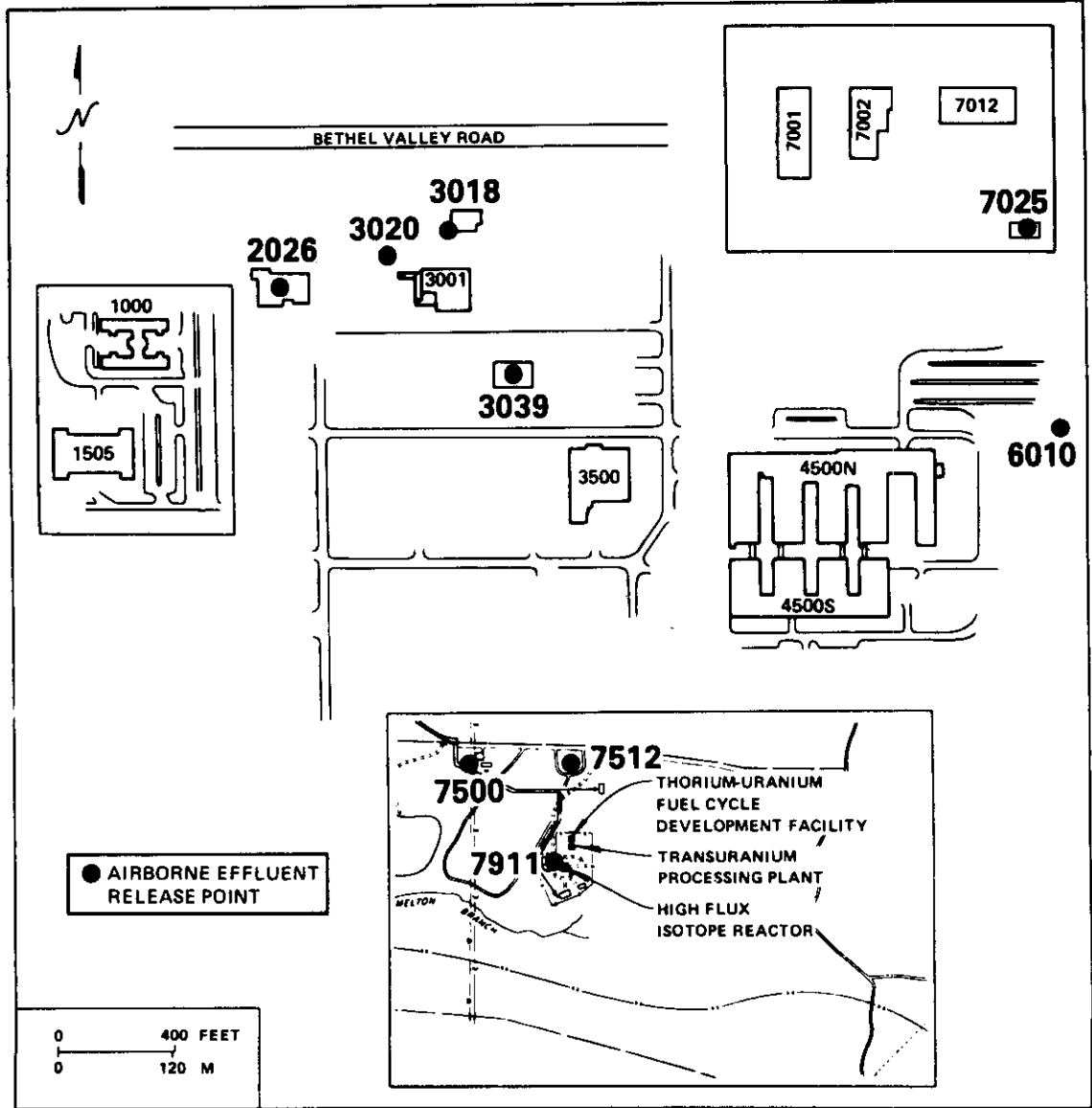


Fig. A.4.1.6. Locations of airborne radioactive effluents at ORNL.

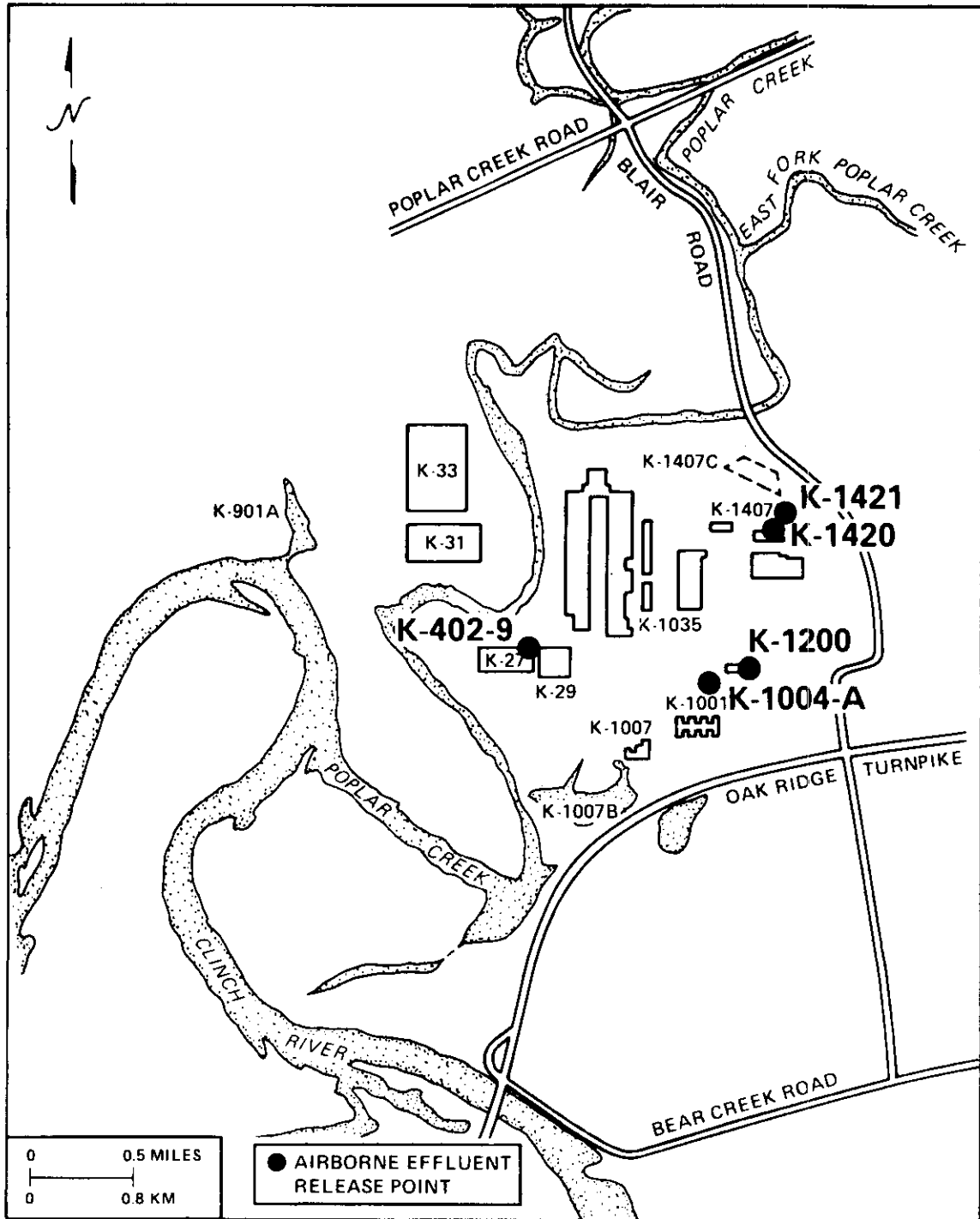


Fig. A.4.1.11. Locations of airborne radioactive effluents at ORGDP.

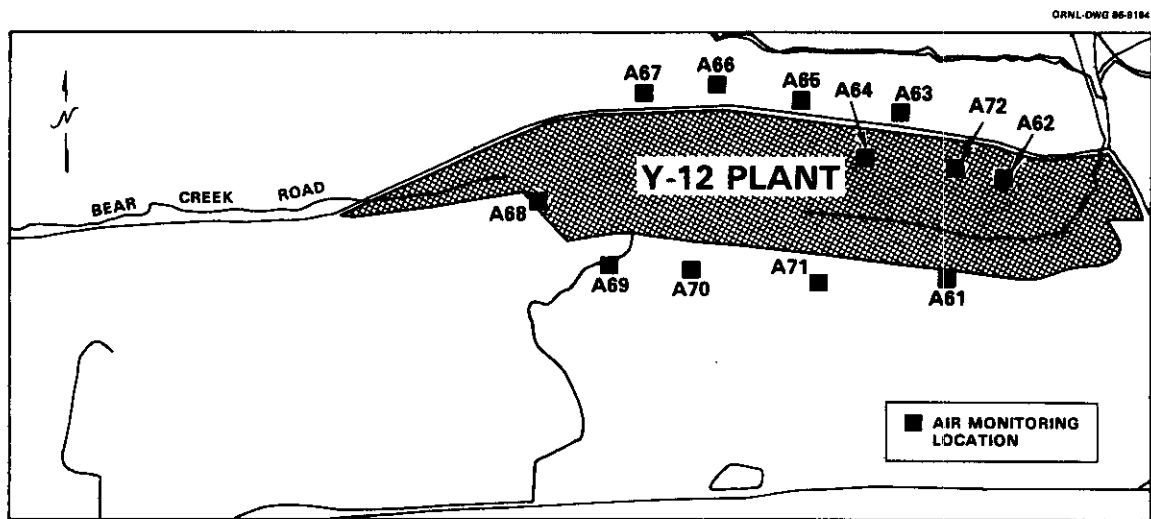


Fig. A.4.2.1. Location map of perimeter air monitoring stations around the Y-12 Plant.

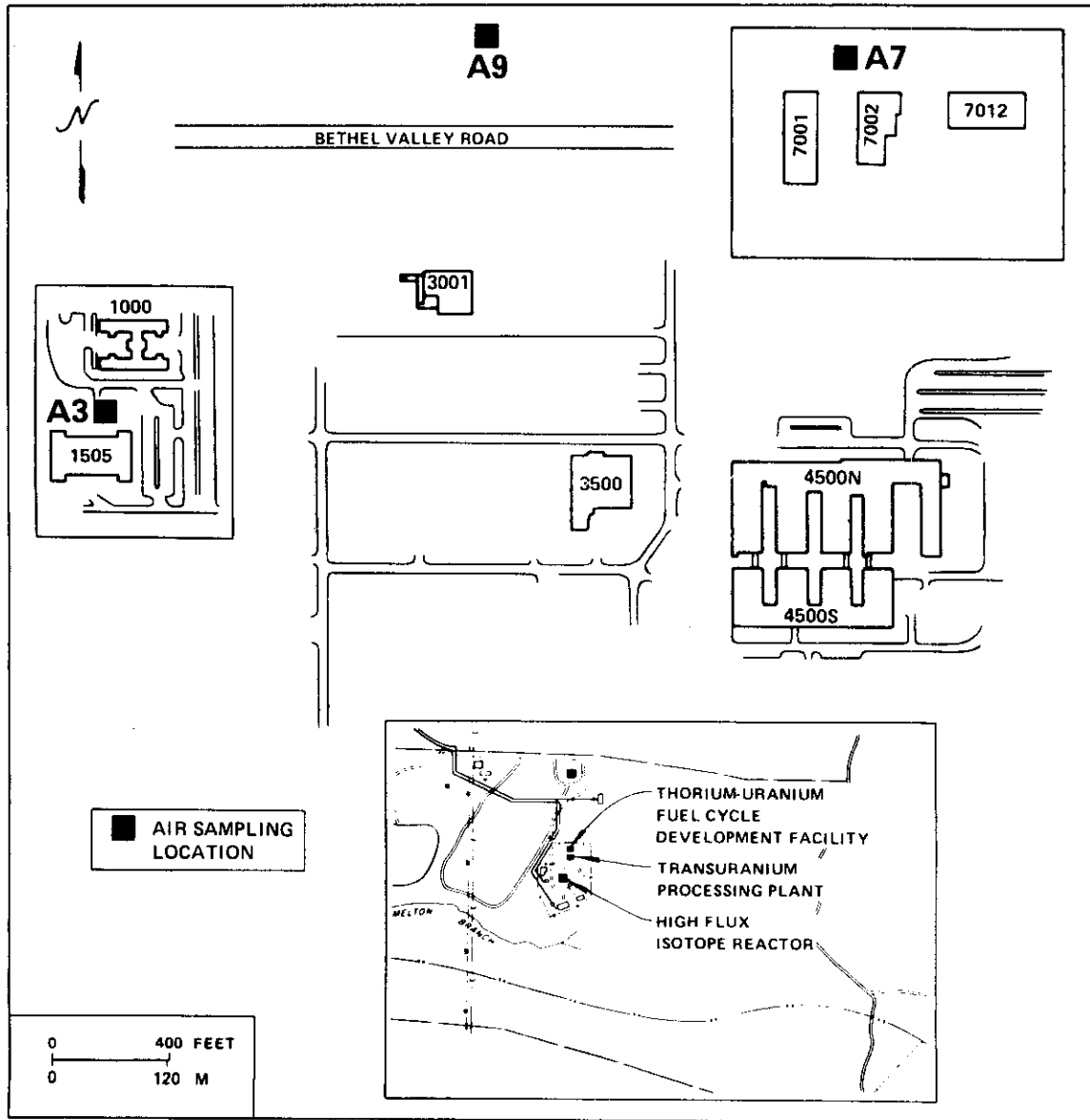


Fig. A.4.2.2. Location map of perimeter air monitoring stations around ORNL.

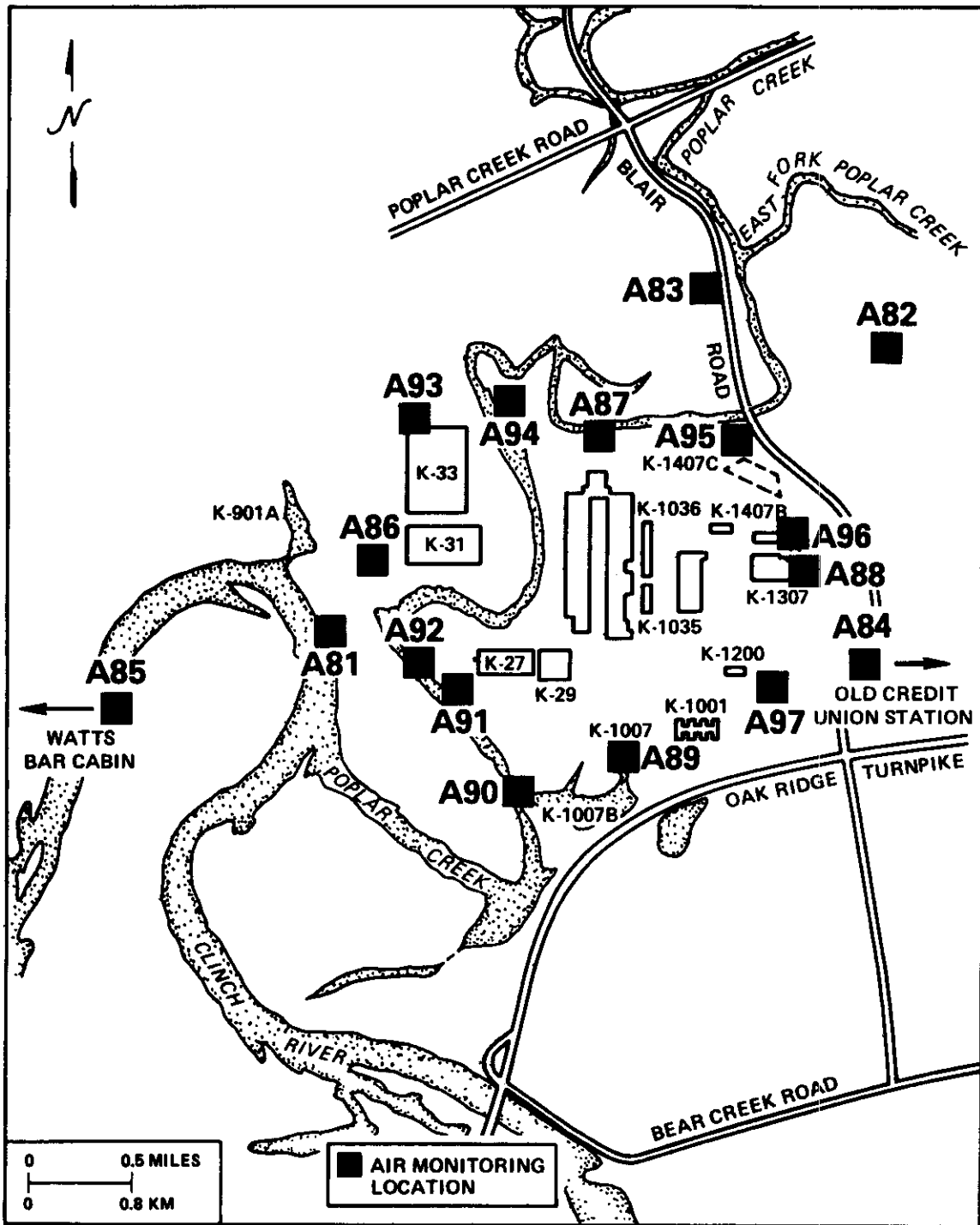


Fig. A.4.2.3. Location map of perimeter air monitoring stations around ORGDP.

