FOV

Oak Ridge Reservation

Annual Site Environmental Report for 1994

Units of radiation measure

Current System	Système International	Conversion
curie (Ci)	becquerel (Bq)	1 Ci = 3.7×10^{10} Bq
rad (radiation absorbed dose)	gray (Gy)	1 rad = 0.01 Gy
rem (roentgen equivalent man)	sievert (Sv)	1 rem = 0.01 Sv

Fractions and multiples of units

Multiple	Decimal equivalent	Prefix	Symbol	Report format
10^6	1,000,000	mega-	M	E+06
10^3	1,000	kilo-	k	E+03
10^2	100	hecto-	h	E+02
10	10	deka-	da	E+01
10^{-1}	0.1	deci-	d	E–01
10^{-2}	0.01	centi-	c	E–02
10^{-3}	0.001	milli-	m	E–03
10^{-6}	0.000001	micro-	μ	E–06
10^{-9}	0.000000001	nano-	n	E–09
10^{-12}	0.000000000001	pico-	p	E–12
10^{-15}	0.000000000000001	femto-	f	E–15
10^{-18}	0.000000000000000001	atto-	a	E–18

On the cover: The purple fringeless orchid (*Platanthera peramoena*). (ORNL PHOTO 7546-90)

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Oak Ridge Reservation
Annual Site Environmental Report for 1994

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Acronyms and Abbreviations

ACGIH	American Conference of Governmental Industrial Hygienists
AIHA	American Industrial Hygiene Association
ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
ARAP	Aquatic Resources Alteration Permit
ARAR	applicable or relevant and appropriate requirement
BCK	Bear Creek kilometer
BMAP	Biological Monitoring and Abatement Program
BOD	biological oxygen demand
CAA	Clean Air Act
CDI	chronic daily intake
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CET	Center for Environmental Technology
CFC	chlorofluorocarbon
CFR	*Code of Federal Regulations*
CLP	Contract Laboratory Program
CMC	criterion maximum concentration
CMTS	Central Mercury Treatment System
CNF	Central Neutralization Facility
CRADA	cooperative research and development agreement
CRK	Clinch River kilometer
CRMP	cultural resource management plan
CWA	Clean Water Act
CWG	citizens' working group
CWM	Center for Waste Management
CX	categorical exclusion
D&D	decontamination and decommissioning
DAC	derived air concentration
DCF	dose conversion factor
DCG	derived concentration guide
DMR	Discharge Monitoring Report QA Study
DNAPL	dense nonaqueous phase liquid
DOE	U.S. Department of Energy
DOE-HQ	U.S. Department of Energy Headquarters
DOE-ORO	U.S. Department of Energy Oak Ridge Operations Office
DWS	drinking water standard
EDE	effective dose equivalent
EESSMS	East End Sanitary Sewer Monitoring Station
EFK	East Fork Poplar Creek kilometer
EFPC	East Fork Poplar Creek

EIS	environmental impact statement
ELPAT	Environmental Lead Proficiency Analytical Testing Program
EML	Environmental Measurements Laboratory
EMP	*Environmental Monitoring Plan for the Oak Ridge Reservation*
EMSL-LV	Environmental Monitoring Systems Laboratory, Las Vegas
Energy Systems	Lockheed Martin (formerly Martin Marietta Energy Systems, Inc.)
EPA	U.S. Environmental Protection Agency
EPA-HQ	U.S. Environmental Protection Agency Headquarters
EPCRA	Emergency Planning and Community Right-To-Know Act
EPPIP	environmental protection program implementation plan
ER	environmental restoration
ES&H	environment, safety, and health
ESD	Environmental Sciences Division (ORNL)
FDA	U.S. Food and Drug Administration
FFA	federal facilities agreement
FFCA	federal facilities compliance agreement
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FONSI	finding of no significant impact
FTIR	Fourier transform infrared (spectroscopy)
FY	fiscal year
GIS	geographic information system
GWPP	Groundwater Protection Program
GWPS	groundwater protection standard
HAZWRAP	Hazardous Waste Remedial Action Program
HCK	Hinds Creek kilometer
HEPA	high-efficiency particulate air (filter)
HQ	hazard quotient
HSWA	Hazardous and Solid Waste Amendments to RCRA (1984)
I/CDI	intake (estimated dose)/calculated daily intake
ICP-MS	inductively coupled plasma mass spectrometry
ICRP	International Commission on Radiological Protection
IHgTU	Interim Mercury Treatment Unit
IRIS	Integrated Risk Information System
IWC	instream waste concentration
IWMF	Interim Waste Management Facility
LC_{50}	lethal concentration to 50% of organisms
LDR	land disposal restriction
LLLW	liquid low-level (radioactive) waste
LLW	low-level (radioactive) waste
LQAP	*Laboratory Quality Assurance Plan*
M&O	management and operating (contractor)
MACT	maximum achievable control technology
MAPEP	Mixed Analyte Performance Evaluation Program

MCL	maximum contaminant level
MEK	Melton Branch kilometer
Mgd	million gallons per day
MIK	Mitchell Branch kilometer
MSDS	material safety data sheet
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NIOSH	National Institute of Occupational Safety and Health
NIST	National Institute of Standards and Technology
NOD	notice of deficiency
NOEC	no-observed-effect concentration
NOEL	no-observed-effect limit
NON	notice of noncompliance
NOV	notice of violation
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRWTF	Nonradiological Wastewater Treatment Facility
ORAU	Oak Ridge Associated Universities
OREIS	Oak Ridge Environmental Information System
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
ORR-PCB-FFCA	Oak Ridge Reservation Polychlorinated Biphenyl Federal Facilities Compliance Agreement
ORS	Occurrence Reporting System
OSHA	Occupational Safety and Health Administration
OU	operable unit
PA/SI	preliminary assessment/site investigation
PAM	perimeter air monitoring (station)
PAT	Proficiency Analytical Testing
PCB	polychlorinated biphenyl
PCK	Poplar Creek kilometer
PCPA	post-closure permit application
PET	Proficiency Environmental Testing
PIDAS	Perimeter Intrusion Detection Assessment System
PM10	particulate matter less than 10 microns in diameter
POTW	publicly owned treatment works
PWMP	Pond Waste Management Project
QA	quality assurance
QA/QC	quality assurance/quality control
QC	quality control
R&D	research and development
RAM	remote air monitoring (station)

RCRA	Resource Conservation and Recovery Act
RCW	recirculating cooling water
RfD	reference dose
RI/FS	remedial investigation/feasibility study
RMPE	Reduction of Mercury in Plant Effluent
RQ	reportable quantity
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SF	slope factor
SHPO	state historic preservation officer
SMCL	secondary maximum contaminant level
SOP	standard operating procedure
SPWTF	Steam Plant Wastewater Treatment Facility
SRF	site ranking form
SSAB	Site-Specific Advisory Board
SWHISS	Surface Water Hydrological Information Support System
SWM	solid waste management
SWMU	solid waste management unit
SWPPP	Storm Water Pollution Prevention Program
SWSA	solid waste storage area
TCMP	Toxicity Control and Monitoring Program
TDEC	Tennessee Department of Environment and Conservation
TDEC/DOE-O	Tennessee Department of Environment and Conservation DOE Oversight Division
TEMA	Tennessee Emergency Management Agency
TOA	Tennessee Oversight Agreement
TPF	Transuranic Processing Facility
TRI	toxic release inventory
TRK	Tennessee River kilometer
TRU	transuranic
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal
TSD	Transportation Safeguards Division
TSP	total suspended particulates
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
UE	uranium enrichment
UE-PCB-FFCA	Uranium Enrichment Polychlorinated Biphenyl Federal Facilities Compliance Agreement
UE-TSCA-FFCA	Uranium Enrichment Toxic Substances Control Act Federal Facilities Compliance Agreement
UEFPC	Upper East Fork Poplar Creek
UST	underground storage tank
UV	ultraviolet
VOC	volatile organic compound

WAG	waste area grouping
WCK	White Oak Creek kilometer
WETF	West End Treatment Facility
WIPP	Waste Isolation Pilot Plant
WMP	waste management program
WOC	White Oak Creek
WOD	White Oak Dam
WOL	White Oak Lake
WP	Water Pollution Performance Evaluation QA Program
WS	Water Supply Laboratory Performance QC Program

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The authors wish to recognize everyone who participated in the publication of the annual site environmental report for this year. Although we cannot name everyone who participated, we'd like to mention a few names in particular.

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1. Site and Operations Overview

L. V. Hamilton, L. W. McMahon, and L. G. Shipe

Abstract

The U.S. Department of Energy (DOE) currently oversees activities on the Oak Ridge Reservation, a government-owned, contractor-operated facility. The three sites that compose the reservation (the Y-12 Plant, Oak Ridge National Laboratory, and the K-25 Site) were established in the early 1940s as part of the Manhattan Project, a secret undertaking that produced the first atomic bombs. The reservation's role has evolved over the years, and it continues to adapt to meet the changing defense and energy needs of the United States. Both the work carried out for the war effort and subsequent research, development, and production activities have produced (and continue to produce) radiological and hazardous wastes. Environmental monitoring and surveillance are carried out on and around the reservation in accordance with DOE Order 5400.1, *General Environmental Protection Program*, to determine the effects (if any) of past and current operations on the reservation and its surroundings.

BACKGROUND

This document contains a summary of environmental monitoring activities on the Oak Ridge Reservation (ORR) and its surroundings and is required for U.S. Department of Energy (DOE) facilities. The monitoring and documentation criteria are described in DOE Order 5400.1, General Environmental Protection Program. The results summarized in this report are based on the data collected during 1994 and compiled in *Environmental Monitoring on the Oak Ridge Reservation: 1994 Results* (Energy Systems 1995a). A shortened version has also been published that offers a condensed summary of this report. Both books are available on request from ORNL Laboratory Records, P.O. Box 2008, Oak Ridge, TN 37831-6285.

To the extent possible, this document follows the *Environmental Monitoring Plan for the Oak Ridge Reservation* (EMP) (DOE 1992), the authorization and requirement for which are also contained in DOE Order 5400.1. The plan, updated and reissued in 1995, outlines the goals of environmental monitoring for the reservation and its facilities. The plan has been approved by the manager of the DOE Oak Ridge Operations Office (DOE-ORO). The update contains revisions in response to comments received from the Tennessee Department of Environment and Conservation (TDEC) in 1994 and more accurately reflects ongoing monitoring activities on the ORR.

Annual environmental monitoring on the ORR consists of two major activities: effluent monitoring and environmental surveillance, as defined in DOE Order 5400.1.

Effluent monitoring is the collection and analysis of samples or measurements of liquid, gaseous, or airborne effluents to characterize and quantify contaminants and process stream characteristics; assess radiation and chemical exposures to members of the public; and demonstrate compliance with applicable standards.

Environmental surveillance is the collection and analysis of samples of air, water, soil, foodstuffs, biota, and other media from DOE sites and their environs and the measurement of external radiation to demonstrate compliance with applicable standards, assessing

radiation and chemical exposures to members of the public, and assessing effects (if any) on the local environment.

DESCRIPTION OF SITE LOCALE

The city of Oak Ridge lies in a valley between the Cumberland and Blue Ridge mountain ranges and is bordered on two sides by the Clinch River. The Cumberland Mountains are 16 km (10 miles) to the northwest; the Great Smoky Mountains National Park is 51 km (32 miles) to the southeast (Fig. 1.1).

The ORR lies primarily within the corporate limits of the city of Oak Ridge and encompasses all of the contiguous land owned by DOE in the Oak Ridge area. The residential section of Oak Ridge forms the northern boundary of the reservation. The Tennessee Valley Authority's (TVA's) Melton Hill and Watts Bar reservoirs on the Clinch and Tennessee rivers form the southern and western boundaries (Fig. 1.2).

The population of the ten-county region is 717,880, with 5% of its labor force employed on the ORR (Fig. 1.3). Other towns nearest the reservation are Oliver Springs, Clinton, Lenoir City, Farragut, Kingston, and Harriman (Fig. 1.4). Knoxville, the major metropolitan area nearest Oak Ridge, is located about 40 km (25 miles) to the east and has a population of about 165,000 (1990 census). Except for the city of Oak Ridge, the land within 8 km of the ORR is predominantly rural and is used primarily for residences, small farms, and cattle pasture. Fishing, boating, water skiing, and swimming are popular recreational activities in the area.

CLIMATE

The climate of the region may be broadly classified as humid continental. The Cumberland Mountains to the northwest help to shield the region from cold air masses that frequently penetrate far south over the plains and prairies in the central United States

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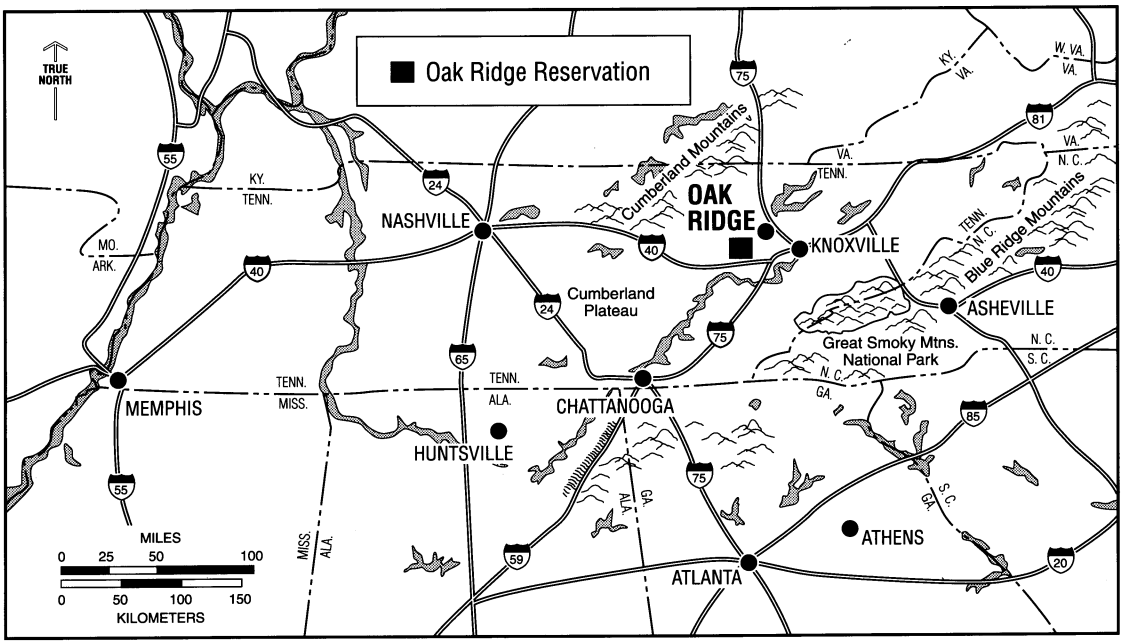

Fig. 1.1. Location of the city of Oak Ridge.

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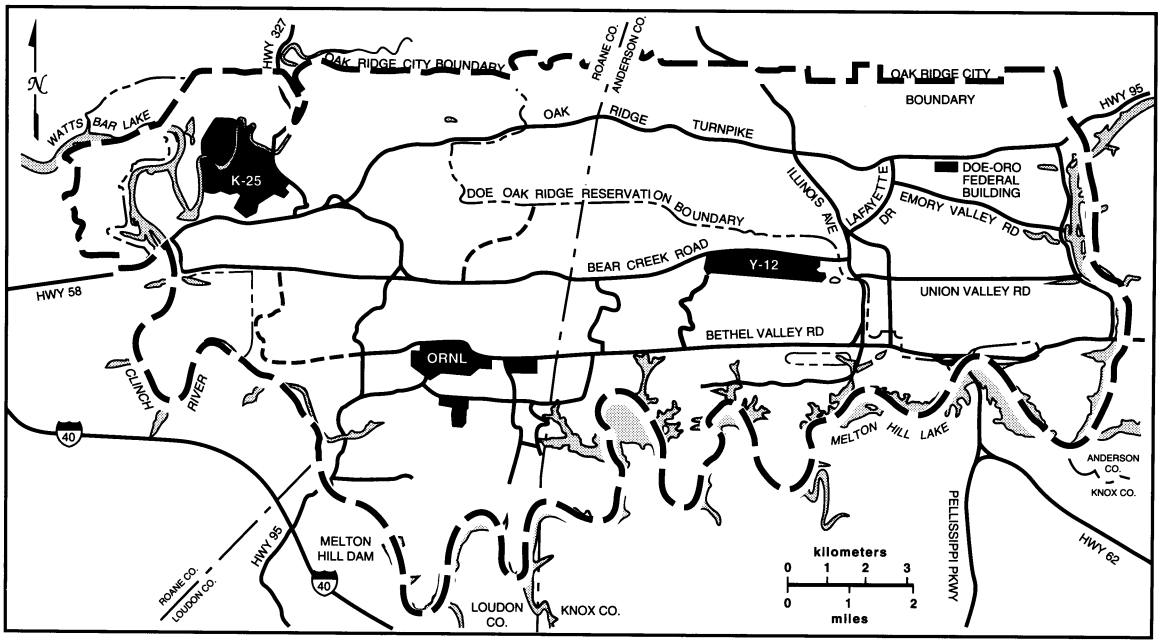


Fig. 1.2. The Oak Ridge Reservation.

ORNL-DWG 94M-8367

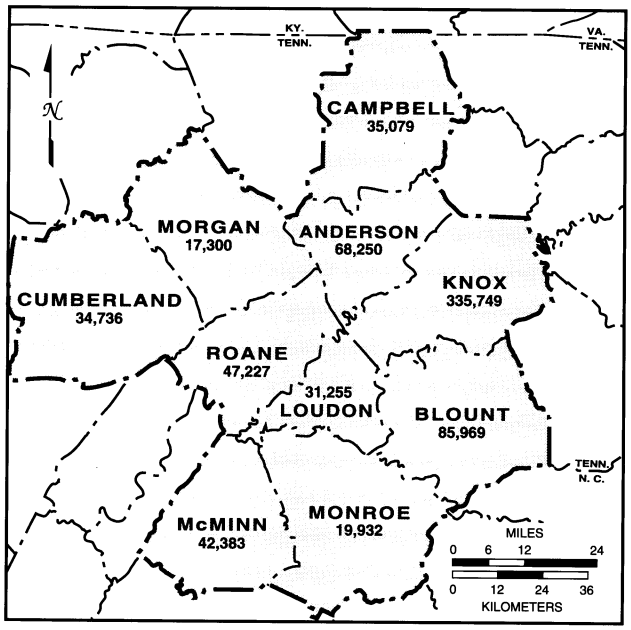


Fig. 1.3. The ten-county region surrounding the Oak Ridge Reservation. (Population figures based on the 1990 U.S. census.)

during the winter months. During the summer, tropical air masses from the south provide warm and humid conditions that often produce thunderstorms; however, anticyclonic circulation around high-pressure systems centered in the western Gulf of Mexico can bring dry air from the southwestern United States into the region, leading to occasional periods of drought.

Temperature

The mean annual temperature for the Oak Ridge area is 14.4°C (58°F) (Webster and Bradley 1988). The coldest month is usually January, with temperatures averaging about 3.3°C (38°F) but occasionally dipping as low as –31°C (–24°F).

July is typically the hottest month of the year, with temperatures averaging 25°C (77°F) but occasionally peaking at over 37.8°C (100°F). In the course of a year, the difference between maximum and minimum daily temperatures averages 12°C (22°F).

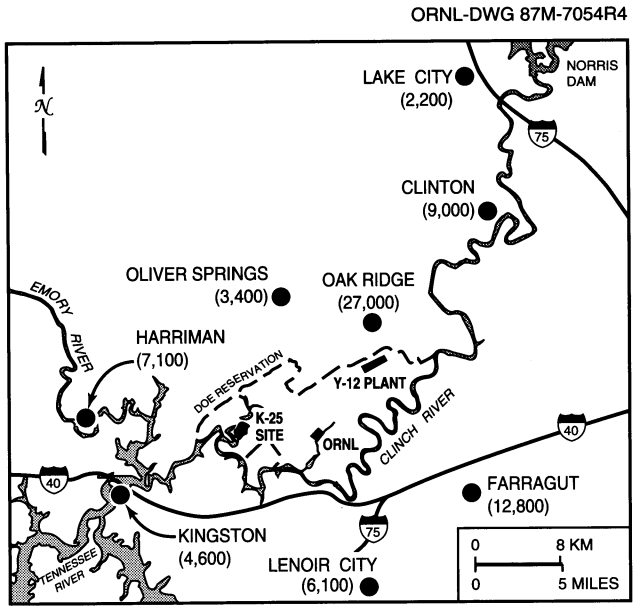


Fig. 1.4. Locations and populations of towns nearest to the Oak Ridge Reservation. (Population figures based on the 1990 U.S. census.)

Winds

Winds in the Oak Ridge area are controlled in large part by the valley-and-ridge topography. Prevailing winds are either up-valley (northeasterly) daytime winds or down-valley (southwesterly) nighttime winds. Wind speeds are less than 11.9 km/hour (7.4 mph) 75% of the time; tornadoes and winds exceeding 30 km/hour (18.5 mph) are rare.

Air stagnation is relatively common in eastern Tennessee (about twice as common as in western Tennessee, for example). An average of about two multi-day air stagnation episodes occur annually in eastern Tennessee, to cover an average of about 8 days per year. August, September, and October are the most likely months for air stagnation episodes.

Precipitation

The 40-year annual average precipitation is 137 cm (53.9 in.), including about 26 cm (10.4 in.) of snowfall. Precipitation in 1994 was 166.6 cm (65.6 in.), about 29.6 cm (11.6 in.) above the annual average. Precipitation in the region is greatest in the summer months (June through August), largely because of thunderstorm activity. The driest periods generally occur during the fall months, when high-pressure systems are most frequent.

Evapotranspiration

Regionally, annual evapotranspiration has been estimated to range from 81 to 89 cm (32 to 35 in.), or 60 to 65% of rainfall (Farnsworth et al. 1982). Evapotranspiration in the Oak Ridge area is 74 to 76 cm (29 to 30 in.), or 55 to 56% of annual precipitation (TVA 1972; Moore 1988; and Hatcher et al. 1989). Evapotranspiration is greatest in association with the growing season, which in the vicinity of the ORR is 220 days, from mid-March through mid-October. During this period, evapotranspiration often exceeds the rate of precipitation, resulting in soil moisture deficits.

DESCRIPTION OF SITE, FACILITIES, AND OPERATIONS

The facilities on the ORR began operating as in 1943 as part of the secret World War II Manhattan Project, producing components for the first nuclear weapons. The ORR continues to be a government-owned, contractor-operated facility, although the nature of the work has changed. The primary missions of the three sites have evolved during the past 50 years and continue to adapt to meet the changing defense and energy needs of the United States.

The reservation contains three major DOE installations: the Oak Ridge Y-12 Plant (Y-12 Plant), the Oak Ridge National Laboratory (ORNL), and the Oak Ridge K-25 Site (K-25 Site). The DOE buildings and structures located on the reservation but outside the major sites consist of the Oak Ridge Institute for Science and Education (ORISE) Scarboro Operations Site, Clark Center Recreational Park, the Central Training Facility, and the Transportation Safeguards maintenance facility.

The off-reservation DOE buildings and structures consist of the Federal Office Building, Office of Scientific and Technical Information, some ORISE offices and laboratories, the Atmospheric Turbulence and Diffusion Division of the Air Resources Laboratory (National Oceanographic and Atmospheric Administration), the American Museum of Science and Energy, the Lockheed Martin Energy Systems administrative support office buildings, and the former museum building. In addition to government-owned property, there are numerous leased buildings housing about 7% of the government and contractor work force.

Lockheed Martin Energy Systems

On March 15, 1995, Lockheed and Martin Marietta completed a merger to create Lockheed Martin Corporation. Following the merger, Martin Marietta Energy Systems, Inc., the prime contractor for the ORR, was renamed Lockheed Martin Energy Systems (Energy Systems).

Energy Systems manages the Y-12 Plant, ORNL, and the K-25 Site as well as most of the other properties on the 14,049-ha (34,700-acre) reservation. In addition, it manages programs at both the Paducah, Kentucky, facility and the Portsmouth plant in Piketon, Ohio. Energy Systems carries out energy research and development, production of enriched uranium and weapons components, and other goals of national importance.

Oak Ridge Y-12 Plant

Until 1992 the primary mission of the Y-12 Plant was the production and fabrication of nuclear weapon components (Fig. 1.5). Activities associated with these functions included production of lithium compounds, recovery of enriched uranium from scrap material, and fabrication of uranium and other materials into finished parts. Fabrication operations included vacuum casting, arc melting, powder compaction, rolling, forming, heat treating, machining, inspection, and testing.

Currently the Y-12 Plant is in the midst of refocusing its technical capabilities and expertise to serve DOE and customers who are approved by DOE. The Y-12 Plant continues to serve as a key manufacturing technology center for the development and demonstration of unique materials, components, and services of importance to DOE and the nation.

To facilitate this effort, the Oak Ridge Centers for Manufacturing Technology have been established at the Y-12 Plant. A total of nine centers are devoted to a specific area of research, manufacturing, and measurement technologies. The facility can accommodate comprehensive development studies and can support the transition of technological areas such as process, environmental management, and manufacturing technology applied to production (Fig. 1.6).

Y-12 Plant Defense Programs assignments include the dismantling of nuclear weapon components returned from the national arsenal, maintaining nuclear production capability

ORNL PHOTO 2623-94

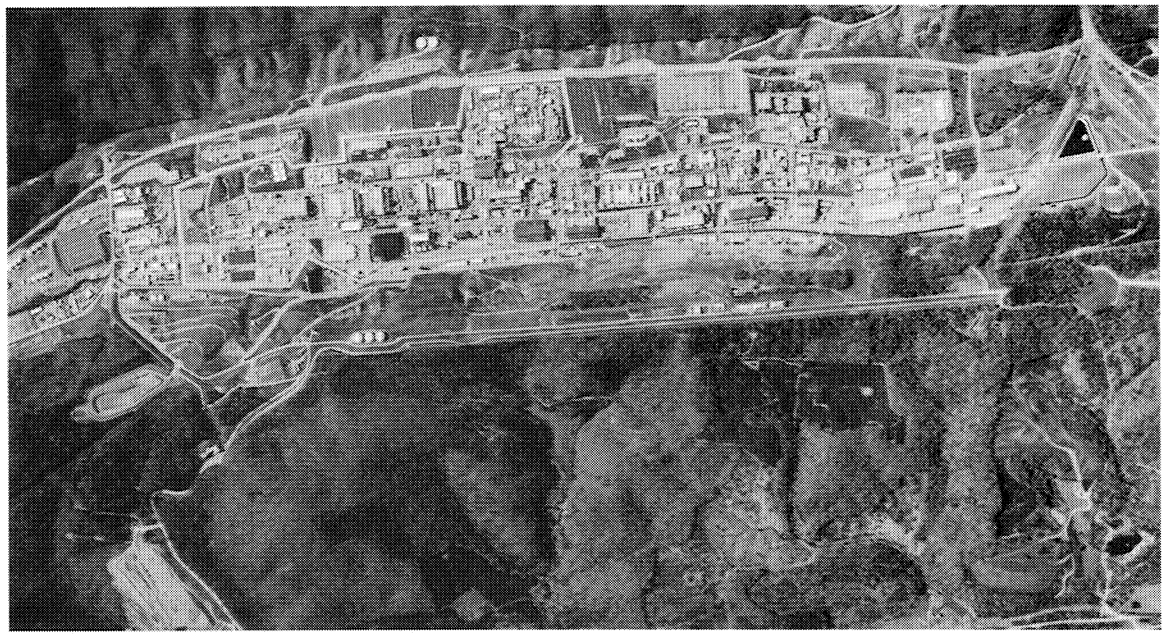


Fig. 1.5. The Oak Ridge Y-12 Plant.

Y-12 PHOTO 293874

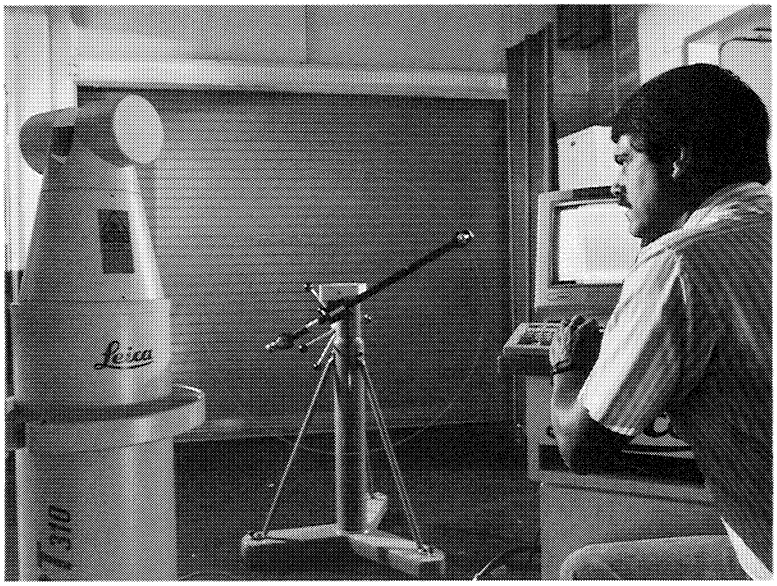


Fig. 1.6. An inspection engineer at the Y-12 Plant operates a portable coordinate measuring machine known as a laser tracker. The laser beam emitted by the device at left is able to track a moving object, such as the mirror mounted on the end of a rotating arm. The machine is used to inspect large shapes.

and stockpile support, serving as the nation's storehouse of special nuclear materials, and providing special production support to DOE programs.

Oak Ridge National Laboratory

ORNL, located toward the west end of Melton and Bethel valleys, is a large, multipurpose research laboratory, the primary mission of which is to expand knowledge, both basic and applied, in areas related to energy and the environment (Fig. 1.7). ORNL's facilities include a high-flux nuclear research reactor, chemical pilot plants, research laboratories, radioisotope production laboratories, accelerators, fusion test devices, and support facilities. In addition to the main ORNL complex, the Oak Ridge National Environmental Research Park (Fig. 1.8) is managed by ORNL.

ORNL PHOTO 2622-94

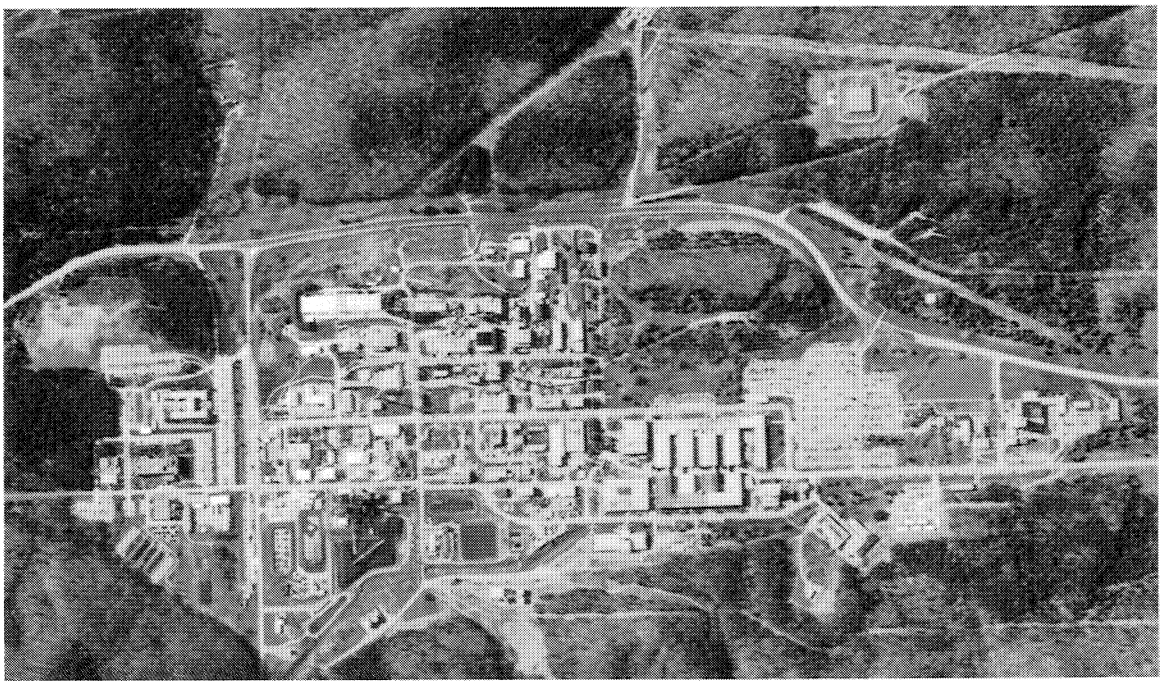


Fig. 1.7. The Oak Ridge National Laboratory.

ORNL PHOTO 10555-91

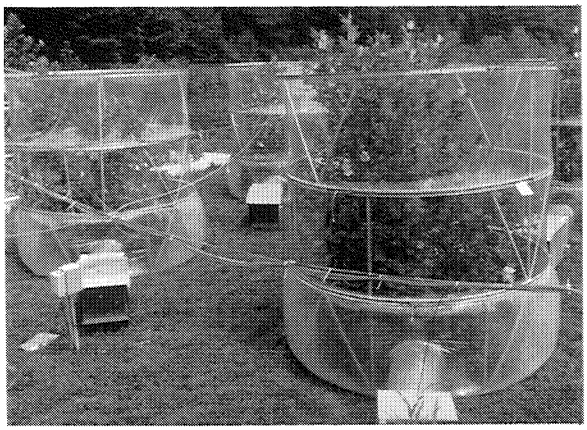


Fig. 1.8. The Global Change Field Research Site, located on the Oak Ridge National Environmental Research Park, is a facility that allows researchers in the ORNL Environmental Sciences Division to investigate the response of plants to a changing atmosphere. Trees have been grown within open-top chambers and exposed continuously to elevated concentrations of carbon dioxide for up to 4 years in a research project sponsored by DOE's Office of Health and Environmental Research.

Oak Ridge K-25 Site

The K-25 Site, formerly known as the Oak Ridge Gaseous Diffusion Plant, began operations in 1945 as part of the Manhattan Project (Fig. 1.9). The original mission was to separate the uranium-235 isotope for use in atomic weapons. In December 1987, DOE permanently shut down the gaseous diffusion processes, and the site was placed on the list of facilities slated for decontamination and decommissioning.

The K-25 Site serves as the home of DOE's Center for Environmental Technology and Center for Waste Management (Fig. 1.10); the multifaceted mission of these centers includes activities in technology development, technology transfer, engineering technology, and support for uranium enrichment as well as Lockheed Martin central functions, which include telecommunications, business management, engineering, and computing.

Specific missions include management of the Toxic Substances Control Act (TSCA) facility, a unique mixed-waste

ORNL PHOTO 2624-94

Fig. 1.9. The Oak Ridge K-25 Site.

incinerator; support of risk-based cleanup programs for all contaminated facilities and natural resources; safe and compliant waste management; development and demonstration of innovative environmental technologies; support of the Hazardous Waste Remedial Action Program (HAZWRAP); and provision of cost-effective support and services to K-25 Site users.

Oak Ridge Institute for Science and Education

ORISE is managed for DOE by the Oak Ridge Associated Universities (ORAU), a nonprofit consortium of 82 colleges and universities (Fig. 1.11). ORISE has stewardship responsibility for 137 ha (340 acres) on the southeastern border of the ORR that from the late 1940s to the mid-1980s was part of an agricultural experiment station owned by the federal government and, until 1981, was operated by the University of Tennessee.

The ORISE Scarboro Operations Site (formerly the South Campus) currently occupies about 36 ha (90 acres) and lies immediately southeast of the intersection of Bethel Valley Road and Pumphouse Road. It houses one of ORISE's four operating divisions and is being developed for other programmatic uses.

The Freels Bend tract, about 101 ha (250 acres) on the northeastern edge of Freels Bend, abutting Melton Hill Lake, is also within ORISE's area of jurisdiction. Although no programmatic activities are conducted at this site, ORISE does provide maintenance and security, including security for the decommissioned system of cobalt-60 sources at the Variable Dose Rate Irradiation Facility.

K/PH 93-2637

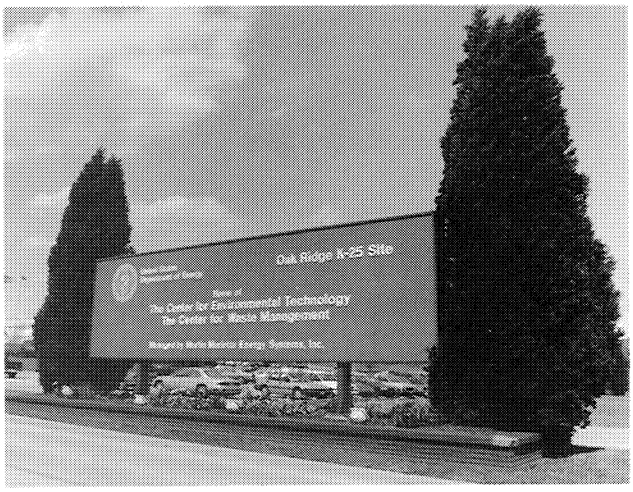


Fig. 1.10. The Oak Ridge K-25 Site is the home of DOE's Center for Environmental Technology and the Center for Waste Management, demonstrating DOE's commitment to environmental leadership. The centers foster partnerships between technology users and technology suppliers from the government, academia, the scientific community, and the private sector to deploy innovative, cost-effective technologies to decrease the cost of environmental restoration and waste management.

ORNL PHOTO 4541-95

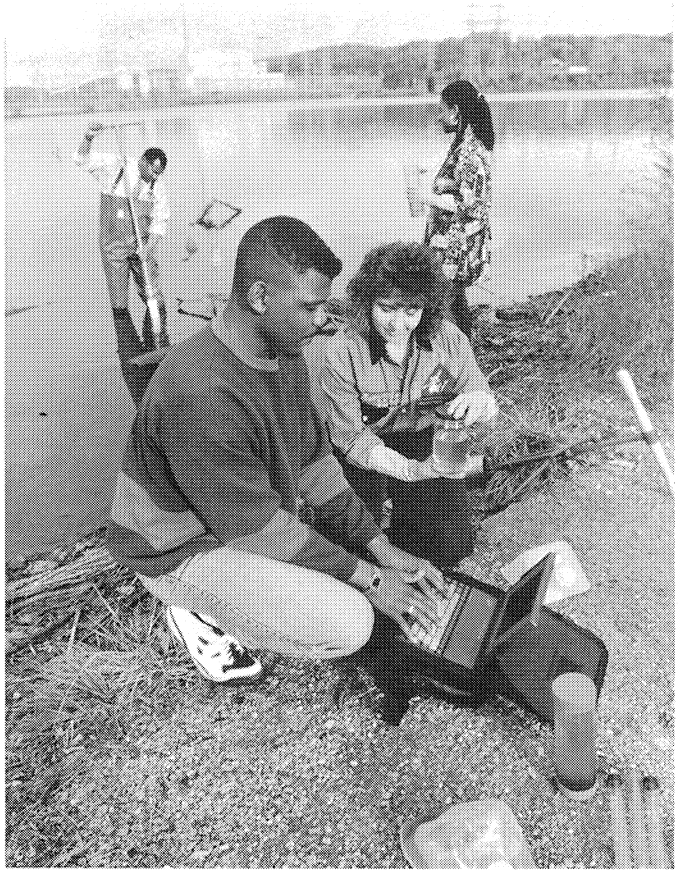


Fig. 1.11. An ORISE program provided training to these faculty and students from historically black colleges and universities who are using the National Library of Medicine data bases in the field. DOE established ORISE to undertake national and international programs in science and engineering education, training and management systems, energy and environment systems, and medical sciences. (Photo courtesy of ORISE.)