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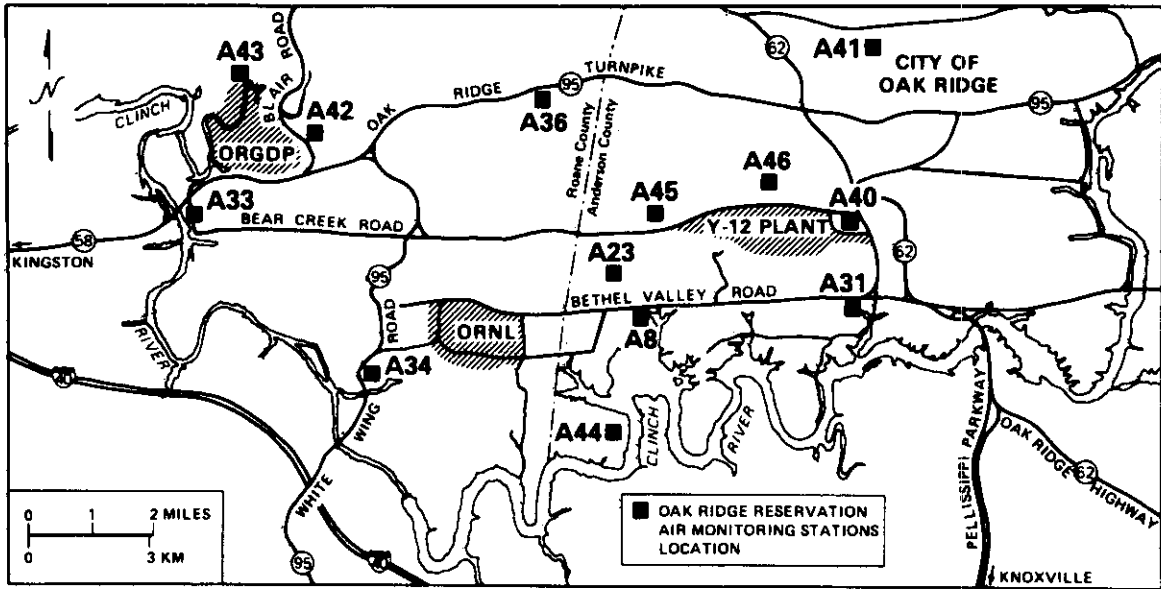


Fig. A.4.2.4. Location map of the Oak Ridge Reservation air monitoring stations.

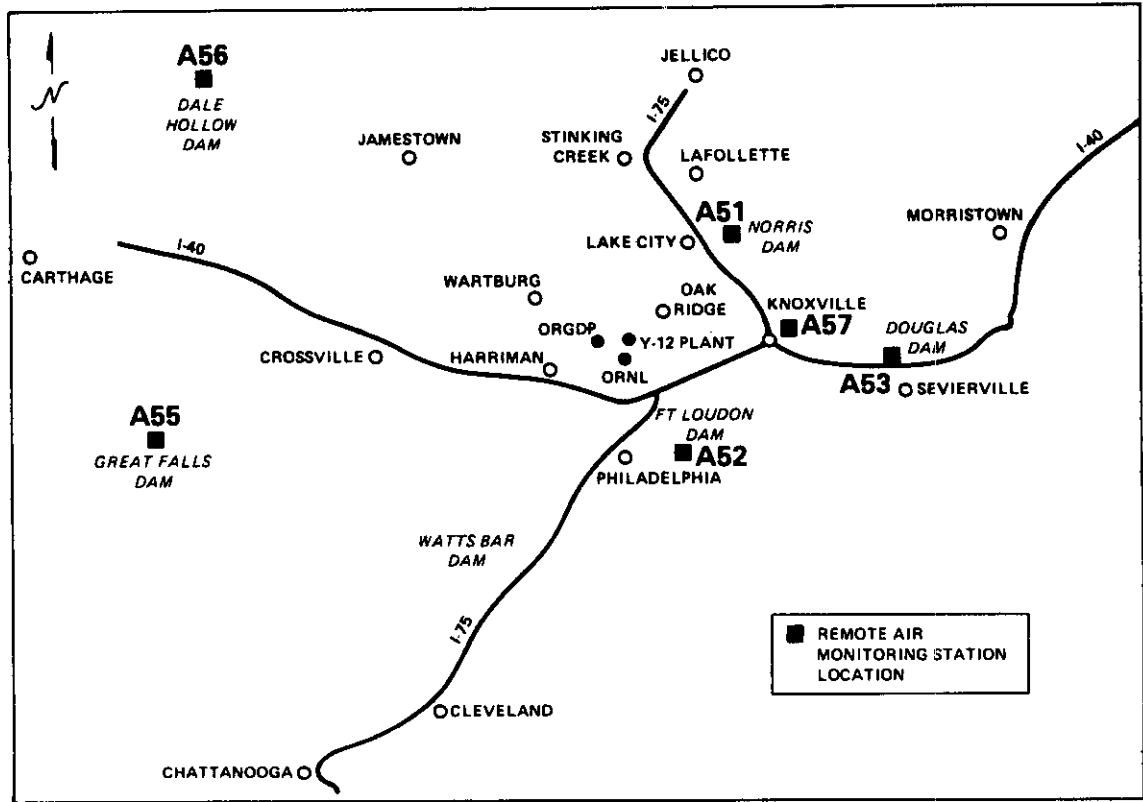


Fig. A.4.2.5. Location map of the remote air monitoring stations.



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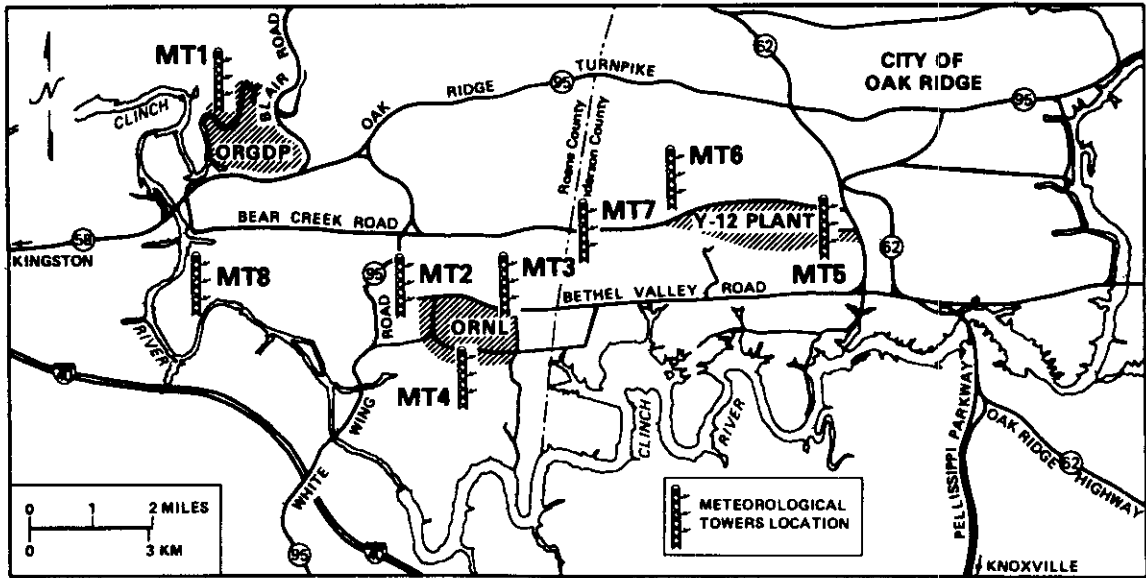


Fig. A.4.3.1. Locations of meteorological towers on the Oak Ridge Reservation.

ORNL-DWG 87-8235

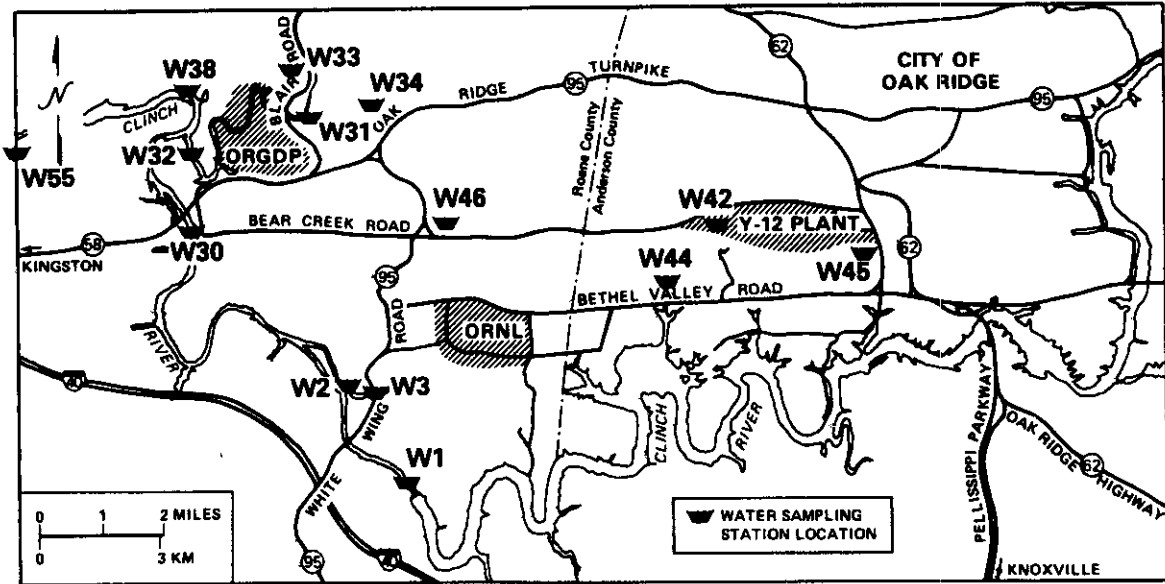


Fig. A.5.2.1. Location map of water sampling stations on the ORR.

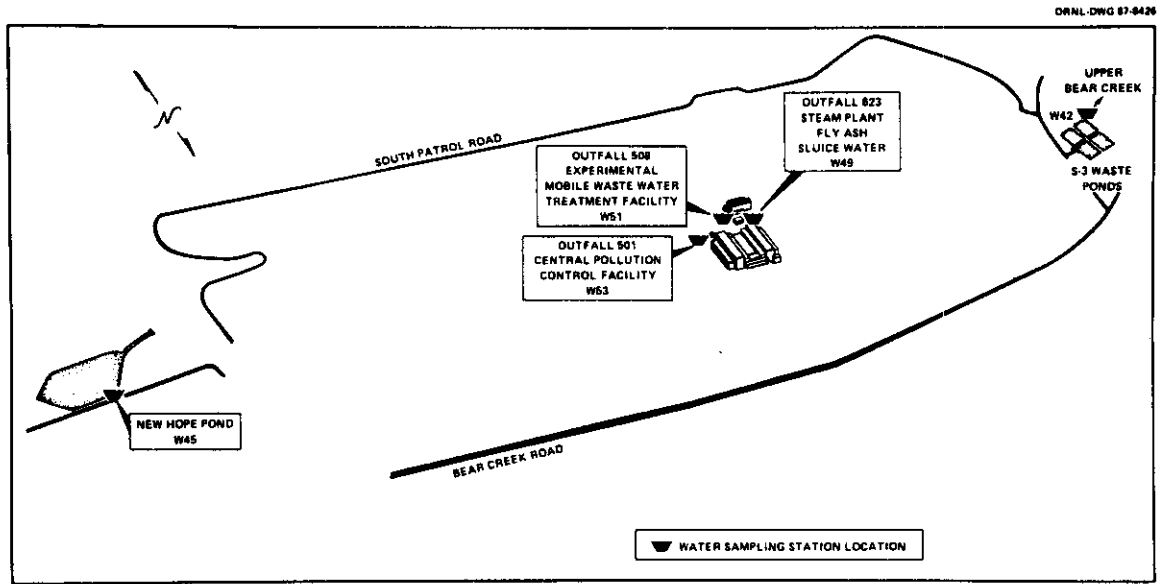


Fig. A.5.3.1. Location of Y-12 Plant NPDES points .

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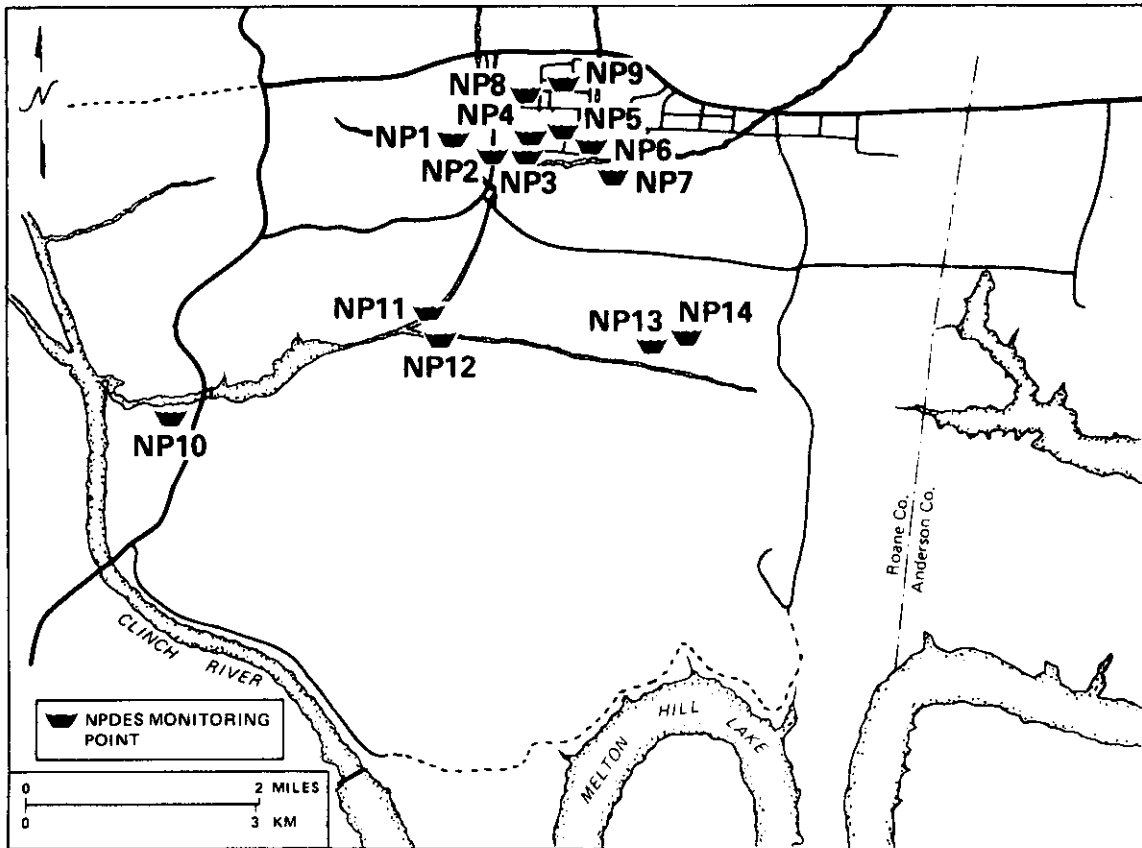


Fig. A.5.3.4. Location map of NPDES monitoring points at ORNL.

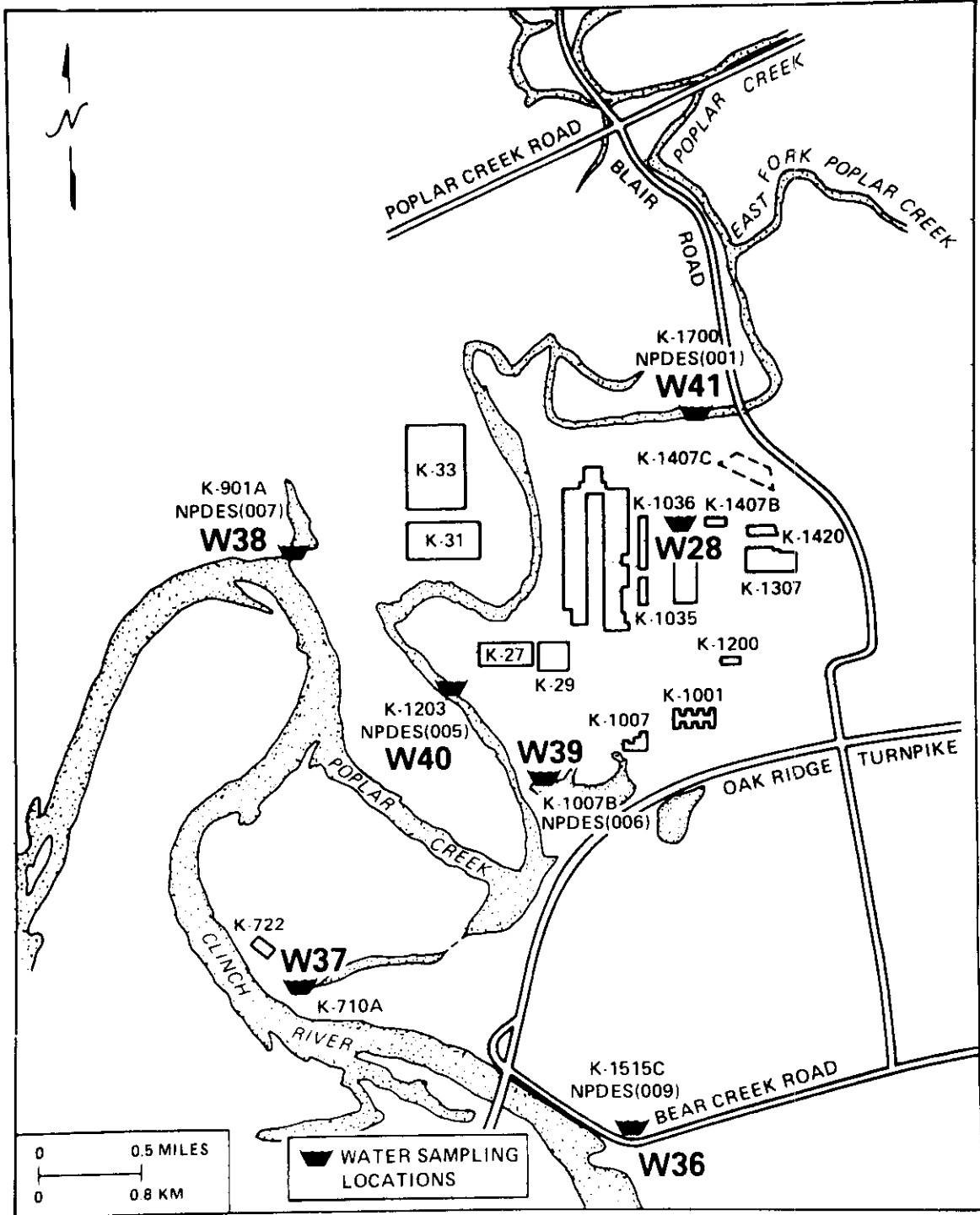


Fig. A.5.3.8. Location map of ORGDP NPDES points.

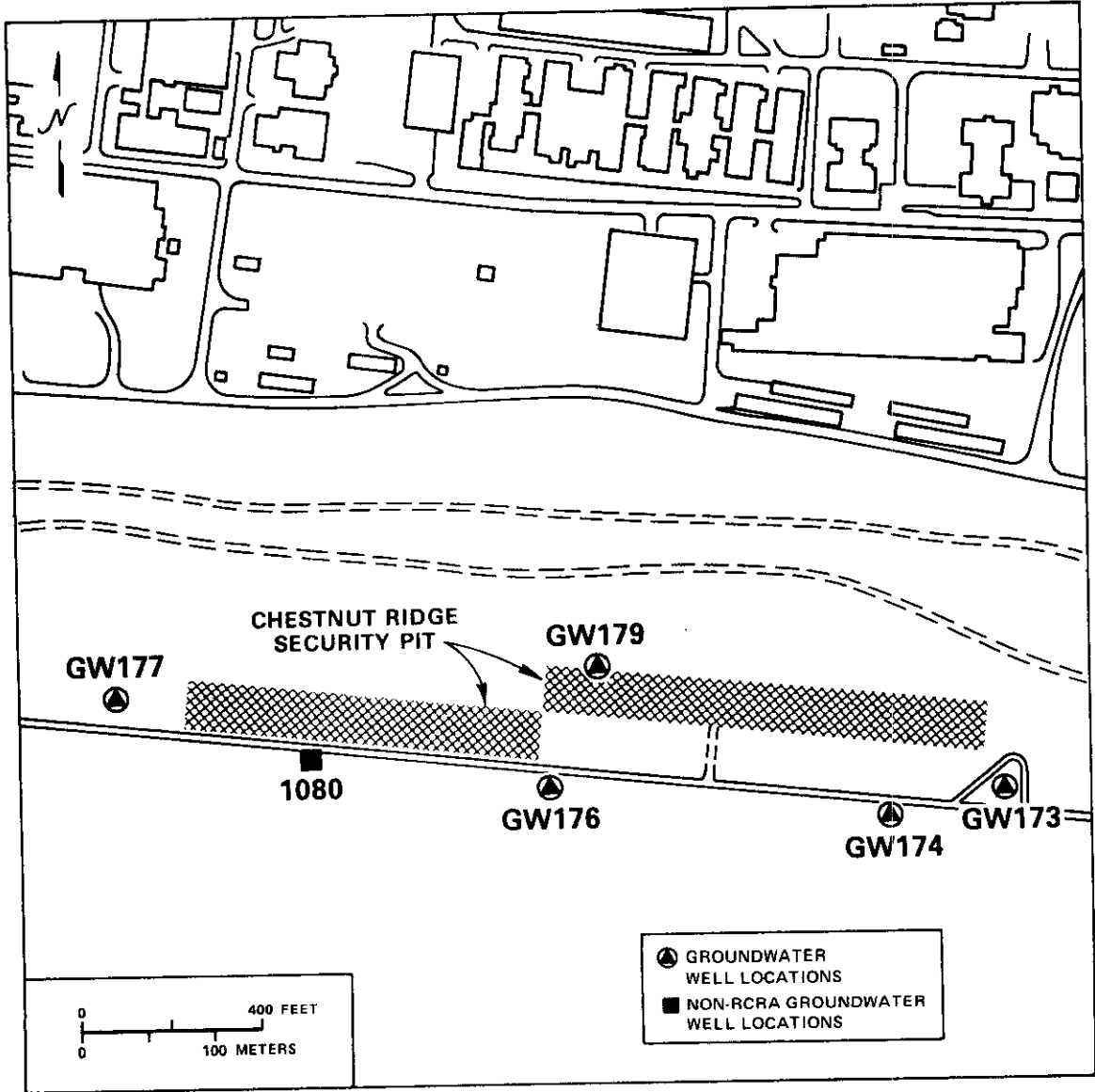


Fig. A.6.3.1. Locations of groundwater wells around Chestnut Ridge Security Pits, Y-12 Plant.

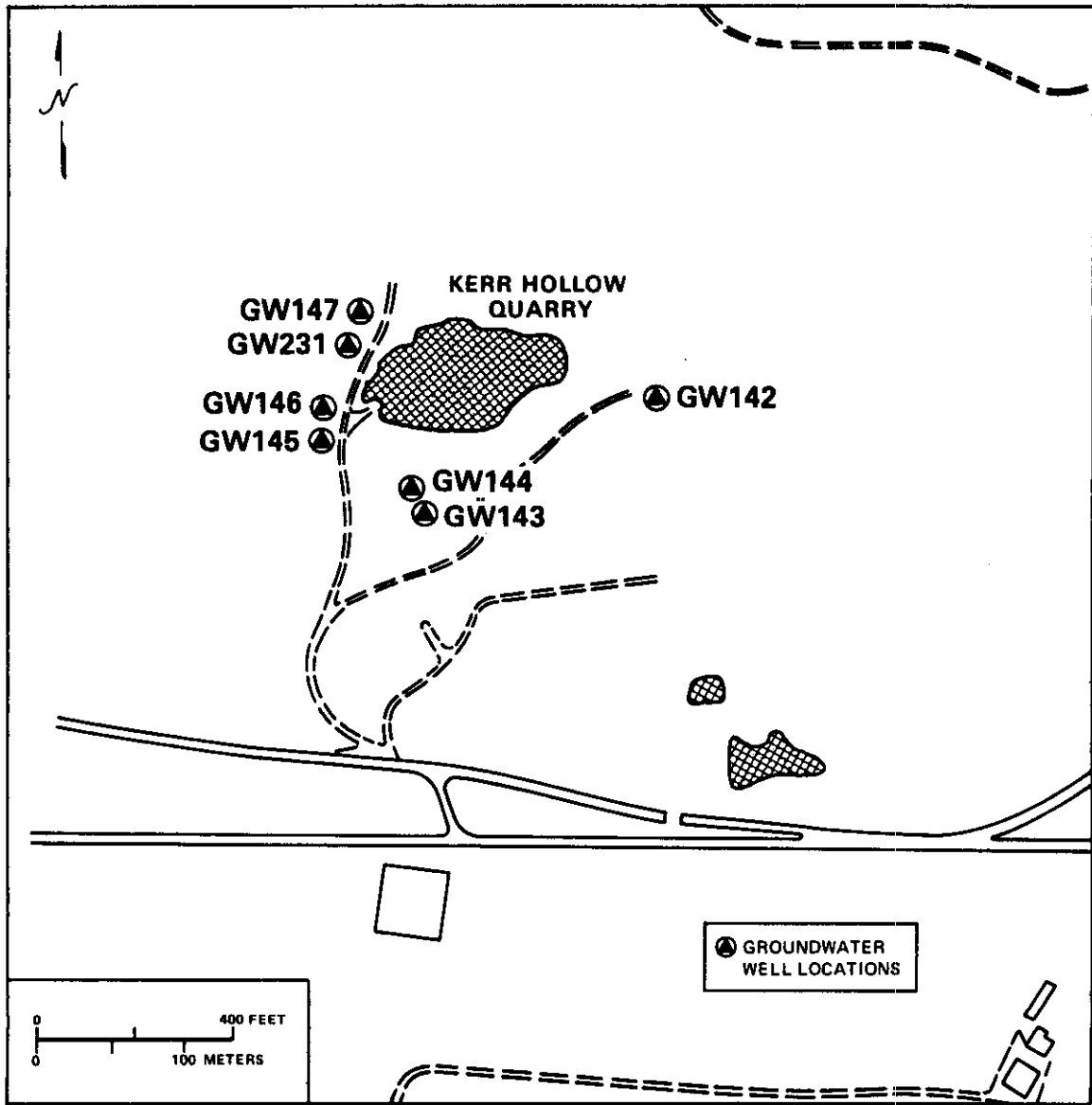


Fig. A.6.3.2. Locations of groundwater wells around Kerr Hollow Quarry, Y-12 Plant.

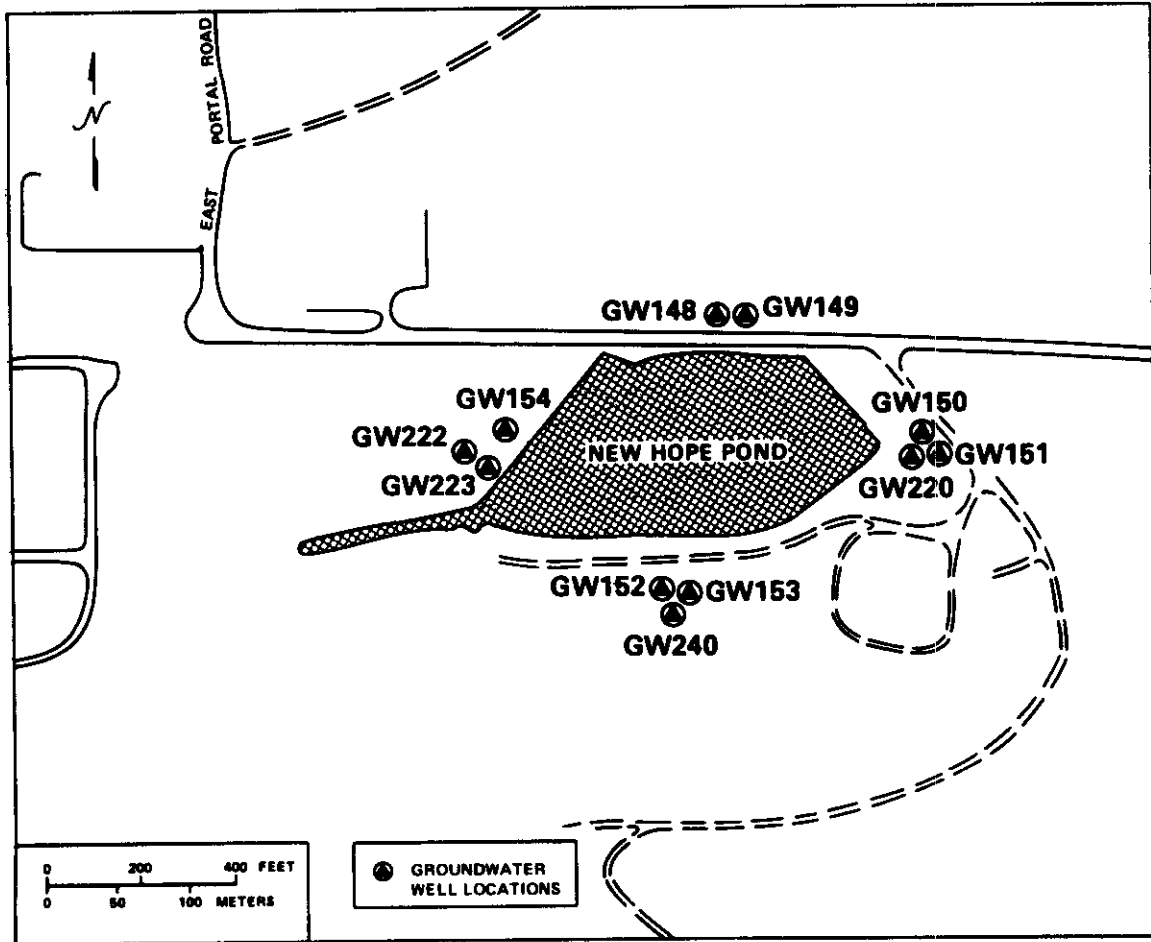


Fig. A.6.3.3. Locations of groundwater wells around New Hope Pond, Y-12 Plant.



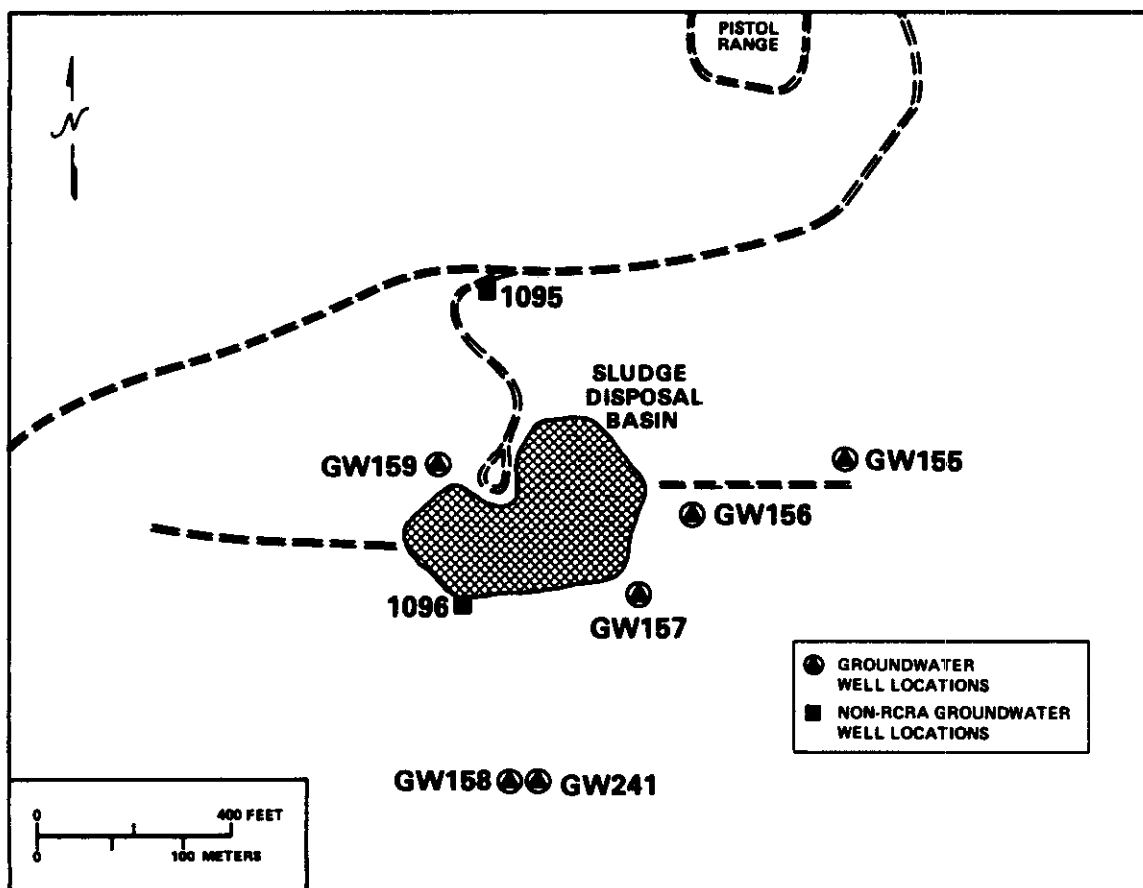


Fig. A.6.3.4. Locations of groundwater wells around Sludge Disposal Basin, Y-12 Plant.