2. Environmental Compliance

Abstract

It is the policy of the U.S. Department of Energy Oak Ridge Operations Office (DOE-ORO) to conduct its operations in compliance with federal, state, and local environmental protection laws, regulations, compliance agreements and decrees, settlement agreements, executive orders, DOE orders, and best management practices. DOE and its contractors make every effort to conduct operations in compliance with the letter and intent of applicable environmental statutes. The protection of the public, personnel, and the environment is of paramount importance.

INTRODUCTION

The ORR includes the three sites managed DOE by Energy Systems, a DOE prime contractor. The three sites include the Oak Ridge Y-12 Plant, ORNL, and the Oak Ridge K-25 Site. Two tracts on the ORR are managed by ORISE: Freels Bend and the Scarboro Operations Site. The MK-Ferguson of Oak Ridge Company serves as a DOE prime contractor for construction management. Johnson Controls World Services, Inc., serves as a DOE prime contractor for operation of the Oak Ridge water plant and for the maintenance and repair of construction equipment, automobiles, and trucks.

DOE's operations on the reservation are required to be in conformance with environmental criteria established by a number of federal and state statutes and regulations, executive orders, DOE orders, and compliance and settlement agreements.

Principal among the regulating agencies are the U.S. Environmental Protection Agency (EPA) (both at headquarters and Region IV) and TDEC. These agencies issue permits, review compliance reports, participate in joint monitoring programs, inspect facilities and operations, and oversee compliance with applicable regulations.

When ongoing self-assessments of compliance status identify environmental issues, the issues are discussed openly with the regulatory agencies in an effort to ensure that compliance with all environmental regulations will be attained. In the following sections, compliance status for the ORR sites with regard to major environmental statutes and DOE orders is summarized by topic.

COMPLIANCE ACTIVITIES

Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) was passed in 1976 to address management of the country's huge volume of solid waste. The law requires that EPA regulate the management of hazardous waste, which includes waste solvents, batteries, and many other substances deemed potentially harmful to human health and to the environment. RCRA also regulates certain nonhazardous and medical wastes and underground storage tanks (USTs) used for the storage of petroleum and hazardous substances.

Subtitle C of RCRA controls all aspects of the management of hazardous waste, from the point of generation to treatment, storage, and disposal. Hazardous waste generators must follow specific requirements for handling these wastes.

The Y-12 Plant, ORNL, and the K-25 Site are large-quantity generators. Each generate both RCRA hazardous waste and RCRA hazardous waste mixed with radionuclides (mixed waste). The hazardous and/or mixed wastes are accumulated by individual generators at locations referred to as satellite accumulation areas or 90-day accumulation areas, as appropriate, where they are picked up by waste management personnel. At the end of 1994, the Y-12 Plant had about 300 generator accumulation areas for hazardous or mixed waste. ORNL had about 350, which is lower than the number reported for 1993; the number resulted from a waste reclassification effort involving a review of waste determinations, including recyclable used oils. The K-25 Site maintains 350 generator accumulation areas.

ORISE is classified under RCRA as a "conditionally exempt small-quantity generator," its site accumulation area is located in the Chemical Safety Building on the Scarboro Operations Site.

RCRA requires that owners and operators of hazardous waste management facilities have operating and/or post-closure care permits. Most of the units at the Y-12 Plant are being operated under interim-status regulations in accordance with a Part A permit application, the most recent version of which was approved in July 1991. Amended Part A permit applications were submitted to TDEC in December 1991, August 1993, and July 1994 but have not yet been acted on. Six RCRA Part B permit applications have been submitted for 20 active storage and treatment units listed on the Part A permit application. Five of these Part B applications are still under review by the state. Three revised Part B permit applications were submitted in 1994 in response to notices of deficiency (NODs) issued by the TDEC for the tank storage units, container storage units, and production-associated units. A permit (TNHW-032) was issued by the TDEC on September 30, 1994, for the tank storage units, which include the following:

- the Building 9811-1 Tank Storage Unit (OD-7), in the western end of the Y-12 Plant;
- the Waste Oil/Solvent Storage Unit (OD-9), on Old Bear Creek Road; and
- the Liquid Organic Solvent Storage Unit (OD-10), in the Bear Creek Burial Grounds.

Ten units at the Y-12 Plant operate in accordance with permit-by-rule regulations.

RCRA post-closure permit applications for the Y-12 Plant Oil Landfarm, Bear Creek Burial Grounds, Chestnut Ridge Sediment Disposal Basin, and Chestnut Ridge Security Pits were submitted to TDEC during 1994. (See the "RCRA/CERCLA Integration" section for additional information.)

ORNL's current Part A revision (October 7, 1993) includes 36 units (3 treatment, 32 storage, and 1 disposal). During 1994, 23 existing units operated as interim-status units; 2 existing units operated as permitted units. Another 11 units were proposed as either new construction or existing buildings awaiting approval to operate. (The proposed units are also considered to be interim-status units). Building 7652 continues to operate under the 1986 permit (TN 1890090003 and HSWA-TN001). TDEC issued two draft permits, and Energy Systems staff submitted comments during 1994 for the eight hazardous and mixed-waste storage units and Building 7652; those permits are expected to be issued in 1995. Tank 7830A, a hazardous waste storage tank at ORNL, continues to operate under its 1992 permit (TNHW-027). A Class 1 permit modification for Tank 7830A, revising the contingency plan, was completed in December 1994. The other ORNL RCRA units operate under interim status, pending issuance of the permits or completion of closure. ORNL has requested that another unit, Solid Waste Storage Area (SWSA) 5N Burial Ground for retrievably stored, remote-handled transuranic (TRU) waste, be removed from RCRA

regulation and, instead, be remediated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Resolution of that request is pending.

The K-25 Site has received four RCRA permits. The K-1435 TSCA Incinerator is a hazardous waste treatment unit operating under a RCRA permit (TNHW-15) issued by TDEC on September 28, 1987. Issuance of a revised RCRA permit based on trial burn results is anticipated by September 1995. A second permit is for storage of waste at the incinerator. Two other permits cover storage in the former process building vaults.

1994 modifications to the K-25 Site RCRA permits included updating contingency plan information, obtaining approval for several new analytical methods, and several physical modifications to various storage areas. Also, two areas were deleted, and approval was obtained to store a wider variety of waste in several of the waste storage units.

RCRA Assessments, Closures, and Corrective Measures

The Hazardous and Solid Waste Amendments (HSWAs) to RCRA, passed in 1984, require any facility seeking a RCRA permit to identify, investigate, and (if necessary), clean up all former and current solid waste management units (SWMUs). The HSWA permit for the ORR was issued as an attachment to the RCRA permit for Building 7652 at ORNL. The HSWA permit addresses past, present, and future releases of hazardous constituents to the environment. Many HSWA permit requirements have now been integrated into the ORR Federal Facilities Agreement (FFA). (See the "RCRA/CERCLA Integration" section for details.)

At the Y-12 Plant, 21 RCRA units have been certified closed by TDEC since the mid-1980s. During 1994, three additional RCRA interim-status units (Walk-in Pits, Kerr Hollow Quarry, and Garage Underground Storage Tanks) were certified closed. Additional RCRA units requiring closure at the Y-12 Plant include the 9409-5 Tank Storage Unit and the northern section of the Interim Drum Yard. Site characterization summary reports have been issued for both units; however, regulatory approval of the closure plans for these units has not been received. Additionally, a closure plan for the Uranium Treatment Unit will be submitted to the state in 1995.

At ORNL, SWSA 6 is currently undergoing RCRA/CERCLA closure. The revised closure plan for SWSA 6 was resubmitted to TDEC for formal review in January 1994. Comments were issued by EPA and TDEC in mid-1994. Those comments and new information are being incorporated into the plan (for resubmittal in early 1995). The revisions focus on the integration of CERCLA remediation processes while still addressing the RCRA closure requirements. In 1994, closure was completed for three units (Building 7826, Building 7834, and Tank 7075).

Closure of the New Hydrofracture Surface Facilities, Building 7860, is pending final approval of the closure plan. RCRA-mandated corrective actions continue under the CERCLA/FFA process.

At the K-25 Site a RCRA closure plan for the K-900 Bottle Smasher was approved by TDEC and was issued on July 23, 1993. Closure of the unit was completed, and the certification of closure was submitted to TDEC in May 1994. Closure of the K-1425 100-gal drain tank was completed in August 1994. A certification of closure was submitted to TDEC and was accepted in October 1994. Closure of the K-1423 Demonstration Project was completed, and the certification of closure was submitted to TDEC in November 1994.

Land Disposal Restrictions

The 1984 RCRA amendments established land disposal restrictions (LDRs), which prohibit the land disposal of untreated hazardous wastes. The amendments require that all untreated wastes meet treatment standards prior to land disposal or that they be disposed of in a land disposal unit from which there will be no migration of hazardous constituents for as long as the waste remains hazardous. These restrictions also allow storage of restricted hazardous or mixed waste only as necessary to facilitate recovery, treatment, or disposal.

Currently, with the exception of a few organic mixed wastes, the same restrictions apply to mixed wastes, which are composed of a mixture of radioactive and hazardous wastes. In June 1992, negotiation was completed on a federal facilities compliance agreement (FFCA) to resolve the compliance issue of storing restricted waste for a period longer than is necessary to facilitate recovery, treatment, or disposal. The FFCA contains a compliance schedule for submittal of strategies and plans for treatment of the backlog of restricted waste through a variety of treatment options. (See the "Federal Facilities Compliance Act" section for more details.)

RCRA/CERCLA Integration

The CERCLA and RCRA corrective action processes are similar. Each process has four steps with similar purposes (Table 2.1).

Table 2.1. RCRA and CERCLA corrective action processes

RCRA	CERCLA	Purpose
RCRA Facility Assessment	Preliminary Assessment/Site Investigation	Identify releases needing further investigations
RCRA Facility Investigation	Remedial Investigation	Characterize nature, extent, and rate of contaminant releases
Corrective Measures Study	Feasibility Study	Evaluate and select remedy
Corrective Measures Implementation	Remedial Design/Remedial Action	Design and implement chosen remedy

EPA, DOE, and TDEC have negotiated the ORR FFA to ensure that the environmental impacts associated with past and present activities at the ORR are thoroughly investigated and that appropriate remedial actions or corrective measures are taken as necessary to protect human health and the environment. This agreement established a procedural framework and schedule for developing, implementing, and monitoring response actions on the ORR in accordance with CERCLA. The ORR FFA is also intended to integrate the corrective action processes of RCRA and CERCLA.

For example, in April 1993, DOE, TDEC, and Energy Systems signed an agreed order regarding the RCRA post-closure permit for the S-3 Site at the Y-12 Plant, formally agreeing to proceed with CERCLA as the lead regulatory program and with RCRA as an applicable or relevant and appropriate requirement (ARAR). Likewise, regulatory comments on the WAG 6 closure plan indicated that RCRA requirements integrated into the CERCLA process (but requiring a post-closure permit) need to be submitted in addition to the revised closure plan. Both will be submitted in 1995.

Comprehensive Environmental Response, Compensation, and Liability Act

CERCLA, also known as Superfund, was passed in 1980 and was amended in 1986 with passage of the Superfund Amendments and Reauthorization Act (SARA). Unlike the other basic regulatory programs summarized in this chapter (such as RCRA or the Clean Water Act), CERCLA is a process to respond to environmental problems using other environmental laws and standards to guide the response action. Under CERCLA, abandoned or uncontrolled hazardous waste sites where a release has occurred or may occur are investigated, and a site is remediated if it poses significant risk to health or the environment. The cleanup standards are typically ARARs to the environmental problems and response actions. CERCLA requires that EPA place sites needing CERCLA response on the National Priorities List (NPL). The ORR was placed on the NPL in December 1989.

More than 200 potentially contaminated units have been identified at the Y-12 Plant, resulting from past operations and waste management practices. Many of these sites have been grouped into operable units (OUs) based on priority, common assessment, or potential remedial actions. During 1994, a remedial investigation/feasibility study (RI/FS) was completed at Bear Creek OU-2. Additionally, the first phase of field work to support an RI/FS for Upper East Fork Poplar Creek OU-1 was initiated. The CERCLA process at the Abandoned Nitric Acid Pipeline (Upper East Fork Poplar Creek OU-2) was completed, and a "no-further-action" record of decision was obtained. A feasibility study at Chestnut Ridge OU-2 was also completed during 1994.

A major strategy change in implementation of CERCLA within the Bear Creek Hydrogeologic Regime was initiated in 1994. Groundwater and surface water are now considered as a combined source rather than as discrete sources. The remaining three operable units, which contain most of the contaminated sites within the regime, were combined into one regime-wide unit, and an integrated RI/FS was begun to address contamination throughout the regime. Such an approach ensures consistent and complementary actions throughout the regime and represents a significant acceleration and streamlining of the CERCLA process compared with its traditional implementation. Additionally, the regime-wide integrated RI/FS is expected to result in a cost savings of several million dollars for the first part of the CERCLA process as well as a significant shortening of the time required to obtain records of decision and subsequent remedial actions within the regime.

The Reduction in Mercury from Plant Effluent (RMPE) Program remediation efforts continued in 1994. Activities included piping reroutes in several mercury-use buildings that resulted in continued reductions in releases of mercury to East Fork Poplar Creek. Installation of an interim mercury treatment unit (IHgTU) in Building 9201-2 was completed, and the unit was brought on line to treat mercury-contaminated waters captured in sumps underneath the building.

ORNL's remediation areas are organized into 20 waste area groupings (WAGs) based on drainage area and similar waste characteristics. There are currently five WAGs and the inactive tanks OU on the ORNL site that are being investigated and/or remediated under CERCLA. These include the following:

- WAG 1: the ORNL main plant area;
- WAG 2: White Oak Creek, its tributaries, and White Oak Lake;
- WAG 4: Solid Waste Disposal Area 4;

- WAG 5: an 88-acre site including SWSA 5, hydrofracture surface facilities, sludge basin, old hydrofracture waste storage tanks, and TRU waste storage area;
- WAG 7: low-level waste pits and trenches; and
- WAG 10: the Subsurface Hydrofracture Facilities, injection wells, observation/monitoring wells, and grout sheets.

A CERCLA removal action to intercept and remove strontium-90 releases from two seeps located along the southern boundary of WAG 5 (along Melton Branch) was initiated in 1994. WAG 2 is currently under an extended environmental monitoring program. WAG 2 RI activities ceased as a result of regulator input. Results of this extended monitoring effort are reported annually by DOE (DOE 1994). In the face of public opposition to the high cost of capping extensive portions of WAG 6, and the relatively low risk associated with past and current operations at WAG 6, DOE decided to perform additional environmental monitoring and research and development (R&D) for another alternative. As a result, in 1994 ORNL implemented a multimedia environmental monitoring program to further investigate the quantities of contaminants emanating from WAG 6. In 1994 RCRA closure activities were integrated with CERCLA, which resulted in the revision of the existing RCRA closure plan for WAG 6. Submission of the RCRA closure plan for WAG 6 will occur in FY 1995.

Two sites at ORNL completed the CERCLA interim remedial design/remedial action process: WAG 11 (the White Wing Scrap Yard) and WAG 13 (the Cesium-137 Contaminated Field and Erosion/Runoff Study Area).

The inactive liquid low-level waste (LLLW) tanks at ORNL continued to be the subject of CERCLA activities. A CERCLA treatability study was initiated at the OU for the gunite tanks and associated tanks in 1994.

Approximately 209 potentially contaminated units at K-25 Site are grouped into 14 source OUs and 1 groundwater OU. 1994 CERCLA activities involved the following OUs:

- K-1070 C/D OU on the eastern edge of the K-25 Site, composed of a 22-acre burial ground, three storage areas, and the K-1414 UST site;
- the K-1070 C/D OU, including K-1070 SW31 perennial spring downgradient of the K-1070 C/D burial ground;
- K-901 OU, composed of contaminated burial ground, landfarm, holding pond, and two construction waste disposal areas;
- K-770 OU, composed of a contaminated scrap metal yard and contaminated debris, two buildings, and a sewage treatment plant; and
- K-25 Groundwater OU, about 1200 acres, bounded on the south by Tennessee Highway 58, on the east by Blair Road, on the north by Black Oak Ridge, and on the west by the Clinch River.

Contaminated water collected from the SW31 spring was transported to the Y-12 Plant's Groundwater Treatment Facility. Activity began in January 1994 as Phase I of the CERCLA remedial action. Phase II will involve upgrading the K-25 Site Central Neutralization Facility (CNF) to treat the water.

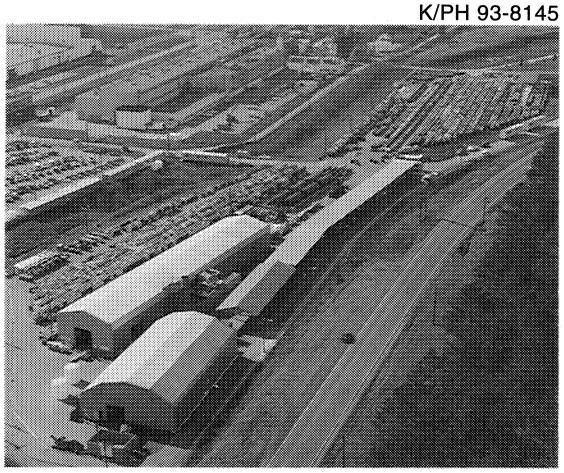
The K-1407-B holding pond and K-1407-C retention basins were RCRA interim-status units until 1994, when closure plans for these units were approved, granting clean closure. Closure certification was received from TDEC in June 1994, and remediation began in July 1994. Remedial construction was completed in January 1995, when both units were filled and capped. These sites are now regulated exclusively by CERCLA.

Operation of the storage yard, also known as the Pond Waste Management Project (PWMP), is managed under both the CERCLA process and RCRA. Implementation of the PWMP action plan began October 1991. About 45,600 drums of stabilized sludge were processed and placed in compliant storage; completion of this phase occurred in October 1992. The drums were stored in existing facilities in Buildings K-31 and K-33, and in new storage facilities constructed in the K-1065 area. Dewatering of about 32,000 drums of raw sludge began in September 1992. The repacking phase was completed 4 months ahead of schedule, under budget, and without environmental insults (Fig. 2.1).

In June 1994, TDEC issued a second commissioner's order against Energy Systems and DOE for failure to meet the June 1993 milestone date for dewatering and repackaging the drums containing unsolidified raw sludge, which had been stipulated in a September 1991 commissioner's order. TDEC assessed a $100,000 penalty against Energy Systems and DOE. It is anticipated that the project will be completed in 1996.

In June 1994, in the same commissioner's order as that for the PWMP, TDEC assessed additional recovery costs of at least $500,000 for remedial activities at five sites. The sites include the Witherspoon Landfill site, the Witherspoon screen arts site, the Witherspoon recycling site, the Dupont-Smith site and Roscoe Field's site. DOE has entered into an agreement with TDEC to be the lead on investigation activities at the Witherspoon landfill site, Witherspoon Screen Arts Site, and Witherspoon recycling site. TDEC is presently performing an RI at the Witherspoon recycling site, and DOE has removed several items suspected to be of DOE origin from the site in January 1995. In 1986 and 1987 DOE removed mill tailings and scrap metal; in 1992 DOE removed approximately 250 drums of contaminated soil and items from the recycling site. At the Dupont-Smith (also known as the ACAP site) site, DOE removed 128 capacitors in 1994 as part of the Phase I capacitor removal action. Most of these capacitors were disposed of at a permitted TSCA incinerator in 1995. DOE will complete a site characterization and investigation as part of Phase II. Data collected from soil borings and groundwater wells are expected to be available by August 1995. As of October 31, 1994, DOE had removed and placed 65 B-25 boxes and 239 drums in overpacks from the Roscoe Field's site in compliant storage at the K-25 Site.

K/PH 93-8145



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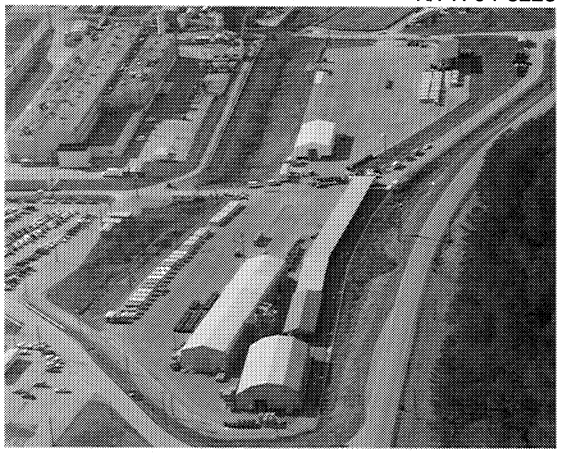

Fig. 2.1. An outdoor storage pad on the K-25 Site once contained 77,000 barrels of wastewater pond sludge (left). Temporary structures (right) contain treatment and packaging equipment.

Federal Facilities Compliance Act

The Federal Facilities Compliance Act was signed on October 6, 1992, to bring federal facilities (including those under DOE) into full compliance with RCRA. The act waives the government's sovereign immunity, allowing fines and penalties to be imposed for RCRA violations at DOE facilities. In addition, the act requires that DOE facilities provide comprehensive data to regulatory agencies on mixed-waste inventories, treatment capacities, and treatment plans for each site. The act ensures that the public will be informed of waste-treatment options and encourages active public participation in the decisions affecting federal facilities. TDEC is the authorized regulatory agency under the act for the DOE facilities in the state of Tennessee.

Site treatment plans are required for facilities at which DOE generates or stores mixed waste. The purpose of the proposed site treatment plan is to identify to TDEC the proposed options (treatment method, facility, and schedule) for treating mixed waste at the ORR. For some waste types, these options include continued waste characterization for treatment, development, and/or modification of treatment technologies. The proposed site treatment plan is also being provided to the EPA pursuant to the requirements contained in the ORR LDR FFCA and the Federal Facilities Compliance Act. To the extent possible, the proposed site treatment plan designates specific facilities for the treatment of mixed waste and proposes schedules as set forth in the Federal Facilities Compliance Act. If it is not possible to designate facilities or to adhere to schedules, the proposed site treatment plan provides schedules for alternative activities, such as waste characterization and technology assessment. The main treatment strategies are as follows:

- Existing and modified on-site facilities will be used to treat mixed waste when possible.
- Off-site DOE capacity will be used when available and appropriate.
- When available and technically appropriate (based on risk, cost, and schedule), commercial-sector resources will be used to treat mixed wastes. Waste types targeted for commercial treatment include inorganic sludges and soils.
- The minimum set of new on-site facilities will be built to treat those wastes for which commercial treatment is unavailable or unsuccessful.
- TRU mixed wastes will be treated only as necessary to meet the waste acceptance criteria of the Waste Isolation Pilot Plant (WIPP) in New Mexico.

The plan calls for mixed low-level waste on the ORR to be treated by a combination of commercial treatment capabilities and existing and modified on-site treatment facilities. Mixed TRU waste streams on the ORR composed of both contact and remote-handled wastes, will be treated in the proposed Transuranic Processing Facility (TPF) only as necessary to meet the waste acceptance criteria for disposal at the WIPP. Nine existing on-site facilities will be used to treat inventoried mixed waste. Construction of one new major on-site facility (the TPF) is proposed for the ORR, as described in the plan. The final configuration of new on-site facilities for mixed low-level waste (LLW) streams will depend on the extent to which commercial resources are available. The proposed site treatment plan will be issued to TDEC by April 6, 1995. TDEC may approve, approve with modifications, or disapprove the plan. If it approves the plan (with or without modifications), TDEC will issue an implementing order by no later than October 6, 1995. The work-off will take about 40 years. Once treatment is available for mixed waste as it is generated, the ORR will be in compliance with the storage prohibition under the LDR.

Underground Storage Tanks

UST Program personnel ensure that all active tank and piping systems are in compliance with applicable performance requirements. These requirements apply to hardware and equipment installed for leak detection, corrosion protection, and spill/overfill prevention. New UST systems (installed after December 22, 1988) must have these features incorporated at the time of installation. Existing UST systems (installed before December 22, 1988) must be upgraded, either by replacement or retrofit, to meet these same performance requirements. UST systems that are not in compliance and will not be upgraded by December 22, 1998 must be permanently closed. Depending on the confirmation of a release, a UST closure can necessitate an environmental assessment of a particular site and a subsequent corrective action.

UST compliance also requires that a certain amount of documentation be maintained in the form of tank tightness records, tank repairs, and/or inventory control records. General operating requirements are outlined in the regulations and are incorporated into the applicable Energy Systems operating procedures. Table 2.2 presents the status of USTs on the ORR.

Table 2.2. ORR UST status, 1994

	Y-12 Plant	ORNL	K-25 Site	ORISE
Active/in service	4	17	6	
Closed	40	34	11	1
Hazardous substance	3[a]	5[b]	5[c]	
Upgraded		2		
Known or suspected sites			16	
Total	47	58	38	1

[a]Two USTs are deferred because they are regulated by the Atomic Energy Act of 1954. The third is a permanently closed methanol UST.

[b]Excluded under 40 CFR 280; regulated under RCRA Subtitle C.

[c]Regulated under RCRA Subtitle I.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) provides a means to evaluate the potential environmental impact of proposed federal activities and to examine alternatives to those actions. Table 2.3 notes the types of NEPA activities conducted at the ORR during 1994.

Energy Systems operates under a procedure that establishes administrative controls and provides requirements for project reviews and compliance with NEPA. Provisions apply (1) to the review of each proposed project, activity, or facility for its potential to result in significant impacts to the environment and (2) to the recommendation based on technical information of the appropriate level of NEPA documentation. The NEPA review process results in the preparation of NEPA documents and supporting information. Federal, state, and local environmental regulations and DOE orders applicable to the environmental resource areas must be considered when preparing NEPA documents. These environmental resource areas include air, surface water, groundwater, terrestrial and aquatic ecology, threatened and endangered species, land use, and environmentally sensitive areas. Environmentally sensitive areas include floodplains, wetlands, prime farm land, habitats

Table 2.3. NEPA activities during 1994

Types of NEPA documentation	Y-12 Plant	ORNL	K-25 Site
Categorical exclusion (CX) recommendation	5	27	20
CX granted	5	23	20
Approved under general CX documents	151	51	85
Environmental assessment	2	9	2
Special environmental analysis	0	0	1
Programmatic environmental assessment	0	0	0
Supplement analysis	0	0	0
Environmental impact statement	0	0	0
Supplemental environmental impact statement	0	0	0
Programmatic environmental impact statement	0	0	0

for threatened and endangered species, historic properties, and archaeological sites. Each ORR site NEPA program also maintains compliance with NEPA through the use of its site-level administrative and operational procedures. These procedures assist in establishing effective and responsive communications with program managers and project engineers with the goal of establishing NEPA as a key consideration in the formative stages of project planning.

The Y-12 Plant has prepared an environmental assessment for the storage of enriched uranium used by the DOE weapons complex. Enriched uranium, including highly enriched uranium from dismantled nuclear weapons, and low-enriched uranium from other sources, has historically been returned to the Y-12 Plant for reprocessing and safekeeping. DOE will continue interim storage at the Y-12 Plant until decisions are made and implemented on long-term disposition of the uranium. DOE engaged in substantial public participation in 1994 and 1995; a conclusion of a "finding of no significant impact" (FONSI) under NEPA has yet to be issued.

As part of the Y-12 Plant mission to manage weapons-grade highly enriched uranium and to prevent proliferation of this material, the Y-12 Plant and Lawrence Livermore National Laboratory prepared the environmental assessment to retrieve more than 1300 lb of highly enriched uranium from the country of Kazakhstan in the former Soviet Union. The environmental assessment evaluated the potential environmental impacts of transporting the uranium to the United States for interim storage at the Y-12 Plant. The assessment and associated information remained classified during the entire project. DOE issued a classified FONSI on October 6, 1994.

National Historic Preservation Act

Section 106 of the National Historic Preservation Act (NHPA) requires federal agencies to take into account the effects of their undertakings on properties included in or eligible for inclusion in the *National Register of Historic Places* (*National Register*). To comply with Section 106 of the NHPA, and its implementing regulations at 36 CFR 800, DOE-ORO has seen to the ratification of a programmatic agreement among DOE-ORO, the Tennessee state historic preservation officer (SHPO), and the Advisory Council on Historic Preservation concerning management of historical and cultural properties on the ORR. The programmatic agreement, ratified on May 6, 1994, outlines DOE-ORO's plan for the management of cultural and historical properties on the ORR. The programmatic agreement stipulates that DOE-ORO will prepare a Cultural Resource Management Plan (CRMP) for the ORR and will provide a draft of the CRMP to the Tennessee SHPO and Advisory

Council on Historic Preservation within 24 months of the ratification of the agreement. The agreement also stipulates that DOE-ORO will conduct surveys to identify significant historical properties within the ORR. A draft outline of the CRMP has been completed and is currently being revised and updated.

Compliance with NHPA at ORNL, the Y-12 Plant, and the K-25 Site is achieved and maintained in conjunction with NEPA compliance. The scope of proposed actions is reviewed in accordance with the programmatic agreement and, if warranted, consultation is initiated with the SHPO and the Advisory Council on Historic Preservation, and the appropriate level of documentation is prepared and submitted. Because the programmatic agreement has improved project review efficiency and has caused a reduction in the number of projects requiring concurrence from SHPO and the advisory council, only eight archeological/historical reviews were prepared by ORNL during 1994. The K-25 Site and Y-12 Plant also experienced a sharp decline in the number of reviews required for submittal to the SHPO and the council.

In 1994, the DOE initiated an effort to evaluate and identify properties at the K-25 Site that are included in (or are eligible for inclusion in) the *National Register* and to provide a survey report of all buildings and facilities. A survey of the Y-12 Plant site was also initiated in 1994 and is expected to have a finalized report in 1995. Also in 1994, ORNL initiated ORR-wide surveys to evaluate and identify pre-World War II structures and known archeological sites on the ORR that are eligible for inclusion in the *National Register*. The survey reports will be completed in the first quarter of 1995, and the results will be incorporated into the CRMP.

A survey has been conducted by a state-approved auditor of all structures on lands managed by ORISE. The survey was carried out in compliance with NHPA Section 106, which requires state approval for removal by a federal agency of any existing structures. Currently, the Freels Bend Cabin, located on land managed by ORISE, is entered in the *National Register*.

Protection of Wetlands

Executive Order 11990 (issued in 1977) was established to mitigate adverse effects to wetlands caused by destruction or modification of wetlands and to avoid new construction in wetlands wherever possible. Protective buffer zones and application of best management practices are required for activities on the ORR. Avoidance of these effects is ensured through implementation of the sensitive-resource analysis conducted as part of the NEPA review process. Coordination with the U.S. Army Corps of Engineers is necessary for activities in waters of the United States, which include wetlands and floodplains. This is also true for the state and waters of the state. Generally, this coordination results in permits from the Corps of Engineers and/or the state.

The ORR implements protection of wetlands through the site NEPA programs offices in accordance with 10 CFR 1022, "Floodplain/Wetlands Environmental Review Requirements." Each of the sites have surveys for the presence of wetlands, and project-specific surveys are conducted by the ORNL Environmental Sciences Division (ESD) personnel where necessary. A wetlands survey for the entire reservation is currently in progress.

TDEC is developing a regulatory position on wetlands protection that includes mitigation; any affected wetlands must be replaced in area and function by newly constructed wetlands.

The Y-12 Plant has conducted two surveys of its wetlands resources. *Identification and Characterization of Wetlands in the Bear Creek Watershed* (Energy Systems 1993a) was completed in October 1993, and a wetland survey of selected areas in the Y-12 area of responsibility was completed in October 1994. The first report surveys the Y-12 Plant and surrounding areas; the second report surveys additional areas for which environmental restoration (ER) activities are planned.

The Y-12 Plant practices wetlands protection by requiring protective buffer zones and other best management practices whenever activities are proposed that may introduce a potential environmental impact. Wetlands protection, documentation, and reporting requirements are administered through the NEPA review and documentation process according to 10 CFR 1022.

In 1994, wetlands ecologists provided delineation of wetlands for various planned activities, including site characterization for the Melton Valley storage tank capacity increase, the Center for Biological Sciences, and the reservation-wide southern pine beetle control effort. Ecologists delineated and flagged stream-management zones, thereby establishing buffer zones around stream and wetland areas for protection as logging crews remove beetle-infested trees.

A wetlands survey for areas within the K-25 Site area of responsibility was conducted during the summer of 1994. Wetlands were identified in the following areas: Mitchell Branch, Poplar Creek, the K-770 Operable Unit, the Powerhouse Area, the southern corner of the K-25 area of responsibility, the K-901 Operable Unit, the Atomic Vapor Laser Isotope Separation site, and the K-25 south site. These wetlands are protected by various best management practices in place at the K-25 Site. In addition, signs delineating buffer-zone boundaries have been placed around wetlands areas and around Mitchell Branch and its tributaries to ensure their protection.

Floodplains Management

Executive Order 11988 (issued in 1977) was established to require federal agencies to avoid to the extent possible adverse impacts associated with the occupancy and modification of floodplains, and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative. Agencies must determine whether a floodplain is present that may be affected by an action, assess the impacts on such, and consider alternatives to the action. The executive order requires that provisions for early public review and measures for minimizing harm be included in any plans for actions that might occur in the floodplain. Floodplain assessments and the associated notices of involvement and statement of findings are prepared in accordance with 10 CFR 1022, as part of the NEPA review and documentation process.

The Y-12 Plant conducted a floodplains assessment and an associated notice of involvement and statement of findings for a project planned to meet an anticipated requirement of the new Y-12 Plant NPDES permit, "East Fork Poplar Creek Flow Management." The notice of involvement was published in the *Federal Register* (59 FR 11782) on March 14, 1994, and the statement of findings was published in the *Federal Register* (59 FR 32694) on June 24, 1994.

Endangered Species Act

The Endangered Species Act of 1973 (as amended) provides for the designation and protection of wildlife, fish, and plants that are in danger of becoming extinct. The act also conserves the ecosystems on which such species depend. The act is implemented through project-sensitive resource surveys.

No threatened or endangered animal species (aquatic or terrestrial invertebrates or vertebrates) or critical habitat listed, or proposed to be listed, by the federal government is known to be present on the ORR. However, the endangered Indiana bat is a possible summer resident along East Fork Poplar Creek and must be included in environmental considerations for proposed construction projects in the area. The federally listed American Bald Eagle is an uncommon visitor or migrant, not currently nesting on the ORR.

Although no federally listed species are known, several animal species listed by the state of Tennessee as threatened (e.g., Cooper's hawk and grasshopper sparrow) (Fig. 2.2) or endangered (osprey and sharp-shinned hawk) are known to occur on the ORR. The Tennessee dace, a fish species inhabiting Bear Creek, East Fork Poplar Creek, and Ish Creek is listed by the state as a special concern. Environmental considerations for any proposed project that would disturb habitats where threatened or endangered species occur must include the potentially affected species.

ORNL PHOTO 5739-95

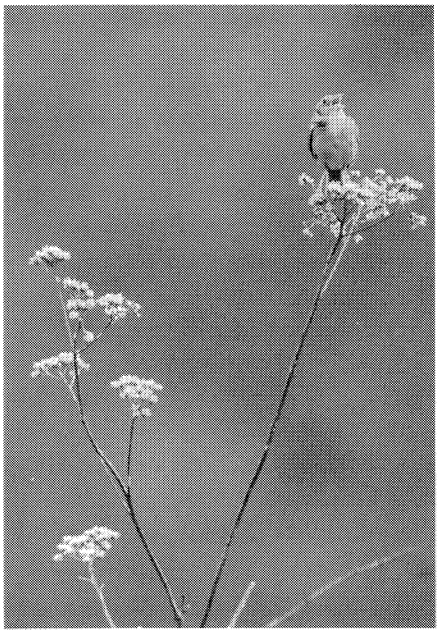

Fig. 2.2. The grasshopper sparrow is listed by the state of Tennessee as threatened. This one was photographed in the Freels Bend area.

Several plant species found on the ORR are candidates for federal listing as being endangered or threatened (e.g., spreading false foxglove and tall larkspur). In addition, several species found on the ORR are listed by the state of Tennessee as being threatened, endangered, or of special concern (e.g., pink lady's slipper and Canada lily).

Surveys are performed, and mitigating measures are designed as needed. DOE-ORO and Energy Systems are currently communicating on threatened and endangered species with the U.S. Fish and Wildlife Service; a reservation-wide survey for threatened and endangered species is ongoing.

Environmental Justice

On February 11, 1994, President Clinton promulgated Executive Order 12898, "Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations." The executive order requires that federal actions not have the effect of excluding, denying, or discriminating on the basis of race, color, national origin, or income level. DOE and Energy Systems have developed a draft of implementing strategies and are working with EPA to finalize implementation plans.

Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) of 1974 is an environmental statute for the protection of drinking-water sources. The act requires EPA to establish primary drinking

water regulations for contaminants that may cause adverse public health effects. Although many of the requirements of the SDWA apply to public water supply systems, Section 1447 states that each federal agency having jurisdiction over a federally owned or maintained public water system must comply with all federal, state, and local requirements regarding the provision of safe drinking water. Because the systems that supply drinking water to the ORR are DOE-owned, the requirements of Section 1447 apply. A second provision of the SDWA requires individual states to establish programs to prevent contamination of underground sources of drinking water by underground injection of hazardous waste.