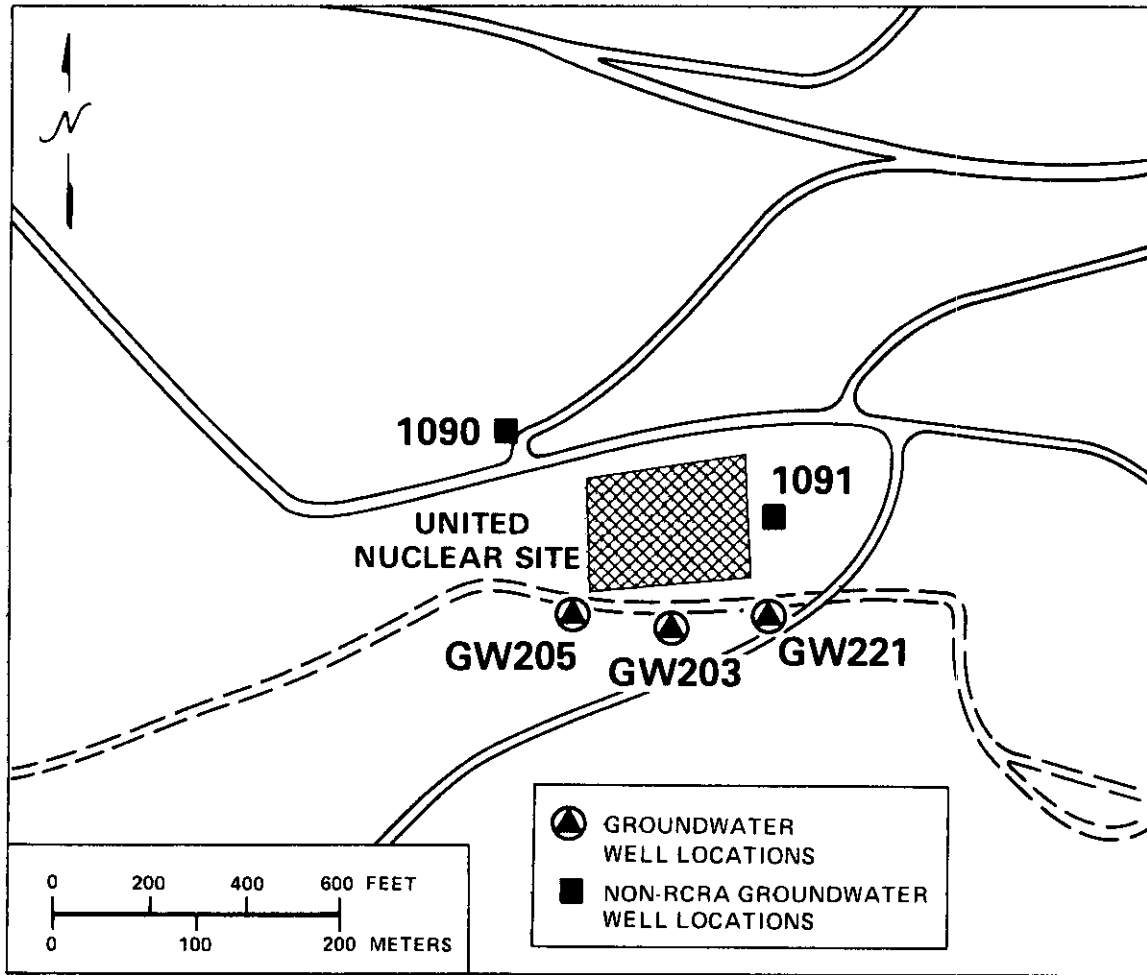


Fig. A.6.3.5. Locations of groundwater wells around United Nuclear Site, Y-12 Plant.

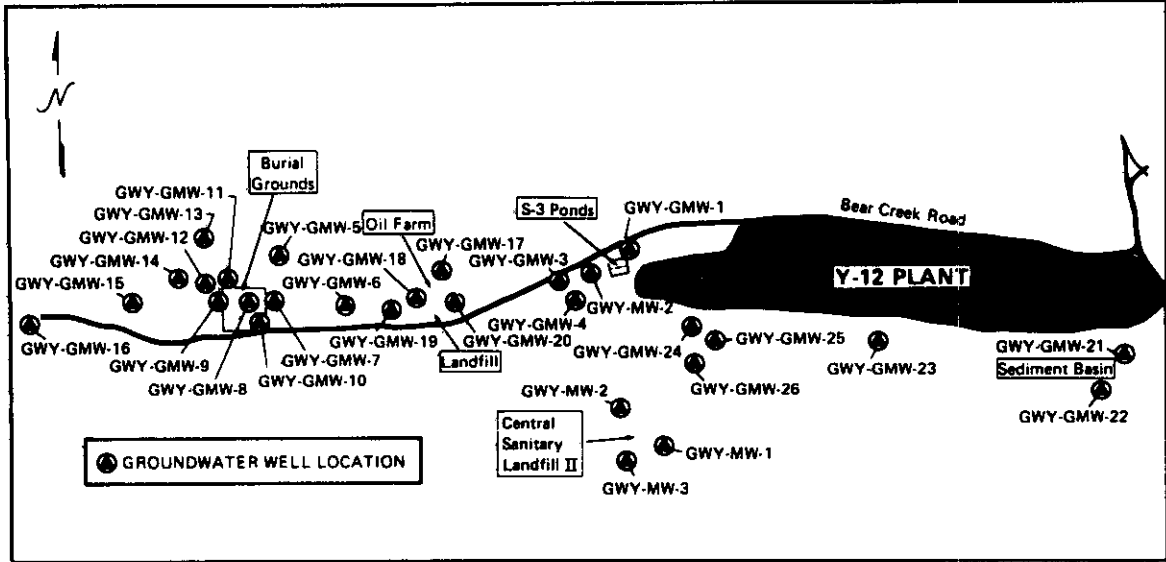


Fig. A.6.3.6. Locations of groundwater wells near Y-12 Plant waste areas.

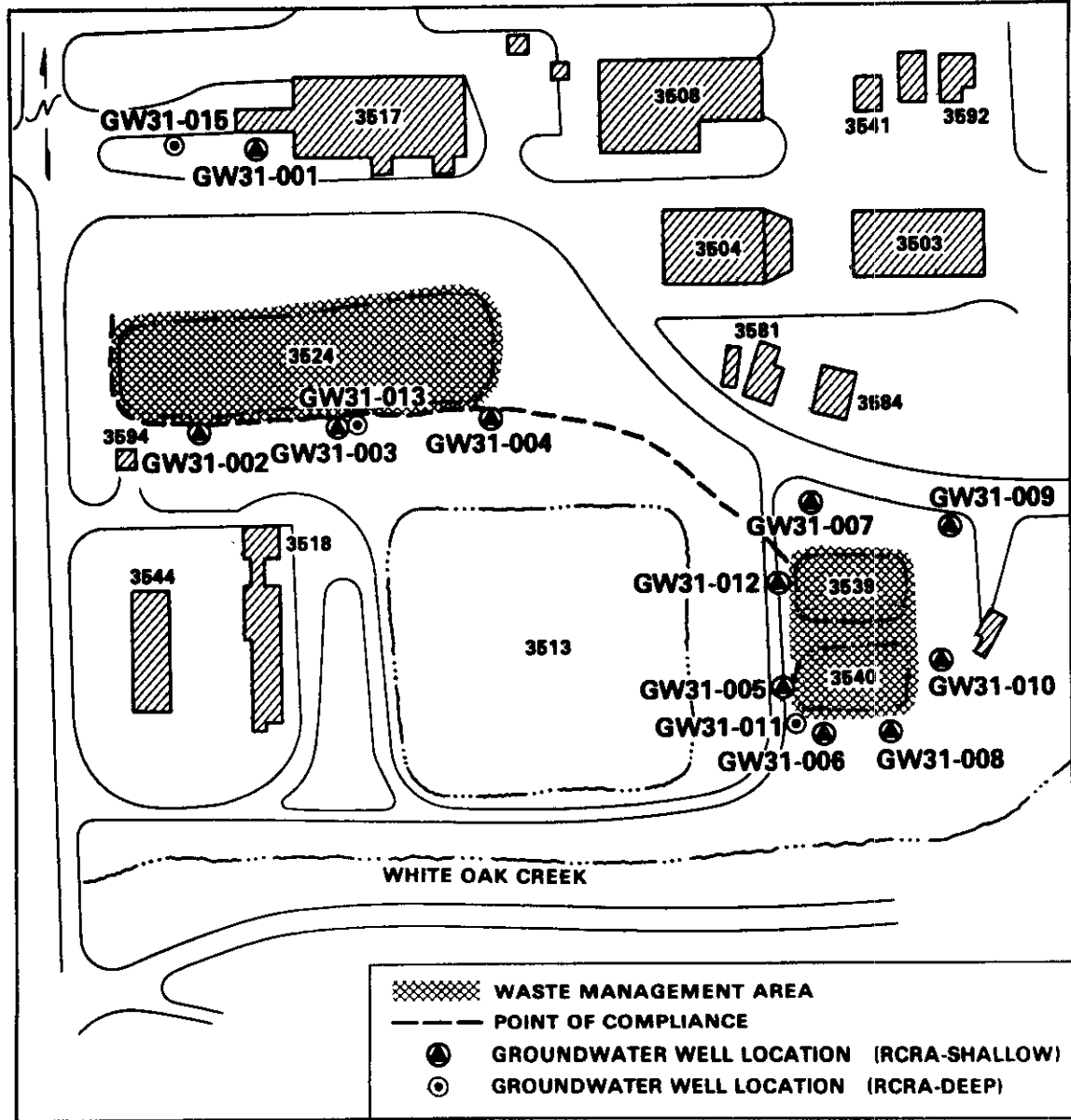


Fig. A.6.4.1. Locations of groundwater wells around ponds 3524, 3539, and 3540, ORNL.

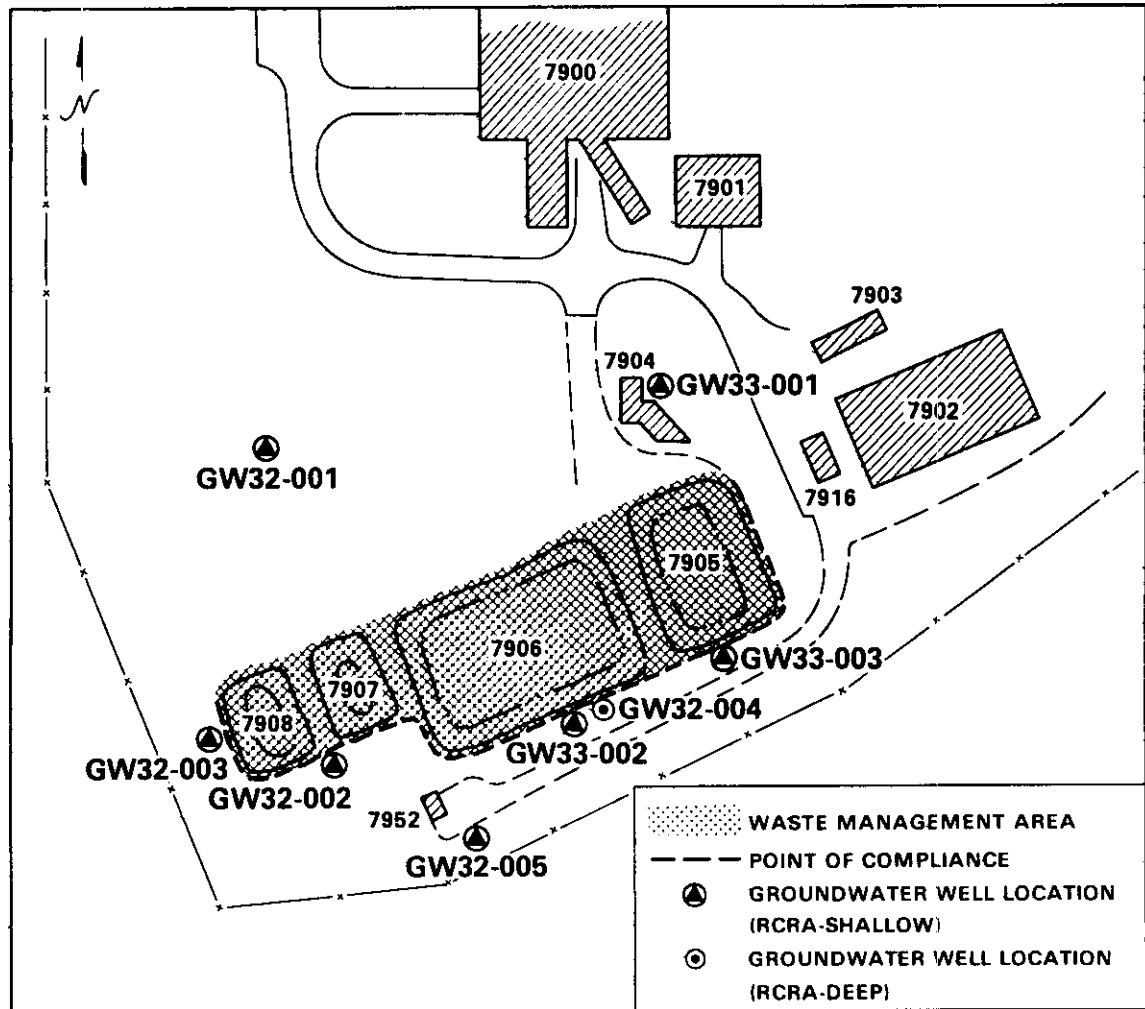


Fig. A.6.4.2. Locations of groundwater wells around ponds 7905, 7906, 7907, and 7908, ORNL.

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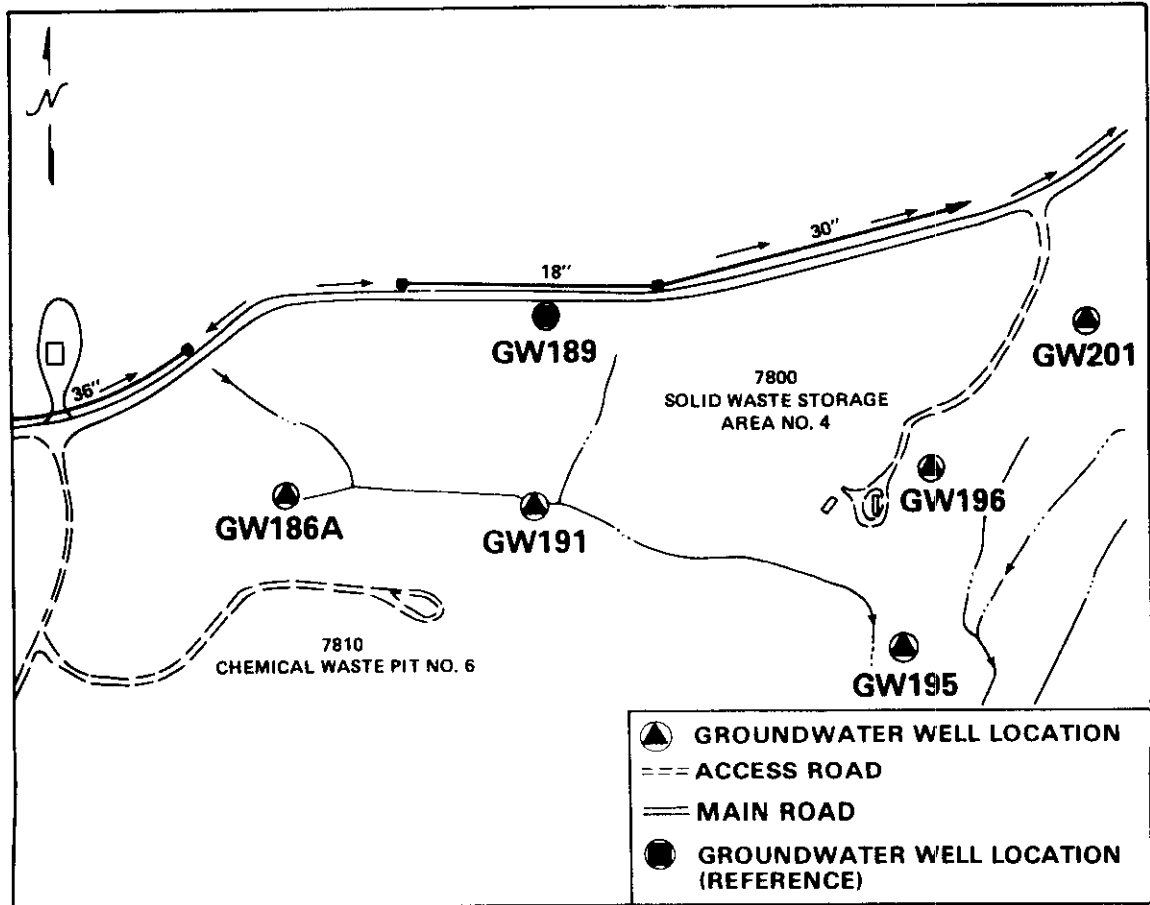


Fig. A.6.4.3. Locations of groundwater wells near Solid Waste Storage Area 4, ORNL.