Potable water for the city of Oak Ridge, the Y-12 Plant, and ORNL is received from a DOE-owned water-treatment facility located northeast of the Y-12 plant and currently managed by Johnson Controls World Services, Inc. Both ORNL and the Y-12 Plant are designated as non-transient non-community water-distribution systems by the TDEC Division of Water Supply, and are subject to the Tennessee Regulations for Public Water Systems and Drinking Water Quality, Chapter 1200-5-1. Under the TDEC regulations, distribution systems that do not perform water treatment can use the records sent to the state by the water treatment facility from which water is received to meet applicable compliance requirements. In 1994, the DOE water treatment plant met all of the Tennessee radiological and nonradiological standards.

In 1991 the Lead and Copper Rule was incorporated into the SDWA, requiring compliance monitoring for these parameters. Treatment-technique requirements are triggered when the ninetieth percentile representative sample exceeds the lead and/or copper action levels (0.015 mg/L and 1.3 mg/L, respectively). In 1993 the Y-12 Plant demonstrated compliance with the rule's sampling requirements, and reduced monitoring was requested and granted. The terms of the reduced monitoring status require that 20 samples be taken annually during the months of July, August, or September for 3 years. Sampling began in 1993. The 1994 sampling results confirmed continued compliance with the lead and copper action levels.

In 1994 the Y-12 Plant filed a request with the state of Tennessee and was granted exemption from asbestos monitoring. Exemption is allowed under TDEC regulations for systems that do not have asbestos-containing pipes.

ORNL's water system met the lead and copper action-level standards during the last 3 years of sampling and has been approved to reduce this sampling from annually to once every 3 years. Sampling will commence in 1996.

The K-1515 Sanitary Water Plant provides drinking water for the K-25 Site and for an industrial park located on Bear Creek Road south of the site. The facility is DOE-owned and classified as a non-transient non-community water-supply system by TDEC and is subject to state regulations. The plant is in compliance with the drinking-water quality standards by testing monthly and quarterly for required constituents and reporting the results to TDEC. Requirements of the lead and copper rule have been met, and the plant has been granted approval to reduce monitoring for these constituents to once per year.

A cross-contamination control program implemented at the Y-12 Plant, ORNL, and the K-25 Site prevents and eliminates cross-connects of sanitary water with process water and utilizes back-flow prevention devices and an engineering review and permitting process. As part of the program, an inventory of installed back-flow prevention devices is maintained, and inspection and maintenance of the devices are conducted in accordance with regulatory requirements.

Clean Water Act

The Clean Water Act (CWA) was originally enacted as the Water Pollution Control Act in 1948, then later established as the Federal Water Pollution Control Act in 1972. Since that time the CWA has been subject to two major amendments. The objective of the CWA is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. With continued amendments, the CWA has established a comprehensive federal and state program to protect the nation's waters from pollutants. A third round of amendments is being considered by Congress.

National Pollutant Discharge Elimination System

One of the strategies developed to achieve the goals of the CWA was the establishment by the EPA of specific pollutant limits that are allowed to be discharged to waters of the United States by municipal sewage treatment plants and industrial facilities. In 1972, the EPA established the National Pollutant Discharge Elimination System (NPDES) permitting program to regulate compliance with these pollutant limitations. The program was designed to protect surface waters by limiting effluent discharges into streams, reservoirs, wetlands, and other surface waters.

The Y-12 Plant NPDES permit encompasses approximately 135 active point-source discharges requiring compliance monitoring that resulted in about 16,000 laboratory analyses in 1994, in addition to numerous field observations. The number of outfalls continues to decline as they are consolidated or eliminated. Although exceedences with the NPDES permit and spills to the environment occur, considerable progress was made in 1994 to minimize exceedences and their effect on receiving streams. Monitoring of discharges demonstrates that the Y-12 Plant has achieved an NPDES permit compliance rate of more than 99%; biological monitoring programs conducted on nearby surface streams provide evidence of the ecological recovery of the streams. At the Y-12 Plant there were 11 NPDES noncompliances in 1994, compared with 14 in 1993 (Fig. 2.3). Only two of the noncompliances during 1994 were because of exceedences of the wastewater discharge limits.

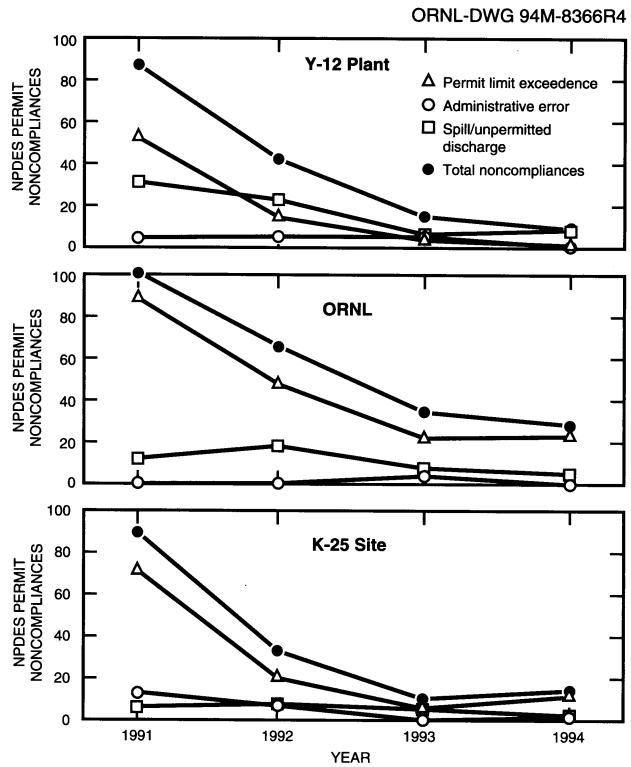

Fig. 2.3. Four-year summary of NPDES noncompliances.

The ORNL NPDES permit, renewed in 1986, lists 161 point-source discharges that require compliance monitoring. Many of these are storm drains, roof drains, parking lot drains, and storage area drains. Occasional spills and precipitation runoff from storm and parking lot drains have resulted in NPDES permit effluent limits being exceeded; however,

most of these exceedences are associated with precipitation runoff. Progress continues toward minimizing or eliminating these exceedences (Fig. 2.3). Compliance was determined by about 18,000 laboratory analyses and measurements in 1994 in addition to numerous field observations by various ORNL staff. The NPDES permit limit compliance rate across all discharge points for 1994 was greater than 99%. About 80% or more of ORNL's permit noncompliances for 1994 were for suspended solids in storm water runoff.

The K-25 Site NPDES permit includes seven major outfalls and 135 storm drain outfalls. Discharges at previously permitted pond outfalls have been altered to include monitoring of the storm drains that discharge into these ponds. Of the seven major outfalls, the discharges through two were permanently ceased during 1993. Two storm drain outfalls were removed from the permit during 1994. Out of about 35,000 NPDES laboratory and field measurements completed in 1994, only 16 excursions occurred, indicating a compliance rate of more than 99% (Fig. 2.3).

Status of NPDES Permits

The Y-12 Plant NPDES permit (TN0002968) expired on May 23, 1990. The plant continued to operate during 1994 under the expired permit, pending issuance of a new permit by TDEC, as provided in Tennessee Regulations 1200-4-1.05(5)(b). TDEC issued a new NPDES permit on April 8, 1995; it became effective on July 1. The new permit addresses revisions that were in the renewal application, such as some previously unlisted miscellaneous outfalls. In addition, it requires that storm water characterizations be made at selected monitoring locations in accordance with a storm water permit application submitted to TDEC in 1992.

ORNL is currently operating under NPDES permit 0002941, issued by TDEC and EPA Region IV on April 1, 1986. The permit expired on March 31, 1991. An application for renewal was submitted to TDEC on September 28, 1990. ORNL submitted a separate, individual NPDES storm water application in October 1992. It is anticipated that storm water discharges will continue to be a part of the ORNL NPDES permit. In May 1993 ORNL prepared at TDEC's request an information package to provide TDEC with updated information for use in the permit renewal process. Throughout 1993, periodic discussions took place between TDEC, DOE, and ORNL personnel regarding NPDES permit renewal, although no additional progress was made in 1994. ORNL has initiated negotiations with TDEC on a revised permit.

The K-25 Site is operating under NPDES permit TN 0002950, issued on October 1, 1992. As required by the permit, a Storm Water Pollution Prevention Plan was completed by October 1993. This plan (1) identifies areas having the potential to discharge pollutants to the receiving waters, (2) includes a pollutant control strategy to identify actions to minimize discharges of pollutants, and (3) outlines the development of annual sampling and analysis plans. Sampling as outlined in the Fiscal Year (FY) 1994 Storm Water Pollution Prevention Sampling and Analysis Plan was initiated during the fourth quarter of 1993 and was completed in 1994. An evaluation of FY 1995 results will be conducted during 1995. The conclusions reached from this evaluation will be used to determine the scope of the FY 1996 Storm Water Pollution Prevention Sampling and Analysis Plan.

Sanitary Wastewater

The CWA includes pretreatment regulations for publicly owned treatment works. Sanitary wastewater for the Y-12 Plant is discharged to the city of Oak Ridge under an

industrial and commercial user permit. The city of Oak Ridge staff performed their annual sanitary sewer compliance inspection on August 30, 1994.

During 1994, the Y-12 Plant met all sampling and allowable discharge limits for pollutants listed in the discharge permit. Comments by city personnel, again as in 1993, included a concern that undesirable materials may enter the sanitary sewer as a result of inflow and infiltration through contaminated soils. To address this concern, a line-item project has been initiated. In 1994, a systems-requirement document was prepared for the upgrade to correct known deficiencies in the Y-12 Plant sanitary sewer system. The city plans to issue new permits for industrial customers during 1995.

Sanitary sewer radiological sample results at the Y-12 Plant are routinely reviewed to ensure compliance with DOE Order 5400.5. As sample results are received they are compared with the derived concentration guides (DCGs) listed in the order. No radiological parameter that is monitored (including uranium) has exceeded a DCG. Typically, the results are three orders of magnitude below DCG limits.

At ORNL, sanitary wastewater is collected, treated, and discharged separately from other liquid wastewater streams through an on-site package sewage treatment plant. Wastewater discharged into this system is regulated by means of internally administered waste acceptance criteria based on the plant's NPDES operating permit parameters. Wastewater streams currently processed through the plant include sanitary sewage from facilities in Bethel and Melton valleys, area runoff of rainwater that infiltrates the system, and point sources such as biodegradable laboratory wastes and biodegradable scintillation fluids. The effluent stream from the sewage treatment plant is ultimately discharged into White Oak Creek through an NPDES-permitted outfall (X-01). Infiltration into the system and the discharge from the on-site laundry has, at times, caused the sludge generated during the treatment process to become slightly radioactive. As a result, the sludge is treated as solid LLW and is disposed of in ORNL SWSAs. ORNL has received funding for comprehensive upgrades of its sanitary sewage system. Upgrades will include sealing the collection system to prevent infiltration of contaminated groundwater and surface water and redirecting contaminated discharges from the laundry to appropriate alternative treatment facilities.

K-25 site domestic wastewater is treated at the K-1203 Sewage Treatment Plant and discharged pursuant to the NPDES permit. A sewer use ordinance and an influent surveillance program are in effect to ensure that effluent from the K-1203 sewage treatment plant continues to meet all NPDES permit limits. The sewer lines are currently being relined to reduce rainwater infiltration. An ultraviolet light disinfection system was installed to reduce the amount of chlorine discharged.

Aquatic Resources Protection

The U.S. Army Corps of Engineers and the TDEC both conduct permitting programs for projects and activities with the potential to affect aquatic resources, including navigable waters, surface waters (including tributaries), and wetlands. These are the Corps of Engineers Section 404 dredge-and-fill permits and the TDEC aquatic resources alteration permits (ARAPs). (See "Environmental Permits" section for ARAP permits.)

Oil Pollution Prevention

Section 311 of the CWA regulates the discharges of oils or petroleum products to waters of the United States and requires the development and implementation of a Spill Prevention Control and Countermeasures Plan to minimize the potential for oil discharges.

This section was then significantly amended by the Oil Pollution Act of 1990, which has as its primary objective the improvement of responses to oil spills.

The Oil Pollution Act requires certain facilities to prepare and implement a facility response plan for responding to a worst-case discharge of oil. The K-25 Site is subject to the requirements for preparing such a plan because of its oil storage capacity and location. The original plan was prepared and submitted to EPA on February 18, 1993; an updated plan was submitted to EPA on February 17, 1995. The plan includes designation of response personnel, description of response equipment, identification of the worst-case discharge scenario and associated response actions, personnel training requirements, testing and inspection requirements, and other oil spill-prevention and response measures. No facility response plan was required for the Y-12 Plant or ORNL.

Clean Air Act

Authority for enforcement of the Clean Air Act (CAA) is shared between TDEC for nonradioactive emission sources and EPA for radioactive emission sources. EPA also enforces rules issued pursuant to the 1990 CAA Amendment, Title VI—Stratospheric Ozone Protection Program.

General CAA Compliance

CAA compliance is an integral part of the TDEC air permit program, in which all three ORR facilities participate. Each site complies with all federal air regulations in addition to the stated air-permit conditions. Hoods at ORISE facilities are exempt from permitting requirements under the ORR laboratory equipment exemption and TDEC approval for exempt sources that handle negligible quantities of carcinogens and radiological materials.

The CAA program staff routinely participate in both walkdown inspections and internal audits to identify areas for improvement in the operation of air sources. Major sources are appropriately permitted, and documentation of compliance is developed. A number of minor sources that are exempt from permitting under state of Tennessee rules are being addressed also. All major emission sources are permitted by TDEC and are operating in compliance with those permits. The procedures for permitting, compliance inspection, and documentation of compliance are in place.

Compliance with 1990 CAA Amendments

An increasing number of the new CAA amendment rules have application at all three ORR facilities. Regarding Title VI—Stratospheric Ozone Protection, compliance activities have included compliance with the final refrigerant-recycling rules that require the purchase and use of certified refrigerant recovery and recycling equipment. In addition, stratospheric ozone protection plans were issued by each facility to outline actions necessary to comply with new limitations on the release of ozone-depleting chemicals and with the 1995 production ban on those chemicals. Compliance requirements for refrigeration-system and motor vehicle air-conditioner maintenance are being met. Studies are proceeding on finding replacements and on performing the necessary modifications to plant refrigeration equipment to accommodate the production ban on ozone-depleting chemicals.

Under Title III—Hazardous Air Pollutants, the major emphasis in 1994 has been on reviewing several potentially applicable proposed and final rules that have greatly expanded the National Emissions Standards for Hazardous Air Pollutants (NESHAP)

regulations, and on completing emissions inventories for permitting these sources under Title V.

Under Title V, each ORR facility is conducting a source identification program. This information will form the basis for the Title V Permit applications that will be submitted in 1995 and 1996. The comprehensive Title V Permit will replace the individual source permits that are currently active at each ORR facility.

National Emission Standards for Hazardous Air Pollutants for Radionuclides

Compliance with the Rad-NESHAP dose limit of 10 mrem/year to the maximum exposed individual of the public was demonstrated by modeling emissions from major and minor point sources during periods of operation. The annual off-site dose to the most-exposed member of the public for the ORR was 1.7 mrem in 1994, which was below the Rad-NESHAP compliance limit of 10 mrem.

Continuous emissions monitoring is performed at the K-25 TSCA Incinerator, at four ORNL radiological sources and at exhaust stacks serving uranium-processing areas at the Y-12 Plant. As of January 1, 1994, the Y-12 Plant had a total of 71 stacks, 68 of which were active and 3 were temporarily shutdown. During September two additional stacks were put into temporary shutdown. Also over the course of the year three stacks were taken out of service. Thus, during the course of the year 68 stacks were monitored and there were 63 stacks being monitored at the end of 1994. Grab samples and other EPA-approved estimation techniques are used on remaining minor emission points and grouped area sources. All three facilities met the emission and test procedures of 40 CFR 61, Subpart H.

NESHAP for Asbestos

The ORR facilities have numerous buildings and equipment that contain asbestos materials. The compliance program for asbestos management includes identification, monitoring, abatement, and disposal of asbestos materials. No reportable-quantity (RQ) releases were identified in 1994.

Other NESHAPs

The Y-12 Plant is subject to a NESHAP rule for machining beryllium. The Y-12 Plant currently monitors four stacks that serve beryllium machining and handling areas to demonstrate compliance with the 10 g/day emission limit. In 1994, measured stack emission rates at the Y-12 Plant were less than 0.003 g/day. The total emitted for 1994 was <1 g. The K-25 Site TSCA Incinerator is also subject to the NESHAP rule for incinerators that process beryllium. The current permitted emission limit for beryllium is <1 g/day, which is well below the NESHAP limit of 10 g/day. EPA is currently developing other NESHAP standards, pursuant to the CAA amendments of 1990. These standards will be evaluated as they are proposed and promulgated.

State-Issued Air Permits

The Oak Ridge Y-12 Plant has 64 active air permits covering 344 air emission points. There are currently 176 documented exempt minor sources and 324 exempt minor emission points.

At the close of 1994, 33 permitted air emission sources were in operation at ORNL. During the year, permit maintenance activities included exemption of one source, a new

permit for one source, permit renewal for four sources, and construction permit applications submitted for three sources. In addition, an internal surveillance of all permitted sources was conducted and TDEC conducted compliance inspections.

There were 165 active air sources at the K-25 Site at the end of 1994. The total includes 52 sources covered by 40 TDEC air permits and 113 sources that are exempt from permitting requirements. Numerous withdrawals of permits are pending for 1995 for sources that are no longer operating.

Toxic Substances Control Act

TSCA regulates the manufacture, processing, distribution in commerce, use, and disposal of chemical substances and mixtures that may present an unreasonable risk of injury to human health or the environment. TSCA gives EPA comprehensive authority to identify and control chemical substances manufactured, processed, distributed in commerce, and used within the United States. EPA imposes strict reporting and record-keeping of new chemicals and new information for existing chemicals relating to any substantial risk to health or the environment.

TSCA specifically banned the manufacture, processing, and distribution in commerce of polychlorinated biphenyls (PCBs), but authorized the continued use of some existing PCBs and PCB equipment. 40 CFR 761 is the codified regulation mandated by TSCA and regulated by EPA. The state of Tennessee restricts PCBs from disposal in landfills, and classifies PCBs as special wastes under the Tennessee solid waste regulations. A special waste exemption is required from the state of Tennessee to dispose of PCBs in landfills. Additionally, PCB discharges into waterways are restricted by the state-regulated CWA and NPDES programs.

Authorized and Unauthorized Uses

In the 50-year history of ORR facilities, a variety of PCB systems and equipment have been in service. Many of the systems and equipment were industry standards and their continued use was authorized under the 1979 PCB regulations. Systems that were authorized included transformers, capacitors, other electrical distribution equipment, heat-transfer systems, and hydraulic systems. Some uses have been phased out at ORR while others remain in service.

The 1979 regulations did not identify or authorize the use of other PCB equipment and systems in service at ORR. These include ventilation gaskets, metal-working lathes, lubricating systems, and other equipment. PCBs have also been discovered in electric cable wire, insulation, and cranes, all of which were not known or authorized by EPA for use. These unauthorized uses of PCBs are included under specific agreements with EPA and are in negotiation for inclusion in the Oak Ridge Reservation PCB Federal Facilities Compliance Agreement (ORR-PCB-FFCA). Additionally, the K-25 Site currently operates PCB activities under the Uranium Enrichment PCB Federal Facilities Agreement Compliance (UE-PCB-FFCA).

Several PCB compliance issues exist at the ORR because the ORR-PCB-FFCA negotiations have not been completed. DOE has submitted all information required by EPA Region IV in drafting the agreement. DOE-ORO is awaiting a draft agreement from EPA Region IV and continues to provide assistance and information as requested by EPA Region IV. The ORR-PCB-FFCA will provide a vehicle for resolution of PCB compliance issues on the ORR.

Ongoing programs are being pursued to phase out the use of PCBs at the ORR by reclassification (a lowering of regulated status by draining and flushing equipment) and by disposal. Other programs to identify equipment and systems containing PCBs and to characterize them by sampling and analysis are aggressively being undertaken. A proposal has been made to EPA to deregulate two PCB-contaminated heat transfer systems at the K-25 Site by draining and flushing the equipment to remove PCBs to below the minimum levels. Another proposal has been made to EPA to allow the cleaning of PCBs to below 10 $\mu g/100\ cm^2$ or to allow the coating of the inside of the K-1206-E fire water tank, where PCBs were recently identified in sludge removed during clean-out of the tank. Other similar proposals for various PCB equipment and systems are being suggested for the ORR-PCB-FFCA. As a result of historical and continuing uses of PCBs within the ORR, a large quantity of PCB waste has been generated and continues to be generated.

Historic PCB Spills

Various locations within the facilities where PCB equipment was used have been identified as sites of historic PCB contamination. These sites resulted from PCB spills occurring throughout the history of the reservation, many of which occurred prior to regulation. K-25 Site historic PCB spill sites are covered under the UE-PCB-FFCA and are to receive cleanup or remediation as required by the agreement. Spill sites at the Y-12 Plant and ORNL are proposed for inclusion in the ORR-PCB-FFCA.

Progress is being made through ongoing cleanup efforts to remediate these sites. Several historic spill sites and some historically contaminated equipment have been decontaminated at ORNL and the Y-12 Plant through use of innovative cleanup technologies. ORNL and the Y-12 Plant have undertaken R&D projects to develop alternative cleanup technologies. These projects are permitted by EPA Region IV. As with the phasing out of PCB equipment in use, spill-cleanup efforts result in the generation of a large quantity of PCB waste on the ORR. Much of this PCB waste is also radioactive.

Storage and Disposal of PCB/Radioactive Wastes

The PCB regulations require PCB wastes to be disposed of within 1 year of the date when the PCBs are removed from service. Because of a lack of available disposal avenues, PCB/radioactive wastes are stored at the K-25 Site, Y-12 Plant, and ORNL for periods exceeding 1 year. The UE-PCB-FFCA allows the K-25 Site to store such wastes generated by the K-25 Site for periods exceeding 1 year. PCB/radioactive wastes older than 1 year generated by other DOE facilities, particularly the Y-12 Plant and ORNL, are also stored at the K-25 Site.

In February 1993, DOE submitted an updated list of PCB compliance issues to EPA Region IV for consideration in developing the ORR-PCB-FFCA. Among these was a request to extend the current UE-PCB-FFCA allowance to store PCB/radioactive wastes for periods exceeding 1 year to all such wastes stored by the three ORR facilities. In addition to the lack of available disposal avenues, concern over the potential for even small amounts of radioactive waste to be shipped off site for disposal has prompted DOE to mandate a self-imposed moratorium on the shipment of waste for off-site disposal pending development of procedures to ensure that no radioactive material is shipped. The K-25 Site TSCA Incinerator is the only facility in the nation permitted to incinerate RCRA/PCB/radioactive waste.

Various difficulties arise in meeting the storage requirements of the PCB regulations because of the unique character and large volume of PCB wastes generated on the ORR.

One of the most significant is the necessity of storing some PCB/radioactive wastes in specific geometrically shaped containers (because of criticality safety concerns) and in areas not meeting PCB regulatory secondary containment requirements. Other storage concerns are the inability to place large items such as ventilation duct systems into containers. Storage concerns of this nature are addressed under the UE-PCB-FFCA and the proposed ORR-PCB-FFCA.

K-25 Site TSCA Incinerator PCB Disposal Approval

The K-25 Site TSCA Incinerator is currently operating under an extension of EPA Region IV approval granted on March 20, 1989. This extension is based on submittal of a reapplication for PCB disposal approval filed with EPA Region IV on December 20, 1991, which was within the time frame allowed for reapplication. Minor amendments, updates, and corrections to the reapplication identified by DOE have been made in the interim and have been submitted to EPA. Quantities of liquid PCBs have been reduced over the course of the year, resulting in a reduction in the risk of spills.

PCB Research and Development Permits

EPA Region IV granted ORNL authorization to conduct two R&D projects on stabilization and solidification techniques for PCB-contaminated materials from various DOE sites. The Chemical Technology Division R&D projects are not designed to destroy the PCBs contained in the waste. The presence of PCBs in the waste stream is incidental to the purpose of the research. These R&D projects are necessary for DOE to meet the requirements of the FFCA between DOE and EPA Region IV.

ORNL received extensions to continue three additional R&D projects in the Chemical Technology Division. ORNL has continued the biological dechlorination research with PCBs. In addition, research has continued on the use of a base-catalyzed dechlorination process for removal and treatment of radioactive PCB-contaminated waste. In 1994, ORNL was granted authorization to conduct a field demonstration on the use of solvated electrons in base-catalyzed destruction of PCB-contaminated material.

In November 1993 EPA Region IV issued the Y-12 Plant an R&D permit for thermal desorption removal/treatment of radioactive PCB-contaminated soil, sediments, and sludge. A request for modification of this permit was approved by EPA Region IV in April 1994.

Compliance Agreements

The Uranium Enrichment Toxic Substances Control Act Federal Facilities Compliance Agreement (UE-TSCA-FFCA) was signed February 20, 1992. This agreement between DOE Headquarters (DOE-HQ) and EPA Headquarters (EPA-HQ) provided a vehicle for resolution of PCB issues at the Portsmouth, Ohio, and Paducah, Kentucky, UE facilities and at the former K-25 UE facility in Oak Ridge. In July 1993 portions of the Portsmouth and Paducah facilities became the United States Enrichment Corporation, a wholly owned enterprise of the U.S. government independent of DOE; however, responsibility for PCB regulatory compliance was retained by DOE for these two facilities.

EPA-HQ agreed to continue the UE-TSCA-FFCA with DOE for the Portsmouth and Paducah facilities but directed EPA Region IV to enter into an agreement with DOE-ORO that would include the K-25 Site as well as the Y-12 Plant and ORNL. The UE-TSCA-FFCA continues in force for the K-25 Site until the ORR-PCB-FFCA can be completed. DOE-HQ and EPA-HQ had met periodically since the signing of the agreement;

however, in January 1994, organizational changes within EPA-HQ caused the suspension of progress meetings. Recently, administration of the UE-TSCA-FFCA has been assigned to the Federal Facilities Enforcement Office, Office of Enforcement and Compliance Assurance, at EPA-HQ. This office has requested a progress meeting on or about 45 days prior to July 1, 1995 (the deadline for the UE-TSCA-FFCA annual compliance report). Several proposals to advance efforts under the UE-TSCA-FFCA have been proposed and accepted by EPA-HQ.

On January 19, 1995, EPA-HQ provided clarification packages on 11 issues that DOE had raised regarding the UE-TSCA-FFCA. The clarification packages set forth EPA's interpretation and guidance on issues brought up by DOE. This action by EPA-HQ will assist DOE in its management of PCBs.

EPA Region IV was provided with documentation concerning the UE-TSCA-FFCA in early 1993. This documentation was to be used as a basis for the ORR-PCB-FFCA. EPA-Region IV has recently informed DOE-ORO that their attorneys are reviewing a final draft. If the draft is accepted by the EPA attorneys without major modifications, DOE-ORO will receive a first draft for review and comment.

In a separate effort, DOE-HQ and EPA-HQ are pursuing a national FFCA, which would cover solely the issue of storage of PCB wastes at DOE facilities for periods longer than 1 year. This agreement would cover all DOE facilities nationwide, but would not address particular issues as does the UE-TSCA-FFCA, or will the ORR-PCB-FFCA.

Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), governs the sale and use of pesticides and requires that all pesticide products be registered by EPA before they may be sold. The regulations for the application, storage, and disposal of pesticides are presented in 40 CFR 150–189.

The Y-12 Plant, K-25 Site, and ORNL maintain procedures for the storage, application, and disposition of pesticides. Individuals responsible for the application of FIFRA materials are certified through the University of Tennessee Department of Agriculture. If a pesticide can be used according to directions without unreasonable adverse effects on the environment or applicator (i.e., if no special training is required), it is classified for general use. A pesticide that can harm the environment or injure the applicator even when being used according to directions is classified for restricted use. To date, no restricted-use pesticide products are used at the K-25 Site. Safrotin®, used for the control of cockroaches, is the only restricted-use pesticide stored and used both at the Y-12 Plant and ORNL. To date, no purchases of this restricted-use material have been made since August 1993, and efforts for substitution are under way at the Y-12 Plant. An inventory of pesticide products is maintained for use at each facility. It is site policy to store, apply, and dispose of these products in a manner that ensures full compliance with the FIFRA requirements.

Emergency Planning and Community Right-To-Know Act

The Emergency Planning and Community Right-To-Know Act (EPCRA), also referred to as SARA Title III, requires reporting of emergency planning information, hazardous chemical inventories, and environmental releases to federal, state, and local authorities. The ongoing requirements of EPCRA are contained in Sections 304, 311, 312, and 313:

- Section 304 addresses reporting of off-site releases to state and local authorities.
- Section 311 requires that either material safety data sheets (MSDSs) or lists of the hazardous chemicals for which the MSDS is required be provided to state and local authorities for emergency planning.
- Section 312 requires that a hazardous chemical inventory be submitted to state and local authorities annually for emergency planning.
- Section 313 requires that releases of toxic chemicals be reported annually to EPA and the state.

The ORR had seven releases subject to Section 304 notification requirements during 1994. The Section 311 lists are updated frequently and are provided to the appropriate officials. The Section 312 inventories for 1994, delivered March 1, 1995, identified 101 hazardous chemicals, documented their locations, and summarized the hazards associated with them. Of these chemicals, 52 were located at the Y-12 Plant, 31 at ORNL, and 18 at the K-25 Site. Under Section 313, five toxic chemicals were reported for 1994. Release data for 1993 and 1994 are summarized in Table 2.4. Compared with 1993 releases, there was a 16.9% reduction in total toxic-chemical releases in 1994.

Table 2.4. EPCRA Section 313 toxic chemical release summary for the ORR

Chemical	Year	Quantity (lb)			
		Y-12 Plant	ORNL	K-25 Site	Total
Chlorine	1993	0	7,146	5,220	12,366
	1994	0	0	0	0
Methanol	1993	47,000	164	1	47,165
	1994	39,000	367	7	39,374
Hydrochloric acid	1993	3,200	0	131	3,331
	1994	1,031	202	81	1,314
Sulfuric acid	1993	401	0	1,085	1,486
	1994	18	1	373	392
Nitric acid	1993	24,000	43	3	24,046
	1994	32,300	43	0	32,343
Total	1993				88,394
	1994				73,423

Environmental Occurrences

CERCLA requires notification of the National Response Center if a nonpermitted release of an RQ or more of a hazardous substance (including radionuclides) is released to the environment. The CWA requires that the National Response Center be notified if an oil spill causes a sheen on navigable waters, such as rivers, lakes, or streams. When notified, the National Response Center alerts federal, state, and local regulatory emergency organizations so they can determine whether government response is appropriate.

During 1994, Y-12 Plant staff reported eight CERCLA RQ releases to federal and state agencies. The National Response Center was notified of seven ethylene glycol (antifreeze) releases within the Y-12 Plant. Six of these involved government vehicles with either overfilled radiators, ruptured radiator hoses, or faulty water pumps. The seventh ethylene glycol release involved an emergency generator. The eighth release was caused by a failed valve assembly for a 350-gal poly tank, releasing acid waste into a diked area.

The National Response Center and the Tennessee Emergency Management Agency (TEMA) were notified of three incidents that involved oil sheens on East Fork Poplar Creek. All three of the incidents resulted from the release of oil through building exits that discharged directly into East Fork Poplar Creek. One of the incidents occurred when hydraulic oil leaked through a stainless steel pan lying over an open floor drain. A second incident occurred when a steam trap began leaking in the basement of one of the buildings and washed residual oil through the building exit. The third oil sheen occurred when rainwater from a leaking roof washed oil from an air-conditioning unit into an open floor drain.

ORNL had one oil sheen on waters of the state in 1994, which was reported to the National Response Center as required under the CWA. ORNL had one reportable release of ethylene glycol, which was reported to the National Response Center as required under CERCLA.

In 1994, four releases occurred at the K-25 Site that required notification of the National Response Center or TEMA. These included the discovery of asbestos-containing material on the ground, the presence of an oil sheen on Mitchell Branch, the accidental release of PCB-contaminated oil, and an oil sheen on the K-1007-B pond caused by an automobile accident.

DOE ORDER COMPLIANCE

The following section has been developed to discuss compliance with those environmental requirements not found in specific statutes or where DOE is primarily self-regulating. The following sections provide compliance information for DOE Orders 5400.1, 5400.5, and 5820.2A.

DOE Order 5400.1, General Environmental Protection Program

DOE Order 5400.1 serves to establish environmental protection program requirements, authorities, and responsibilities for DOE operations to ensure compliance with applicable federal, state, and local environmental protection laws and regulations, executive orders, and internal DOE policies. The order specifically defines the mandatory environmental protection standards (including those imposed by federal and state statutes), establishes reporting of environmental occurrences and periodic routine significant environmental protection information, and provides requirements and guidance for environmental monitoring programs. Implementation of the order is provided by specific program plans, as detailed in Chapter III of the order. The internal environmental protection programs mandate the creation of several environmental reports.

Reports include the radioactive effluent and on-site discharge data report submitted annually to the Waste Information Systems Branch at the Idaho National Engineering Laboratory, the 5-year plan required by Office of Management and Budget Circular A-106, the annual site environmental report, and reports of significant nonroutine releases of hazardous substances consistent with DOE Order 5000.3B, "Occurrence Reporting and

Processing of Operations Information." An environmental protection program implementation plan (EPPIP) is required and is updated annually. The EPPIPs for the Y-12 Plant, ORNL, and the K-25 Site were reissued in November 1994. The EPPIP defines specific environmental objectives, including the means and schedules for accomplishment during the year.

An environmental monitoring plan is to be prepared, reviewed annually, and updated every 3 years or as needed. The Environmental Monitoring Plan for the ORR was released by DOE in September 1992. The plan provides a single point of reference for the effluent monitoring and environmental surveillance programs of the Y-12 Plant, ORNL, the K-25 Site, and ORR areas outside specific facility boundaries. The annual review identified the need to update the plan. A revised document was drafted during 1994 for further review and was issued as a controlled document in May 1995. The three ORR sites are in compliance with DOE Order 5400.1. Selected requirements demonstrating compliance follow.

Pollution Prevention/Waste Minimization

The ORR pollution prevention strategy is based on four major elements: (1) evaluating processes for pollution prevention opportunities and associated projects, (2) conducting pollution prevention awareness activities, (3) tracking and reporting activities and projects, and (4) exchanging information and technology.

Pollution prevention councils have been established at all three sites, with representation from each of the site organizations. The councils exchange information to promote pollution prevention activities. Responsibilities within the divisions at each site include the development of pollution prevention goals and implementation of programs and activities necessary to reduce both the amount and the toxicity of waste and environmental pollutants, communication of Energy Systems pollution prevention goals, documentation and communication of progress made toward implementation, and promotion of employee awareness.

During 1994, much effort was placed on identifying pollution prevention opportunities and on the implementation of pollution prevention projects. Tracking systems developed for all three sites track pollution prevention progress. During 1994, several source-reduction and recycling projects were completed. Projects include facility-specific activities as well as programmatic activities. Table 2.5 summarizes the results of selected recycling activities on the ORR during the past 4 years.

Table 2.5. Results of selected Oak Ridge Reservation recycling activities for the past 4 years

Material	Quantity (tons)			
	1991	1992	1993	1994
Aluminum cans	15.7	24.8	28.7	25.3
Cardboard	85.5	315.4	428.5	354.6
Paper	302.4	552.8	786.6	734.4

Groundwater

The hydrogeologic system at the Y-12 Plant has been divided into three hydrogeologic regimes, based on topography and surface water and groundwater flow patterns. An exit-pathway well network, as required by DOE Order 5400.1, has been completed to monitor flow from each hydrogeologic regime at Y-12 Plant. Water quality data from the exit-pathway wells at the east end of the Y-12 Plant indicate the volatile organic compounds carbon tetrachloride and tetrachlorethane, common industrial solvents previously used in large quantities at the Y-12 Plant, are being transported off the ORR through the Maynardville Limestone at depths of 100 to 300 ft. Property owners in the area have been notified and have been provided with a status report. Investigations during 1994 have confirmed that no drinking water wells are in the affected area. A remedial investigation of the off-site plume is being conducted under CERCLA.

Additional well installation and groundwater monitoring activities continued through 1994 in support of the Y-12 Plant UST Program and the construction and permitting of new industrial landfills to service the reservation.

Exit-pathway monitoring was initiated at ORNL in 1993. The program monitors groundwater at four general locations that are thought to be likely exit pathways for ORNL groundwater. Wells that are part of the ORNL WAG perimeter monitoring network and four surface water locations have been identified as monitoring locations.

Exit-pathway monitoring at the K-25 Site is conducted at locations where groundwater flowing from relatively large areas converges before discharging to surface water locations. The exit-pathway monitoring of groundwater quality in both the unconsolidated zone and the bedrock is supported by surface water monitoring at three convergence points. Existing wells have been incorporated into the exit-pathway network where possible. Four exit-pathway surveillance wells were installed during 1994 to complete the eight-well perimeter groundwater surveillance network. Baseline sampling of these wells, using micropurging and low-flow sampling procedures, began in FY 1994.

An off-site residential drinking water quality monitoring program has been conducted since 1989. The objective of the program is to document water quality from groundwater sources near the ORR and to monitor the potential impact of DOE-ORO operations on the quality of these groundwater sources. Currently, sixteen wells and three springs are included in the program; these sites were selected on the basis of their proximity to the ORR and a representative distribution of sources from the different geologic formations of the area. The wells are sampled semiannually, and results are provided in individual reports to the well owners. In past years, no contaminant movement to these off-site locations has been indicated, and the results from sampling in 1994 continue to support this.

Groundwater well installation, sampling, plugging and abandonment, and the overall operation of the ORR groundwater protection programs were the subject of numerous DOE and internal assessments during 1994. No major findings resulted from these assessments. No notices of violation (NOVs) or NODs were issued by the TDEC in 1994. The 1994 annual TDEC RCRA groundwater compliance evaluation inspections were conducted in June at the Y-12 Plant and in August at ORNL. No findings or recommendations were issued as a result of the inspections.

DOE Order 5400.5, Radiation Protection of the Public and the Environment

DOE Order 5400.5 provides guidance and establishes radiation protection standards and central practices designed to protect the public and the environment against undue risk from DOE operations. This order requires that no member of the public receive an effective dose equivalent (EDE) in a year greater than 100 mrem via all pathways and that no member of the public receive a radiation dose equivalent greater than 10 mrem in a year from airborne emissions. In addition, dose limits imposed by other federal and state regulations (40 CFR Parts 61, 191, and 192 and 10 CFR Parts 60 and 72) must be met. The primary dose limit is expressed as an EDE, which requires the weighted summation of doses to specified organs of the body. Monitoring of effluents released to the environment is required to ensure that radiation doses to the public are as low as reasonably achievable (ALARA) and are consistent with prescribed dose standards.