ORNL-DWG 86-0012R4

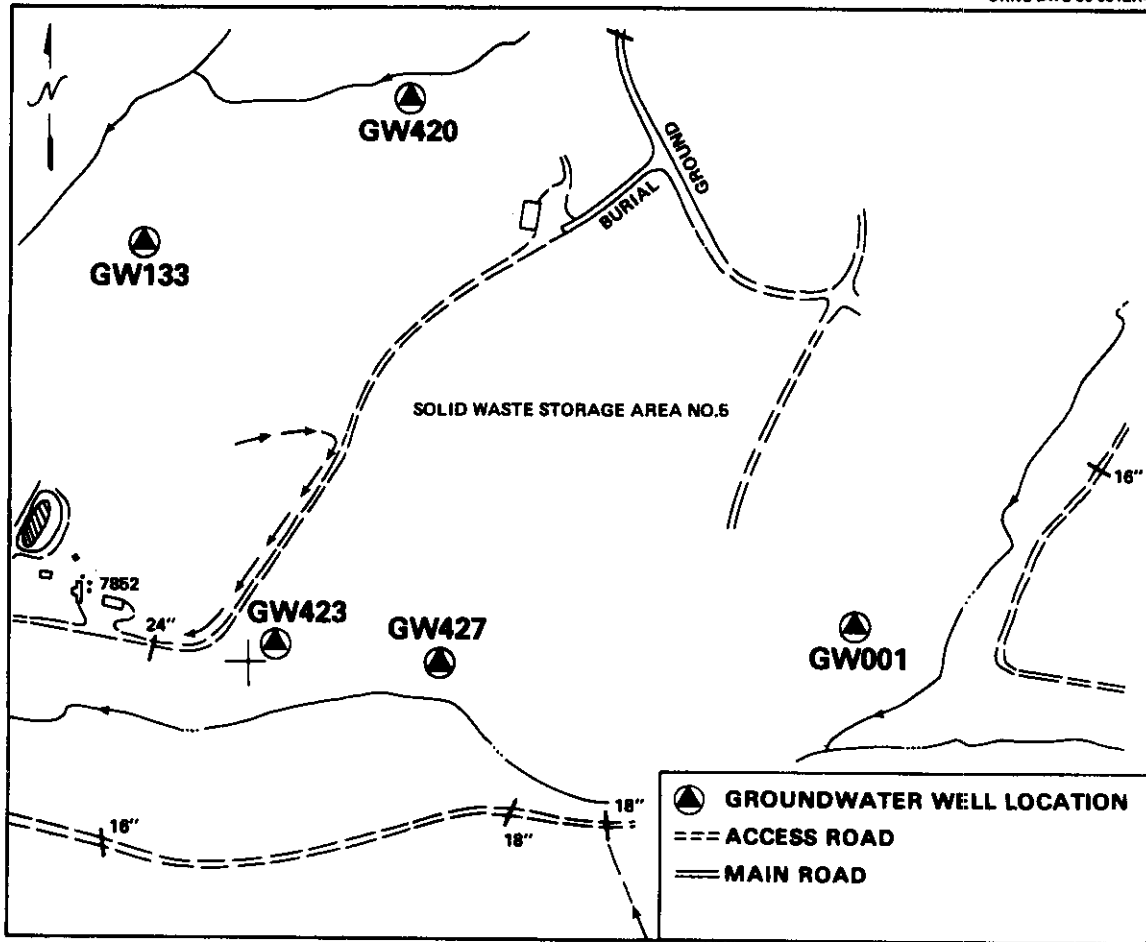


Fig. A.6.4.4. Locations of groundwater wells near Solid Waste Storage Area 5, ORNL.

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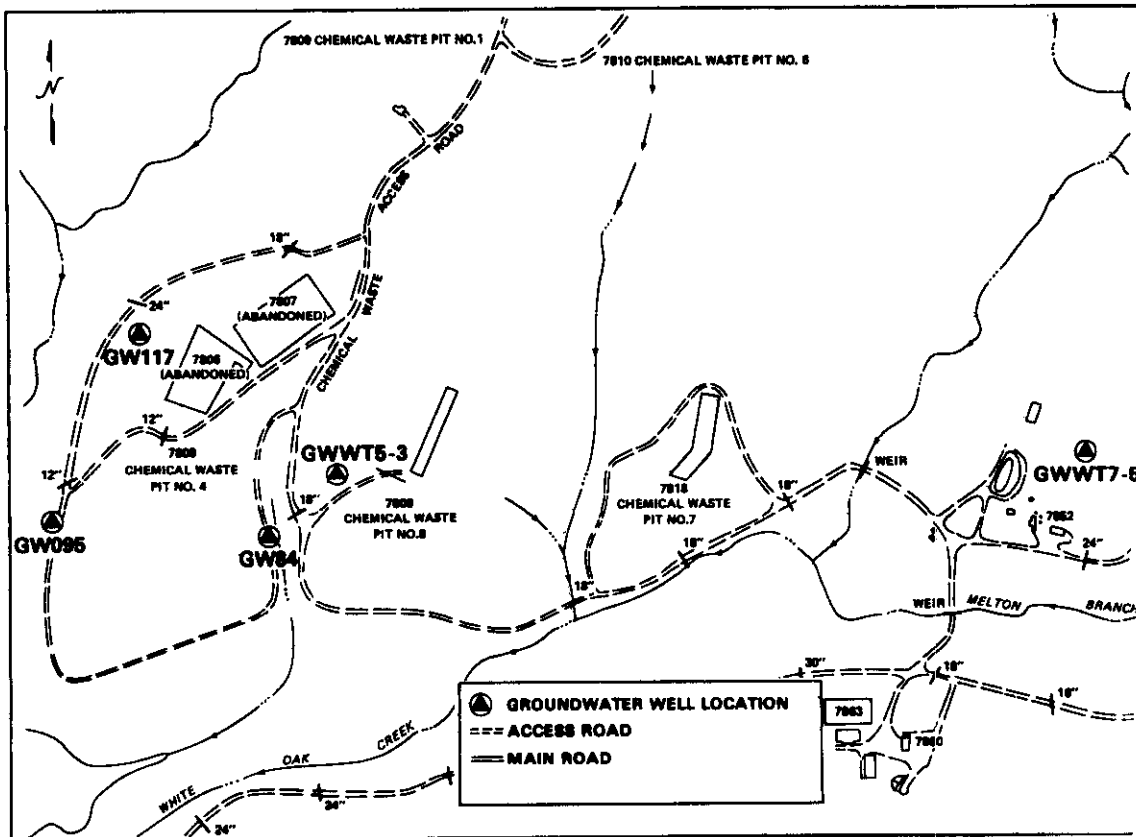


Fig. A.6.4.5. Locations of groundwater wells near pits, ORNL.



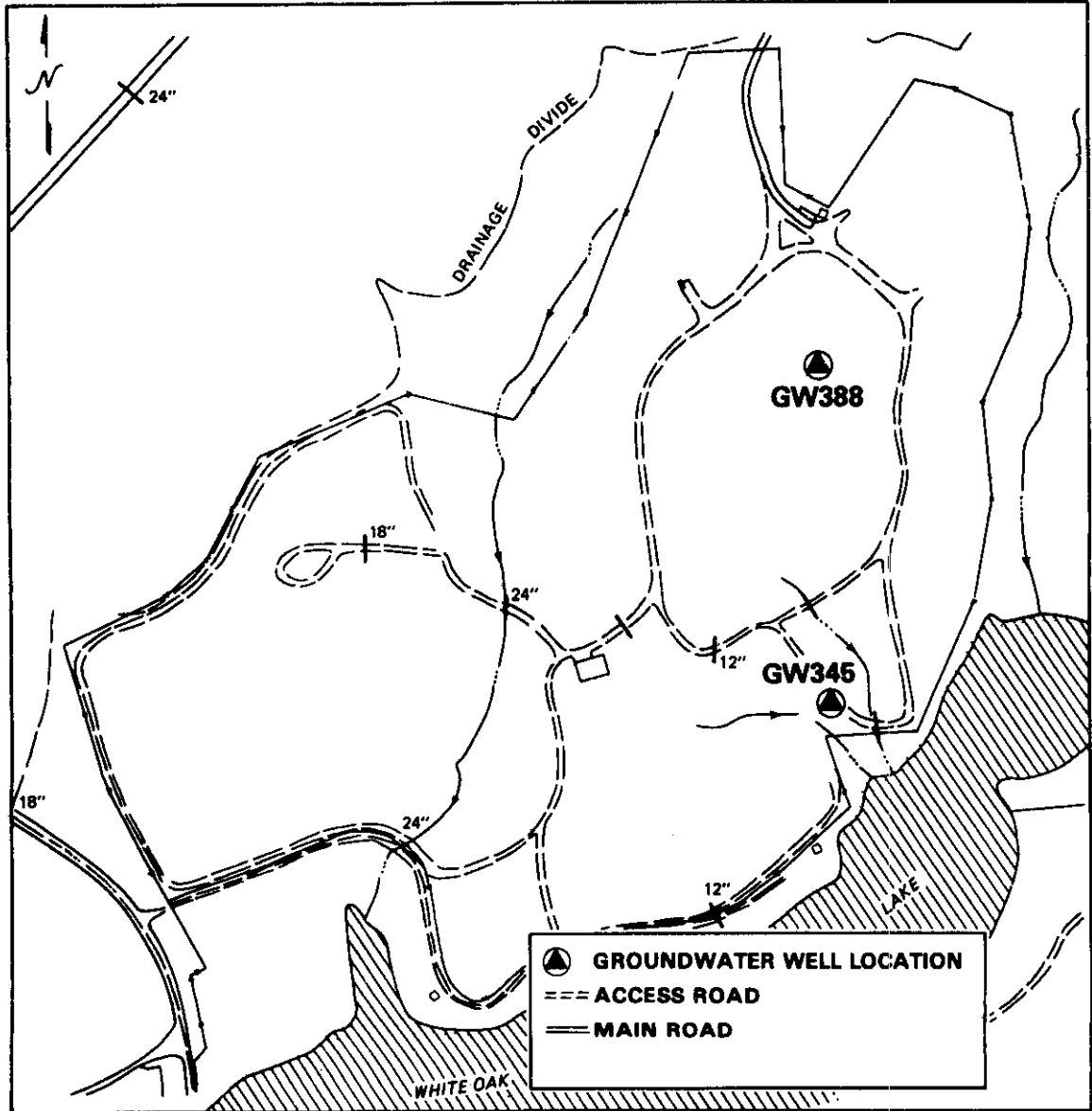


Fig. A.6.4.6. Locations of groundwater wells near Solid Waste Storage Area 6, ORNL.

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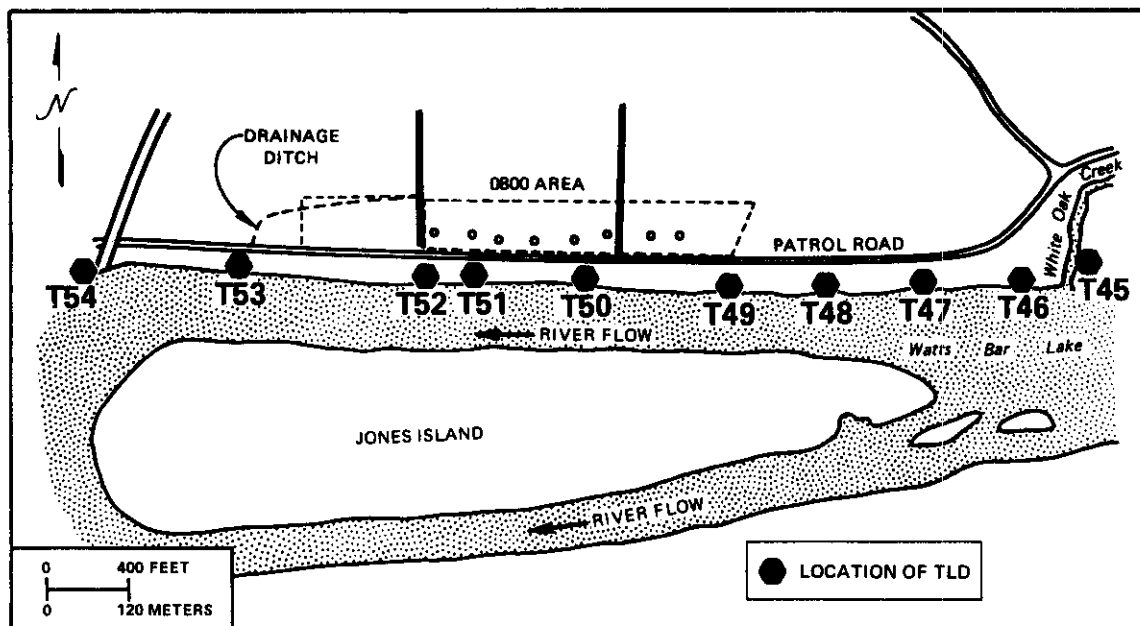


Fig. A.7.1. Location map of TLDs along the Clinch River.

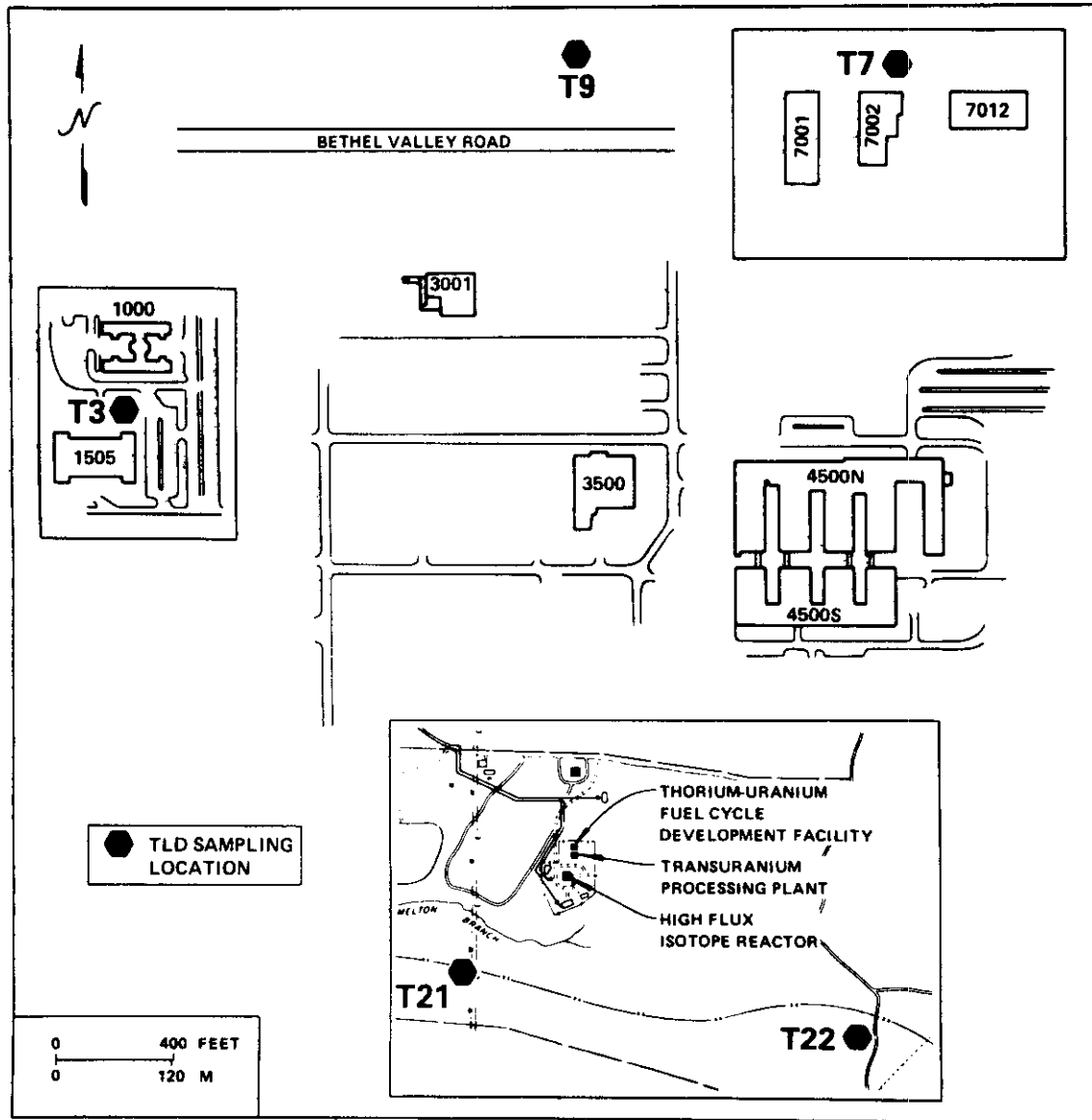


Fig. A.7.2. Location map of TLDs around the ORNL Perimeter.