Liquid and airborne radiological effluent annual average concentrations on the ORR did not exceed the applicable DCGs at points accessible to the public. At specific locations, ORNL storm water and groundwater discharges from areas with legacy contamination exceeded the DCGs. Several such contaminated streams are intercepted by sumps and storm drain catch basins and routed to treatment facilities. CERCLA remediation is ongoing for such releases at specific discharge points. ORR doses are well below applicable standards (such as those for airborne emissions and drinking water).

DOE Order 5820.2A, Radioactive Waste Management

DOE Order 5820.2A establishes the policies and minimum requirements for managing ORR radioactive wastes and the radioactive component of mixed wastes. The order requires that each DOE site prepare a waste management plan for radioactive waste generation, treatment, storage, and disposal operations. In previous years each site had prepared its own waste management plan. These plans have now been consolidated into one document: *The Oak Ridge Reservation Waste Management Plan* (Energy Systems 1995b).

No high-level waste is generated on the ORR. ORNL manages TRU waste and LLW. Radioactive waste management activities at both the K-25 Site and Y-12 Plant are primarily related to LLW. Although material contaminated with TRU elements exists on the K-25 Site, the concentrations are less than the limits for TRU waste.

The receipt of TRU waste from Nuclear Fuel Services, Inc., of Irwin, Tennessee, was completed in 1994. A total of 822 drums was received, including one drum of mixed waste and 20 drums that were originally packaged as mixed-oxide waste. This project involved receipt, inspection, and storage in contact-handled TRU waste storage facilities at ORNL.

The above-grade tumulus Interim Waste Management Facility (IWMF) at ORNL is currently the only solid LLW disposal facility on the ORR. No hazardous, mixed, or TRU wastes were disposed of on the ORR or at IWMF during 1994.

Shipments of combustible and compactible material as well as contaminated metal continued from the ORR to Scientific Ecology Group, Inc., in Roane County for smelting, incineration, and supercompaction. About 2 million pounds of radioactively contaminated scrap metal were shipped during FY 1994 for smelting and casting into shielding blocks. Process residuals are returned to the ORR for storage as radioactive waste. The shielding blocks are used in the DOE High Energy Physics Program.

APPRAISALS AND SURVEILLANCES OF ENVIRONMENTAL PROGRAMS

Numerous appraisals, surveillances, and audits of the ORR environmental activities occurred during 1994 (see Tables 2.6, 2.7, and 2.8). These tables do not include internal Energy Systems and Lockheed Martin corporate assessments.

Tiger Team Environmental Assessment

Table 2.9 provides a summary of the status of corrective actions from the Tiger Team assessments.

Defense Nuclear Facilities Safety Board

In September 1994, during a Defense Nuclear Facilities Safety Board tour of a storage building in 9204-2E, a discrepancy with specific stipulations of the criticality safety approval for storage of fissile material in that area was identified. As a result, a number of operations at the Y-12 Plant were curtailed. However, environmental management operations (compliance monitoring, reporting, and oversight) have continued operations, and there have been no environmental impacts as a result of the stand-down. Work continues at the Y-12 Plant to respond to recommendations from the board concerning

Table 2.6. Summary of environmental audits and assessments conducted at the Y-12 Plant, 1994

Date	Reviewer	Subject	Issues
1/10–13	EPA	RCRA/TSCA ORR field trip	1
4/1	DOE	Pollution prevention implementation and RCRA compliance	4
4/1–5/13	DOE	East Fork Poplar Creek buffer zone maintenance	0
5/23–25	TDEC	NPDES compliance evaluation inspection	0
6/10–11	DOE	West End Treatment Facility	0
6/15	DOE	Clean Air Act surveillance	3
6/20–24	TDEC	RCRA annual inspection	0
7/6–8/2	DOE	TDEC annual air emission compliance inspection	0
7/18	DOE	Maintenance of oil/water separator on East Fork Poplar Creek	0
7/25–8/5	DOE	Use of general categorical exclusions	0
8/2–3	TDEC	RCRA groundwater compliance evaluation inspection	0
8/22–9/2	DOE	Routine environmental audit of the Y-12 Plant	7
11/1–3	DOE	Health and safety surveillances of Building 9201-1	0

Table 2.7. Summary of environmental audits and assessments conducted at ORNL, 1994

Date	Reviewer	Subject	Issues
1/13	EPA	Selected hazardous mixed waste storage units	0
2/7	TDEC	Preparation of annual waste activity reports	0
3/7	USDA & Tenn. Dept. of Agriculture	ORNL projects and procedures on handling soils before disposal	0
3/17	DOE-ORO	UST certificates	0
5/2–4	TDEC	Inspection of treatment, storage, and disposal facilities; groundwater; and generator areas	0
11/8–10	TDEC	Inspection of groundwater and RCRA programs	0

Table 2.8. Summary of environmental audits and assessments conducted at the K-25 Site, 1994

Date	Reviewer	Subject	Issues
2/7–18	DOE-ORO	Multimedia environmental, health, safety, and quality audit	44
2/14–18	EPA	Annual RCRA inspection	0
2/14–25	DOE	Multimedia environmental audit	11
9/12–13	TDEC	Annual inspection of TSCA Incinerator	0
9/21	Federal Energy Regulatory Commission and TDEC	Inspection of dams at water impoundments	0
11/7	TDEC	Annual air inspection of four air emission sources	0
11/17	U.S. Army Corps of Engineers	Inspection of Central Neutralization Facility pipeline extension in Poplar Creek	0

Table 2.9. Summary of Tiger Team corrective actions

Date of review	Site	Environmental findings	Status
6/89 2/10–21/92 (follow-up visit)	Y-12 Plant	62	58 have been closed (52 of these 58 have been verified closed by DOE); 4 remain open.
10/22–11/30/90	ORNL	69	53 have been closed; 45 of these 53 have been verified as closed by DOE; 16 remain open.
11/12–12/18/91	K-25 Site	102	63 have been closed; none of these 63 have been verified as closed by DOE; 39 remain open.

formality of operations. In December 1994 the Defense Nuclear Facilities Safety Board assessed the K-25 Site; however, the assessment did not involve environmental issues.

ENVIRONMENTAL PERMITS

Table 2.10 contains a summary of environmental permits for the three ORR sites.

Table 2.10. Summary of permits as of December 1994

	Y-12 Plant	ORNL	K-25 Site
Resource Conservation and Recovery Act			
Part B	1[a]	2	4
Part B applications in process	5[b]	3	0
Post-closure	1	1	0
Permit-by-rule units	10	173[c]	92
Solid waste landfills	6[d]	0	0
Annual petroleum UST facility certificate	2	1	1
Clean Water Act			
NPDES	1[e]	1	1
Storm water	1[f]	1[g]	1[f]
Aquatic resource alteration/U.S. Army Corps of Engineers 404 permits	2	2	7
General storm water construction	2[h]	0	3
Clean Air Act			
Operating air	64	37	52
Construction	6	0	1
Prevention of significant deterioration	0	0	0
Sanitary Sewer			
Sanitary sewer	1	0	0
Toxic Substances Control Act			
TSCA Incinerator	0	0	1
R&D for alternative disposal methods	1	2	0

[a]One permit was issued in 1994 for the Tank Storage Units (includes three storage units).

[b]Five applications are under review by TDEC, representing 17 active units.

[c]Tanks regulated by permit-by-rule.

[d]Four landfills are operational, one (Spoil Area 1) is inactive, and one (Landfill VII) is constructed but not in operation as of the end of 1994.

[e]Issued 4/28/95 for the Y-12 Plant.

[f]TDEC has incorporated storm water into individual NPDES permit applications.

[g]TDEC is expected to incorporate storm water into the NPDES permit applications.

[h]Notice of intent that accesses a general NPDES permit. Two notices of intent remain on file for construction at landfill V, VII, and the Walk-in Pits. No notice of completion had been issued for the Walk-in Pits by the end of 1994.

NOTICES OF VIOLATIONS AND PENALTIES

No new NOVs or penalties were received by the Y-12 Plant in 1994. However, a commissioner's order issued by TDEC on January 8, 1992, alleging that Energy Systems failed to provide immediate notification of a statistically significant change in a groundwater contaminant measured near a former Y-12 Plant hazardous waste disposal unit, has been the subject of negotiation. The order was a result of a TDEC audit during 1991, where sampling data from 1990 were reviewed (Energy Systems 1992). The order imposed a penalty of $8,000. Energy Systems filed a timely appeal of the fine. The technical issues associated with the penalty were resolved in March of 1992 when TDEC formally approved a false-positive determination. On the advice of Energy Systems' Office of General Counsel and with the verbal agreement of the DOE Office of General Counsel, the penalty was paid, recognizing that payment of the penalty was more cost-effective than litigation. (TDEC returned the payment when a negotiated settlement was reached.)

ORNL received one NOV. DOE received one NOV and one notice of noncompliance (NON) in 1994 for ORNL. On March 10, 1994, ORNL received an NOV for violations of the NPDES permit for the periods ending December 31, 1993, and January 31, 1994, for total suspended solids, oil and grease, and iron. On March 30, 1994, Environmental Restoration received an NOV for an unpermitted discharge to White Oak Creek from surface impoundment basin 3513. On November 2, 1994, ORNL received NOVs for violations of the NPDES permit for the periods ending March 31, 1994, and June 30, 1994, for total suspended solids.

The K-25 Site received two NOVs in 1994, but one of these was issued for a noncompliance that actually occurred in 1993. In December 1993, heavy rains infiltrated aging sewer pipes, causing the influent flow to the K-1203 Sewage Treatment Plant to exceed the design parameters of the plant. As a result, the NPDES limit for fecal coliform bacteria was exceeded. Corrective actions taken by the K-25 Site to address this problem included an extensive effort to reline the sewer pipes to reduce infiltration, and a modification of the disinfection process to increase the bactericidal efficiency. An NOV was also issued in August 1994. Remedial activities at the Pond Waste Storage Area have been under way for several years, but have been slowed by funding and safety concerns. In January 1994, an NOV was issued citing lack of progress in correcting certain conditions. The NOV was followed in June 1994 by a commissioner's order assessing civil penalties. The conditions have since been corrected as stipulated by TDEC.

CURRENT ISSUES

Actions Filed by Friends of the Earth, Inc.

On January 17, 1992, Friends of the Earth, Inc., a nonprofit corporation, filed a lawsuit against Admiral James D. Watkins (then secretary of energy) and DOE in the U.S. District Court for the Eastern District of Tennessee, Northern Division. The suit alleges that DOE is violating the terms and conditions of its NPDES permits for the Y-12 Plant, ORNL, and the K-25 Site. Specifically, the complaint alleges that discharges of certain quantities of various pollutants into tributaries of the Clinch River that have their sources at the Y-12 Plant, ORNL, and the K-25 Site have exceeded (and are exceeding) the allowable discharge limits established by the NPDES permits. The injunction seeks to force DOE to comply in all respects with DOE's NPDES permits, declaratory judgments, and the award of various other costs.

Friends of the Earth made a request for production of documents, which were provided by DOE. The complaint was amended to add another environmental group and several individuals as plaintiffs to the lawsuit. Friends of the Earth took depositions in August 1993, and toured the facility with their expert witness in October 1993.

In October 1992 Friends of the Earth filed a motion for summary judgment with the court. In January 1993 DOE and the U.S. Department of Justice filed a cross-motion for denial of summary judgment. A hearing was held in Federal District Court in Knoxville, Tennessee, in May 1993. At that time, the court ordered the parties to prepare charts or tables summarizing the parties' positions regarding the number and extent of the alleged violations of the NPDES permits and the corrective actions taken, planned, or requested. The parties have complied with this order. Oral arguments were held in March 1995, in Knoxville. A trial date has not been set.

Action Filed by Boat Dock Owners on Watts Bar Lake

On August 30, 1991, nine marina/boat dock owners on Watts Bar Lake filed a civil lawsuit against Union Carbide Corporation and Energy Systems in the U.S. District Court, Knoxville, Tennessee. The suit alleged that plaintiffs have suffered economic losses because of publicity regarding discharge by the defendants of various substances into Watts Bar Lake from the DOE Oak Ridge facilities. Plaintiffs also traced their asserted injury to a fishing advisory issued by the state of Tennessee in February 1991. The plaintiffs based their allegations on negligence, strict liability, and nuisance theories, and sought compensatory and punitive damages. The plaintiffs, who relied solely on certain 1990 media reports discussing three draft environmental reports issued by DOE and Energy Systems, claimed that public perception created by the news media reports and fishing advisories might cause a decline in business at their resorts at some point in the future.

On January 15, 1993, defendants filed a joint motion for summary judgment on the grounds that the plaintiffs have failed to show that they have sustained a significant interference with their businesses and enjoyment of their property, and thus no private nuisance claim exists. On December 1, 1993, the district court judge denied defendants' motion. This case was settled before the trial date of August 8, 1994.

Moratorium on Off-Site Shipment of Hazardous Waste

In May 1991 a moratorium on the off-site shipment (to non-DOE sites) of PCB and RCRA hazardous waste was placed on DOE facilities, including those on the ORR. The moratorium was put in place to prevent waste containing any radioactive material from being shipped to a facility that is not licensed to handle it. The moratorium essentially requires all PCB and RCRA hazardous waste generated at the ORR to be managed as mixed waste (hazardous wastes also contaminated with radioactivity), until appropriate procedures are approved by DOE-HQ to ensure that waste streams are free of radioactivity above background. These procedures have been prepared by each of the sites and submitted to DOE-HQ for review and approval. The Y-12 Plant received approval from DOE-HQ on January 13, 1994, to use its procedures. Since that time, two waste streams have been certified as "no-rad-added" for potential off-site shipment. The Y-12 Plant has achieved a total lifting of the moratorium. ORNL is currently under the moratorium.

In 1994 the K-25 Site operated under a partial lifting of the moratorium. Full lifting of the moratorium is pending the resolution of national issues related to bulk contamination release limits.

Tennessee Oversight Agreement

The state of Tennessee and DOE have entered into a 5-year monitoring and oversight agreement intended to assure Tennessee citizens that their health, safety, and environment are being protected during facility operations, ongoing cleanup activities, and emergency response efforts for the ORR and the surrounding areas.

The Tennessee Oversight Agreement (TOA) was signed on May 13, 1991, and reflects the obligations and agreements between DOE and the state regarding technical and financial support provided by DOE and the state for its oversight of these activities. The agreement may be extended beyond 5 years or amended as necessary. It may also be modified as appropriate to address community issues that arise.

TDEC is the lead Tennessee state agency for implementation of the agreement. TDEC has established the DOE Oversight Division (TDEC/DOE-O), located in the city of Oak Ridge and currently staffed by about 70 employees. TDEC has developed other agreements with various state and local agencies to support oversight activities. TDEC/DOE-O administers the agreements with the Tennessee Wildlife Resources Agency (TWRA), a local oversight committee to assist public understanding of issues and activities, and TEMA to conduct emergency management oversight.

A DOE-TOA steering committee composed of site and major program representatives has been established to coordinate implementation and to promote consistency in implementation across the ORR. Energy Systems and other selected DOE prime contractors have established internal organizations, including the designation of TOA coordinators to facilitate implementation of the agreement.

To date, a variety of activities have been conducted under the agreement. DOE has provided security clearances and training necessary for state employees to gain access to the sites. Environmental data and documents associated with environmental, emergency management, environmental restoration, and decontamination and decommissioning programs have been provided or have been made available to the state for their review.

TDEC/DOE-O Radiological Monitoring and Oversight section began its Facility Survey Program in September 1994. The goal of the program is to provide an independent evaluation of the condition of these facilities for the citizens of the state of Tennessee. Twenty buildings/facilities were identified for a walk-through by the state. Fifteen of the 20 were surveyed during 1994.

In December 1994 TDEC/DOE-O made its Environmental Monitoring Plan for 1995 available to DOE. The plan involves environmental monitoring (which includes sampling and analysis, site audits and inspections, reviews of sampling and analysis data from many sources, review of plans, and oversight). The plan is intended to characterize and monitor chemical and radiological emissions in the air, water, and soil both on and off the ORR. The DOE Oversight Division routinely visits the three DOE sites to attend formal meetings and briefings, conduct walk-throughs of buildings and grounds, or to conduct observations of site operations to ensure compliance with environmental regulations and DOE orders. DOE has also been engaged in a dialog with TDEC/DOE-O concerning further development of the specific DOE and state commitments required by the agreement.

3. Environmental Management Program

Abstract

The Oak Ridge Environmental Management Program has four primary components:

- *environmental restoration* studies environmental contamination and proposes cleanup solutions;
- *decontamination and decommissioning* removes bulk contaminants and contaminated equipment from process buildings no longer in use;
- *waste management* treats, stores, and disposes of waste generated from DOE operations and cleanup work; and
- *technology development* creates new or modifies existing technologies to solve environmental problems.

INTRODUCTION

For nearly a half century, one of the primary missions of DOE and its predecessor agencies was the production of nuclear weapons for the nation's defense. Weapons production on the ORR, which began in 1943 as part of the secret World War II Manhattan Project, resulted in radioactive and hazardous waste contamination. In 1989, the reservation was placed on EPA's National Priorities List (NPL), which names waste sites across the country most in need of cleanup.

Once the reservation was added to the NPL, cleanup became subject to the process specified by CERCLA, more commonly known as Superfund. This law requires federal agencies and private-sector companies to investigate and remedy abandoned or uncontrolled hazardous waste sites where a release has occurred or may occur. It also requires public involvement to ensure that citizens are informed of and are involved in making cleanup decisions.

In 1990, DOE HQ established the Office of Environmental Management, making DOE-ORO responsible for cleanup of the reservation, with Energy Systems serving as its managing and operating contractor.

The following sections highlight some environmental management projects that were initiated or completed in 1994.

K/PH 94-3643

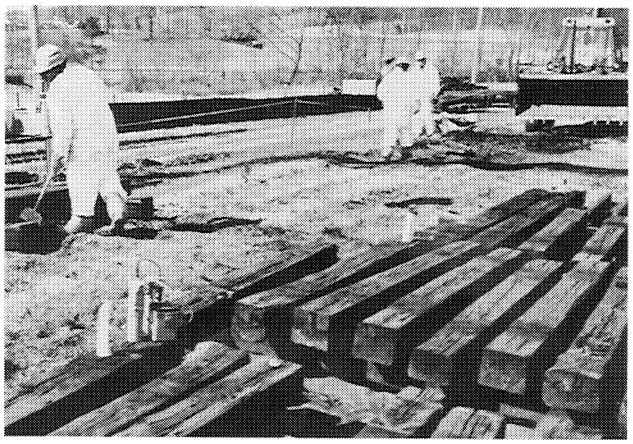

Fig. 3.1. Cleanup work being conducted along CSX railroad tracks.

CLEANUP ALONG CSX RAILROAD TRACKS

DOE completed cleanup of radioactive contamination in areas along the CSX railroad track in Oak Ridge (Fig. 3.1). Materials contaminated with ^{137}Cs were removed from the railroad bed in an area next to

Scarboro Road (near the Y-12 Plant) and on Warehouse Road (on the east end of Oak Ridge). DOE confirmed the presence of ^{137}Cs contamination during a 1986 radiological survey of the railroad spur. Preliminary assessments indicated that the contamination did not pose an immediate risk to human health or the environment. The cleanup, which began in February, included the removal of about 500 cubic yards of crossties, ballast (the gravel material between the tracks), soil, and rails. The soil and ballast were packaged for indoor storage at the K-25 Site. The contaminated crossties and metal were sent to Scientific Ecology Group for incineration and smelting, respectively. The smelted metal will be recycled into shielding materials for high-energy accelerators.

K-25 SITE DRUMS

In March 1994, workers began repackaging the remaining 32,000 of 77,000 drums stored on a 6-acre outdoor asphalt pad at the K-25 Site (see Fig. 2.1). Improvements in equipment and procedures allowed workers to repackage up to 300 drums per day. As a result, repackaging was completed in December 1994—four months ahead of schedule and $2 million under projected cost. The drums contained contaminated sludge removed from two wastewater ponds in the late 1980s. When the ponds were dredged, about 45,000 drums of sludge were mixed with cement and flyash, but the remaining 32,000 drums were filled with raw, untreated sludge. The solidified sludges were moved to storage in the K-31 and K-33 buildings during 1992 and are currently being shipped to Envirocare (Fig. 3.2). In the next phase of the project, contractors will be asked to demonstrate their ability to treat the raw sludges so they too can be shipped to Envirocare for final disposal.

ORNL PHOTO 9155-94

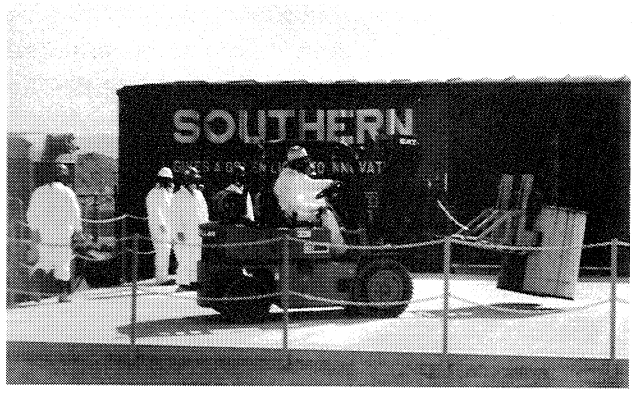

Fig. 3.2. Workers at Envirocare of Utah, Inc., receive a shipment of treated mixed waste from the Oak Ridge K-25 Site.

ENVIROCARE SHIPMENTS

DOE and Envirocare of Utah, Inc., signed a contract in March 1994 allowing DOE to ship treated mixed waste (waste that contains both radioactive and hazardous components) to Envirocare's permitted disposal facility located 80 miles west of Salt Lake City. Since August 1994, more than 4,300 drums of stabilized sludge from two dredged ponds at the Oak Ridge K-25 Site and 20 drums of ash from the TSCA Incinerator have been shipped to the Envirocare facility, which is the only commercial facility in the United States licensed to dispose of mixed waste once it has been treated to stabilize its hazardous components. After arriving at Envirocare by rail, the drums are unloaded, tested to ensure they meet the waste acceptance criteria, and placed in a lined disposal cell. When the cell is filled sufficiently, steel box lids are placed around the drums, forming a boundary. Clean concrete is then poured over the drums to fill void space between them. When the cell is completely full, it is capped with clean soil (Fig. 3.2).

PERFORMANCE-BASED ENVIRONMENTAL MANAGEMENT PROJECTS

Under a newly negotiated, performance-based contract, Energy Systems will have authority to direct the work of all participants and will control all work phases of environmental management projects.

In the first of these projects, facilities to treat two seeps (small flows of groundwater that come to the surface) in WAG 5 at ORNL began operating in mid-November 1994 (Fig. 3.3). The WAG 5 Seeps Project involved constructing two facilities to remove ^{90}Sr (a radioactive substance with chemistry and biological availability similar to calcium) from the two seeps.

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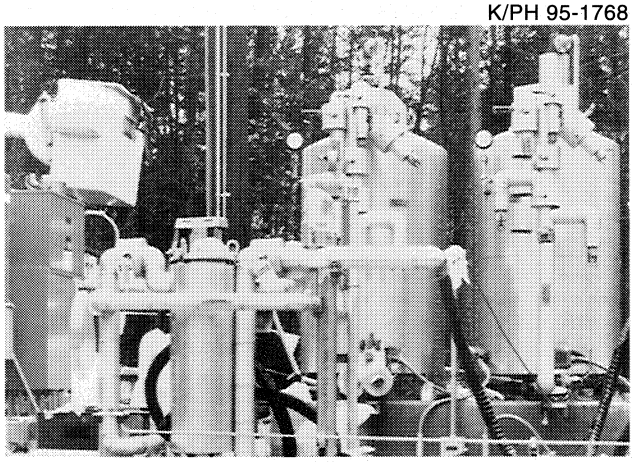

Fig. 3.3. Process equipment at Seep D Treatment Facility at WAG 5.

Two other projects began in April 1994: demolition of the K-25 powerhouse, expected to be completed in December 1996 (Fig. 3.4), and demolition of the K-25 cooling towers, expected to be completed in March 1997. Additional proposals are being prepared for projects at ORNL, the K-25 Site, and the Portsmouth and Paducah gaseous diffusion plants.

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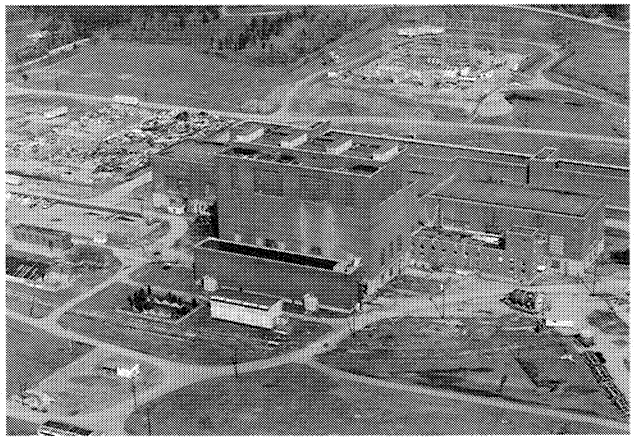

Fig. 3.4. The K-25 powerhouse.

EAST FORK POPLAR CREEK CLEANUP PLAN

In November DOE submitted to regulators its proposed cleanup plan to remove mercury contamination from East Fork Poplar Creek floodplain soils (Fig. 3.5). The proposed action involves excavating soil from areas along the creek that contain mercury contamination in excess of 400 parts per million. DOE, EPA, and TDEC have agreed to this limit, which is documented in the draft record of decision. According to the plan, about 10,000 cubic yards of soil would be removed and disposed of at a permitted landfill at the Y-12 Plant. East Fork Poplar Creek originates at the Y-12 Plant and runs through the city of Oak Ridge for about 14.5 miles until it empties into Poplar Creek just north of the K-25 Site. In 1983, DOE announced that the creek had been contaminated with mercury as a result of weapons production activities at the Y-12 Plant during the 1950s and 1960s. A public meeting on the proposed plan was held in January 1995. DOE is in the process of reviewing public comments with EPA and TDEC.

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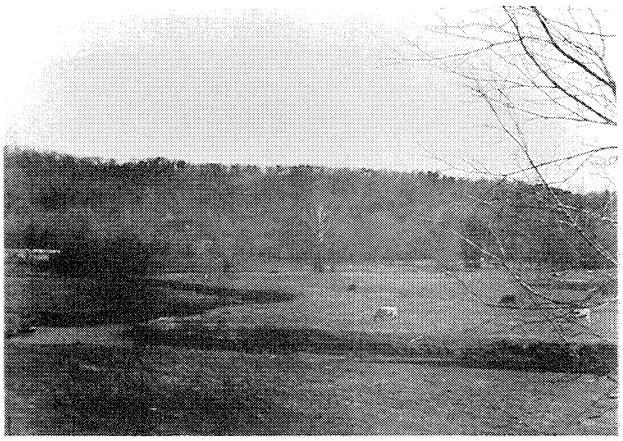

Fig. 3.5. East Fork Poplar Creek runs through the city of Oak Ridge for approximately 14.5 miles before emptying into Poplar Creek near the K-25 Site.

PCBs IN LOWER WATTS BAR RESERVOIR

DOE completed its environmental investigation of Lower Watts Bar Reservoir, which includes the entire reservoir downstream from Kingston. The results show that current risks from contaminants in the reservoir are very low; therefore, DOE is recommending that no remedial action be conducted.

The primary concern is that certain fish, primarily catfish, striped bass, and largemouth bass, are contaminated with PCBs. PCBs are man-made chemicals once used in electrical equipment, but they are no longer made in the United States because they are believed to be carcinogens (cancer-causing agents). The study also addresses small amounts of radioactive cesium in the sediment of Watts Bar Lake. Most of this contamination was released 40 years ago and today is buried under cleaner sediment in the deep-water areas of the lake, where human contact is very unlikely. DOE's alternative for the contamination problem in Lower Watts Bar Reservoir involves fish-consumption advisories and institutional controls. Both actions are currently implemented by other federal agencies.

DOE has agreed to assist TVA and the U.S. Army Corps of Engineers (agencies that regulate dredging in most East Tennessee lakes) by collecting and analyzing samples of any areas in the lake where dredging is proposed. Deep-water sediments in the lake have never been dredged. DOE will continue monitoring conditions in the study area for at least 5 years. At that time, DOE, EPA and the state of Tennessee will decide if continued monitoring is needed.

PUBLIC INVOLVEMENT

DOE's Public Involvement Program continued to hold quarterly stakeholder meetings, public hearings, and workshops to update people on environmental management projects taking place on the reservation (Fig. 3.6). The following sections highlight some of the program's accomplishments in 1994.

Site-Specific Advisory Board

A 16-member volunteer committee worked with DOE to develop a proposal for establishing a Site-Specific Advisory Board (SSAB) for the reservation. The committee began meeting twice a month in January and submitted their proposal to DOE in July. In early 1995 DOE decided to establish an SSAB in Oak Ridge to advise the agency on environmental management issues, including recommendations for cleanup levels, technology development, and long-term waste management issues. The group will include 15 to 20 representatives from communities potentially affected by cleanup decisions as

ORNL PHOTO 3946-95

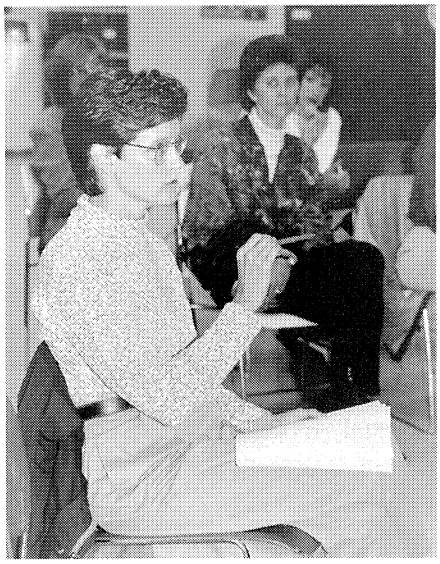

Fig. 3.6. An interested citizen expresses her thoughts at one of the public information meetings held to discuss the formation of a Site-Specific Advisory Board for the ORR.

well as governing bodies and other interested groups. Representatives from DOE and its regulator agencies, EPA Region IV and TDEC, will serve on the Oak Ridge SSAB as nonvoting members. Most DOE sites across the country have already established SSABs.

Common Ground Process

Before initiating any environmental cleanup, DOE must evaluate current and future land use to define acceptable risks and to determine cleanup levels that will be protective of human health and the environment. This evaluation is referred to as the "common ground process." In other words, DOE must decide "how clean is clean." In December 1993, Assistant Secretary for Environmental Management Thomas P. Grumbly directed all DOE operations offices to conduct land-use studies, examine future use and missions, and involve stakeholders in developing a list of preferred land-use options. To involve stakeholders in the common ground process, DOE's effort to gather public opinions and ideas about how the ORR should be used in the future, public workshops were held in Oak Ridge, Farragut, Spring City, Clinton, and Harriman in November and December. Public input from these workshops, along with information from city, state and professional planners, will be included in a future-land-use document, which DOE-ORO will submit to DOE HQ in December 1995.

EnvironMENTAL Fair

About 2000 sixth-graders from 11 East Tennessee counties traveled to Oak Ridge to participate in DOE's third annual EnvironMENTAL Fair, which was held October 6 at the American Museum of Science and Energy (Fig. 3.7).

Sponsored by DOE's Oak Ridge Environmental Management Program, the event is designed to increase students' awareness of local and global environmental issues and to spark their interest in science.

DOE-ORO held the fair for the first time in 1992. Since then, nearly 8,000 East Tennessee students have had the opportunity to learn about environmental work being conducted in Oak Ridge and around the country.

K/PH 94-6731

Fig. 3.7. Two sixth-graders enjoy one of many hands-on activities at the 1994 EnvironMENTAL Fair.

CENTER FOR ENVIRONMENTAL TECHNOLOGY

The Center for Environmental Technology (CET) has been conducting business since its dedication at the K-25 Site in May 1993. The center was established to integrate environmental technology activities for the ORR, to provide focus on technology programs that are market-driven, and to accelerate the commercialization of environmental innovation. CET has four components.

- *The Office of Technology Alliances* serves as the primary point of contact for CET customers and facilitates collaborative activities between government and the private sector for developing and demonstrating environmental technologies.
- *The Office of Environmental Technology Development* manages R&D projects for DOE to support environmental restoration and waste management programs.
- *The Office of Environmental Technology Assessment* performs analyses of candidate technologies in the area of risk, public policy, regulation, potential acceptance, socioeconomic impacts, cost, and commercial viability.
- *The Hazardous Waste Remedial Actions Program* develops, promotes, and applies innovative and cost-effective hazardous waste management techniques and environmental technologies for federal agencies.

The following technology demonstrations were hosted by CET at the ORR in 1994.

- *Rotasonic drilling.* Alliance Environmental, Inc., demonstrated a drill that uses sonic energy for operation. This approach is faster than conventional drilling, removes continuous core samples from the earth and generates virtually no waste cuttings.
- *Aqueous-based soil wash system.* Soil Tech Environmental Systems, Inc., demonstrated a technology for extracting contaminants from soils. Originally developed for use in oil fields, this technology has potential applications for removing contaminants from soils throughout the DOE complex.
- *Asbestos-destruction technology.* A demonstration was conducted of a treatment method developed by DSI Industries Consolidated, Inc., to provide a low-cost alternative for disposing of asbestos-contaminated waste. In the DSI process, fibrous solid asbestos is placed in a liquid acidic medium, where it reacts with fluoride and is transformed into a nonasbestos, nonhazardous material form.
- *Electrokinetic concrete decontamination.* Isotron Corporation conducted the first phase of a four-part demonstration of an electrokinetic process for removing uranium contamination from concrete. The process uses an electric current to draw contamination to the surface of the concrete for collection in a special gel.
- *Gamma ray telescope.* Physitron, Inc., performed the first major field test of a telescope that scans sites from a variety of angles and measures the direction of gamma ray movement. The telescope has potential uses in mapping waste sites and monitoring radioactive emissions at nuclear facilities.
- *Ultraviolet (UV)/hydrogen peroxide system.* W. J. Schafer Associates and Peroxidation Systems demonstrated a new surface discharge lamp for use with an available UV/hydrogen peroxide system for removing organic contaminants from water. The new lamp enables the system to remove additional organic contaminants.

Major Oak Ridge Environmental Restoration Accomplishments, 1989–94

- 114 acres capped
- 28 surface impoundments closed
- 14 remedial investigations completed
- 503,556 ft^2 of waste storage space developed
- 13 miles of asbestos removed
- 13,867 pieces of PCB-contaminated equipment removed
- 385,054 gallons of PCB-contaminated fluids disposed of
- 700,000 ft^2 of contaminated soil treated
- 5 million lb of scrap metal recycled
- 50 million gal of surface water and groundwater treated

THE CENTER FOR WASTE MANAGEMENT

DOE has more than 100,000 tons of mixed waste (waste containing both radioactive and hazardous components) on the ORR that needs to be treated. The Center for Waste Management (CWM), which was established at the K-25 Site in May 1993, is dedicated to providing new technologies to treat this huge volume of waste and to maximize private-sector involvement in the treatment process. Through CWM, private industry and the academic community will be called on to help the government meet the waste management opportunities and challenges faced in Oak Ridge. This strong partnership will help private industries mobilize new technologies and expertise to help solve a national waste management problem. CWM's focus is on the long-term treatment, storage, and disposal of radioactive, chemically hazardous, and toxic waste materials generated by environmental restoration activities and ongoing operations on the ORR and at other DOE sites.

OTHER ENVIRONMENTAL PROGRAMS

Underground Storage Tank Programs

The UST Programs were established at the Y-12 Plant, ORNL, and the K-25 Site to accomplish the following

- identify existing UST systems (systems installed prior to December 22, 1988) and establish their regulatory status,
- minimize UST liability by regulating certain exempt or deferred USTs in the interest of best management practice,
- permanently close out-of-service or unnecessary systems,

Y-12 PHOTO 302567

Fig. 3.8. Tank 2395-U, formerly used to store fuel oil, was removed from the Y-12 Plant in June 1993.

- evaluate in-service systems for potential reconfiguration and/or aboveground alternatives, and
- ensure that new UST systems (systems installed after December 22, 1988) meet UST regulatory requirements.

The permanent closure of a UST system routinely involves the excavation and removal of the tank and associated piping (Fig. 3.8). Tanks can also be inert-filled and closed in place. The chronology of activities associated with a UST removal on the ORR is in accordance with regulatory guidance from TDEC. These activities can include overexcavation (including disposal of project-related waste), site characterization, and site restoration. Site restoration may include implementation of an approved corrective action plan.

For USTs where corrective action is or has been anticipated, alternatives to active remediation have been pursued. The TDEC Division of USTs allows a UST owner-operator to evaluate or rank an individual UST site with the potential for replacing anticipated remediation with semiannual monitoring. A comparative result can be achieved by pursuing a site-specific standard.

Alternatives at the Y-12 Plant to Active UST Remediation

At the Y-12 Plant, TDEC has approved the site ranking forms (SRFs) for the three UST sites that have been ranked: the Rust Garage Facility, Building 9754-1, and Building 9720-15; Building 9201-1; and Building 9204-2. Groundwater monitoring was initiated at each site following TDEC approval. The following monitoring activities have been conducted to date:

- Rust Garage Area (SRF approved in March 1994)
  - Four wells were sampled during three sampling events.
  - Three monitoring reports were submitted.
  - Analytical results: Parameter concentrations had increased compared with 1993 results. Results were relatively stable; some seasonal fluctuation was observed in the total petroleum hydrocarbon levels in two wells.
- Building 9201-1 (SRF approved May 1994)
  - Seven wells were sampled during two sampling events.
  - Two monitoring reports were submitted.
  - Analytical results: Results changed little compared with 1993 results. A slight decrease was observed in certain parameters.
- Building 9204-2 (SRF approved March 1995)
  - Five wells were sampled during one sampling event.
  - Analytical results: Pending.

The Y-12 Plant, ORNL, and K-25 Site UST programs are working to ensure regulatory compliance by the 1998 deadline. Compliance status for each site is summarized in Sect. 2. (See Appendix E, Table E.1, for the Y-12 Plant UST summary table, which includes a record of submittals of documentation to appropriate regulatory agencies.)

Land Application of Sewage Sludge

The city of Oak Ridge owns and operates a publicly owned treatment works (POTW) that receives wastewater from a variety of industrial, commercial, and residential generators in Anderson and Roane counties. One of the chief contributors is the Y-12 Plant, which produces 20% of the total influent to the POTW. The POTW uses a standard activated-sludge process, in which sludge from both primary and secondary sedimentation is fed into four anaerobic digesters.

Under an agreement with DOE and the state of Tennessee, the city transports digested municipal sewage sludge to approved sites on the ORR and applies the sludge as a soil conditioner and fertilizer (Fig. 3.9). The city has been applying sludge at state-approved sites on the ORR since 1983. The current sludge land application program utilizes five sites totaling 160 acres. The sludge, which contains trace quantities of heavy metals and radionuclides, is regulated under the provisions of the Clean Water Act (40 CFR 503); it is not considered to be RCRA waste or radioactive waste.

In 1994, the total amount of city sewage sludge hauled to the ORR was 3,623,243 gal. Heavy-metal levels in the sludge were far below the limits in 40 CFR 503. In addition, the sludge was in compliance with land-application-approval permits for semivolatile and volatile organic compounds, inorganic compounds, radionuclides, and organo-pesticides. All of the sites on the ORR where sludge was applied were sampled, as were adjacent sites where it is known that sludge had not been applied.

Soil samples were analyzed for pH, cation-exchange capacity, total solids, total volatile solids, total Kjeldahl nitrogen, soluble phosphorus, and radionuclides. The analytical data

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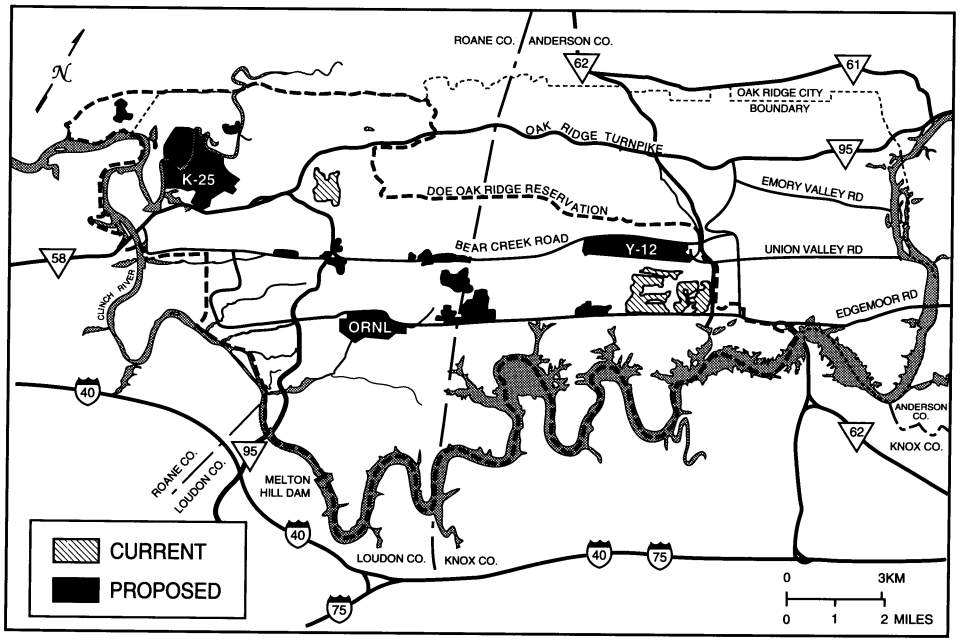

Fig. 3.9. Current and proposed sludge application sites on the ORR.

were reported to the state of Tennessee in the *City of Oak Ridge 1994 State Biosolids Management Report* (City of Oak Ridge 1994). Vegetation (e.g., hay and fruit) was also sampled and analyzed in 1994 for radionuclides as an additional part of the extensive environmental monitoring program. Except for a possible trace amount of iodine-131, no anthropogenic radionuclides were detected.

4. Effluent Monitoring

S. Baloga, E. T. Collins, L. V. Hamilton, K. G. Hanzelka, J. M. Loar, D. Lyles, D. M. Maguire, H. B. McElhoe, R. R. Painter, M. J. Peterson, E. M. Schilling, I. D. Shelton, L. R. Shugart, G. R. Southworth, and M. M. Stevens

Abstract

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

AIRBORNE DISCHARGES

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

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

DOE requirements for airborne emissions are established in DOE Order 5400.1, DOE Order 5400.5, 40 CFR 61 Subpart H, and the *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (DOE 1991). The criteria in NESHAP regulations and DOE orders define major effluent sources as emission points that have the potential to discharge radionuclides in quantities that could cause an EDE of 0.1 mrem/year or greater to a member of the public. Potential emissions are calculated for a source by assuming the loss of pollution control equipment while the source is otherwise operating normally.

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

an emissions inventory program that includes stack sampling to determine the amounts of pollutants that are not removed by the air pollution control equipment.

Y-12 Plant Radiological Airborne Effluent Monitoring

The release of radiological contaminants, primarily uranium, into the atmosphere at the Y-12 Plant occurs almost exclusively as a result of plant production, maintenance, and waste management activities. NESHAP regulations for radionuclides require continuous emission sampling of major sources; (a "major source" is considered to be any emission point that potentially can contribute >0.1 mrem/year EDE to an off-site individual). During 1994, 58 of the Y-12 Plant's 71 stacks were judged to be major sources; three of these sources were not operational in 1994 because of work in progress on process and stack modifications. Twenty-three of the stacks having the greatest potential to emit significant amounts of uranium are equipped with alarmed breakthrough detectors, which alert operations personnel to process-upset conditions or to a decline in filtration-system efficiencies, allowing them to investigate and correct the problem before a significant release occurs.

As of January 1, 1994 the Y-12 Plant had a total of 71 stacks, 68 of which were active and 3 were temporarily shut down. During September two additional stacks were placed into temporary shutdown. Also during the course of the year three stacks were taken out of service. Thus, during the course of the year 68 stacks were monitored, and there were 63 stacks being monitored at the end of 1994.

Radionuclides other than uranium are handled in millicurie quantities as part of ORNL and Y-12 Plant laboratory activities at facilities within the boundary of the Y-12 Plant. The releases from these activities are minimal, however, and have negligible impact on the total Y-12 Plant dose. Emissions from unmonitored process and laboratory exhausts, categorized as minor emission sources, are estimated according to EPA-approved calculation methods. Emissions from room ventilation systems are estimated from health physics data collected on airborne radioactivity concentrations in the work areas. Areas where the monthly average concentration exceeded 10% of the DOE derived air concentration (DAC) worker protection guidelines were included in the annual emission estimate.

Sample Collection and Analytical Procedure

Uranium stack losses were measured continuously on 68 process exhaust stacks in 1994. Particulate matter (including uranium) was filtered from the stack sample; filters at each location were changed routinely, from one to five times per week, and analyzed for total uranium. In addition, the sampling probes and tubing were removed quarterly and washed with nitric acid; the washing was analyzed for total uranium. At the end of the year, the probe-wash data were included in the final calculations in determining total emissions from each stack.

In 1994, 68 emission points were identified from unmonitored radiological processes and laboratories. In addition, seven ventilation areas from buildings that house enriched uranium operations were identified from health physics data, where one or more average monthly concentration exceeded 10% of the DAC. For those areas, the annual average concentration is used, with design ventilation rates, to arrive at the annual emission estimate. No areas from buildings that house depleted uranium operations met these criteria.

Results

An estimated 0.049 Ci (28.5 kg) of uranium was released into the atmosphere in 1994 as a result of Y-12 Plant activities (Table 4.1). The specific activity of enriched uranium is much greater than that of depleted uranium, and about 71% of the curie release was composed of emissions of enriched uranium particulate, even though only 2% of the total mass of uranium released was enriched material. Figure 4.1 illustrates the decrease in curies of uranium emissions over the past 5 years.

Table 4.1. Y-12 Plant airborne uranium emission estimates, 1994

Source of emissions	Quantity emitted	
	Ci[a]	kg
Enriched uranium		
Process exhaust (monitored)	0.027	0.41
Process and laboratory exhaust (unmonitored)	0.003	0.05
Room exhaust (from health physics data)	0.007	0.11
Depleted uranium		
Process exhaust (monitored)	0.010	23.9
Process and laboratory exhaust (unmonitored)	0.002	4.0
Room exhaust (from health physics data)	0.000	0.0
Total	0.049	28.5

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

The increase in kilograms of uranium emissions in 1994, shown in Fig. 4.2, is from moisture in one of the depleted uranium areas. The ventilation systems served by this stack feed emissions into an underground duct/tunnel prior to being exhausted; a significant amount of water accumulated in the ductwork during the latter part of the year. Because operations in the area had been shut down, the water is believed to be from rain and groundwater infiltration. The increase in moisture content resulted in large, wet particles being blown up the stack and collected in the sampling system. Heavier particles are likely to fall out close to the emission point; however, all material measured in the sampling system is included in the emission estimate and is assumed to contribute to the potential off-site dose.

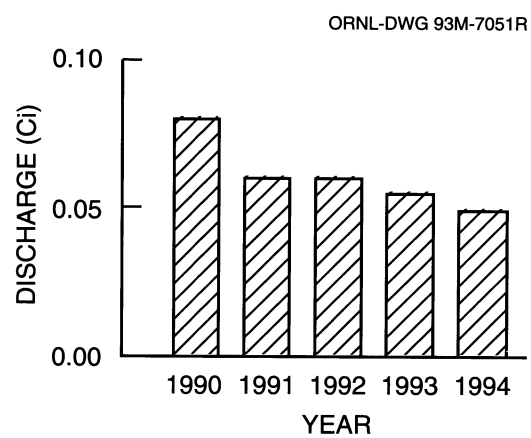

Fig. 4.1. Total curies of uranium discharged from the Y-12 Plant to the atmosphere, 1990–94.

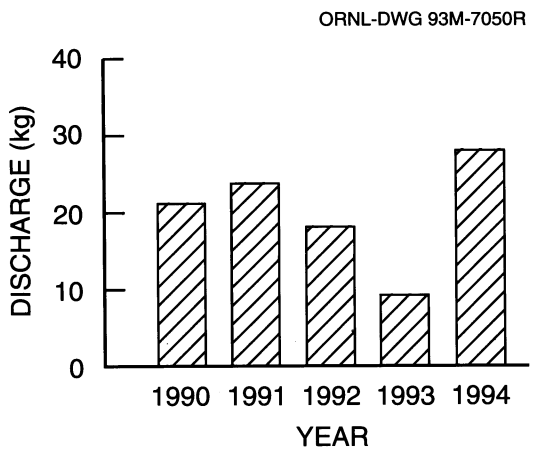

Fig. 4.2. Total kilograms of uranium discharged from the Y-12 Plant to the atmosphere, 1990–94.

ORNL Radiological Airborne Effluent Monitoring

Airborne discharges at ORNL consist primarily of ventilation air from radioactively contaminated or potentially contaminated areas, vents from tanks and processes, and ventilation for reactor facilities. Typically, radioactively contaminated and potentially contaminated airborne emissions are treated, then filtered with high-efficiency particulate air (HEPA) and/or charcoal filters before discharge to ensure that any radioactivity released is as little as possible.

Airborne discharges are unique because of the wide variety of research activities performed at ORNL. Radiological gaseous emissions from ORNL typically consist of solid particulates, adsorbable gases (e.g., iodine), tritium, and nonadsorbable gases. The major radiological emission point sources for ORNL consist of the following four stacks located in Bethel and Melton valleys (Fig. 4.3):

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

A stack and vent survey was performed to identify and assign unique numbers to all emission points at ORNL. Each stack and vent was assessed for its potential to discharge regulated air pollutant emissions. Those with no potential for regulated air pollutant emissions, such as steam vents, do not require any further documentation. The first phase of the stack and vent survey focused primarily on radioactive emission sources. These sources are updated annually. In 1994, there were 19 minor point/group sources, and emission calculations/estimates were made for each of these sources.

Sample Collection and Analytical Procedure

Each of the four major point sources is equipped with a variety of surveillance instrumentation, including radiation alarms, near-real-time monitors, and continuous sample collectors. Only data resulting from analysis of the continuous samples are used in this report because the other equipment does not provide data of sufficient accuracy and precision to support the quantitation of emission source terms. The single exception is for noble gases at Stack 7911, for which a combination of grab samples and an on-line detector was used. In April 1994 a high-purity germanium detector was installed on Stack 7911's sample line. The detector (with a NOMAD analyzer) allows continuous isotopic identification and quantification of radionuclides present in the effluent stream.

In addition to the major sources, ORNL has a number of minor sources that have the potential to emit radionuclides to the atmosphere. Minor sources are composed of any

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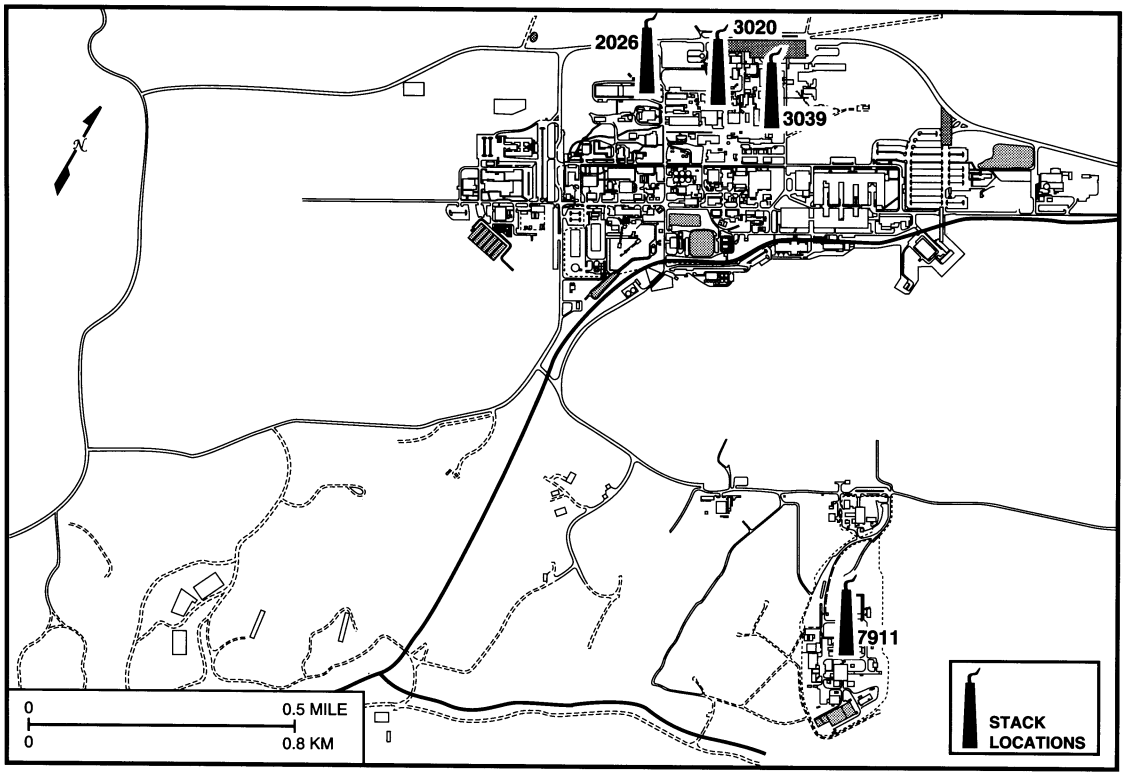

Fig. 4.3. Locations of major stacks (rad emission points) at ORNL.

ventilation systems or components such as vents, lab hoods, room exhausts, and stacks that do not meet the criteria for a major source but are located in or vent from a radiological control area.

All ORNL in-stack source sampling systems comply with ANSI N 13.1 (1969, R-1982) criteria. The sampling systems generally consist of a multipoint in-stack sampling probe, sample transport line, a particulate filter, activated charcoal cartridges, a silica-gel tritium trap (as required), flow measurement and totalizing instruments, a sampling pump, and a return line to the stack. The system at Stack 7911 includes an additional on-line noble-gas detector. In addition, end-of-the-year samples are collected by cleaning stack probes to ensure that all radioactive particulate matter emitted from a major source is collected and analyzed. This program requires annual removal, inspection, and cleaning of sample probes.

Velocity profiles are performed following the criteria in EPA Method 2. This profiling ensures that the continuous samplers are sampling at acceptable isokinetic conditions and are obtaining accurate stack flow data for subsequent emission-rate calculations. An annual leak-check program is carried out to verify the integrity of the sample transport system, including the sample components.

In addition to major sources, minor sources were also evaluated during 1994 in accordance with the new NESHAP requirement. A variety of methods were used to determine the emissions from the various minor sources. All methods used for minor source emission calculations complied with criteria agreed upon by EPA and/or included in the NESHAP Compliance Plan for the ORR. These minor sources are evaluated on a 1- to 3-year basis, depending on the source type. All emissions, both major and minor, are compiled annually to determine the overall ORNL source term and associated dose.

Results

The 1994 radioactive airborne emissions data for ORNL included more than 45 isotopes. The charcoal cartridges, particulate filters, and silica gel traps were collected weekly. The use of charcoal cartridges is a standard method for capturing and quantifying radioactive iodines in airborne emissions. Gamma spectrometric analysis of the charcoal samples quantifies the adsorbable gases. Analysis was performed weekly.

Particulate filters were held for 8 days prior to a weekly gross alpha and gross beta analysis to minimize the contribution from short-lived isotopes such as ^{220}Rn and its daughter products. At Stack 7911, a weekly gamma scan is conducted to better detect short-lived gamma isotopes. The weekly filters were then composited quarterly and analyzed for alpha-, beta-, and gamma-emitting isotopes inherent to this source. Compositing provides a better opportunity for quantification of these low-concentration isotopes. At the end of the year, each sample probe was rinsed, and the rinsate was collected and submitted to the laboratory for isotopic analysis identical to that of the particulate filter. The data from the charcoal cartridges, silica gel, probe wash, and the quarterly filter composites are compiled to give the annual emissions for each major source and some minor sources.

Annual radioactive airborne emissions for major sources are presented in Table 4.2; data for the minor sources are presented in Table 4.3. All data presented were determined to be significantly different from zero at the 95% confidence level. Any number not statistically different from zero was not included in the emission calculation. Historical trends for ^{3}H and ^{131}I are presented in Figs. 4.4 and 4.5, respectively. The ^{131}I emission for 1994 is attributable to emissions from Stack 7911. The tritium emissions have decreased sharply since 1991, as shown in Fig. 4.4.

K-25 Site Radiological Airborne Effluent Monitoring

Locations of airborne radioactivity point sources at the K-25 Site are shown in Fig. 4.6. These locations include both individual point sources and grouped point sources such as laboratory hoods. Radioactive emissions data were determined from either EPA-approved sampling results or EPA-approved calculation methods.

Sample Collection and Analytical Procedure

Routine emission estimates from the TSCA Incinerator were generated from the continuous stack sampling system. The TSCA Incinerator is the only significant radionuclide emission source at the K-25 Site and is therefore the only stack that is continuously monitored. Estimates of TSCA emissions were based upon a 1-month composite of weekly stack samples.

Representative grab-sample techniques (e.g., EPA Method 5 techniques) in combination with operational parameters were used to generate emissions for the following minor sources: K-1015 Laundry, K-31/K-33 buildings R-114 transfer project. The laundry is a minor source from washing and drying contaminated work clothing. Emissions from the K-31 and K-33 buildings are incidental releases associated with a project to transfer R-114 refrigerant from the inactive K-25 Site to the active Paducah, Kentucky, and Portsmouth, Ohio, gaseous diffusion plants.

Material balance calculations were used to generate the emission estimates for the K-1004-A–D laboratories. These laboratories are used to analyze a large number of small-volume samples from across the K-25 Site.

Table 4.2. Major sources of radiological airborne emissions at ORNL, 1994 (in curies)[a]

Isotope	Stack			
	2026	3020	3039	7911
241Am	5.8E–06	4.8E–07	2.2E–07	1.4E–07
^{137}Ba	8.2E–05	3.2E–06	1.7E–04	1.1E–05
^{41}Ar				1.5E+03
^{137}Ba	8.2E–05	3.2E–06	1.7E–04	1.1E–05
^{140}Ba			1.2E–05	2.5E–04
^{7}Be			1.7E–03	
^{244}Cm	7.9E–05	8.9E–08	1.7E–07	1.1E–07
^{60}Co	1.6E–08	2.7E–07	5.8E–06	
^{137}Cs	8.2E–05	3.2E–06	1.7E–04	1.1E–05
^{138}Cs				1.2E+03
^{155}Eu	9.7E–08	9.7E–08		
^{3}H	5.6E–01		7.0E+01	1.5E+02
^{203}Hg				1.3E–02
^{129}I				3.2E–06
^{131}I	1.8E–04	1.1E–06	6.8E–04	6.4E–02
^{132}I				2.7E–02
^{132m}I				
^{133}I			2.9E–03	2.1E–01
^{135}I	6.5E–05	2.1E–04	9.0E–03	6.1E–01
^{188}Ir			8.1E–01	
^{85}Kr				2.1E+01
^{85m}Kr				3.3E+00
^{87}Kr				6.4E+00
^{88}Kr				1.2E+00
^{89}Kr				1.1E+00
^{90}Kr				6.8E–02
^{140}La				5.4E–03
^{191}Os		8.7E–05	1.2E–01	
^{212}Pb	1.3E–01	1.8E–01	4.2E–01	2.2E–01
^{238}Pu	9.8E–06	8.3E–09	2.4E–08	
^{239}Pu	1.1E–05	2.9E–07	9.4E–07	2.8E–09
^{188}Re			5.7E–02	
^{105}Ru				1.8E–02
Sr, total	4.9E–06	2.8E–06	5.0E–05	3.2E–05
^{228}Th	3.1E–06	2.2E–08	4.4E–08	2.1E–08
^{230}Th	5.0E–06	6.3E–08	2.8E–08	2.4E–08
^{232}Th	6.0E–07	9.9E–09	2.9E–08	1.5E–08
^{234}U	1.2E–05	4.9E–07	4.4E–07	1.5E–07
^{235}U	4.8E–07	1.4E–07	2.4E–08	3.6E–08
^{238}U	2.5E–07	1.0E–07	2.1E–07	2.5E–08
^{131}Xe				1.5E+01
^{133}Xe				2.6E+02
^{133m}Xe				6.5E+01
^{135}Xe				1.1E+02
^{135m}Xe				5.0E+02
^{137}Xe				7.3E+01
^{138}Xe				4.9E+02

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

Table 4.3. Minor sources of radiological airborne emissions at ORNL, 1994 (in curies)[a]

Isotope	Group											
	2000	3018	3074	3544	7025	7512	7567	7569	7830	7852	7860	7877
^{241}Am		5.4E–12	6.6E–13			7.1E–07	2.0E–09	2.0E–09	8.2E–09	6.5E–12	6.5E–12	1.4E–10
^{137}Ba		3.8E–11	1.4E–10	3.9E–07		2.5E–06	2.1E–05	2.1E–05	8.4E–05	4.7E–09	4.7E–09	
^{140}Ba												
^{7}Be		3.0E–09	6.3E–11	1.8E–06			1.2E–07	1.2E–07	4.6E–07			
^{244}Cm		4.6E–13	2.8E–11			6.0E–06	7.1E–09	7.1E–09	2.8E–08	6.7E–11	6.7E–11	
^{60}Co		4.9E–11	5.3E–13	9.5E–09			7.5E–08	7.5E–08	3.0E–07	2.5E–11	2.5E–11	
^{134}Cs							2.8E–08	2.8E–08	1.1E–07			
^{137}Cs		3.8E–11	1.4E–10	3.9E–07		2.5E–06	2.1E–05	2.1E–05	8.4E–05	4.7E–09	4.7E–09	
^{138}Cs												
^{152}Eu			1.8E–12							2.1E–11	2.1E–11	
^{154}Eu			1.3E–12							1.3E–11	1.3E–11	
^{3}H	6.6E+01				1.2E+02		5.9E–02	5.9E–02	2.3E–01			
^{203}Hg												
^{129}I							1.4E–06	1.4E–06	5.4E–06			
^{131}I				2.1E–07		1.8E–07	6.5E–08	6.5E–08	2.6E–07			
^{133}I							4.9E–09	4.9E–09	1.9E–08			2.8E–07
^{135}I				1.8E–05		3.0E–05	3.5E–06	3.5E–06	1.4E–05			4.3E–06
^{212}Pb				1.1E–05		6.0E–03	2.5E–02	2.5E–02	1.0E–01			1.3E–05
^{238}Pu			1.8E–13			1.8E–07	1.1E–09	1.1E–09	4.4E–09	3.2E–12	3.2E–12	
^{239}Pu		3.4E–12	1.2E–13	3.4E–10		5.6E–07	1.1E–09	1.1E–09	4.4E–09	1.7E–12	1.7E–12	
Sr, total radioactive		4.7E–10	6.9E–11	5.4E–07		4.6E–08	1.5E–06	1.5E–06	6.1E–06	8.8E–10	8.8E–10	1.8E–09
^{228}Th		1.4E–12	3.9E–13	6.3E–10		5.6E–08	1.7E–08	1.7E–08	7.0E–08	1.6E–12	1.6E–12	6.1E–10
^{230}Th		2.6E–12	3.1E–13	7.4E–10		3.3E–09	1.9E–10	1.9E–10	7.4E–10	1.7E–13	1.7E–13	5.7E–10
^{232}Th		1.3E–12	3.6E–13	6.8E–10		4.3E–09	1.5E–10	1.5E–10	5.8E–10	7.1E–14	7.1E–14	6.9E–10
^{234}U	3.2E–09	1.4E–11	2.3E–12	3.3E–09		2.3E–07	7.1E–09	7.1E–09	2.8E–08	4.7E–12	4.7E–12	1.1E–09
^{235}U			1.6E–13	4.7E–10		1.8E–09	3.3E–10	3.3E–10	1.3E–09	1.3E–13	1.3E–13	1.2E–10
^{238}U	1.7E–09	5.6E–12	9.3E–13	6.7E–10		2.3E–08	9.9E–10	9.9E–10	4.0E–09	2.6E–13	2.6E–13	6.9E–10
^{135}Xe												4.9E–04

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

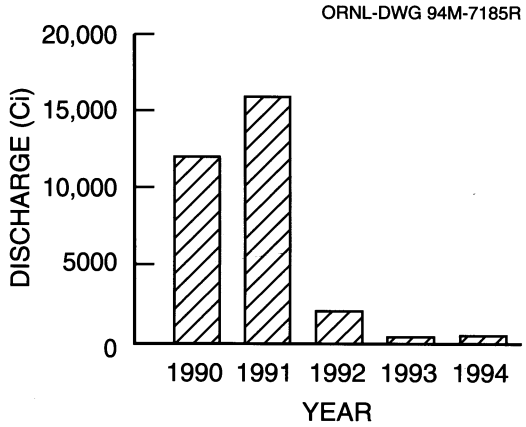

Fig. 4.4. Total discharges of ^{3}H from ORNL to the atmosphere, 1990–94.

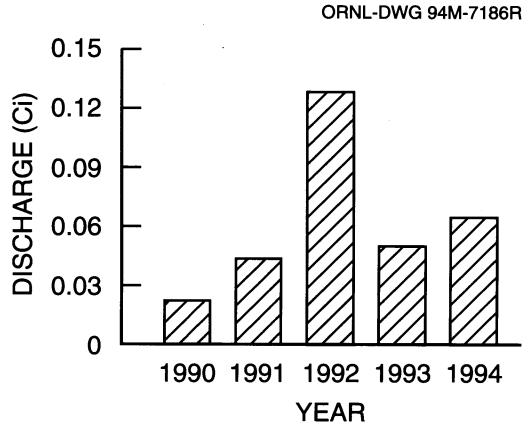

Fig. 4.5. Total discharges of ^{131}I from ORNL to the atmosphere, 1990–94.

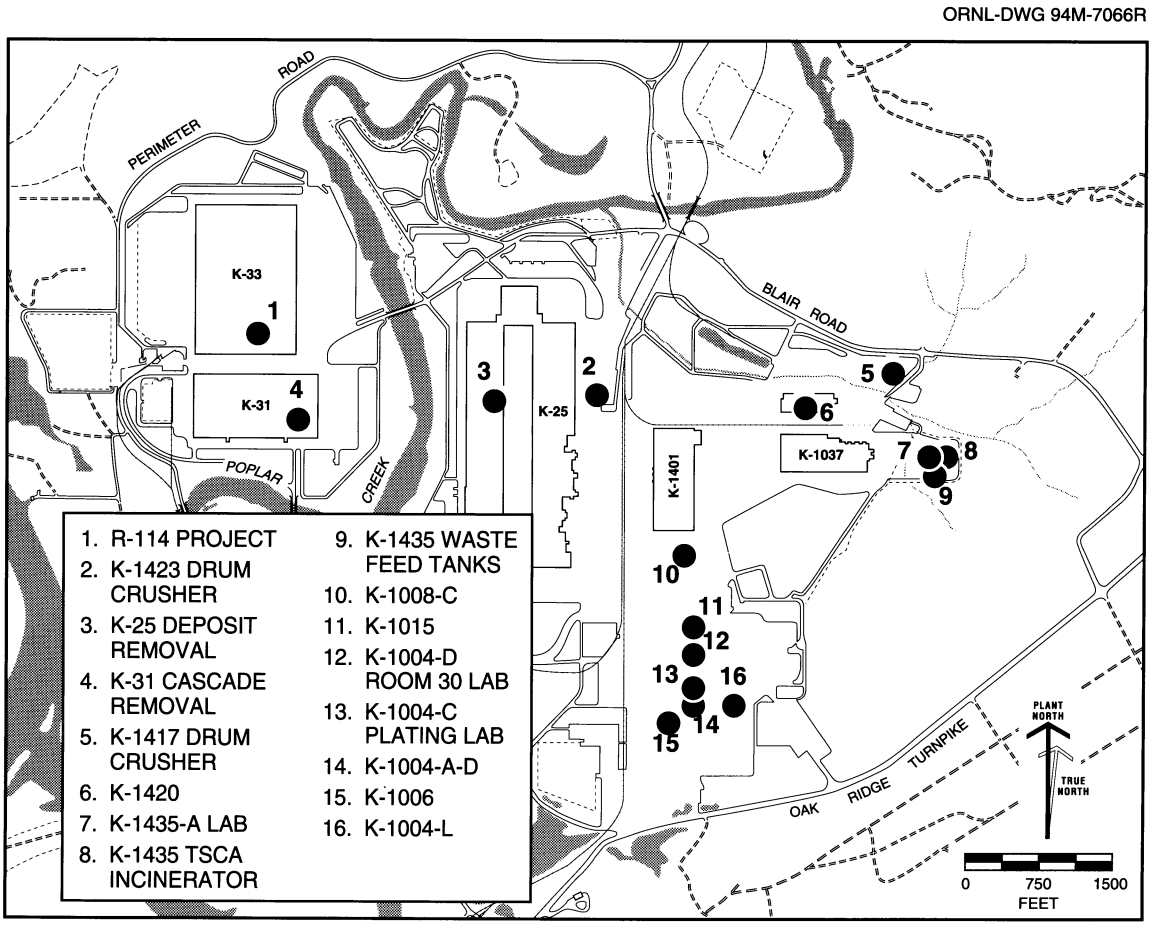

Fig. 4.6. K-25 Site point sources of airborne radioactivity.

The remaining active sources at the K-25 Site were calculated from emission factors found in 40 CFR 61, Appendix D. The Appendix D emission factors are used in a conservative method of estimating emissions based on the physical form of the radionuclides and the maximum operating temperature of the processes.

Four new minor point sources were initiated in 1994. A project was initiated in late 1993 to repackage wet pond waste material into long-term storage containers. The K-1417 and K-1423 drum-crushing operations were initiated as part of this project and other repackaging activities. These devices have dedicated HEPA filters. The K-31 equipment removal project required the purging of subject equipment prior to removal. This was a one-time operation during 1994 with the potential to emit only small quantities of uranium compounds. All emissions during purging operations passed through a series of alumina traps that maintained 99% control efficiency. The K-25 Building deposit removal project removes various assays of uranium from inactive cascade support equipment. This minor point source activity is in a controlled environment with a dedicated HEPA filtered exhaust. Two additional sources, the K-1420 Disassembly Area and the K-1004-C Plating Laboratory did not operate in 1994; however, both sources are still in the operational state.

Results

The K-25 Site's 1994 radionuclide emissions from the TSCA Incinerator and minor emission sources (other than the TSCA Incinerator) are shown in Table 4.4. Additionally, Figs. 4.7 and 4.8 compare the total K-25 Site's 1994 discharges of uranium in curies and kilograms with those of previous years. Uranium is the primary radionuclide of concern at the K-25 Site, and the totals are lower since 1992 because of decreased emissions from the TSCA Incinerator. Decreased emissions are the result of lower levels of contamination in the waste feed to the incinerator.

Table 4.4. K-25 Site radionuclide air emission totals, 1994 (in curies)[a]

Radionuclide	TSCA Incinerator	Minor sources
^{3}H	1.23E–01	1.79E–04
^{40}K	1.88E–04	9.75E–07
^{60}Co	1.46E–04	
^{99}Tc	8.49E–02	8.61E–04
^{106}Ru		–5.09E–07
^{137}Cs	–3.95E–05	1.57E–06
^{237}Np	5.00E–04	4.07E–04
^{238}Pu	–7.64E–05	2.40E–06
^{239}Pu	–1.20E–04	1.39E–06
^{228}Th	2.07E–05	1.72E–06
^{230}Th	3.93E–04	5.32E–06
^{232}Th	7.56E–06	2.22E–07
^{234}Th	2.40E–02	9.88E–04
^{234m}Pa	1.29E–01	2.36E–03
^{234}U	1.96E–03	1.73E–03
^{235}U	9.20E–05	9.09E–05
^{236}U		3.12E–10
^{238}U	1.99E–03	8.93E–04
Totals[b]	3.66E–01	7.52E–03

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

[b]Negative values are not included.

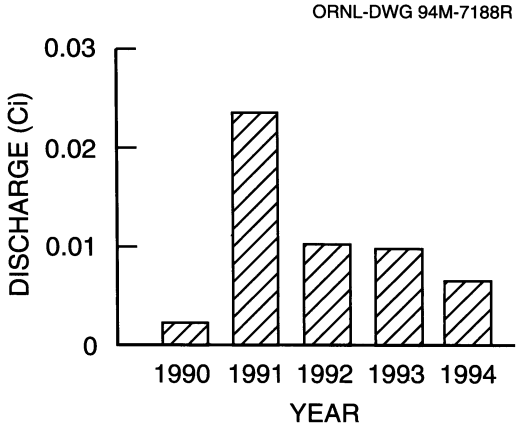

Fig. 4.7. Total curies of uranium discharged from the K-25 Site to the atmosphere, 1990–94.

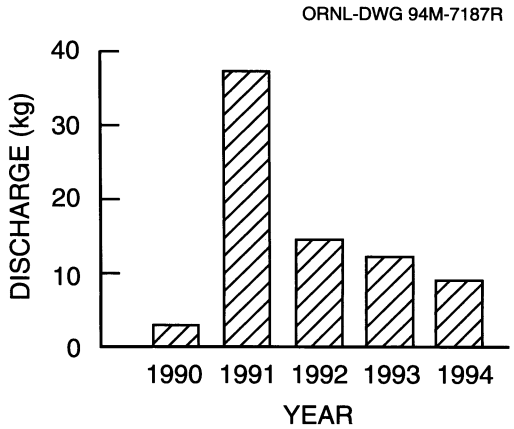

Fig. 4.8. Total kilograms of uranium discharged from the K-25 Site to the atmosphere, 1990–94.

Y-12 Plant Nonradiological Airborne Emissions Monitoring

The release of nonradiological contaminants into the atmosphere at the Y-12 Plant occurs as a result of plant production, maintenance, and waste management operations and of steam generation. Most process operations are served by ventilation systems that remove air contaminants from the workplace. TDEC has issued 64 air permits that cover 344 of these emission sources. The allowable level of air pollutant emissions from permitted and exempt emission sources in 1994 was 27,345 tons per year of regulated pollutants, which is slightly less than the amount for 1993. The actual emissions are much lower than the allowable amount. The Y-12 Plant annual emission fee was calculated by TDEC personnel based on 9499 tons per year of allowable emissions of regulated pollutants, with an annual emission fee of $75,992, as defined in TDEC regulations, Chapter 1200-3-26, Subparagraph (2)(d). In calculating the annual emission fee, TDEC personnel used Schedule III of Chapter 26, where the adjusted emissions equal the total emissions minus carbon monoxide and exempt emissions, and a 4000-ton cap for SO_2 and NO_x. The emission fee rate is based on $8 per ton of regulated pollutant. The emission fee rate for major sources in FY 1995 (for Title V permitting) will increase from $8 to $32.20 per ton of regulated pollutant.

The level of pollutant emissions is expected to decline in the future because of the changing mission of the Y-12 Plant and downsizing of production areas. More than 90% of the pollutants are attributed to the operation of the Y-12 Steam Plant; however, as a best management practice, Y-12 Plant personnel also monitor emissions from four areas that process beryllium.

In anticipation of permitting requirements and implementation of maximum achievable control technology standards under Title V of the CAA amendments, an effort is under way to improve the stack and vent survey, criteria pollutant emission inventory, and hazardous air pollutant emission inventory. A draft of the Oak Ridge Y-12 Plant Title V permit applications is expected to be prepared in 1995.

Planning for compliance with anticipated and newly issued requirements under Title VI of the CAA amendments is a major effort. In accordance with the Y-12 Plant CAA implementation plan, a stratospheric ozone protection plan has been issued to outline actions necessary to comply with the new limitations on the release of ozone-depleting

chemicals and with the 1995 production ban on these chemicals. The Y-12 Plant stratospheric ozone protection committee has successfully implemented work practices required to minimize releases of ozone-depleting refrigerants to the atmosphere. Requirements for refrigeration-system and motor-vehicle air-conditioner maintenance compliance are being met. To accommodate the production ban on ozone-depleting chemicals, studies are proceeding to find suitable replacements, and plant refrigeration equipment is being modified as needed. The Retrofit Heating, Ventilation, and Air Conditioning and Chillers for Ozone Protection project, currently in conceptual design, will eliminate the use of chlorofluorocarbon (CFC) refrigerants in chillers, direct expansion air conditioners, and process coolers, either by replacement with new equipment that operates on "ozone-friendly" refrigerants or by retrofit of existing equipment with new components to operate on "ozone-friendly" refrigerants.

Sample Collection and Analytical Procedure

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

Currently, four exhaust stacks that serve beryllium processing areas are sampled continuously by extracting a portion of the stack gas and filtering out particulate matter. The samples are then analyzed for beryllium, and emission rates are calculated.