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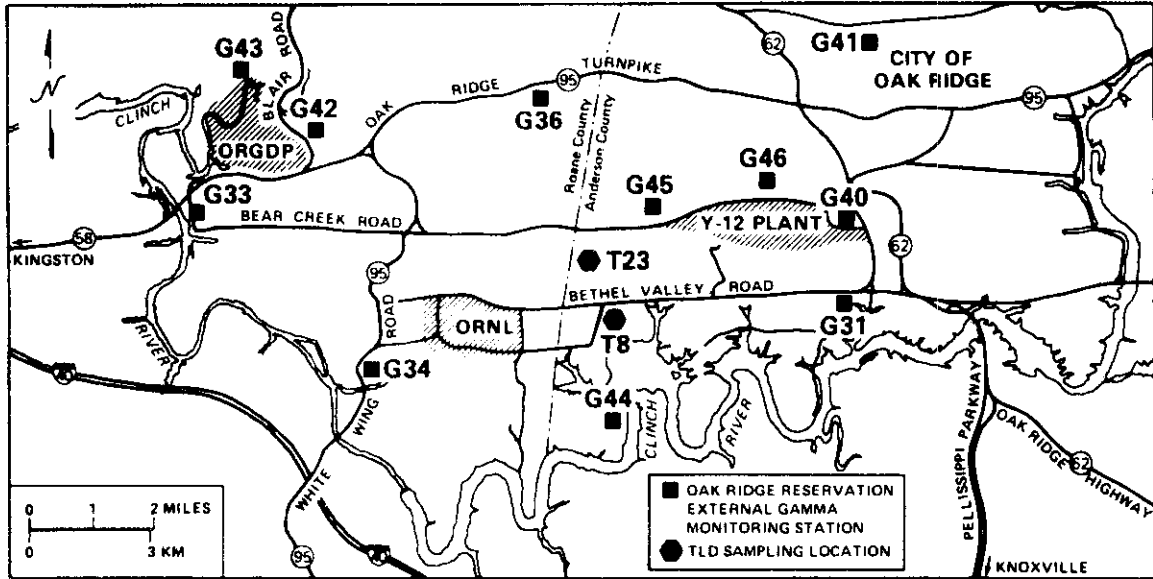


Fig. A.7.3. Location map of external gamma radiation monitoring stations on the ORR.

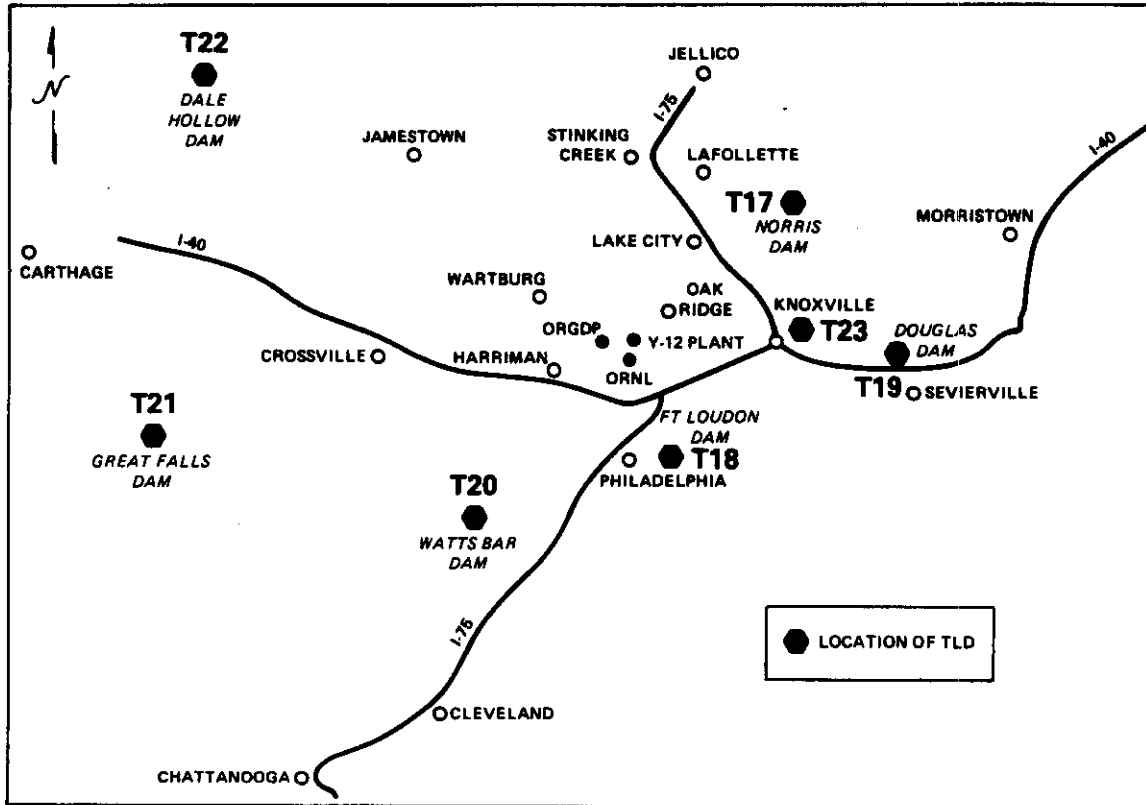


Fig. A.7.4. Location map of TLDs at remote locations.

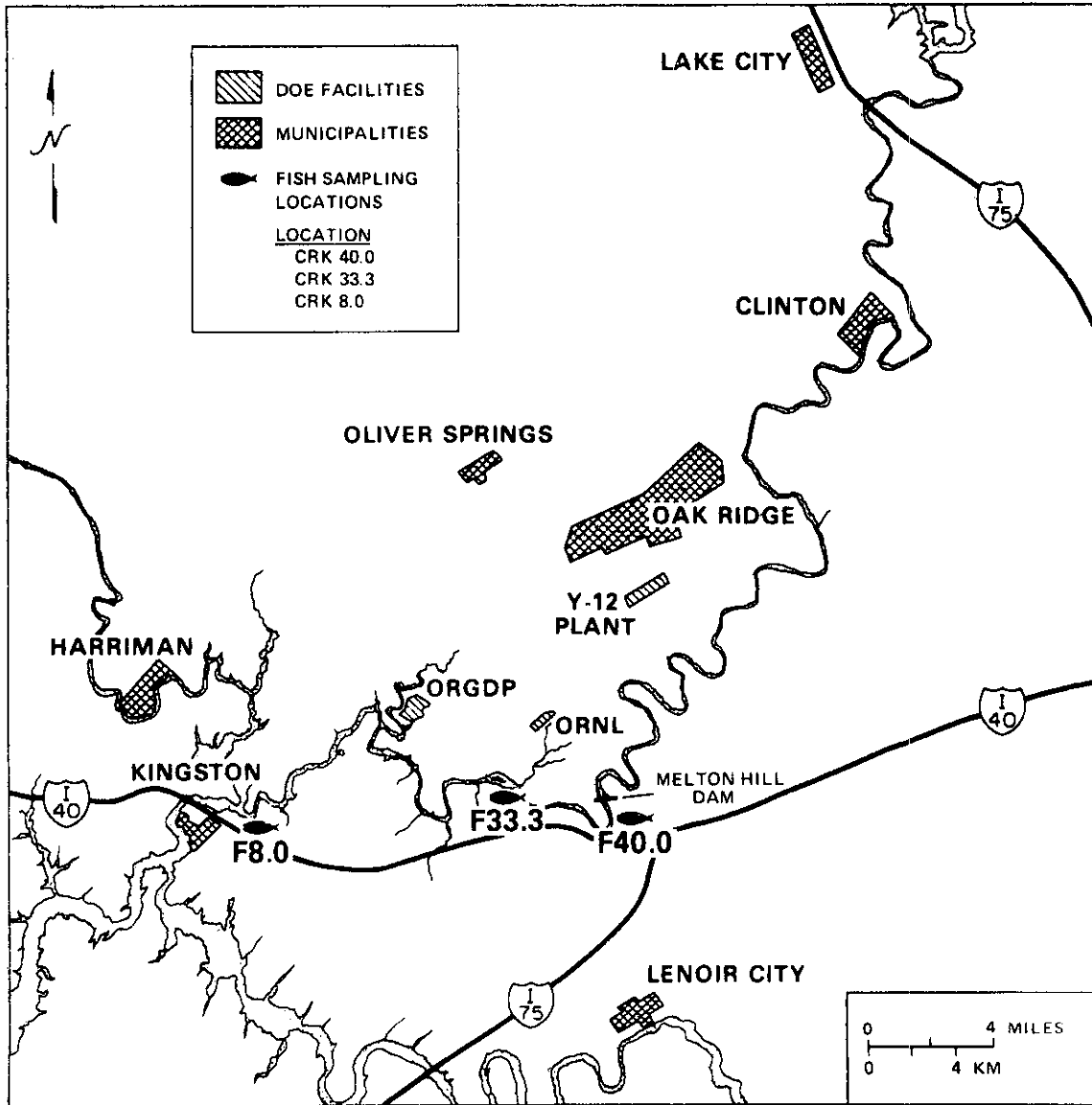


Fig. A.8.1.1. 1986 fish sampling locations.

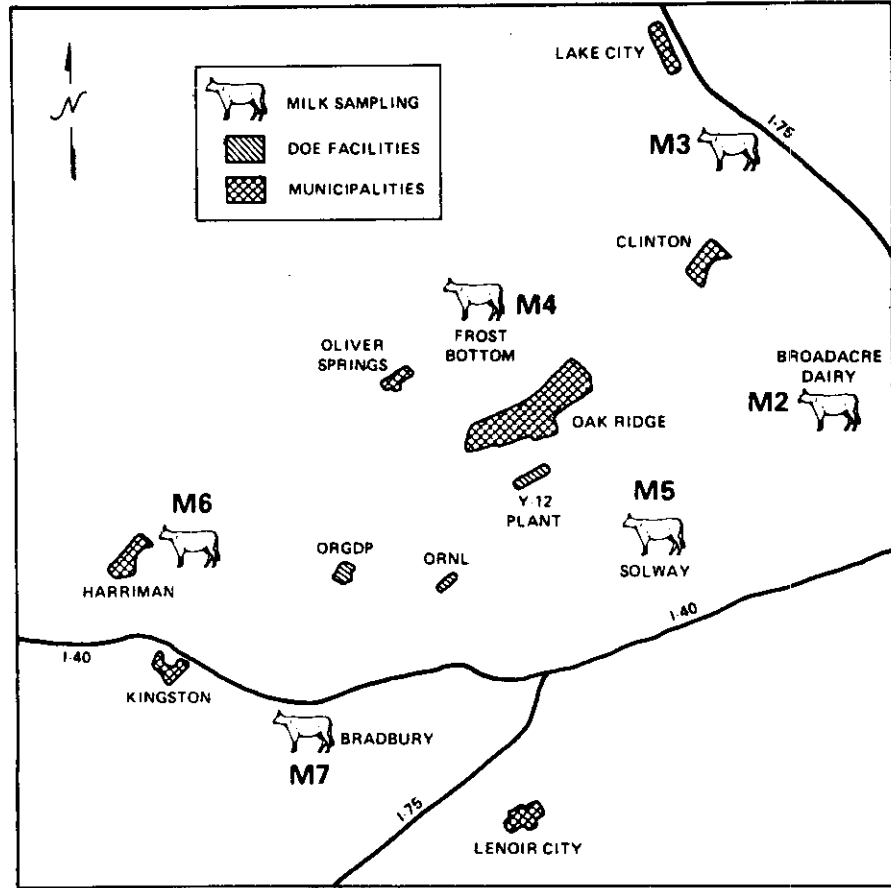


Fig. A.8.2.1. Map showing milk sampling locations near the Oak Ridge area.

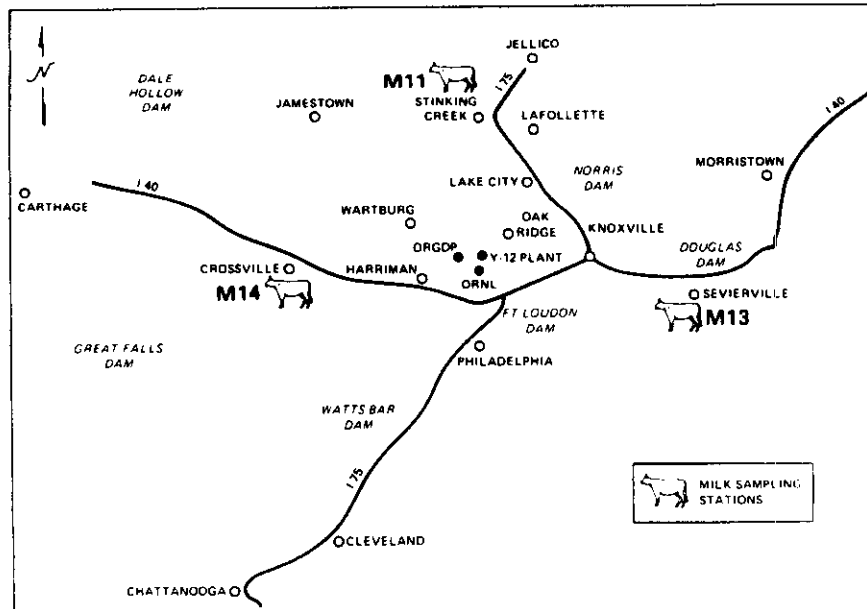


Fig. A.8.2.2. Map showing milk sampling locations remote from the Oak Ridge area.

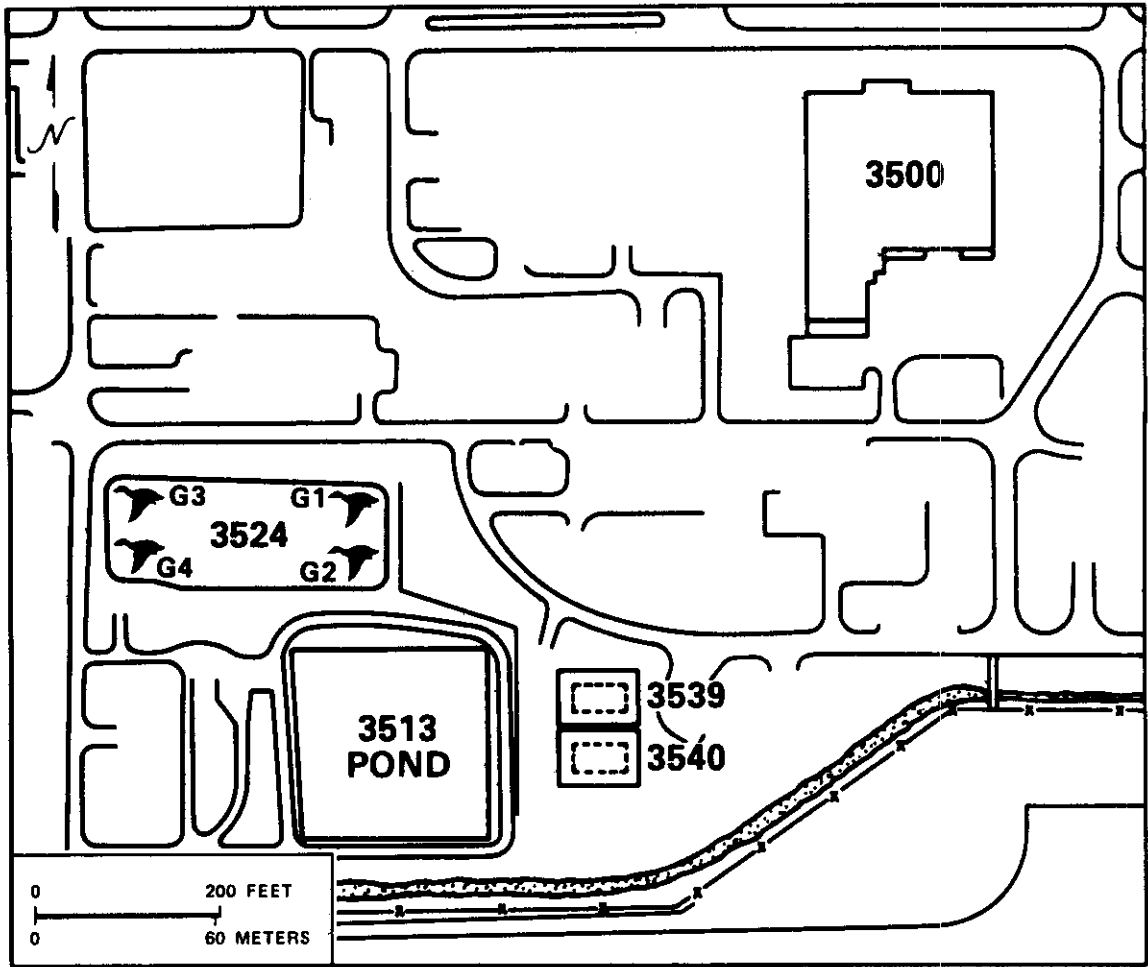


Fig. A.8.3.1. Map showing waterfowl sampling locations at ORNL.