Results

The east and west Y-12 Steam Plant stack opacity monitors were each operational more than 99% of the time in 1994. Both systems were taken out of service for annual calibration/recertification and for maintenance activities to repair stuck shutters, monitor malfunctions, and self-check. The calibration/recertification was performed by a subcontractor in May. Four periods of excess opacity emission occurred on December 1, 1994, from the east stack. The excess opacity was limited to four 6-min periods and was the result of a malfunction of a solenoid valve that caused the No. 4 baghouse bypass to open. Quarterly excess opacity reports of the operational status of the Y-12 Steam Plant are submitted to personnel at TDEC within 30 days after the end of each calendar quarter to comply with Condition 10 of the current air permit. The annual opacity calibration error test reports were submitted to TDEC in July 1994.

Beryllium stack sampling results indicated that <1 g of beryllium was released during 1994; most readings on the filters were less than the plant laboratory detectable level. Thus, emission rates of beryllium are well below the NESHAP limit of 10 g/day. Emissions of other materials have been estimated and are provided in Table 4.5. The TDEC annual inspection, conducted in July 1995, found no noncompliances.

The Y-12 Plant has reduced CFC emissions by more than 70%, and improvements are continuing. The efforts of Y-12 Plant management and personnel to minimize emissions of ozone-depleting substances was recognized by EPA at the International Chlorofluorocarbons (CFC) and Halon Alternatives Conference. The Y-12 Plant staff shared in a 1994 EPA Stratospheric Ozone Protection Award with four other Martin Marietta Corporation facilities around the country. The award recognized the efforts of Y-12 Plant personnel to reduce emissions, establish an outstanding stratospheric ozone protection plan, and develop projects necessary to replace and retrofit plant refrigeration equipment to use alternative refrigerants. The EPA staff presented a total of 50 awards in

Table 4.5. Y-12 Plant nonradiological airborne emissions, 1994

Chemical	Quantity released		Major release source	Basis of estimate
	lb	kg		
		SARA 313 chemicals[a]		
Hydrochloric acid	1,000	455	Chemical processing aid	Engineering calculations
Methanol	39,000	17,727	Cleaning/cooling	Engineering calculations
Nitric acid	32,300	14,682	Chemical processing aid	Material balance
Sulfuric acid	3	1.4	Chemical processing aid	Engineering calculations
		Other large-inventory chemicals[b]		
Freon 11	2,350	1,068	Refrigerant	Operating records
Freon 12	160	73	Refrigerant	Operating records
Freon 22	1,048	476	Refrigerant	Operating records
		Steam plant emissions (all calculated emissions)[c]		
Particulates	24,487	11,180	Stack emission	Engineering calculations based on emission factors
SO_x	4,972,218	2,260,099	Stack emission	Engineering calculations based on emission factors
Carbon monoxide	59,303	26,956	Stack emission	Engineering calculations based on emission factors
Volatile organic compounds	5,416	2,462	Stack emission	Engineering calculations based on emission factors
NO_x	2,570,607	1,168,458	Stack emission	Engineering calculations based on emission factors

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

1994 to individuals and corporations from the United States and 9 foreign countries worldwide. The Martin Marietta award was one of 21 corporate awards presented.

ORNL Nonradiological Airborne Emissions Monitoring

ORNL operates 33 permitted air emission sources. Most of these sources are small-scale activities and result in very low emission rates. TDEC air permits for ORNL sources do not require stack sampling or monitoring; however, an opacity monitor is used at the steam plant to ensure compliance with visible emissions. The steam plant and two small oil-fired boilers are the largest emission sources at ORNL and account for 98% of all allowable emissions.

In 1995, ORNL will pay $75,554 in annual emission fees to TDEC. This fee is based on allowable emissions (actual emissions are lower than allowable emissions). In early 1995, TDEC inspected all permitted emission sources to ensure compliance; no noncompliances were noted.

ORNL is currently preparing the permit application that will be required under the Title V permit program. It is anticipated that this application will be due to TDEC in the

summer of 1996. To facilitate the preparation of this application, an existing survey of all emission points at ORNL is being updated. This survey will locate all emission points and will evaluate their compliance status. Survey results will provide information regarding small sources that are currently exempt from air permit requirements. The survey will also assist with compliance efforts that may be required under Title III, Hazardous Air Pollutants.

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

Results

The opacity monitor at the steam plant operated without incident during 1994. No opacity exceedences of permit limits were noted. Emissions of other materials have been estimated and are provided in Table 4.6.

Table 4.6. ORNL nonradiological airborne emissions, 1994

Chemical	Quantity released		Major release source	Basis of estimate
	lb	kg		
		SARA 313 chemicals[a]		
Nitric acid	43	20	Tank emissions	Engineering calculations
Sulfuric acid	0	0	Tank emissions	Engineering calculations
		Other large-inventory chemicals[b]		
Freon 11	1,800	818	Refrigerant	Operating records
Freon 12	1,645	748	Refrigerant	Operating records
Freon 22	3,515	1,598	Refrigerant	Inventory records
Freon 113	1,712	778	Refrigerant, laboratory uses	
		Steam plant emissions (all calculated emissions)[c]		
Particulates	14,429	6,559	Stack emission	Engineering calculations based on emission factors
SO_x	1,953,862	888,119	Stack emission	Engineering calculations based on emission factors
Carbon monoxide	117,715	53,507	Stack emission	Engineering calculations based on emission factors
Volatile organic compounds	2,556	1,162	Stack emission	Engineering calculations based on emission factors
NO_x	422,705	192,139	Stack emission	Engineering calculations based on emission factors

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

K-25 Site Nonradiological Airborne Emissions Monitoring

The CAA provides the basis for protecting air quality and regulating air pollution. The TDEC Division of Air Pollution Control has been delegated the authority by EPA to implement and enforce the sections of the CAA related to nonradiological air emissions in the state of Tennessee. Title V of the CAA amendments of 1990 will require the Oak Ridge K-25 Site to submit a new permit application package to TDEC for all sources in operation. Preparation for the new permit application includes an air emissions inventory of potential and actual emissions from the K-25 Site. To verify the annual air emission fee assessment, which is based on the K-25 Site's potential to emit air pollutants, an inventory of potential emissions from the permitted sources at the K-25 Site is updated annually. Table 4.7 shows the potential emissions of criteria pollutants from the K-25 Site for the past 3 years. An inventory of annual emissions from all permitted sources in operation at the K-25 Site was completed in 1994. Table 4.8 shows actual emissions from the K-25 Site in 1994.

Title VI of the CAA amendments addresses stratospheric ozone protection. This addition to the act requires that EPA promulgate a number of regulations to phase out the production and to limit the release of ozone-depleting substances. The substances have been used at the K-25 Site, primarily as refrigerants in gaseous diffusion processes. Because the K-25 Site is no longer involved in uranium enrichment, its stockpile of ozone-depleting substances was shipped in 1993 to the operational gaseous diffusion plants in Portsmouth, Ohio, and Paducah, Kentucky, for recycling. Releases of these materials are estimated annually (Table 4.9).

On July 1, 1992, a prohibition went into effect on the release of Class I and II compounds from air conditioning and cooling units during service, repair, and disposal. CFC-114 shipments to Portsmouth and Paducah were completed in 1993; however, purging of the residual quantity of CFC-114 from process equipment continued until February 1995. The emission amount for CFC-114 in Table 4.9 is the total amount emitted up to the point of completion of purging operations. No emissions of CFC-114 will be reported for 1995 because purging has been completed.

Table 4.7. Potential emissions of criteria pollutants from the K-25 Site, 1992–94

Pollutant	Potential to emit (tons/year)		
	1992	1993	1994
Particulate matter	172	180	141
Volatile organic compounds	262	166	153
Sulfur dioxide	429	429	429
Nitrogen oxides	226	226	226
Carbon monoxide	157	157	157
Miscellaneous	291	291	145
Total	1537	1449	1251

Table 4.8. Actual emissions of criteria pollutants from the K-25 Site, 1994

Pollutant	Estimated emissions (tons/year)
Particulate matter	2.41
Volatile organic compounds	8.18
Sulphur dioxide	5.24
Nitrogen oxides	15.08
Carbon monoxide	20.49
Miscellaneous	0.05

Table 4.9. Estimated K-25 Site emissions of ozone-depleting substances, 1994

Ozone-depleting substance	Estimated emissions (lb/year)
CFC-12	88
HCFC-22	1,450
CFC-114	15,900

Additional refrigeration equipment service practices were implemented in 1993 in response to the phase-in of the final refrigerant recycling and emissions reduction rule. The primary areas of applicability were record keeping, a leak repair program for equipment with refrigerant capacity of 50 lb or more, and a safe equipment-disposal program.

EPA has promulgated regulations requiring air conditioner maintenance personnel to recover and recycle refrigerants used in vehicles and other refrigeration appliances. It also requires that these personnel be trained and certified in the use of approved refrigerant recycling equipment. The K-25 Site's service personnel have been trained in the use of the equipment and have entered into the broader EPA-required certification program for refrigerant recycling and emissions reduction.

Results

TDEC has issued 40 air permits for 52 point sources on the K-25 Site. Only 18 of the 52 sources operated during 1994. (Thirty-four permitted sources were not actively operating in 1994 and are considered to be in standby status.) No concerns or violations were noted during the annual TDEC inspection of air emission sources, which was conducted in March 1994.

The major sources of criteria air pollutants at the K-25 Site are the four boilers in operation at the K-1501 Steam Plant. These boilers use natural gas as their primary fuel source, with No. 2 fuel oil used as backup during curtailment of the natural gas supply. Table 4.10 presents the estimated and allowable emissions from the steam plant for 1994.

Table 4.10. Estimated air emissions from the K-1501 Steam Plant at the K-25 Site, 1994

Pollutant	Emissions (tons/year)	
	Estimated	Allowable
Particulate matter	1.55	18
Sulfur dioxide	5.06	390
Nitrogen oxides	15.08	205
Organics	0.96	8
Carbon monoxide	20.48	138

The TSCA Incinerator is also a source of air emissions from the K-25 Site. Emissions from the incinerator are controlled by extensive exhaust-gas treatment. Estimated emissions from the incinerator are significantly less than the permitted allowable emissions (Table 4.11).

Table 4.11. Estimated air emissions from the TSCA Incinerator at the K-25 Site, 1994

Pollutant	Emissions (tons/year)		Percentage of allowable
	Estimated	Allowable	
Lead	0.00032	0.57	0.06
Beryllium	0.0000076	0.00037	2.07
Mercury	0.0043	0.088	4.89
Fluorine	0.00033	2.83	0.01
Chlorine	0.028	16.12	0.17
Sulfur	0.19	38.54	0.48
Particulate	0.018	13.14	0.14

LIQUID DISCHARGES

Radiological Liquid Discharges

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

DOE Order 5400.5 also established DCGs for radionuclides in water. (See Appendix A for a list of radionuclides and their half-lives.) The DCG is the concentration of a given radionuclide for one exposure pathway (e.g., drinking water) that would result in an EDE of 100 mrem (1 mSv) per year to reference man, as defined by International Commission on Radiological Protection (ICRP) publication 23 (ICRP 1975). The consumption of water is assumed to be 730 L/year at the DCG level. DCGs were calculated using methodologies consistent with recommendations found in ICRP publications 26 (ICRP 1977) and 30 (ICRP 1978). DCGs are used as reference concentrations for conducting environmental protection programs at DOE sites, as screening values for considering best available technology for treatment of liquid effluents, and for making dose comparisons. Radiological data are determined as percentages of the DCG for a given isotope. In the event that a sum of the percentages of the DCGs for each location ever exceeds 100%, an analysis of the best available technology to reduce the sum of the percentages of the DCGs to less than 100% would be required as specified in DOE Order 5400.5.

Y-12 Plant Radiological Summary

Regulatory Requirements

At the Y-12 Plant, radiological monitoring of effluents and surface waters is also a component of the NPDES permit (TN002968). The permit requires the Y-12 Plant to maintain a TDEC-approved radiological monitoring plan and to submit results from the monitoring program quarterly, as an addendum to the NPDES Discharge Monitoring Report. There are no discharge limits set by the NPDES permit for radionuclides; the requirement is only to monitor and report. In 1992, *Radiological Monitoring Plan for the Y-12 Plant Liquid Effluent Discharge to the Environment* (Energy Systems 1992a) was revised and reissued to better characterize the radiological components of plant effluents and to reflect changes in plant operations. The monitoring program was designed to monitor effluent at three types of locations: (1) treatment facilities, (2) other point and area source discharges, and (3) instream locations. The revised monitoring plan was fully implemented in 1993. A further revision of this plan is proposed for 1995 to incorporate anticipated requirements of a new NPDES permit and the proposed requirements of 10 CFR 834.

The following parameters are monitored routinely under the plan:

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

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

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

As with the NPDES permit, there are no associated discharge limits set by the city of Oak Ridge permit for radionuclides. The current permit requirement is only to monitor and report.

Results

Radiological monitoring plan sampling locations are noted in Fig. 4.9. Table 4.12 identifies the monitored locations, the frequency of monitoring, and the sum of DCG percentages for radionuclides measured in 1994. Radiological data for all locations were well below the allowable DCGs. The highest summed percentage of DCGs was from the Central Pollution Control Facility; ^{228}Ra, ^{90}Sr, ^{234}U, and ^{238}U were the major contributors of radioactivity there, contributing 4.4%, 1.4%, 1.0%, and 1.0%, respectively, to the total 8.8% of the sum of the percentages of the DCGs. Minor contributors account for the remaining 1%.

The Central Pollution Control Facility (Outfall 501) is the only treatment facility that has exceeded maximum allowable DCGs in the past; however, improvements in the treatment process have resulted in effluent data consistently well below DCGs. This improvement can be seen in Fig. 4.10, which shows ^{238}U concentrations since 1989.

Additional radiological monitoring at kilometer 12.4 (mile 7.7) on Upper Bear Creek is conducted in response to Section IV, Part 4, of a 1983 memorandum of understanding agreed to by DOE, EPA, and TDEC.

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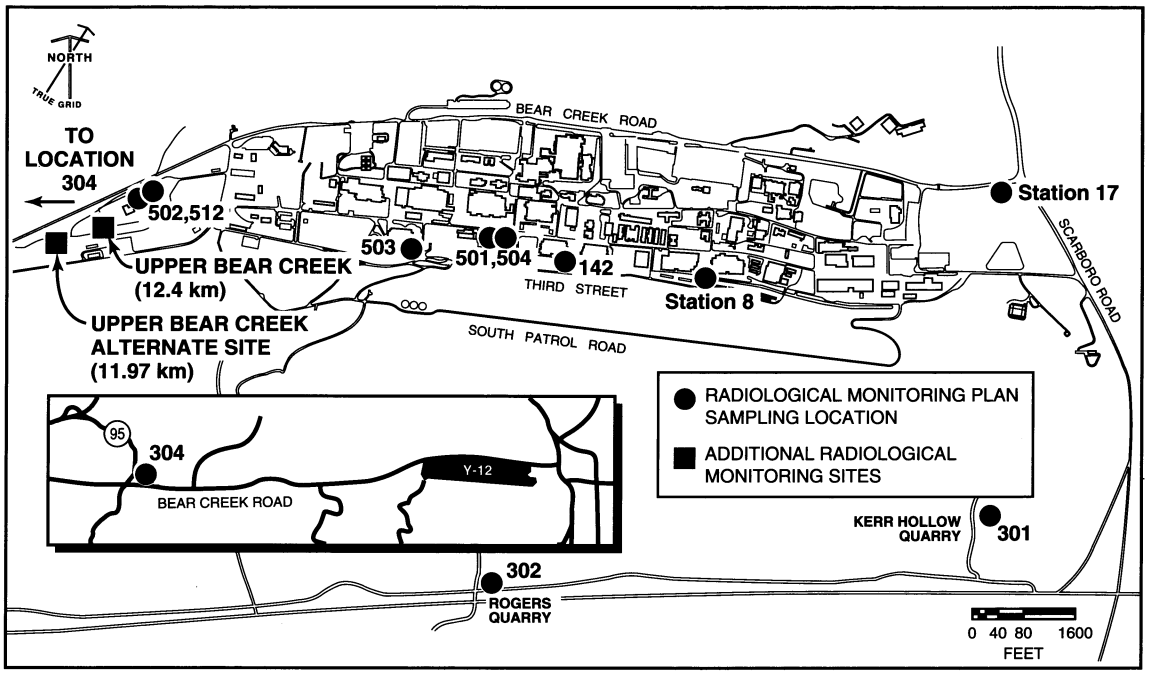

Fig. 4.9. Surface water radiological sampling locations at the Y-12 Plant.

Table 4.12. Summary of Y-12 Plant radiological monitoring plan sample requirements

Outfall No.	Location	Sample frequency	Sample type	Sum of DCG percentage
	Y-12 Plant wastewater treatment facilities			
501	Central Pollution Control Facility	1/week	Composite during batch operation	8.80
502	West End Treatment Facility	1/week	24-hour composite	0
503	Steam Plant Wastewater Treatment Facility	1/week	24-hour composite	0.057
504	Plating Rinsewater Treatment Facility	1/week	24-hour composite	3.70
512	Groundwater Treatment Facility	1/week	24-hour composite	1.60
	Other Y-12 Plant point and area source discharges			
142	Isotope Separation Process	1/month[a]	24-hour composite	0.43
301	Kerr Hollow Quarry	1/month	24-hour composite	0.19
302	Rogers Quarry	1/month	24-hour composite	0.36
	Y-12 Plant instream locations			
304	Bear Creek, Plant Exit (west)	1/week	7-day composite	3.1
Station 17	East Fork Poplar Creek, Plant Exit (east)	1/week	7-day composite	1.9
Station 8	East Fork Poplar Creek, Plant Site	1/week	7-day composite	3.4

[a]Only one sample was collected in 1994; there was no flow for 11 months of the year.

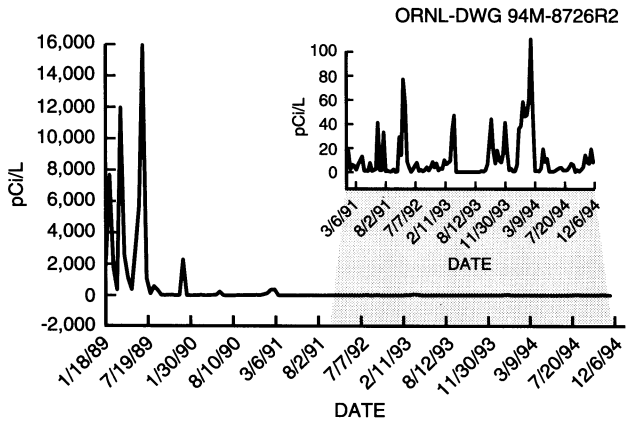

Fig. 4.10. Concentrations of ^{238}U at the Y-12 Plant Outfall 501, January 1989 through December 1994. The allowable DCG for ^{238}U is 600 pCi/L.

The site at kilometer 12.4, where the creek first approaches Bear Creek Road, was agreed upon as a point in the stream that is characteristic of the effects of the seepage of the S-3 ponds. Because of decreased flow at this site since the closure of the S-3 ponds, a new site at kilometer 11.97 is also being monitored and has been proposed as a replacement site. Analytical data from both these sites have been compared with each other to support the proposed monitoring change. These changes are proposed for implementation in 1995. Analytical data are reported monthly to TDEC as an attachment to the discharge monitoring report required by NPDES. These sites were monitored once per week. For each of these instream locations, all radiological results for 1994 were below 5% of the DCGs.

In 1994, the total of uranium and associated curies released from the Y-12 Plant at the easternmost monitoring station, Station 17 on Upper East Fork Poplar Creek (UEFPC), and the westernmost monitoring station, at Bear Creek kilometer 4.55 (NPDES Outfall 304), was 421 kg, or 0.24 Ci (8.88E+9 Bq) (Table 4.13). Figure 4.11 illustrates a 5-year trend of these releases.

Table 4.13. Release of uranium from the Y-12 Plant to the off-site environment as a liquid effluent, 1990–94

Year	Quantity released	
	Ci[a]	kg
	Station 17	
1990	0.135	197
1991	0.162	235
1992	0.087	130
1993	0.081	134
1994	0.11	185
	Outfall 304	
1990	0.131	204
1991	0.082	159
1992	0.060	110
1993	0.094	167
1994	0.13	236

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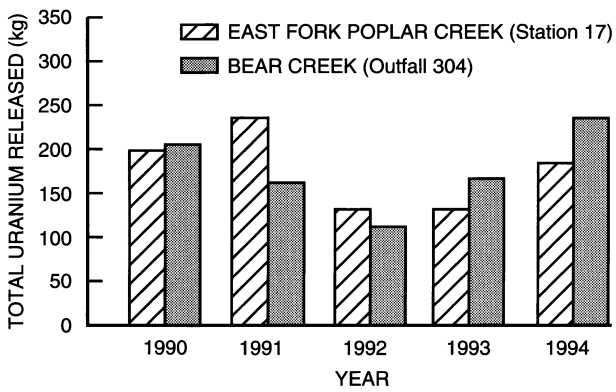

Fig. 4.11. Five-year trend of Y-12 Plant release of uranium to surface water.

The City of Oak Ridge Industrial and Commercial User Waste Water Discharge Permit allows the Y-12 Plant to discharge wastewater to be treated at the Oak Ridge Wastewater Treatment Facility through two main sewage lines into the Oak Ridge sanitary sewer system in accordance with effluent limitations, monitoring requirements, and other conditions set forth in the permit. Prior to June 28, 1994, samples from the sanitary sewer were collected from two sites to monitor compliance with the permit (Fig. 4.12), the City Monitoring Station (SS4) and the Union Valley Station (SS5). The Y-12 Plant contribution was calculated by subtracting the loading of the Union Valley Station from the loading of the City Station. The Union Valley Station does not have any Y-12 Plant waste streams associated with it. Two additional in-plant monitoring points (SS1 and SS2) were monitored in past years as a best management practice; however, monitoring of these locations was discontinued with the construction of the East End Sanitary Sewer Monitoring Station (EESSMS). On July 28, 1994, the EESSMS (SS-6) was put into service. Completion of the monitoring station and associated sewer line reroute combined all Y-12 Plant sanitary sewer effluent into one discharge line. The EESSMS is capable of monitoring all Y-12 Plant sanitary sewer effluent. Thus, no additional sampling sites are required and back calculation of contaminant releases based on two monitoring locations is no longer necessary.

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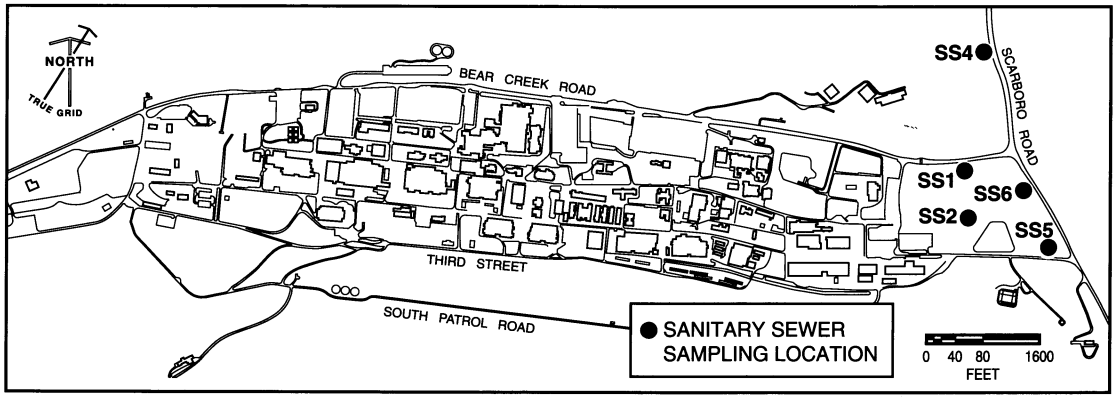

Fig. 4.12. Sanitary sewer sampling locations at the Y-12 Plant.

No single radionuclide in the Y-12 Plant contribution to the sanitary sewer exceeded 1% of the DCG. Summed percentages of DCGs calculated from the Y-12 Plant contribution to the sewer are essentially zero. Results of radiological monitoring were reported to the city of Oak Ridge with the quarterly monitoring report.

Potential sources of radionuclides discharging to the sanitary sewer had been identified in previous studies at the Y-12 Plant as part of a best management practices initiative to meet the ALARA goals of the Y-12 Plant. These data show that levels of radioactivity are orders of magnitude below regulatory levels established in DOE orders and are not thought to pose a safety or health risk. An update to the report *A Review of the Y-12 Plant Discharge of Enriched Uranium to the Sanitary Sewer* (Energy Systems 1991) will be issued in 1995 to further document radionuclide discharges to the sanitary sewer. Figure 4.13 illustrates the 5-year trend of total uranium discharges from the Y-12 Plant Sanitary Sewer.

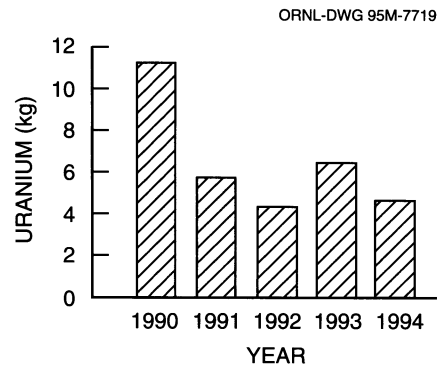

Fig. 4.13. Five-year trend of total uranium discharges from the Y-12 Plant Sanitary Sewer.

ORNL Radiological Summary

ORNL Surface Waters Receiving Effluents

Water samples are collected for radiological analyses from Melton Hill Dam and White Oak Creek headwaters, two locations above ORNL discharge points that serve as references for other water sampling locations at the ORNL site. Water samples are also collected from six on-site streams: White Oak Creek, Melton Branch, First Creek, Fifth Creek, Northwest Tributary, and Raccoon Creek. Sampling for radiological analyses is conducted at six ambient stations around ORNL and at five NPDES locations. The six ambient stations are 7500 Road Bridge, First Creek, Fifth Creek, Melton Branch 2, Northwest Tributary, and Raccoon Creek. The five NPDES stations are Sewage Treatment Plant (X01), Nonradiological Wastewater Treatment Facility (X12), Melton Branch 1 (X13), White Oak Creek (X14), and White Oak Dam (X15) (Fig. 4.14).

DCGs are used in this document as a means of standardized comparison for effluent points with different isotope signatures. The average concentration is expressed as a percentage of the DCG when a DCG exists and when the average concentration is significantly greater than zero. The calculation of percentage of the DCG for ingestion of water does not imply that effluent points or ambient water sampling stations at ORNL are sources of drinking water. For 1994, only three radionuclides had an average concentration greater than 5% of the relevant DCG; the largest was radioactive strontium at Melton Branch 1 at 47% of the DCG (Fig. 4.15). The sum of DCG percentages at each effluent point and ambient water station was less than 100%.

The discharge from ORNL of radioactive contaminants to the Clinch River is affected by stream flows. Clinch River flows are regulated by a series of TVA dams, one of which is Melton Hill Dam. The flow in Melton Branch is usually less than one-third of that in White Oak Creek except in the wet months such as February and March, when flows may be about equal. In 1994, the monthly ratio of flow in White Oak Creek (measured at White Oak Dam) to flow in the Clinch River (measured at Melton Hill Dam) ranged from 0.0013

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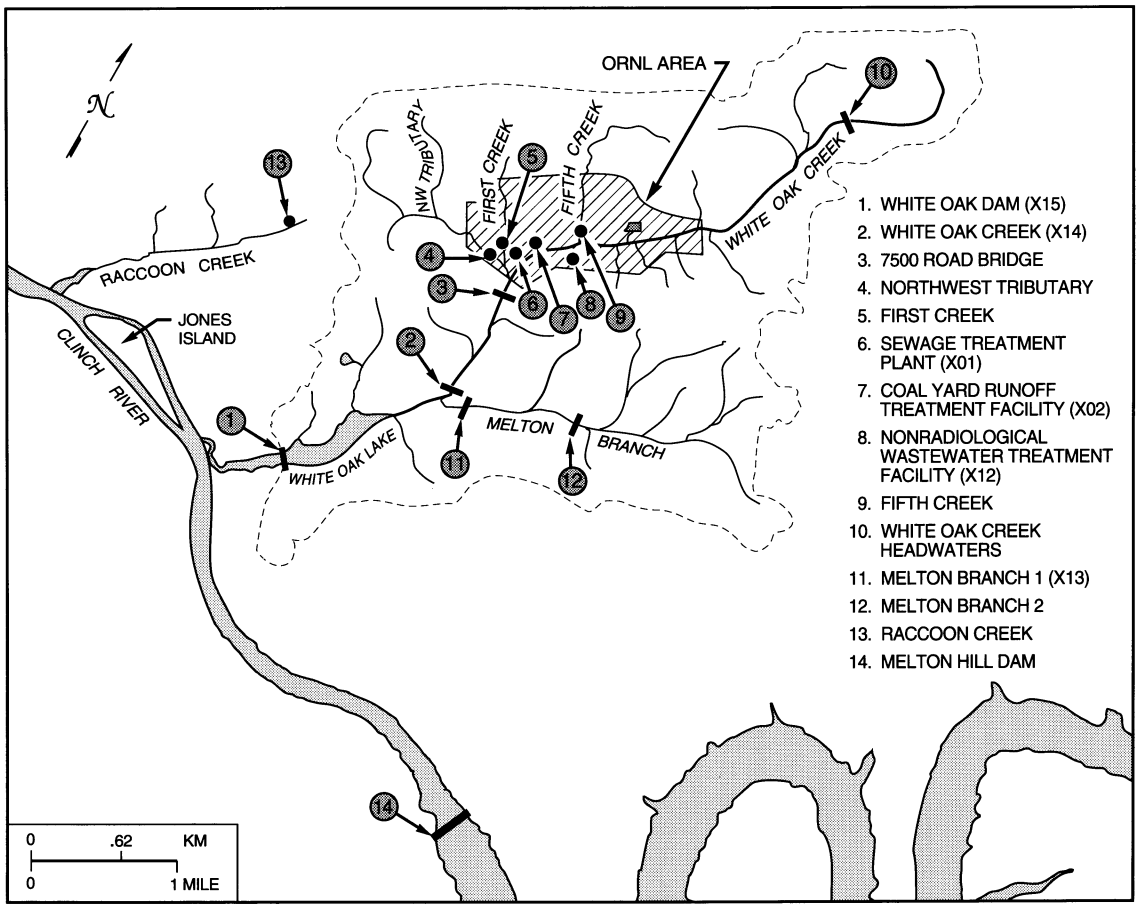

Fig. 4.14. ORNL surface water, NPDES, and reference sampling locations. Bars (|) indicate sampling locations that have weirs.

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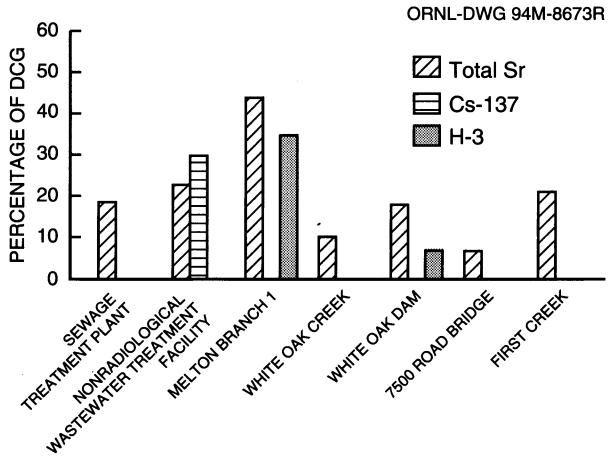

Fig. 4.15. Radionuclides at ORNL sampling sites having average concentrations greater than 5% of the relevant derived concentration guides in 1994.

to 0.015, thus providing significant dilution of any radioactivity released into the Clinch River from White Oak Creek.

Amounts of radioactivity released at White Oak Dam are calculated from concentration and flow. As shown in Figs. 4.16 through 4.21, the total discharges, or amounts, of radioactivity released at White Oak Dam during the past 4 years have remained in the same range of values but showed a slight increase in 1994 over 1993.

Categories of Effluents

Radiological monitoring is conducted at NPDES Category I and Category II outfalls. Category I

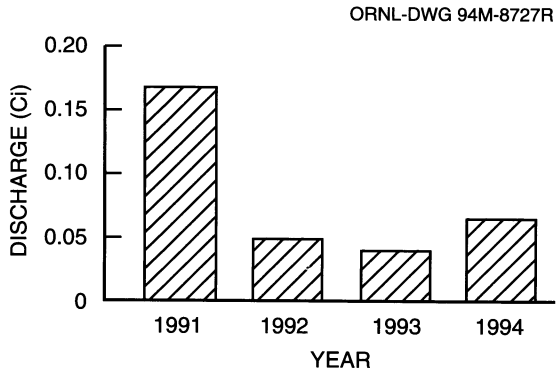

Fig. 4.16. Cobalt-60 discharges at White Oak Dam, 1991–94.

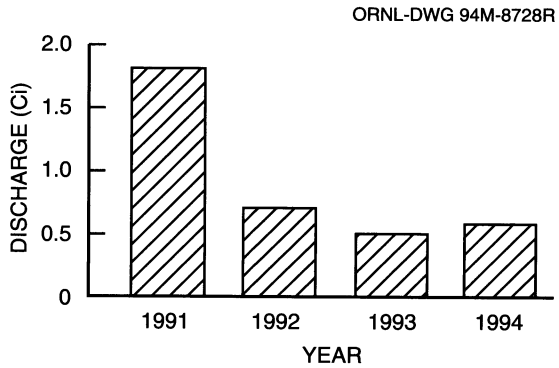

Fig. 4.17. Cesium-137 discharges at White Oak Dam, 1991–94.

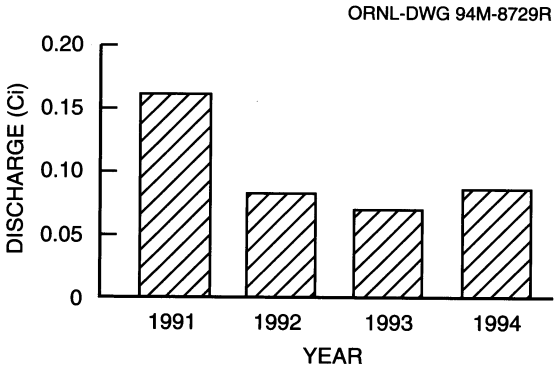

Fig. 4.18. Gross alpha discharges at White Oak Dam, 1991–94.

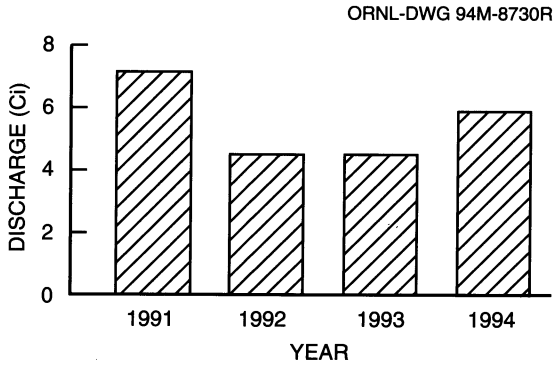

Fig. 4.19. Gross beta discharges at White Oak Dam, 1991–94.

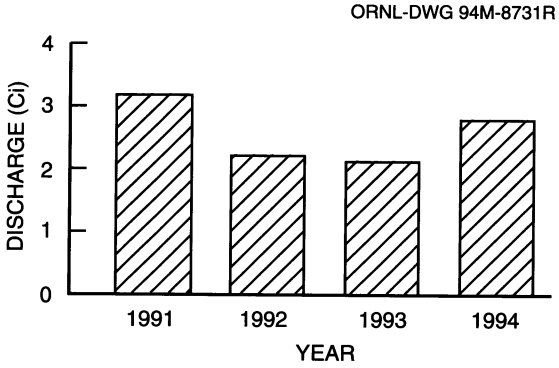

Fig. 4.20. Total radioactive strontium discharges at White Oak Dam, 1991–94.

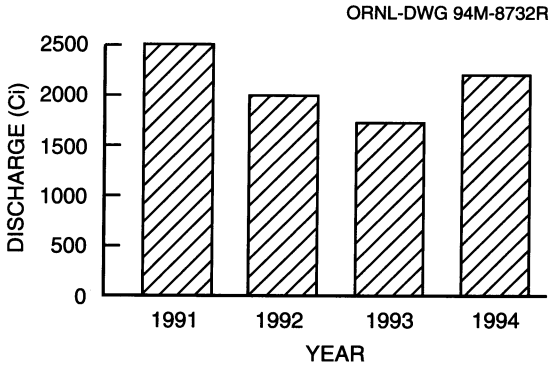

Fig. 4.21. Tritium discharges at White Oak Dam, 1991–94.

outfalls are storm drains. Category II outfalls are roof drains, parking lot drains, storage area drains, spill area drains, once-through cooling water, cooling-tower blowdown, condensate, and disposal demonstration area. Under the NPDES Radiological Monitoring Plan, gross beta is the only radioactivity sought; however, if a gross beta result exceeds a trigger level (810 pCi/L), then a total radioactive strontium analysis is conducted.

The number of outfalls sampled in 1994 increased from 1993. Samples at Category I outfalls increased by three; Category II outfalls increased by seven. In 1994, only one Category II gross beta result triggered a total radioactive strontium analysis; none of the Category I gross beta results exceeded the strontium trigger level. The maximum gross beta value of 3500 pCi/L occurred at Category II Outfall 204 (parking lot runoff into White Oak Creek west of Building 3544). The next highest value was considerably lower, 650 pCi/L, also at Outfall 204.

K-25 Site Radiological Summary

The K-25 Site conducts radiological monitoring of liquid effluent to determine compliance with applicable dose standards and the ALARA process by maintaining potential exposures to members of the public as low as is reasonably achievable.

Sample Collection and Analytical Procedure

The K-25 Site monitors three major effluent discharge points for radiological parameters: the K-1203 Sewage Treatment Plant discharge (outfall 005), the K-1407-J treated effluent from the CNF (outfall 011), and the K-1515-C filter backwash from the Sanitary Water Treatment Facility (outfall 009) (Fig. 4.22). Weekly samples are collected

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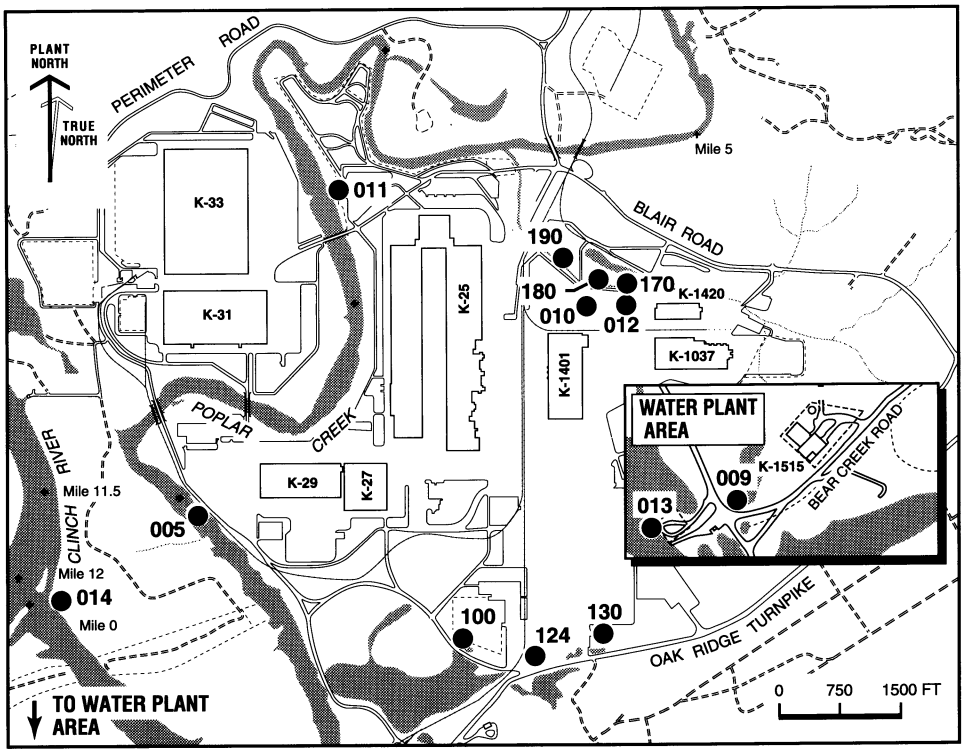

Fig. 4.22. K-25 Site NPDES major outfalls and Category I storm drain outfalls.

from each of these locations. The weekly samples are composited into monthly samples and analyzed for radionuclides. Results of these sampling efforts are compared with the DCGs.

Table 4.14. Radionuclides released to off-site surface waters from the K-25 Site, 1994
Effluent discharge locations are K-1203, K-1407-J, and K-1515-C

Isotope	Amount (Ci)[a]	Isotope	Amount (Ci)[a]
^{143}Ce	1.1E–01	^{99}Tc	7.0E–02
^{137}Cs	7.9E–03	^{228}Th	1.6E–02
^{40}K	2.8E–02	^{234}Th	8.7E–02
^{237}Np	4.0E–04	^{234}U	1.9E–02
^{238}Pu	–2.1E–04	^{235}U	1.4E–02
^{239}Pu	–1.8E–04	^{236}U	3.4E–04
^{234m}Pa	1.87E–02	^{238}U	3.3E–03

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

Results

The sum of the fractions of the DCGs for each of the effluent locations (K-1203, K-1407-J, and K-1515-C) remained below 35%. Table 4.14 lists radionuclides released from the K-25 Site to off-site surface waters in 1994.

Uranium releases to surface waters over a 5-year period (1989–93) were investigated to observe their trend (Fig. 4.23). The effluent point having the greatest DCG percentage was the K-1407-J outfall. Uranium isotopes contributed to this percentage as shown in Fig. 4.24. The increase in uranium discharges is attributed to TSCA Incinerator wastewater. The wastewater stream is sent to the CNF for treatment before discharging at K-1407-J.

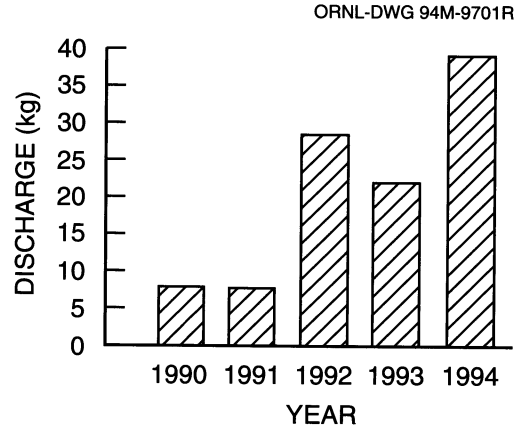

Fig. 4.23. Five-year trend of uranium releases to surface waters from the K-25 Site. Analysis includes discharge locations K-1203 and K-1407-J.

Nonradiological Liquid Discharges

The Federal Water Pollution Control Act and its amendments, more commonly known as the Clean Water Act (CWA), were the culmination of almost a century of litigation and political debates about water pollution. The two main goals of the CWA are (1) to attain a level of water quality that provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water and (2) to eliminate the discharge of pollutants into waters of the United States.

The CWA requires that EPA establish limits on the amounts of specific pollutants that may be discharged to surface waters. The standards, called effluent limitations,

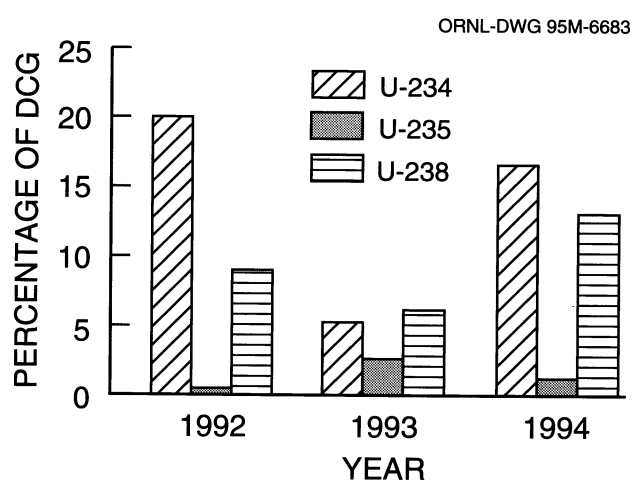

Fig. 4.24. Percentage of DCG for uranium isotopes from the K-1407 outfall.

are written into NPDES permits issued to all municipal and industrial dischargers. The Y-12 Plant, ORNL, and the K-25 Site are each required to monitor discharges at frequencies specified in their permits to ensure compliance with the NPDES effluent limitations. The TDEC Division of Water Pollution Control has the authority to issue NPDES permits and to monitor compliance with the permits in the state of Tennessee under the Tennessee Water Control Act and according to the rules and regulations of the Tennessee Water Quality Control Board. DOE waste treatment facilities have formal wastewater acceptability control and surveillance programs that ensure the protection of the facilities and the proper treatment of wastes. Among other things, these programs define pretreatment requirements and waste acceptance criteria. Discharges are regulated under NPDES permits.

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

Sanitary wastewater from the Y-12 Plant is discharged to the city of Oak Ridge POTW. Both ORNL and the K-25 Site have on-site sewage treatment plants.

Y-12 Plant Surface Water and Liquid Effluents

The current NPDES permit, issued May 25, 1985, is a reflection of the 1977 amendments to the Federal Water Pollution Control Act and the Y-12 FFCA signed by EPA and DOE on April 17, 1985. This current NPDES permit combines water quality and effluent limitations based on the best available industrial technology for the metal-finishing and steam electric-power-generation industries with emphasis on biological and toxicological monitoring. Under the conditions of the permit, the Y-12 Plant was required to accomplish the following:

- develop and implement a best management practices plan that prevents or minimizes the potential of wastewater discharge from Category I and II outfalls (precipitation runoff, cooling waters, condensate, foundation drains, and groundwater),
- determine the biological toxicity of wastewater streams from several locations and develop a toxicity characteristic monitoring plan as necessary,
- develop a radiological monitoring plan,
- develop a PCB monitoring plan,
- develop a biological monitoring and abatement program (BMAP) for East Fork Poplar Creek (EFPC), and
- comply with discharge limitations on identified miscellaneous discharge points.

The Y-12 Plant is committed to achieving effluent characteristics that are better than those specified by the best available technology. The effluent limitations for each treatment facility may be adjusted if the treated effluent results in instream toxicity as determined by the toxicity control and monitoring program (TCMP) plan or if EFPC does not display a healthy ecological system as determined by BMAP.

The Y-12 Plant NPDES permit requires sampling and analysis at 11 serially numbered outfalls, 80 categorized outfalls, and 14 miscellaneous discharges. This listing is subject to change as outfalls are eliminated or consolidated. Fourteen outfalls to EFPC were eliminated (source flows were stopped and outfalls were physically removed) in 1994. Thirty-two outfalls had previously been eliminated in 1993. Since the mid-1980s, more than 250 untreated waste water point sources that previously discharged to the surface water have either been routed for treatment or eliminated from direct discharge to the creek.

The water quality of surface streams in the vicinity of the Y-12 Plant is affected by current and past operations. Discharges from Y-12 Plant processes affect water quality and flow in EFPC before entering the Clinch River. In past years, discharge of coal bottom ash slurry to the McCoy Branch Watershed from the Y-12 Steam Plant occurred. This practice has been stopped, and coal ash is currently collected dry and disposed of in a landfill.

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

Outfalls 302 (Rogers Quarry) and 304 (Bear Creek km 4.55), which are considered instream sampling points for McCoy Branch and Bear Creek, respectively, are also compared with state of Tennessee water quality criteria, as a component of surveillance monitoring conducted by the Y-12 Plant. The most restrictive of either the fresh water fish and aquatic life criterion maximum concentration (CMC) or the recreation concentration for organisms only standards (10^{-5} risk factor for carcinogens) was used. See Sect. 5 for these and other results of surveillance monitoring.

The existing Y-12 Plant NPDES permit expired in May 1990. An application for permit renewal was submitted to TDEC and EPA in November 1989, and an addendum to this application was submitted to TDEC in February 1993. The addendum contains an extensive collection of proposed monitoring points and subsequent categories, consisting of 33 Category II outfalls (storm water and cooling water condensate), 12 Category III outfalls (process wastewater only), and 6 treatment facilities. Process wastewater is defined as the combination of any of the following types of wastewater:

- once-through noncontact cooling water,
- cooling tower blowdown,
- steam condensate,
- discharges through a previously monitored NPDES permit point,
- periodic discharges regulated under best management practices or other administrative control, or
- discharges regulated by an approved water management plan.

Energy Systems, DOE, and TDEC informational meetings began in October 1992 to start the process of issuing a renewed NPDES permit to the Y-12 Plant. A new permit, issued on April 28, 1995, is effective as of July 1, 1995. Some of the more significant changes in the new permit as compared with the 1985 NPDES permit are the following:

- toxicity limitation for the headwaters of EFPC,
- quarterly toxicity testing at the wastewater treatment facilities,
- a compliance schedule to reduce mercury in EFPC,
- a compliance schedule for chlorine limitations at all outfalls containing cooling water,
- chlorine limitations of water quality criteria at the headwaters of EFPC,
- a compliance schedule for correction of elevated ammonia concentrations discharged to EFPC from a groundwater spring,
- a requirement to manage the flow of EFPC such that a minimum flow of 7 million gal per day is guaranteed by adding raw water from the Clinch River to the headwaters of the creek,
- sampling of storm water at a minimum of 25 locations per year, and
- instream pH limitations on tributaries to Bear Creek and various other tributaries on the south side of Chestnut Ridge.

Sanitary Wastewater

Sanitary wastewater from the Y-12 Plant is discharged to the city of Oak Ridge POTW under Industrial and Commercial Users Wastewater Permit Number 1-91. Monitoring is conducted under the terms of the permit for a variety of organic and inorganic pollutants.

Prior to June 28, 1994, samples from the sanitary sewer were collected from two sites to monitor compliance to the permit: the City Monitoring Station (SS4) and the Union Valley Station (SS5) (Fig. 4.12). The Y-12 Plant contribution was calculated by subtracting the loading of the Union Valley Station from the loading of the City Station. The Union Valley Station does not have any Y-12 Plant waste streams associated with it. Two additional in-plant monitoring points (SS1 and SS2) were monitored as a best management practice. On July 28, 1994, the EESSMS (SS-6) was put into service. Completion of the monitoring station and rerouting of the associated sewer line combined all Y-12 Plant sanitary sewer effluent into one discharge line. The EESSMS is capable of monitoring all Y-12 Plant sanitary sewer effluent. Thus no additional sampling sites are required and back-calculation of contaminant releases based on two monitoring location is no longer necessary.

As required by the city of Oak Ridge, a sanitary sewer application revision and a questionnaire were submitted in September 1993. The questionnaire is used by the city's POTW staff to set limits for industrial and commercial discharges. Permits are being reviewed throughout the industrial community to ensure that regulatory limits are met at the POTW discharge point. It is anticipated that the Y-12 Plant will be issued a new discharge permit in late 1995.

Results

In 1994 the Y-12 Plant reduced NPDES excursions by more than 20% from 1993 (from 14 in 1993 to 11 in 1994). Only two of the excursions were caused by exceedences of wastewater discharge limits. In 1994, none of the Y-12 Plant NPDES excursions were attributable to administrative errors such as missing analytical sample holding times, loss of a sample, or improper sample preservation. Of the NPDES excursions that occurred at the Y-12 Plant, 36% were observations made at outfalls located directly on the bank of East Fork Poplar Creek. More than 160,000 observations were made along the bank of East Fork Poplar Creek for changes in creek conditions or visible discharges from outfalls (e.g., foam or oil sheen). All Y-12 Plant NPDES permit excursions recorded in 1994 are summarized in Table 4.15. Table 4.16 records the NPDES compliance monitoring requirements and the 1994 compliance record.

Table 4.15. Summary of Y-12 Plant NPDES excursions, 1994

Date	Location	Excursion	Explanation	Corrective action
1/27/94	Outfall 125	Visible oil sheen	An oil sheen was observed emitting from Outfall 125 on EFPC. The oil was traced back to a hydraulic pump for a heat exchanger that had been taken out of service for repairs. The oil leaked through a stainless steel drain cover that had deteriorated through years of use. The drain discharged directly to EFPC	Upon detection of the oil sheen, the water to the heat exchanger was shut off and booms were positioned on the creek at the outfall. The stainless steel drain cover was removed, and the drain was plugged with concrete
2/10/94	Outfall 503 (Steam Plant Wastewater Treatment Facility)	Treatment facility bypass	An unanticipated bypass occurred following exceptionally heavy rain event, which accounted for nearly five in. of accumulation between 2/7 and 2/10. The rain event, linked with extremely saturated ground conditions, placed a severe hydraulic load on the treatment facility. The south equalization basin filled to overflow capacity despite the increased hours of treatment operation. The bypass outlet was plugged, but about 100 gal of wastewater overflowed into the bypass during the operation	The facility was placed on 24-hour operation. Once the bypass pipe was plugged, water from the equalization basin was pumped back to the coal pile for temporary holding
2/23/94	Outfall 503 (Steam Plant Wastewater Treatment Facility)	Treatment facility bypass	The equalization basin remained full after the heavy rains during the week of February 7. The treatment facility was inefficient, resulting in less water being treated and discharged and more frequent recycling of water than in normal operations. A second rain event on 2/22 and 2/23 loaded the facility to near basin capacity. The additional storm water runoff from the coal pile overflowed the collection ditch and about 10 to 20 gal per minute entered one of the area storm drains for an estimated 90-min period	The bypass pipe at the equalization basin was plugged, operations at the facility were increased, and sand bags were placed along the concrete collection ditch and around nearby storm drains
3/9/94	Outfall 503 (Steam Plant Wastewater Treatment Facility)	Sample concentration (1.2 mg/L iron) exceeded permit limit	Heavy rains during February and March accounted for twice the normal volume of coal pile runoff accumulating in the holding basins, which increased the potential for a treatment facility bypass. The operation was increased to reduce the water level in the basins. This increased throughput compromised the efficiency of iron removal	Heavy rains quit and the water level in the basins was returned to normal. With the reduced water level, operations returned to normal

Table 4.15 (continued)

Date	Location	Excursion	Explanation	Corrective action
4/8/94	Outfall 503 (Steam Plant Wastewater Treatment Facility)	Unauthorized discharge	Coal pile runoff and sediment in the concrete trench surrounding the coal pile was being moved when a slug of coal fines was washed into a nearby storm drain. The black cloudy slug was observed at the North/South Pipes on EFPC	Coal fines and residual material were removed from the storm drain. Signs were posted to limit the access of personnel to the area. All employees have been given instruction in the importance of environmental protection
5/17/94	Outfall 160	Unauthorized discharge (acid waste)	A mix of sulfuric acid, caustic, and water was being pumped through a fire hose from the west side of Building 9404-18 to the east side of the building when the hose ruptured. The acid waste entered a nearby storm drain that flows through Outfall 160	A new pump for the west sump is on order. Until the new pump arrives, the fire hose has been shortened to provide stability. The hose is also being directed through the building, which serves as a dike
7/10/94	Outfall 21	Visible oil sheen	An oil sheen was observed emitting from Outfall 21. The sheen was traced back to a leaking steam trap in a pit in the basement of Building 9210. The steam leak may have generated enough moisture to wash residual oil into the pipes	The leaking steam trap was repaired
7/12/94	Outfall 67	Visible oil sheen	The roof of Building 9706-1A leaked water into a room containing a central air-conditioning unit. The water picked up residual oil from the equipment and carried it to an open floor drain that drained directly to Outfall 67	The floor drain was sealed with concrete. Roof repairs are being planned
8/1/94	Outfall 150	Visible oil sheen	A low-pressure hydraulic hose failed on a 75-ton crane and spilled about 2 gal of hydraulic fluid to the pavement. Some fluid entered into a nearby storm drain	The crane was repaired at the scene
8/18/94	Outfall 55	Unauthorized discharge (muddy water)	During a cleanout of the basement sump in Building 9201-2, sediments suspended in water were discharged to EFPC	The sump pump is shut down during clean-out operations
12/23/94	Outfall 503 (Steam Plant Wastewater Treatment Facility)	Sample concentration (1.3 mg/L iron) exceeded permit limit	Clarifier plates clogged with soft scale, and the facility was unable to optimize the treatment process. Treated wastewater was diverted to sanitary sewer system. A valve, inadvertently open, discharged wastewater to EFPC	The valve discharging to the creek is now under lock out/tag-out procedures. The clarifier plates are scheduled to be cleaned and/or replaced, and a final filtration filter for the treatment facility is being designed

Table 4.16. NPDES compliance monitoring requirements and record for the Y-12 Plant, 1994

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily av (kg/d)	Daily max (kg/d)	Daily av (mg/L)	Daily max (mg/L)		
301 (Kerr Hollow Quarry)	Lithium				5.0	100	18
	pH, standard units			*a*	8.5	100	18
	Total suspended solids			30.0	50.0	100	18
	Temperature, °C				30.5	100	18
	Zirconium				3.0	100	18
302 (Rogers Quarry)	Oil and grease			10.0	15.0	100	52
	pH, standard units			*a*	8.5	100	52
	Settleable solids, mL/L				0.5	100	52
	Total suspended solids			30.0	50.0[b]	100	52
	Temperature, °C				30.5	100	52
304 (Bear Creek)	Oil and grease			10.0	15.0	100	52
	pH, standard units			*a*	8.5	100	52
307 (West Borrow Area)[c]	Temperature, °C					100	4
	pH, standard units					100	4
	Oil and grease					100	4
	Total suspended solids					100	4
308 (East Borrow Area)[c]	Temperature, °C					100	4
	pH, standard units					100	4
	Oil and grease					100	4
	Total suspended solids					100	4
501 [Central Pollution Control Facility (CPCF-I)]	Cadmium, total	0.07	0.19	0.26	0.69	100	69
	Chromium, total	0.5	0.75	1.71	2.77	100	69
	Copper, total	0.6	0.9	2.07	3.38	100	69
	Cyanide, total	0.2	0.33	0.65	1.20	100	69
	Lead, total	0.12	0.19	0.43	0.69	100	69
	Nickel, total	0.65	1.1	2.38	3.98	100	69
	Oil and grease	7.1	14.2	26.0	52.0	100	69
	pH, standard units			*a*	9.0	100	69
	Silver, total	0.07	0.12	0.24	0.43	100	69
	Temperature, °C				30.5	100	69
	Total suspended solids	8.5	16.4	31.0	60.0	100	69
	Total toxic organics		0.6		2.13	100	69
	Zinc, total	0.4	0.7	1.48	2.61	100	69
502 [West End Treatment Facility (WETF)]	Cadmium, total	0.07	0.019	0.26	0.69	100	30
	Chromium, total	0.5	0.75	1.71	2.77	100	30
	Copper, total	0.6	0.92	2.07	3.38	100	30
	Cyanide, total	0.2	0.33	0.65	1.20	100	31
	Lead, total	0.12	0.19	0.43	0.69	100	30
	Nickel, total	0.65	1.10	2.38	3.98	100	30
	Oil and grease	7.1	14.2	26.0	52.0	100	31
	pH, standard units			*a*	9.0	100	31
	Silver, total	0.07	0.12	0.24	0.43	100	30
	Temperature, °C				30.5	100	31
	Total suspended solids	8.5	16.4	31.0	60.0	100	30
	Total toxic organics		0.6		2.13	100	8
	Zinc, total	0.4	0.7	1.48	2.61	100	30
503 (Steam Plant Wastewater Treatment Facility	Chromium, total	0.38	0.38	0.20	0.20	100	151
	Copper, total	1.89	1.89	1.0	1.0	100	151
	Iron, total	1.89	1.89	1.0	1.0	99	151
	Zinc, total	1.89	1.89	1.0	1.0	100	151
	Oil and grease	28.4	37.9	15.0	20.0	100	151
	Total suspended solids	57.0	189.0	30.0	100.0	100	151
	Temperature, °C				30.5	100	151
	pH, standard units			*a*	9.0	100	151

Table 4.16 (continued)

Discharge point	Effluent parameter	Effluent limits: Daily av (kg/d)	Daily max (kg/d)	Daily av (mg/L)	Daily max (mg/L)	Percentage of compliance	No. of samples
Category I outfalls (precipitation runoff and small amounts of groundwater)	pH, standard units			*a*	8.5	100	38
Category II outfalls (cooling waters, condensate, precipitation runoff, and building, roof, and foundation drains)	pH, standard units			*a*	8.5	100	77
	Temperature,[d] °C					100	77
Category III outfalls (process wastewaters)	pH, standard units			*a*	8.5	100	40
Category IV outfalls (untreated process wastewaters)	pH, standard units			*a*	8.5	100	74
504 (Plating Rinsewater Treatment Facility)	Cadmium, total	0.07	0.019	0.26	0.69	100	3
	Chromium, total	0.50	0.75	1.71	2.77	100	3
	Copper, total	0.60	0.92	2.07	3.38	100	3
	Cyanide, total	0.2	0.33	0.65	1.20	100	3
	Lead, total	0.12	0.19	0.43	0.69	100	3
	Nickel, total	0.65	1.10	2.38	3.98	100	3
	Oil and grease	7.1	14.2	26.0	52.0	100	3
	pH, standard units			*a*	9.0	100	3
	Silver, total	0.07	0.12	0.24	0.43	100	3
	Temperature, °C				30.5	100	3
	Total suspended solids	8.5	16.4	31.0	60.0	100	3
	Total toxic organics		0.6		2.13	100	3
	Zinc, total	0.4	0.7	1.48	2.61	100	3
501/504 (combined discharge from Central Pollution Control Facility and Plating Rinsewater Treatment Facility)	Cadmium, total	0.07	0.019	0.26	0.69	100	4
	Chromium, total	0.50	0.75	1.71	2.77	100	4
	Copper, total	0.60	0.92	2.07	3.38	100	4
	Cyanide, total	0.2	0.33	0.65	1.20	100	4
	Lead, total	0.12	0.19	0.43	0.69	100	4
	Nickel, total	0.65	1.10	2.38	3.98	100	4
	Oil and grease	7.1	14.2	26.0	52.0	100	4
	pH, standard units			*a*	9.0	100	4
	Silver, total	0.07	0.12	0.24	0.43	100	4
	Temperature, °C				30.5	100	4
	Total suspended solids	8.5	16.4	31.0	60.0	100	4
	Total toxic organics		0.6		2.13	100	4
	Zinc, total	0.4	0.7	1.48	2.61	100	4
623 (Steam Plant fly ash sluice water)	pH, standard units			*a*	8.5	*e*	
506 (9204-3 sump pump oil)	Temperature, °C				30.5	*e*	
	Oil and grease			10.0	15.0	*e*	
	pH, standard units			*a*	8.5	*e*	
508 (Experimental Mobile Wastewater Treatment Facility)	Mercury, total			0.002	0.004	*e*	*a*
	pH, standard units			*a*	9.0	e	
	Total suspended solids			30.0	45.0	*e*	

Table 4.16 (continued)

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily av (kg/d)	Daily max (kg/d)	Daily av (mg/L)	Daily max (mg/L)		
510 (Waste Coolant Processing Facility)	Biochemical oxygen demand	1.33	2.65			*e*	
	Oil and grease			15.0	20.0	*e*	
	pH, standard units			*a*	9.0	*e*	
	Temperature, °C				30.5	*e*	
	Total suspended solids			30.0	50.0	*e*	
512 (Groundwater Treatment Facility)	Oil and grease			*a*	15	100	508
	Iron, total			*a*	1.0	100	508
	pH, standard units			*a*	9.0	100	continuous
	PCBs					100	508
Miscellaneous discharges (cooling tower blowdown)	Chromium, total				1.0	100	36
	Copper, total			0.5	1.0	100	36
	Free available chlorine			0.2	0.5	100	48
	pH, standard units			*a*	8.5	100	48
	Temperature, °C			35	38	100	48
	Zinc, total			0.5	1.0	100	36
Miscellaneous discharges (demineralizers)	pH, standard units			*a*	8.5	*e*	
	Total suspended solids			30	50	*e*	

[a]Not applicable.
[b]Limit not applicable during periods of increased surface runoff resulting from precipitation.
[c]Application submitted to add this outfall to the permit. No limits have been set.
[d]Temperature shall be controlled such that the stream temperature standards delineated in the General Water Quality Criteria for the Definition and Control of Pollution in the Waters of Tennessee, as amended, are not violated as a result of this discharge.
[e]No discharge.

The PCB Monitoring Plan for the Y-12 Plant specifies sampling locations and frequencies of sampling for PCBs. Quarterly monitoring was conducted at Kerr Hollow Quarry (Outfall 301), Rogers Quarry (Outfall 302), Bear Creek (Outfall 304), and from EFPC within the Y-12 Plant boundary. All results for the year were less than the analytical detection limit, which is 0.005 mg/L (Table 4.17).

Monitoring of nonradiological parameters at kilometer 12.4 (mile 7.7) on Upper Bear Creek continued in 1994, as it did for radiological parameters, to monitor the influence of seepage from the S-3 ponds site. Because of decreased flow at this site since closure of the S-3 ponds, a new site at kilometer 11.97 is also being monitored and has been proposed as a replacement site. Analytical data from both sites have been compared, and changes in the monitoring routine have been proposed for implementation in 1995. Analytical data are reported monthly to TDEC in an attachment to the discharge monitoring report required by NPDES. These sites were monitored once per week for nonradiological parameters. Surface water in the upper reaches of Bear Creek contains elevated trace metals and nitrate concentrations. Nitrate-nitrogen has been used as a key parameter to monitor the influence of the S-3 ponds site on surface water. Figure 4.25 shows average total nitrate data from 1987 to 1994 for the Upper Bear Creek site at kilometer 12.4. Nitrate levels have decreased by more than an order of magnitude since the late 1980s.

Table 4.18 summarizes Y-12 Plant contributions to the sanitary sewer system for 1994. Results are given for both the calculated contribution (prior to June 28, 1994) and the measurements taken after June 28 when the new EESSMS (SS-6) was put into service.

Table 4.17. Surface water analytical results of polychlorinated biphenyls monitoring for the Y-12 Plant, 1994

Site No.	Location	Date sampled	PCB concentration (mg/L)
PCB-1	Outfall 301, Kerr Hollow Quarry	3/2	<0.0005
		4/4	<0.0005
		7/25	<0.0005
		10/13	<0.0005
PCB-2	Outfall 302, Rogers Quarry	3/2	<0.0005
		4/4	<0.0005
		7/25	<0.0005
		10/13	<0.0005
PCB-3	Outfall 303, New Hope Pond	*a*	<0.0005
PCB-5	New Hope Pond Inlet	*b*	<0.0005
PCB-6	Upstream of Outfall 135	3/2	<0.0005
		4/4	<0.0005
		7/25	<0.0005
		10/13	<0.0005
PCB-7	Outfall 304, Bear Creek	3/2	<0.0005
		4/4	<0.0005
		7/25	<0.0005
		10/13	<0.0005

[a]This outlet was closed in April 1989.
[b]This inlet was closed in November 1988.

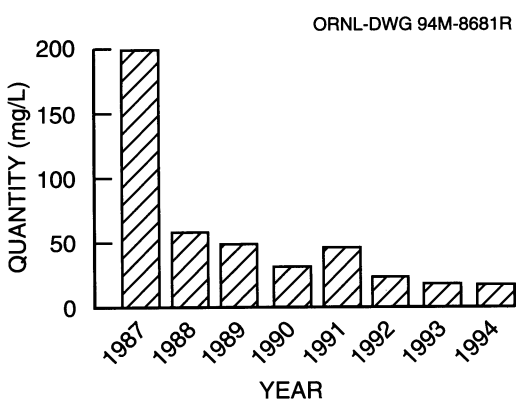

Fig. 4.25. Total nitrate data for Upper Bear Creek site at kilometer 12.4, 1987–94.

There was one exceedence of the permit limit in 1994. The permit limit for copper is 0.04 mg/L and a single measurement at EESSMS was 0.048 mg/L.

Progress in Implementing Corrective Actions and Significant Improvements

East Fork Poplar Creek Dechlorination

Two dechlorination systems that began operating in December 1992 continued to provide dechlorination for 75% of EFPC flow (20% of EFPC flow is estimated to be groundwater). Instream levels of total residual chlorine were typically about 0.01 mg/L during 1994 as compared with the previous outfall discharge levels of about 0.3 to 1.0 mg/L. Fish populations and density have increased significantly. Additional dechlorination has been achieved by installation of 33 tablet dechlorinators during 1994 (which now total 37) at chlorine-discharge sources. About six more tablet units are planned for installation in 1995 to bring outfalls into compliance with the anticipated new NPDES permit requirements. Outfall 125, the next largest nondechlorinated outfall, will begin treatment in 1995, following installation of a dechlorination system in late 1994.

Ecological recovery of EFPC is continuing, with some significant recent trends. Pollution-intolerant fish species are being found below Lake Reality, and there has been substantial reduction in toxicity above Lake Reality. However, both fish and benthic

Table 4.18. Calculated sanitary sewer concentrations for parameters having a discharge limit, Y-12 Plant, 1994

Parameter	No. of samples	Concentration[a]			Reference value[b]	No. of values exceeding reference
		Max	Min	Av		
January 1, 1994 through June 27, 1994						
pH, standard units	30	8.3	6.1	c	6–9[d]	0
Cyanide	30	<0.01	<0.01	<0.01	0.007	30[e]
Oil and grease	30	14	<2[f]	<4	50	0
Phenols	30	0.047	<0.001[f]	<0.01	5.0	0
Biochemical oxygen demand	30	96	<5[f]	<20	300	0
Hexavalent chromium	30	<0.01	<0.01	<0.01	0.002	30[e]
Mercury	29	0.0155	<0.0002	<0.002	0.1	0
Total Kjeldahl nitrogen	30	21.6	<0.2[f]	1	90	0
Total suspended solids	30	199.1	<5[f]	<20	300	0
Arsenic	30	<0.04	<0.04[f]	<0.04	0.1	0
Cadmium	30	<0.004	<0.004	<0.004	0.000024	30
Copper	30	0.035	<0.006[f]	<0.01	0.04	0
Iron	30	0.94	<0.06[f]	<0.4	1.5	0
Lead	30	<0.02	<0.02	<0.02	0.0016	30[e]
Manganese	30	0.107	9[f]	0.051	1.0	0
Nickel	30	<0.008	<0.008[f]	<0.006	0.10	0
Silver	30	<0.026	<0.006	<0.007	0.1	0
Zinc	30	0.2	<0.01[f]	<0.1	2.0	0
June 28, 1994 through December 31, 1994						
pH, standard units	26	8.1	7.1	c	6–9[d]	0
Cyanide	26	<0.01	<0.01	<0.01	0.007	26[e]
Oil and grease	26	8.6	<2.0	<4.0	50	0
Phenols	26	0.136	<0.005	<0.02	5.0	0
Hexavalent chromium	25	<0.01	<0.01	<0.01	0.002	25[e]
Mercury	26	0.0036	<0.0002	<0.001	0.1	0
Total Kjeldahl nitrogen	26	24	6.6	13	90	0
Total suspended solids	26	96	<5	<40	300	0
Arsenic	26	<0.04	<0.04	<0.04	0.1	0
Cadmium	26	<0.004	<0.04	<0.004	0.000024	26[e]
Copper	26	0.048	0.011	0.018	0.04	1
Iron	26	0.75	0.24	0.45	1.5	0
Lead	26	<0.02	<0.02	<0.02	0.0016	26[e]
Manganese	26	0.064	0.028	0.044	1.0	0
Nickel	26	<0.008	<0.008	<0.008	0.10	0
Silver	26	0.012	<0.006	<0.007	0.1	0
Zinc	26	0.28	0.09	0.1	2.0	0

[a]All units in mg/L unless otherwise indicated.
[b]Sanitary Sewer Industrial Discharge permit limits.
[c]Not applicable.
[d]Minimum value/maximum value.
[e]The detection limit of this parameter is above the reference value.
[f]Calculated value was below the detection limit.

macroinvertebrate communities in UEFPC are dominated by pollution-tolerant species, especially above Lake Reality. Additional recovery may occur in response to reductions in mercury levels in EFPC. Complete recovery may not occur because water temperatures are elevated, inadvertent discharges/spills may occur, and availability of habitat is limited above Lake Reality.

Cooling Tower Ozone Treatment

Two cooling towers were converted from chemical to ozone treatment in 1994, completing the planned conversion of cooling towers that discharge directly to EFPC without the benefit of dechlorination. This conversion eliminates the use of chemical additions to the cooling towers for control of bacteria. Blowdown from these towers has also been eliminated, thus reducing discharges to EFPC.

Flow Management (or Raw Water) Project

Discharges to EFPC have decreased in volume from about 10 million gal/day in the early 1980s to about 3.5 million gal/day currently, primarily because of reductions in plant operations. These reductions have increased concern about the Y-12 Plant treatment facilities maintaining discharge contaminant levels that would not affect EFPC. Accordingly, the proposed new NPDES permit requires addition of Clinch River water to the headwaters of EFPC (North/South Pipe—Outfall 200 area) by March 1997 so that a minimum flow of 7 million gal/day is maintained at the point where EFPC leaves the reservation. Design of this project began in 1993 and will be completed in early 1995. Construction is planned to be completed in early 1996.

Ammonia Reduction at Outfall 17

A urea pile was maintained above Outfall 17 for about 10 years; the urea was used for deicing roads and sidewalks. Elevated levels of ammonia nitrate in EFPC were traced to Outfall 17 as a result of a fish kill in December 1992. The urea pile was removed at that time; however, the soil in the area of the pile remains contaminated. The sudden toxic effect on fish was attributed to the start-up of dechlorination efforts on EFPC in the preceding month, which reduced available chlorine that apparently was reacting with and neutralizing the ammonia.

A feasibility study completed in late 1994 defines possible corrective actions. The new NPDES permit will contain compliance requirements for Outfall 17 that are already being achieved as a result of natural flushing of contaminants from the site.

Non-Point-Source Studies

Storm water runoff is required to be periodically sampled and analyzed for a large number of contaminants by the NPDES permit and a draft storm water pollution prevention plan. The objective of this data collection is to identify possible sources of contaminants that exceed water quality criteria and to provide a basis and direction for corrective actions. Storm water runoff data from previous years were analyzed and the *Feasibility Study of Best Management Practices for Non-Point Source Pollution Control at the Oak Ridge Y-12 Plant* (CDM 1993) was issued in 1993. Additional studies were initiated on the basis of this report. Sampling of parking lots, the metal scrap yard, and selected building roofs was completed in 1994. The data will help determine whether the areas are specific sources of contaminants observed in storm water flow in EFPC. These types of investigations will continue as necessary to ensure compliance with the NPDES permit and other regulatory requirements.

Drain Modifications and Reroutes

Extensive drain surveys conducted in years previous to 1993 identified incorrectly connected building drains to either the sanitary or storm sewers. Most of these drains were administratively closed at that time. Permanent and physical changes to provide correct drain routings were designed and initiated in 1993 for 32 "major" buildings. One building was completed in 1993, and 25 buildings were completed in 1994. Several changes were made to the initial plans because of the ongoing downsizing of the plant. The remaining buildings will be completed as funding appropriations permit.

An additional design effort, which began in 1993, identified drains (primarily floor drains) that needed to be closed to ensure that accidental or unauthorized discharges are not made to either sanitary or storm sewers. The original scope included 21 buildings but has been reduced to about 18 because managers were proactive in closing off drains that were under their control and for which sufficient funding was available. This design was completed in 1994. Work in six buildings was completed in 1994 and will continue into 1995.

Several additional projects have been initiated to eliminate drains incorrectly discharging to EFPC or the sanitary sewer. Two main buildings in the Biology complex (9208 and 9207) were corrected in 1993 and 1994, respectively, by the rerouting of drains from EFPC to the sanitary sewer. A steam condensate discharge of about 40,000 gal/day to the sanitary sewer from Building 9769 will be rerouted to the steam plant in early 1995.

In addition, a project was begun in late 1994 to survey all the remaining and previously unsurveyed building drains at the Y-12 Plant. The survey is scheduled to be complete by mid-1995. Incorrectly routed drains are being identified for closure or correction. Many drains were corrected or eliminated. Corrective actions will be taken as funding appropriations permit.

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

The legacy of contamination resulting from use and storage of mercury at the Y-12 Plant has prompted a series of remedial measures. The RMPE II program is structured to serve as a bridge between downstream remediation of EFPC and upstream remedial actions at the Y-12 Plant. A key goal of this program is to reduce the annual mercury release from Y-12 Plant by about 70% by the end of the 5-year NPDES permit period. Six projects (four building source elimination efforts and two treatment units) have been identified under the RMPE II Program to reduce mercury contamination to UEFPC.

Significant progress was made in 1994 toward reduction of mercury in discharges to EFPC. Construction and start-up of an interim mercury treatment unit for Building 9201-2 has been completed. A study has been started to evaluate upgrading the Interim Mercury Treatment Unit (IHgTU) to a permanent system The IHgTU, which continues to operate, treated more than 1 million gal of water in 1994. In addition, rerouting of pipes for buildings 9201-2 and 9201-5 has been completed to eliminate sources of mercury. Design work was completed in 1994 for reroutes in buildings 9201-4 and 9204-4; construction is expected to be completed in 1995.