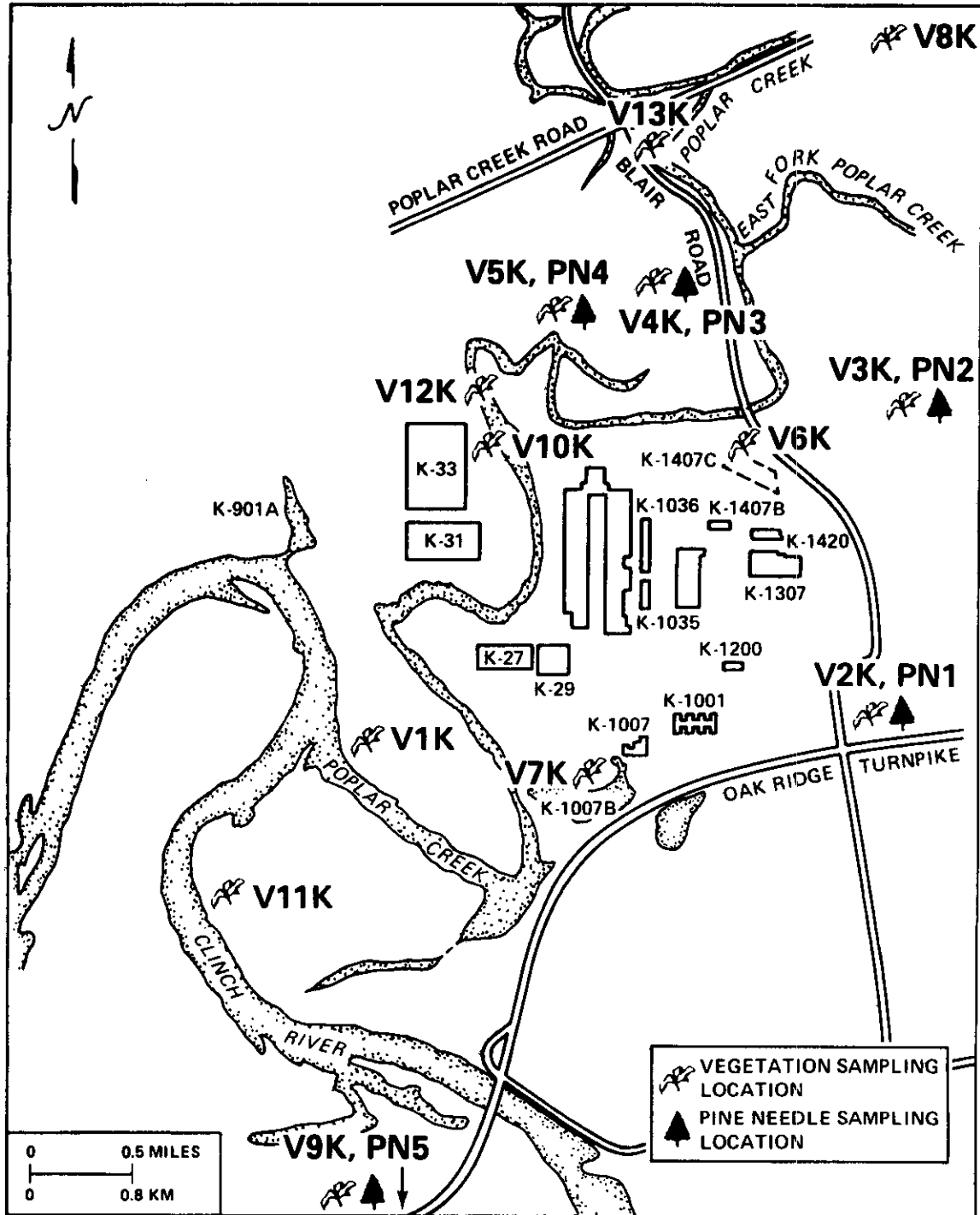


Fig. A.9.1.1. Map of ORGDP pine needle and grass sampling locations.

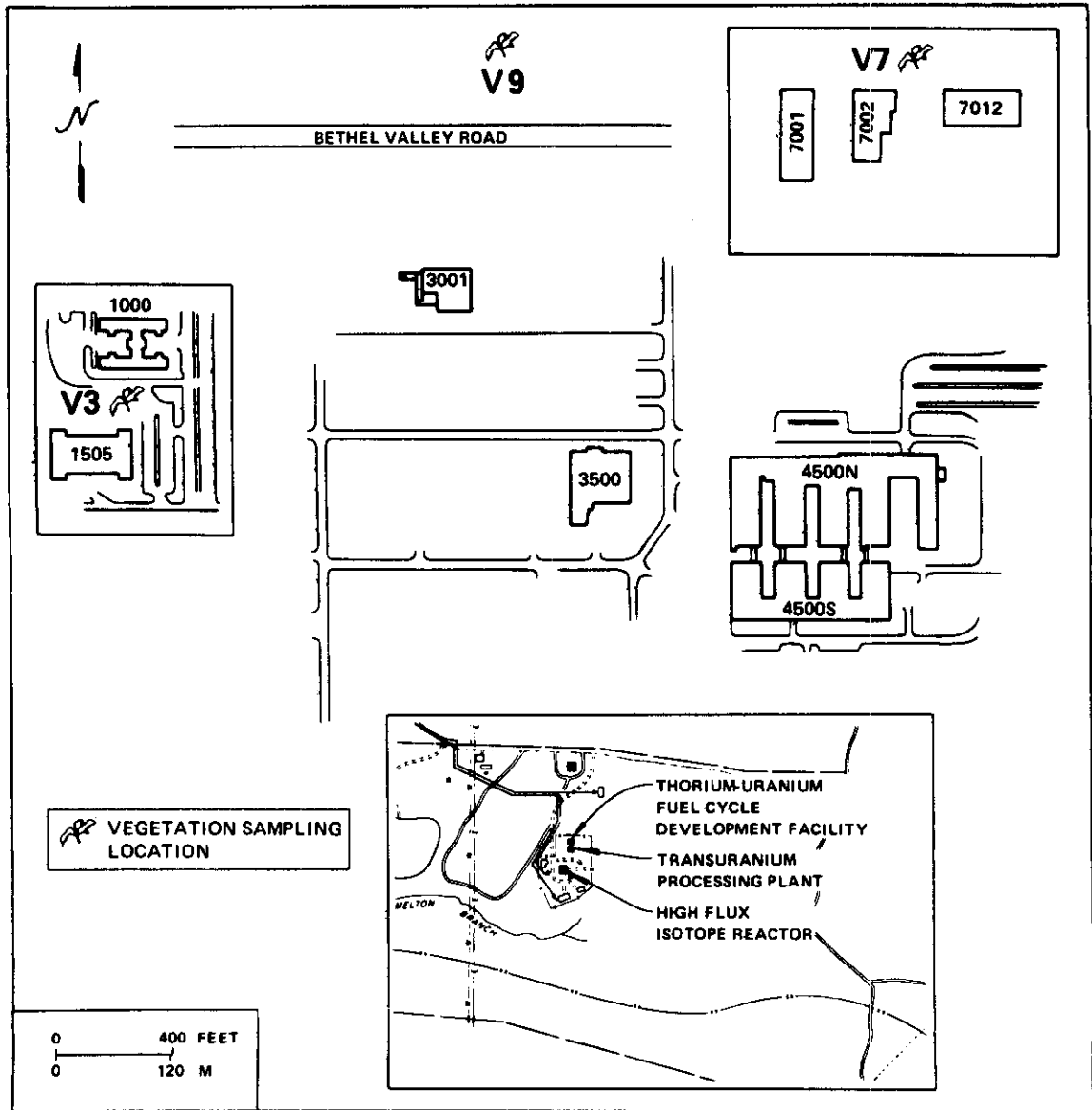


Fig. A.9.1.2. Map of ORNL grass sampling locations.

ORNL-DWG 87-9292

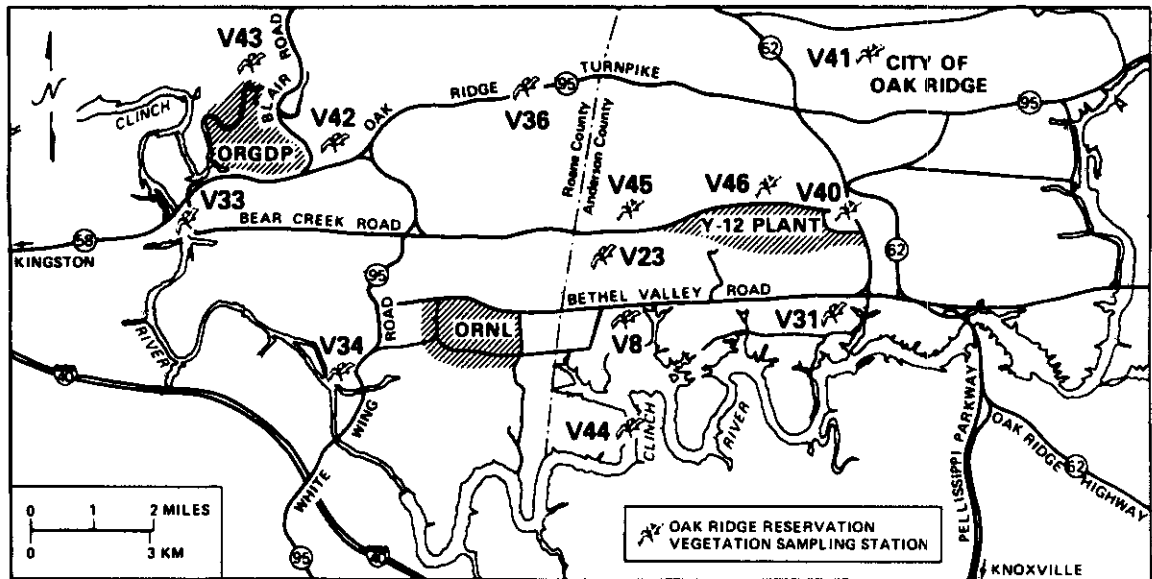


Fig. A.9.1.3. Map of ORR grass sampling locations.

ORNL-DWG 87-7080

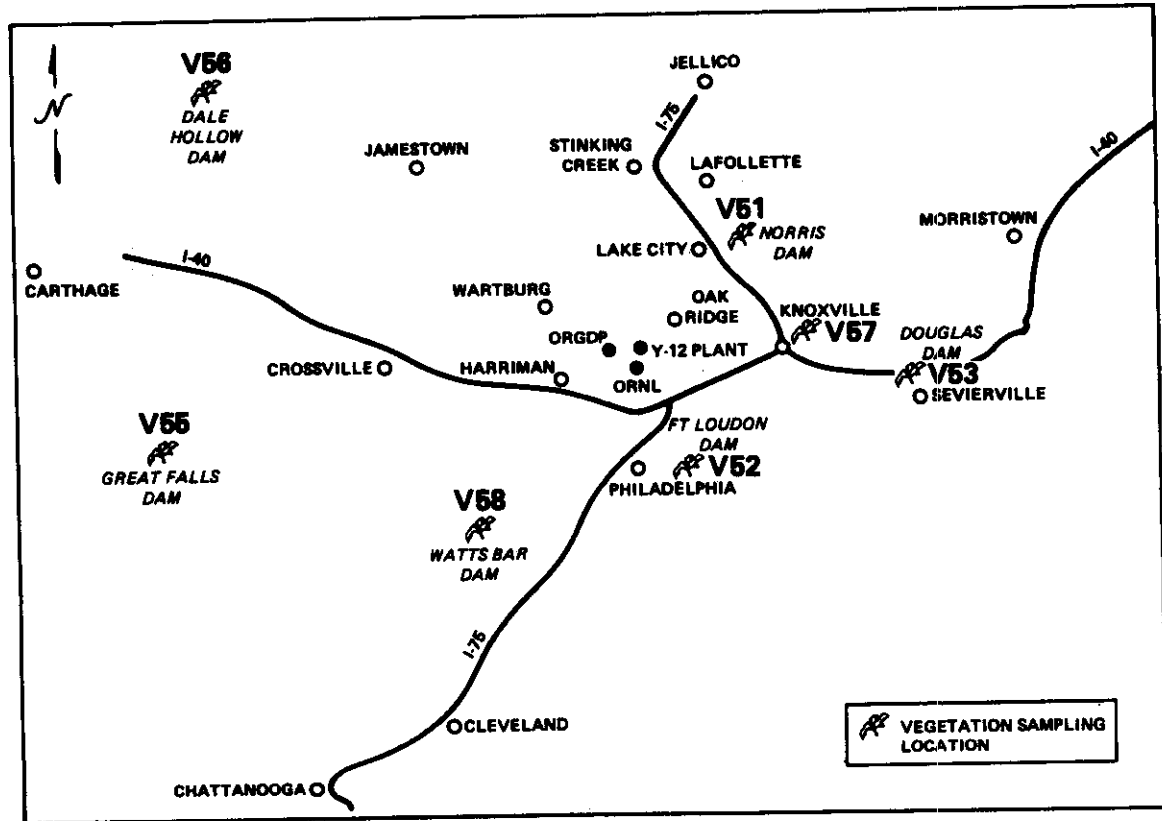


Fig. A.9.1.4. Map of remote grass sampling locations.

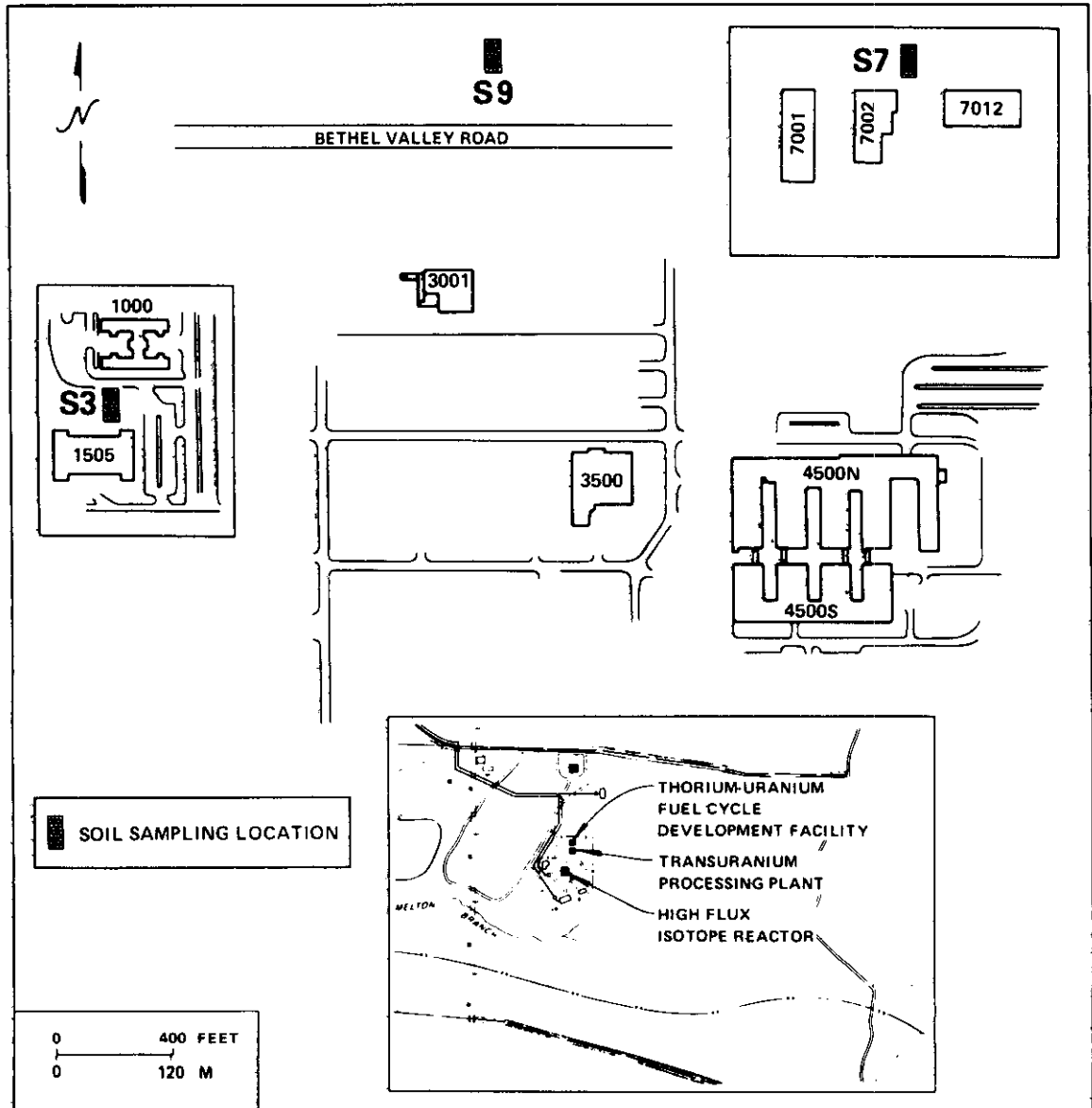


Fig. A.9.2.1. Soil sampling locations around ORNL.

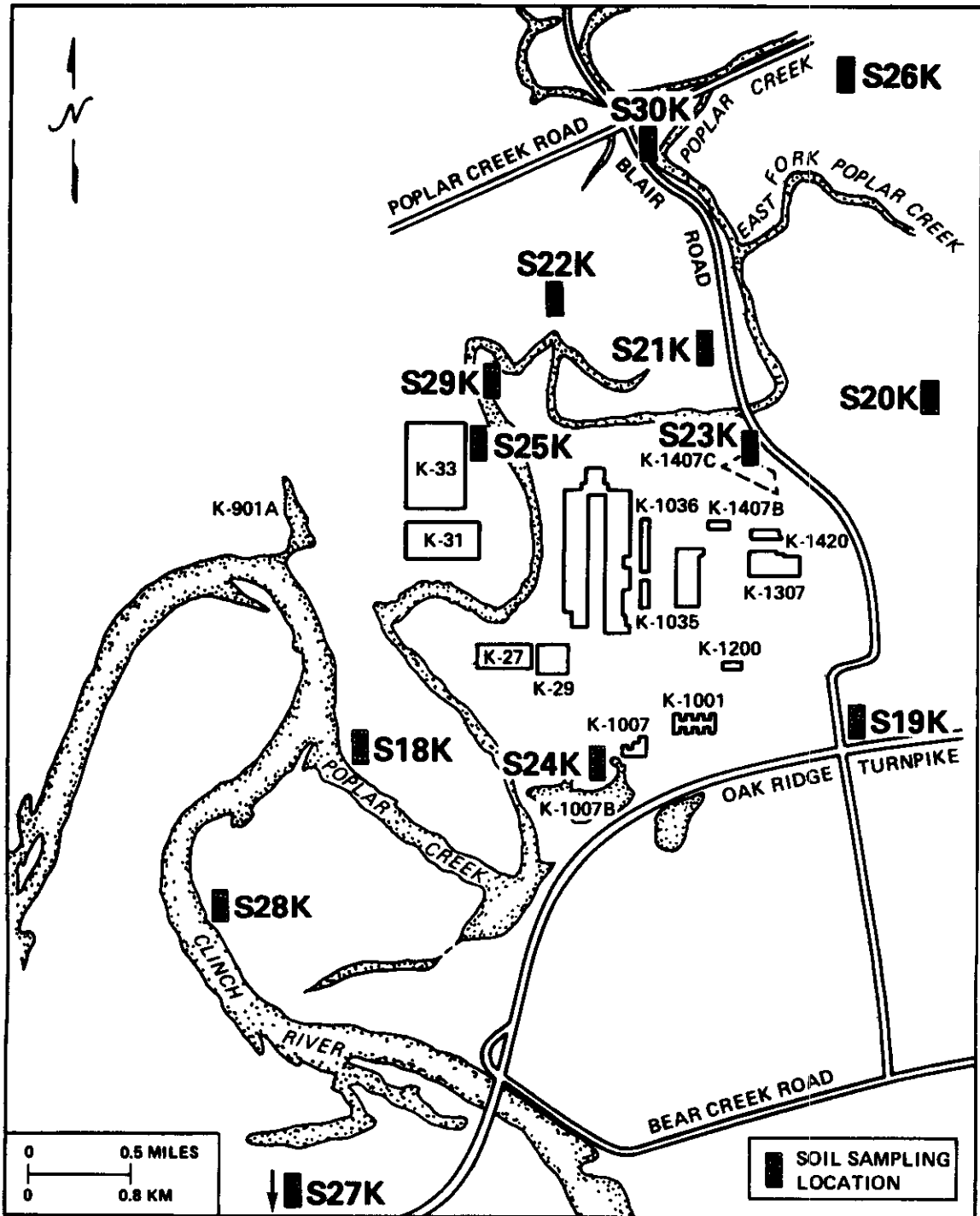


Fig. A.9.2.2. Soil sampling locations around ORGDP.

ORNL-DWG 87-6971

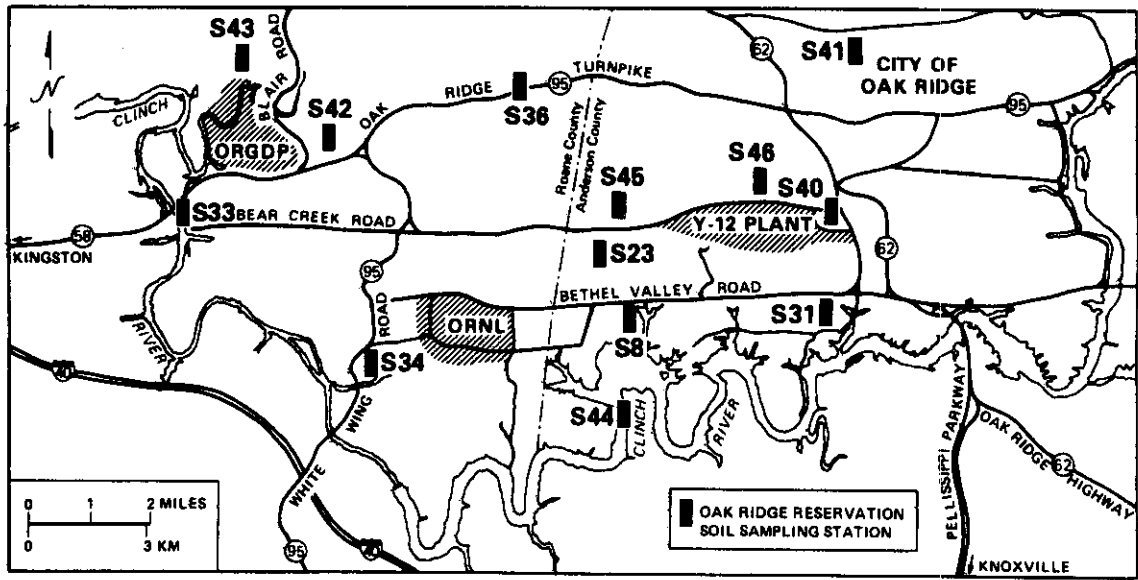


Fig. A.9.2.3. Locations of ORR soil sampling areas.

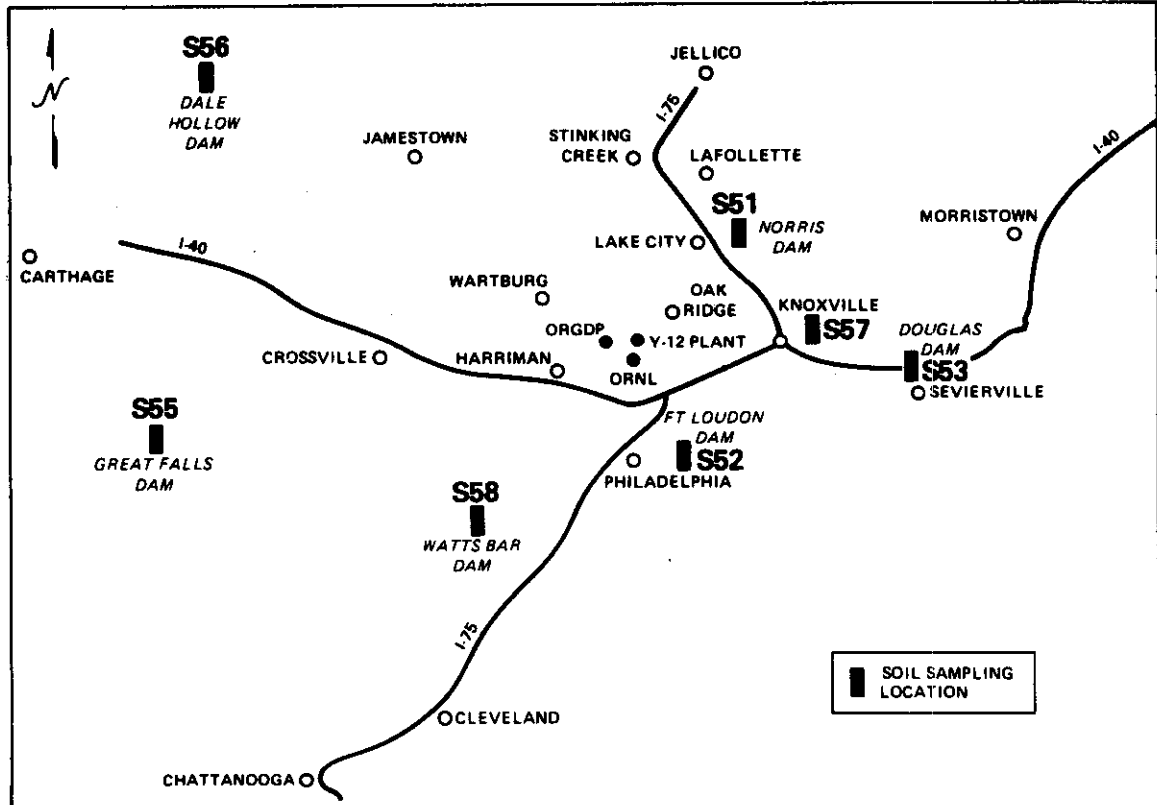


Fig. A.9.2.4. Locations of remote soil sampling areas.



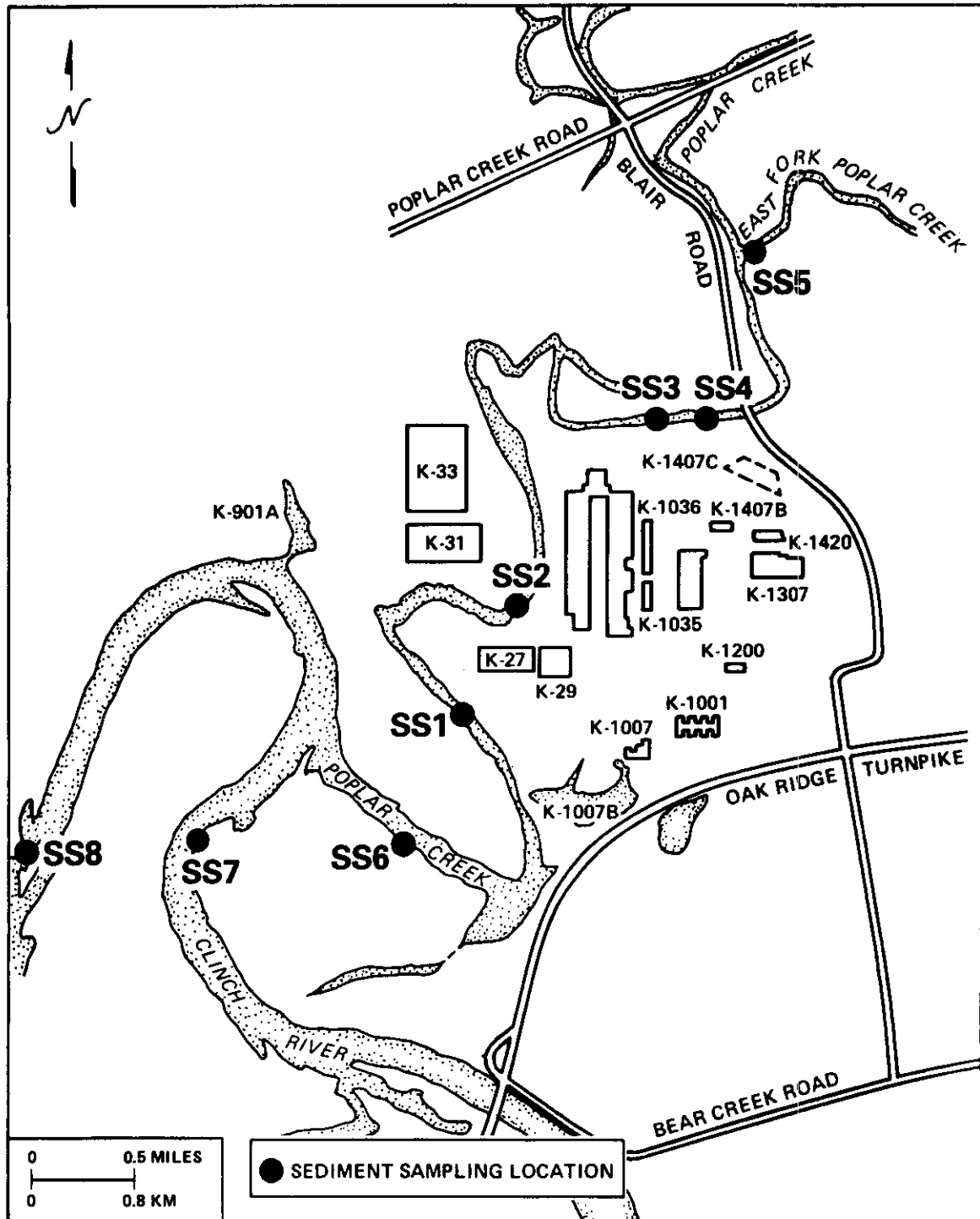


Fig. A.9.3.3. Stream sediment sampling locations at ORGDP.

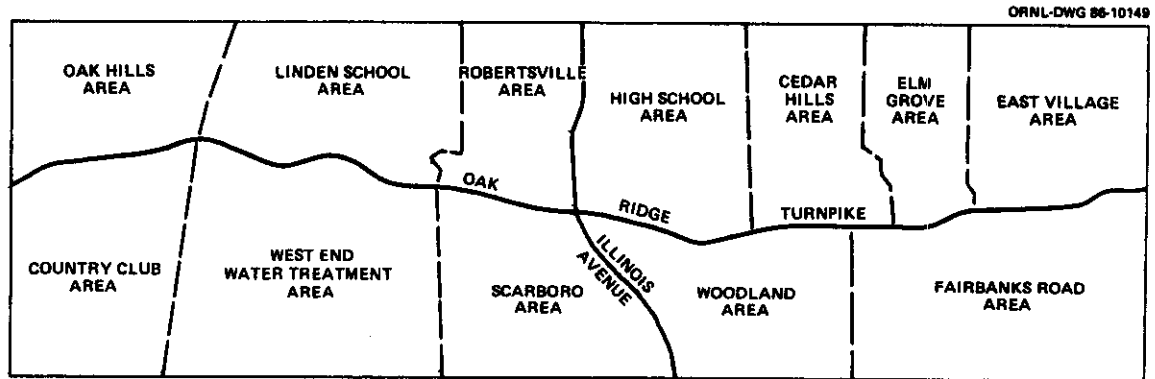


Fig. A.10.2.1. Private property areas in the Oak Ridge community.

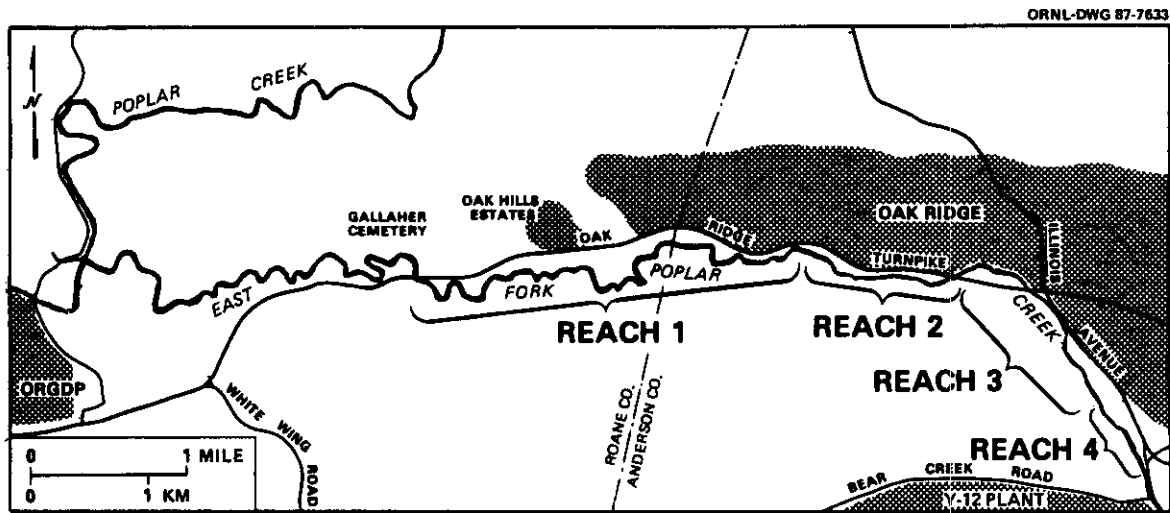


Fig. A.10.2.2. EFPC and its subdivisions.

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