To provide permanent mercury treatment capability, the Central Mercury Treatment System (CMTS) is currently in design. The facility will be in the existing Central Pollution Control Facility in Building 9623. Mercury-contaminated groundwater originating from sumps in buildings 9201-4, 9201-5, and 9204-4 will be collected and transported to CMTS for treatment. The system will be sized based on treatability studies such that water

released to EFPC is within the anticipated NPDES limits (2 part per billion, monthly average). The discharge of the CMTS will be through a new NPDES outfall.

Treatment Plant Discharge

The Y-12 wastewater treatment facilities have done an excellent job during past years in complying with the current NPDES permit (issued in 1985), with very few excursions (see Fig. 2.2). Even though these excursions have been minor and infrequent, the goal is to eliminate noncompliances to the greatest extent possible. The Treatment Plant Discharge Project was scoped with the requirement of improving treatment-facility capability to ensure that the more stringent effluent standards of the new NPDES permit could be met using the best available technology. This project addressed four major areas: (1) outfall consolidation, (2) addition of effluent storage, (3) construction of a new polishing facility for all treatment plant discharges, and (4) improvements to the Steam Plant Wastewater Treatment Facility (SPWTF). The feasibility study was completed in 1993; the conceptual design began in 1994.

It became evident during the conceptual design process and from other reviews that the existing treatment facilities were operating without excursions (one in 1993 and zero in 1994) and that compliance to the new draft NPDES permit limits could be achieved without the scoped changes, except for the SPWTF. Accordingly, the project was redefined to include only improvements to the SPWTF. This line item for FY 1997 is scheduled to begin construction in 1997.

Fish Kill Summary

During 1994 the Y-12 Plant reported four incidents to TDEC involving fish kills within the Y-12 Plant boundaries. Three of these incidents were attributable to activities within the plant; the fourth incident was attributed to natural causes. Of the three incidents attributable to plant activities, two of them involved elevated levels of chlorine; the cause of the other incident has yet to be determined.

On January 29, 1994, an estimated 2000 gal of chlorinated water inadvertently entered nearby storm drains during the flushing of a 10-in. potable water line. The potable water line had been out of service for repairs. Flushing the line with chlorinated water was the final step in preparing the water line for service. The dechlorination unit, located at Outfall 21, was unable to handle the sudden rush of chlorinated water. The overload of chlorinated water to the creek resulted in 125 dead fish. Dead fish were limited to the area in and around the tributary at Outfall 21. Procedures for flushing water lines have been revised to address possible runoff associated with this type of activity.

On October 30, 1994, a pump controller for one of the dechlorination units failed, resulting in elevated levels of chlorine in the area of the North/South Pipes. Forty-two dead fish were retrieved as a result of this incident. The pump controller was immediately taken out of service and a new one installed. Back-up pumps have been installed at each of the dechlorination units.

Between December 2 and December 30, 1994, 761 dead fish were retrieved from EFPC. The exact cause of the fish kill has not been identified. A review of Y-12 Plant operations indicated no reported spills or releases. Biological review of the fish indicated no diseases, fungus, or parasites. Water quality data indicated no toxic contaminants, and no changes were seen in the environmental monitoring stations. Efforts to identify possible sources of contaminants to EFPC continue.

Between March 23 and May 27, 1994, 493 dead fish were reported to TDEC as a result of spawning activities. As seen in past stoneroller spawning seasons, the dead fish retrieved during this time period were predominantly stonerollers. Seventy-three percent were tuberculate male stonerollers. Some mortality is to be expected with spawning activities, especially for the older males because of the physically demanding behavior. Stoneroller mortality during spawning will continue to be seen in EFPC during the spring of the year.

ORNL Nonradiological Summary

Effluents

ORNL NPDES permit TN0002941 became effective on April 1, 1986, and expired in March 1991; the conditions of the expired permit remain in effect until a new permit is negotiated. The permit renewal application was submitted in September 1990. It is anticipated that ORNL's permit will be renewed in the 1995–96 time-frame. Data collected for the NPDES permit are submitted to the state of Tennessee in monthly discharge monitoring reports.

ORNL's current NPDES permit requires that point-source outfalls be sampled before they are discharged into receiving waters or before they mix with any other wastewater stream (see Fig. 4.14). Numeric and aesthetic effluent limits have been placed on the following locations:

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

Permit limits and compliance are shown by location in Table 4.19. Compliance with the NPDES permit for the last 3 years is summarized by major effluent locations in Fig. 4.26. The figure provides a list of the effluent locations and the number of noncompliances at each location. The maximum number of noncompliances in 1994 occurred at the Category II outfalls. All Category II limit excursions in 1994 were associated with total suspended solids, typically residual dust or dirt particles, conveyed in stormwater runoff.

In 1994, at X01, the chlorine excursion was attributed to failure of an electronic component in the sewage treatment plant's effluent chlorination system. The component was replaced immediately and no other problems were noted. At X02, iron-limit excursions were attributed to the uptake of iron by algae in the Coal Yard Runoff Treatment Facility discharge basin. Algal strands collected in effluent samples were contributing to iron levels in the effluent analyses. To correct the problem, measures have been taken to prevent algae from moving from the basin into the effluent sample collection point, which has been

Table 4.19. 1994 NPDES compliance at ORNL

Discharge point	Effluent parameters	Permit limits					Permit compliance		
		Monthly av (kg/d)	Daily max (kg/d)	Monthly av (mg/L)	Daily max (mg/L)	Daily min (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance[a]
X01 (Sewage Treatment Plant)	Ammonia, as N (summer)	3.5	5.2	4.0	6.0		0	92	100
	Ammonia, as N (winter)	7.8	11.8	9.0	13.5		0	64	100
	Biochemical oxygen demand (summer)	8.7	13.1	10	15		0	92	100
	Biochemical oxygen demand (winter)	17.4	26.2	20	30		0	64	100
	Chlorine, total residual				0.5		1	157	99
	Dissolved oxygen					6.0	0	249	100
	Downstream pH (SU)				9.0	6.0	0	52	100
	Fecal coliform (col/100 mL)[b]			1000	5000		0	156	100
	Oil and grease	8.7	13.1	10	15		0	156	100
	pH (SU)				9.0	6.0	0	52	100
	Total suspended solids	26.2	39.2	30	45		0	156	100
X02 (Coal Yard Runoff Treatment Facility)	Chromium, total			0. 2	0.2		0	52	100
	Copper, total			1.0	1.0		0	52	100
	Downstream pH (SU)				9.0	6.0	0	249	100
	Iron, total			1.0	1.0		3	52	94
	Oil and grease			15	20		0	51	100
	pH (SU)				9.0	6.0	0	263	100
	Selenium, total			0.22	0.95		0	52	100
	Temperature (°C)				30.5		0	263	100
	Total suspended solids				50		0	52	100
	Zinc			1.0	1.0		0	52	100
X12 (Nonradiological Wastewater Treatment Facility)	Cadmium, total	0.79	2.09	0.26	0.69		0	52	100
	Chromium, total	5.18	8.39	1.71	2.77		0	52	100
	Copper, total	6.27	10.24	2.07	3.38		0	52	100
	Cyanide, total	1.97	3.64	0.65	1.20		0	52	100
	Downstream pH (SU)				9.0	6.0	0	249	100
	Lead, total	1.30	2.09	0.43	0.69		0	52	100
	Nickel, total	7.21	12.06	2.38	3.98		0	52	100
	Oil and grease	30.3	45.4	10	15		0	52	100

Table 4.19 (continued)

Discharge point	Effluent parameters	Permit limits					Permit compliance		
		Monthly av (kg/d)	Daily max (kg/d)	Monthly av (mg/L)	Daily max (mg/L)	Daily min (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance[a]
X12 (continued)	pH (SU)				9.0	6.0	0	c	100
	Silver, total	0.73	1.30	0.24	0.43		0	52	100
	Temperature (°C)				30.5		0	249	100
	Total suspended solids	93.9	182	31	60		0	52	100
	Total toxic organics		6.45		2.13		0	52	100
	Zinc, total	4.48	7.91	1.48	2.61		0	52	100
Category I outfalls[d]	Downstream pH (SU)				9.0	6.0	0	28	100
	Oil and grease			10	15		0	28	100
	pH (SU)				9.0	6.0	0	28	100
	Temperature (°C)				30.5		0	28	100
	Total suspended solids			30	50		8	28	71
Category II outfalls	Downstream pH (SU)				9.0	6.0	0	161	100
	Downstream temperature (°C)[e]				30.5		0	35	100
	Oil and grease			10	15		0	159	100
	pH (SU)				9.0	6.0	0	161	100
	Total suspended solids			30	50		15	159	91
Cooling Systems	Chlorine, total residual				0.2		0	35	100
	Chromium, total				1.0		0	34	100
	Copper, total			0.5	1.0		0	34	100
	Downstream pH (SU)				9.0	6.0	0	34	100
	pH (SU)				9.0	6.0	0	34	100
	Temperature (°C)			35	38		0	34	100
	Zinc, total			0.5	1.0		0	34	100

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

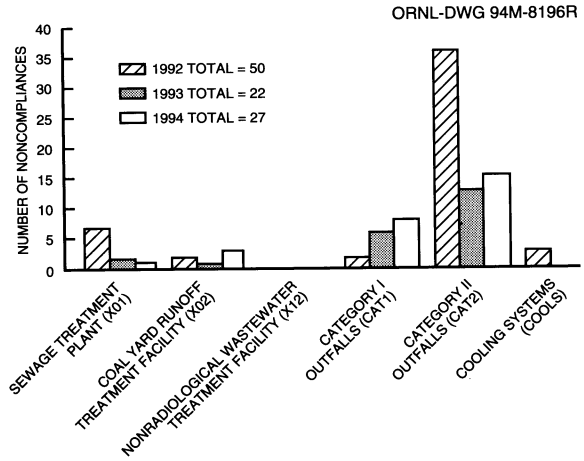

Fig. 4.26. ORNL NPDES noncompliance status comparison and sources of noncompliances, 1992–94.

relocated to the downstream side of the discharge flume. At X12, all parameters were 100% in compliance. ORNL had no fish kills in 1994.

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

Mercury in the Aquatic Environment

The mercury monitoring program at ORNL is conducted to comply with the CWA and Part III of ORNL's NPDES permit. Samples of surface water and stream sediment in Bethel and Melton valleys are collected semiannually and analyzed for mercury content. The primary purpose of this effort is to identify, locate, and minimize all mercury contamination from ORNL discharged to the aquatic environment.

Prior to the stringent regulations now in effect, some contaminants reached various streams, primarily as the result of accidental spills or leakages. Most mercury spills occurred from 1954 through 1963, when ORNL was involved with OREX and METALLEX separations processes. Most of this activity occurred in or around buildings 4501, 4505, and 3592. These processes are no longer in operation at ORNL. During the time of operation, an unknown number of mercury spills occurred. The spills were cleaned up; however, some quantities of mercury escaped and reached the surrounding environment. Sampling locations have been placed in areas surrounding known mercury spills; near outfalls from building areas with a history of mercury concern; and near outfalls from storage areas, spill areas, roads, and parking lot drains. Additional sampling locations have been placed downstream from the outfalls and drains to determine the extent to which any mercury has been transported in surface water and sediment.

Surface water locations are shown in Fig. 4.27. A total of 78 samples were taken from 13 locations. Samples were collected by the manual grab method and placed in 500-mL polyethylene bottles with the teflon-lined polyethylene caps. In the laboratory, the samples were analyzed for total mercury content by manual cold vapor atomic absorption. Mercury was detected at 5 of the 13 sampling locations, in contrast to 8 of 13 locations in 1993. The highest value reported was 0.43 μg/L near Outfall 207 in White Oak Creek; average concentrations ranged from 0.050 to 0.22 μg/L. The Tennessee Water Quality Criteria for

ORNL-DWG 92M-13528R2

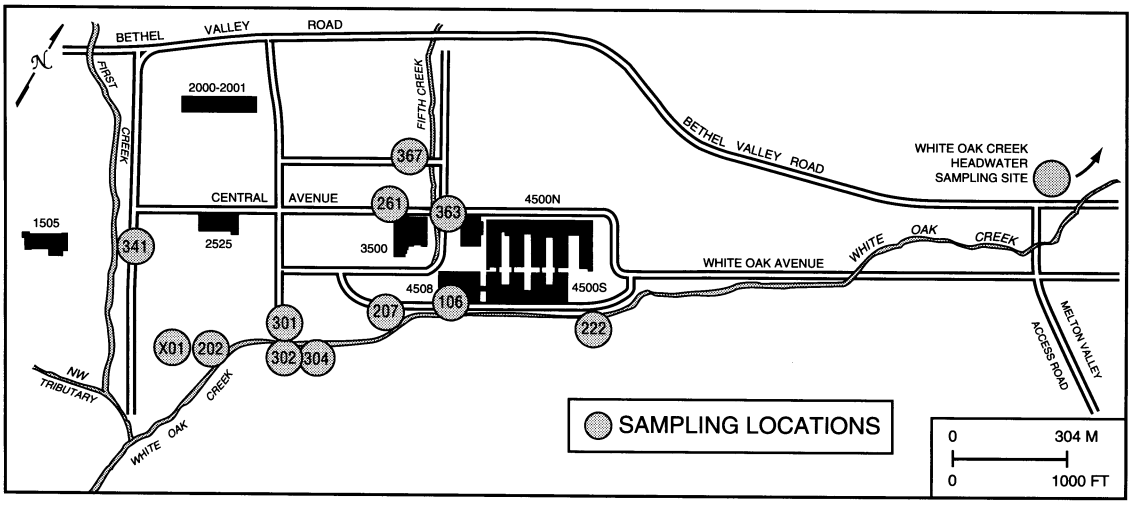

Fig. 4.27. ORNL sampling locations for mercury in water.

the protection of fish and aquatic life has set a maximum concentration of 2.4 μg/L for mercury in water. The highest concentration, near Outfall 207, was 18% of the reference value.

Sediment sampling locations are shown in Fig. 4.28. A total of 54 sediment samples were taken from 9 stream locations. Samples were collected by the manual grab method and placed in glass containers. In the laboratory, the samples were analyzed for total mercury content by manual cold vapor atomic absorption. The highest value reported was 190 μg/g near Outfall 261 on Fifth Creek. Average values at the other sites ranged from 0.058 μg/g to 11 μg/g. In general, results from samples collected in 1994 were similar to those for 1993.

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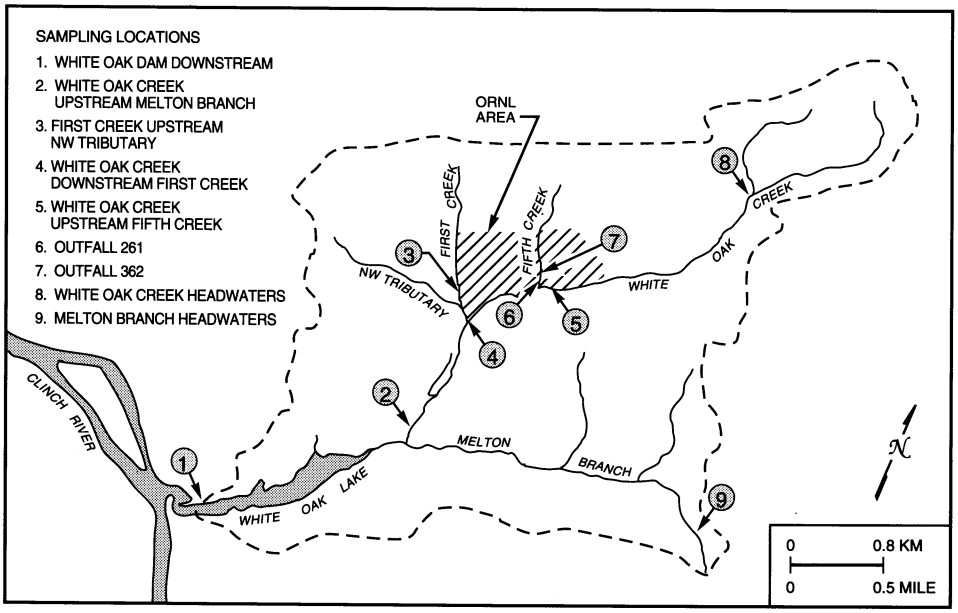

Fig. 4.28. ORNL sampling locations for mercury in sediment.

PCBs in the Aquatic Environment

The PCBs program at ORNL is conducted to comply with the CWA and Part III of ORNL's NPDES permit. Samples of stream sediment are collected semiannually and analyzed for PCB aroclor content. The program to collect water samples for PCB analysis was dropped in 1992 because PCB levels in the water samples had been below analytical detection limits for several years. There are currently no regulatory guidelines for PCB concentrations in stream sediment.

Duplicate samples of sediment were collected at ten locations in streams at and around ORNL (Figs. 4.29 and 4.30). Samples from each location were analyzed by the analytical laboratory for aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260. Only three locations had results above detection limits. Four additional locations had laboratory-estimated values below the detection limit. The two maximum concentrations, 2200 μg/kg for aroclor-1254 and 1400 μg/kg for aroclor-1260, were reported on White Oak Creek, upstream of the weir at the 7500 Road Bridge. This location represents the area of maximum sediment deposition and collectively represents potential releases from upstream locations in the ORNL main plant area. Detected aroclor levels are similar to or slightly lower than those detected in 1993. Results for most samples collected in 1994 either were below laboratory detection limits or were estimated by the laboratory.

K-25 Site Surface Water Effluents

The K-25 Site was issued a new NPDES permit on October 1, 1992. Currently, this permit covers 7 major outfalls and 135 storm drain outfalls. All process water discharges from the plant pass through an NPDES permitted monitoring point and discharge to the Clinch River, Mitchell Branch, or Poplar Creek. Compliance with the permit for the last 5 years is summarized by the major effluent locations in Fig. 4.31. Table 4.20 details the permit requirements and compliance records for all of the outfalls that discharged during 1994. The table provides a list of the discharge points, effluent analytes, permit limits,

ORNL-DWG 92M-13529R2

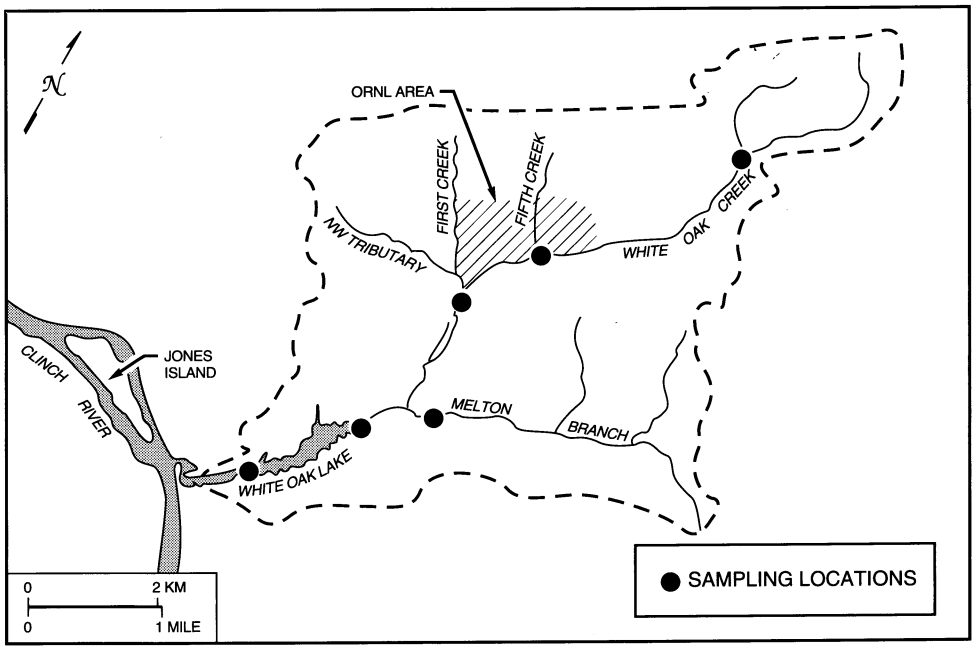

Fig. 4.29. ORNL sampling locations for polychlorinated biphenyls.

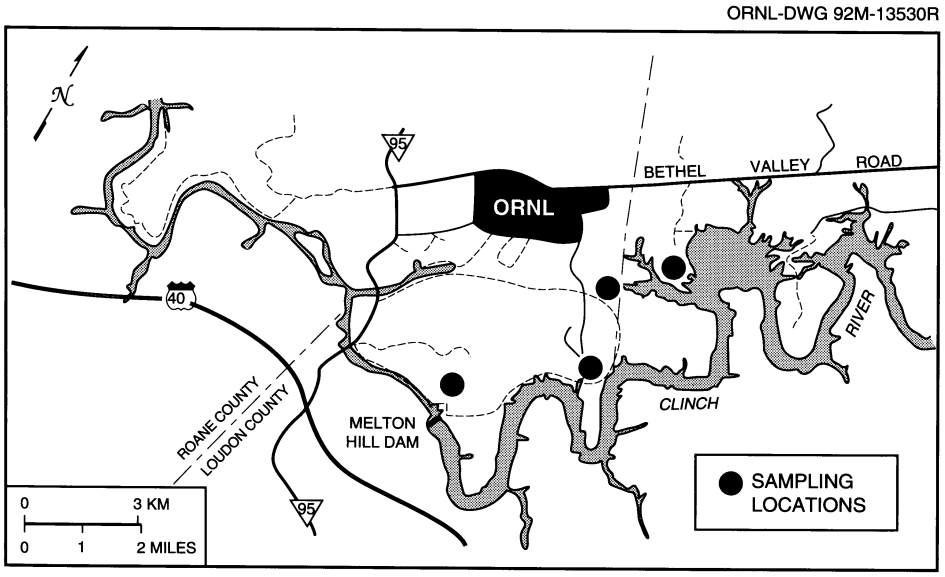

Fig. 4.30. Sampling locations for polychlorinated biphenyls in the greater ORNL area.

number of noncompliances, and the percentage of compliance for 1994. Samples from these outfalls are collected and analyzed as specified in the NPDES permit.

The following are the seven major outfalls at the K-25 Site (Fig. 4.22):

- 005 (K-1203 Sewage Treatment Plant),
- 009 (K-1515 Sanitary Water Treatment Facility),
- 010 (K-1407-E Pond),
- 011 (K-1407-J Central Neutralization Facility discharge to Poplar Creek),
- 012 (K-1407-F Pond),
- 013 (K-1513 Sanitary Water Intake Backwash Filter), and
- 014 (K-1407-J Central Neutralization Facility discharge to the Clinch River).

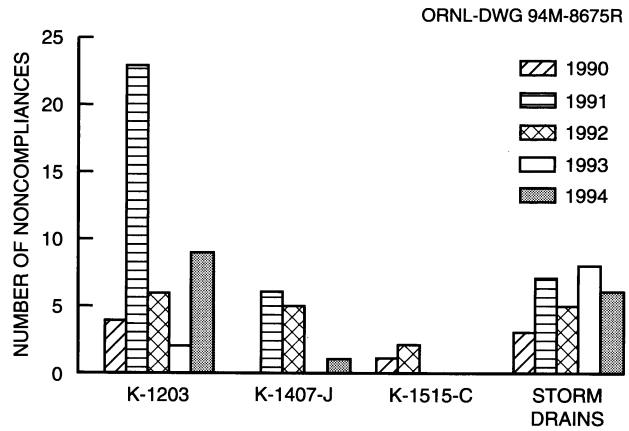

Fig. 4.31. K-25 Site NPDES compliance history by source of noncompliance.

In accordance with the compliance schedule in Section E of the NPDES permit, the discharges through outfalls 010 and 012 ceased permanently on December 30, 1993. Neither of these outfalls had any discharges during 1994. Although no monitoring was required at Outfall 013, routine inspections were conducted to ensure that no unsightly debris or scum discharged through this point as the result of backwash operations from the K-1513 sanitary intake filter. Outfall 014, which is currently under construction, is a permitted outfall for the discharge of effluent from the CNF to the Clinch River. This effluent is currently discharged to Poplar Creek through Outfall 011. Section E of the permit requires that discharges through Outfall 011 cease and discharges through Outfall 014 start by April 30, 1996. As of November 1994, construction for this project was

Table 4.20. NPDES compliance at the K-25 Site, 1994

Discharge point	Effluent parameter	Effluent limits				No. of noncompliances	Percentage of compliance
		Monthly av[a]	Daily max[a]	Monthly av (kg/d)	Daily max (kg/d)		
005 (K-1203 Sewage Treatment Facility)	Ammonia nitrogen	5	7	12	17		100
	Biochemical oxygen demand	15	20	37	49	2	98.7
	Chlorine, total residual	0.14	0.24				100
	Dissolved oxygen		5[b]				100
	Fecal coliform, col/100 ml	200[c]	400			6	92.3
	Flow, Mgd	*d*	*d*				100
	LC_{50}, *Ceriodaphnia*, %		14.6[b]				100
	LC_{50}, *Pimephales*, %		14.6[b]				100
	NOEL,[e] *Ceriodaphnia*, %		4.2[b]				100
	NOEL,[e] *Pimephales*, %		4.2[b]			1	83.3
	pH, standard units		6.0–9.0				100
	Settleable solids, mL/L		0.5				100
	Suspended solids	30	45	74	111		100
	Unpermitted discharge	*f*	*f*	*f*	*f*		*f*
009 (K-1515-C Sanitary Water Plant)	Aluminum	1.0	2.0				100
	Chlorine, total residual		1.0				100
	Flow, Mgd	*d*	*d*				100
	pH, standard units		6.0–9.0				100
	Settleable solids, mL/L		0.5				100
	Suspended solids	30	40				100
	Unpermitted discharge	*f*	*f*	*f*	*f*		*f*
011 (K-1407-J Central Neutralization Facility)	1,1,1-Trichloroethane	*d*	*d*				100
	Acetone	*d*	*d*				100
	Acetonitrile	*d*	*d*				100
	Benzene	*d*	*d*				100
	Bromoform	*d*	*d*				100
	Cadmium	0.18	0.69				100
	Carbon tetrachloride	0.5	0.5				100
	Chemical oxygen demand	*d*	*d*				100
	Chloride, total	9711	39,479				100
	Chlorine, total residual		0.14			1	99.7
	Chlorodibromomethane	*d*	*d*				100
	Chloroform	0.5	0.5				100
	Chromium	1.71	2.77				100
	Copper	1.34	2.15				100
	Dichlorobromomethane	*d*	*d*				100
	Flow, Mgd	*d*	*d*				100
	Ethylbenzene	*d*	*d*				100
	Gross alpha, pCi/L	*d*	*d*				100
	Gross beta, pCi/L	*d*	*d*				100
	LC_{50}, *Ceriodaphnia*, %		7.05[b]				100
	LC_{50}, *Pimephales*, %		7.05[b]				100
	Lead	0.38	0.69				100
	Methyl ethyl ketone	*d*	*d*				100
	Methylene chloride	*d*	*d*				100
	Naphthalene	*d*	*d*				100
	Nickel	2.38	3.98				100
	NOEL,[e] *Ceriodaphnia*, %		2.11[b]				100
	NOEL,[e] *Pimephales*, %		2.11[b]				100
	Oil and grease		30				100
	PCB	0.00014	0.00014				100
	pH, standard units		6.0–9.0				100
	Silver	0.24	0.43				100
	Suspended solids		40				100
	Temperature, °C	*g*	*g*				100

Table 4.20 (continued)

Discharge point	Effluent parameter	Effluent limits				No. of noncompliances	Percentage of compliance
		Monthly av[a]	Daily max[a]	Monthly av (kg/d)	Daily max (kg/d)		
	Tetrachloroethylene		0.7				100
	Toluene	*d*	*d*				100
	Total toxic organics		2.13				100
	Trichloroethylene	0.5	0.5				100
	Unpermitted discharge	*f*	*f*	*f*	*f*		*f*
	Uranium, total	*d*	*d*				100
	Vinyl chloride	0.2	0.2				100
	Zinc	1.48	2.61				100
Category I storm drains	Flow, Mgd	*d*	*d*				100
	pH, standard units		4.0–9.0				100
	Unpermitted discharge	*f*	*f*	*f*	*f*		*f*
Category II storm drains	Flow, Mgd	*d*	*d*				100
	pH, standard units		4.0–9.0				100
	Suspended solids	*d*	*d*				100
	Unpermitted discharge	*f*	*f*	*f*	*f*		*f*
Category III storm drains	Flow, Mgd	*d*	*d*				100
	Oil and grease	*d*	*d*				100
	pH, standard units		4.0–9.0				99.7
	Suspended solids	*d*	*d*				100
	Unpermitted discharge	*f*	*f*	*f*	*f*	1	*f*
Category IV storm drains (to Poplar Creek)	Chlorine, total residual		0.14			3	98.1
	Flow, Mgd	*d*	*d*				100
	Oil and grease	*d*	*d*				100
	pH, standard units		6.0–9.0				99.3
	Suspended solids	*d*	*d*				100
	Unpermitted discharge	*f*	*f*	*f*			*f*
Category IV storm drains (to Mitchell Branch)	Chlorine, total residual		0.019			1	99.5
	Flow, Mgd	*d*	*d*				100
	Oil and grease	*d*	*d*				100
	pH, standard units		6.0–9.0				100
	Suspended solids	*d*	*d*				100
	Unpermitted discharge	*f*	*f*	*f*	*f*	1	*f*

[a]Units are mg/L unless otherwise stated.
[b]Daily minimum.
[c]Geometric mean.
[d]Nonlimited parameter.
[e]No-observed-effect limit.
[f]Not applicable.
[g]Effluent must not cause the temperature of the receiving stream to exceed 30.5°C.

35% complete; however, because of safety issues, the subcontractor who was performing this work was terminated. Additional funds will be required to complete the project as originally scoped.

Results

Outfall 005 is the discharge point for the K-25 Site Sewage Treatment Plant, which is an extended aeration treatment plant having a rated capacity of 2.3 million L/d (0.6 Mgd) and a current use of about 1.4 million L/d (0.36 Mgd). Treated effluent from the main plant is discharged into Poplar Creek through this outfall. This facility had nine permit noncompliances during 1994. Six of these were fecal coliform permit limit exceedences,

five of which were the direct result of heavy rainfall events that caused excessive flow through the plant, thereby exceeding the treatment capacity of the disinfection system. These exceedences were classified as upsets in accordance with the NPDES permit. The sewage plant was placed in service in 1976, and many factors, including age, have contributed to degradation of the sewer system piping network. The degradation has allowed infiltration of storm water and groundwater into the system, which contributes to influent volumes exceeding the plant design capacity. A sanitary sewer upgrade project to minimize infiltration was initiated in 1990. Phase 1 of this project included raising the on-site manholes. Phase 2 of the project, which started in November 1994, includes relining of the sanitary sewer system pipes by a subcontractor. By the end of 1994, approximately 8000 linear feet of pipe were relined. Relining activities will continue in 1995. In addition to the upgrade project, sewage treatment plant personnel have implemented several operational changes during heavy rainfall events to minimize the chance of upsets. The sixth fecal coliform exceedence was caused by bacterial regrowth in the effluent stream subsequent to UV treatment. The previous upsets had caused sludge to accumulate in the chlorine contact basin downstream of the UV system. This sludge is a medium of bacterial regrowth, and it contaminated the effluent. From March until May 1994, when this exceedence occurred, the UV disinfection was solely relied on for disinfection. Subsequently, however, chlorine feed for additional disinfection was reinstated to ensure that no additional exceedences occur. Additional precautions such as relocating the discharge of the screen washing process to the plant influent and removing the sludge from the chlorine contact basin were implemented in May 1994. The previously mentioned upsets during the spring of 1994 were the root causes for a biological oxygen demand (BOD) exceedence and a failed toxicity test, both of which were noncompliances. The ninth noncompliance at the Sewage Treatment Plant occurred because of a laboratory administration error during a BOD sample analysis. BOD results are required to be read after 5 days of sample incubation. In September 1994, a routine BOD sample was read after 2 days of incubation, and the sample was then discarded. The results should have been obtained after 5 days. Laboratory personnel have reviewed their procedures and have implemented several changes to their BOD sample tracking protocol to prevent recurrence of this situation.

Outfall 009 is the discharge point for the K-1515 Sanitary Water Plant, which provides sanitary water to the K-25 Site to be used for drinking, fire protection, and other purposes. It also provides water to two industries in the Bear Creek Road Industrial Park through an arrangement with the city of Oak Ridge. Raw water is taken from the Clinch River and treated at K-1515. During treatment, residual streams are managed by discharging them to the K-1515-C settling lagoon located adjacent to K-1515 and then to the Clinch River through Outfall 009. In accordance with Section E of the permit, a new lagoon is currently being constructed and will discharge to the Clinch River by September 30, 1995. This location exhibited 100% compliance with the NPDES permit during 1994.

Outfall 011 is the current discharge point for the CNF, which has provisions for the treatment of nonhazardous and hazardous wastes. Nonhazardous flow entering the CNF consists of steam plant effluents and various small-quantity or infrequent streams from waste disposal requests. Hazardous streams include effluents from the TSCA incinerator, the steam plant hydrogen softener waste stream, and various small-quantity or infrequent streams from waste disposal requests. After treatment, these waste streams are currently discharged to Poplar Creek. By April 1996, they will discharge to the Clinch River through Outfall 014. This facility had one noncompliance in 1994 for a total residual chlorine permit limit exceedence. Upon notification of the exceedence, all discharge activities

ceased and an additional amount of dechlorination chemical was added. A direct cause for this noncompliance could not be determined; however, the following corrective actions were taken to reduce the chances of a recurrence: (1) treated effluent is now used as the makeup water for the backwash tank instead of chlorinated sanitary water; (2) daily chlorine readings are taken in the settling basin to ensure that the chlorine level is below the NPDES Permit limit; (3) site personnel use sodium metabisulfite as the dechlorination chemical instead of sodium thiosulfate; and (4) a continuous, in-line chlorine monitor and alarm system was installed in the sludge thickener.

The 135 storm drain outfalls are grouped into four categories based on their potential for pollutants to be present in their discharge. Category I storm drains have intermittent flow and drain storm water runoff from areas remotely associated with plant activities and subsurface runoff; Category II storm drains have intermittent flow and drain stormwater runoff from building roof drains and paved areas associated with plant activities; Category III storm drains have intermittent flow and drain storm water runoff from areas associated with concentrated storage areas, roof drains, coolant systems, and parking lots; and Category IV storm drains have continuous flow and drain cooling water discharges and runoff from industrial areas. Monitoring at storm drain outfalls is conducted semiannually, quarterly, monthly, or weekly for Categories I through IV, respectively, with those storm drains that have the highest potential for pollution being sampled most frequently. During 1994 Outfalls 152 and 994 were removed from the permit because they do not discharge directly to waters of the state. For that reason, summary statistics for storm drains 152 and 994 are not in this report.

The remaining six noncompliances occurred at storm drain outfalls. Three were caused by elevated total residual chlorine readings at storm drain 190, which is a Category IV storm drain. Historically, chlorine has been the primary pollutant in the Category IV storm drains because they once contained cooling water and sanitary water. Upon notification of each chlorine exceedence, site personnel began an investigation to determine the chlorine sources. No sources were found in any instance. Additional monitoring of several catch basins that flow into Outfall 190 did not indicate elevated levels of chlorine. During May through August 1993, a project to identify possible chlorinated water sources to storm drains was initiated. The project surveyed several K-25 Site buildings' sinks and drains by dye testing. Sinks and drains that tied into the storm sewer system were identified and rerouted to the appropriate wastewater treatment facility. Additionally, site personnel performed building assessments to identify additional chlorinated sources (i.e., chlorinated cooling units). All identified sources discharging to the storm drain system were eliminated by rerouting to a wastewater treatment facility.

In 1994 another project was initiated that used video cameras to survey the physical conditions of the K-25 Site storm drain network. Outfall 190 is included in this comprehensive storm drain survey and will be upgraded/modified based on survey results. Another storm drain noncompliance occurred during the annual characterization of the K-25 Site storm drains, which is required by the NPDES permit. This characterization requires sampling for all suspected contaminants. PCBs are suspected contaminants that are sampled for in all K-25 Site storm drains. Part I, Section A, of the permit states, "There shall be no discharge of PCB from electrical switchyards." This means that PCBs above the detection limit in a switchyard storm drain discharge is considered a noncompliance with the NPDES permit. Such an event occurred during the annual characterization sampling of Outfall 700. An investigation of the potential sources of PCB was conducted upon notification of the sample results. PCBs were detected in two sumps that drain to Outfall 700. This investigation is continuing; corrective actions will be implemented in

accordance with the findings. The remaining two noncompliances were an unpermitted discharge to a storm drain and the appearance of a visible sheen on receiving waters. These incidents occur for reasons such as spills, pipeline breaks, and inappropriate storm drain connections. All NPDES noncompliances were reported under the Occurrence Reporting System (ORS). Corrective actions to prevent reoccurrence were documented and tracked under the ORS.

Of the 15 cooling towers on the K-25 Site, only five are active. The remaining ten are scheduled for decontamination and decommissioning. None of the active cooling towers discharged blowdown to the storm drainage system during 1994.

A Storm Water Pollution Prevention Program (SWPPP) is another requirement of the NPDES permit. The K-25 SWPPP was initiated in October 1993 and addresses the following components:

- the storm water monitoring program;
- a site assessment;
- best management practices;
- development of a site map;
- inspections, evaluation, and record keeping; and
- definition of organizational responsibilities.

The sampling program was conducted to evaluate and characterize storm water runoff. Storm drains were monitored for various contaminants, depending on the types of areas drained by the system. Every storm drain was sampled for PCBs, chemical oxygen demand, and radioactivity. Very low concentrations of PCBs were detected in 18 storm drains. Because of spills and past storage practices, PCBs can be present in environmental media and can discharge slowly through storm waters. All storm drains were sampled for gross alpha and gross beta radioactivity. There was no sitewide trend of radioactive contamination, but almost all of the areas that contained elevated levels have known sources of radioactive contamination. Through the evaluation of storm water effluent, further sampling or investigation was defined, and pollutant sources and areas for corrective actions were identified.

A sampling and analysis plan was developed with the information from the 1987 and 1994 sampling results, knowledge of various processes and functions conducted at the K-25 Site, material storage and handling practices, and waste disposal practices in the drainage areas for each outfall. Storm drains that drained similar areas were grouped during 1994 to eliminate the number of storm drains to be sampled. Thirty storm drains were placed into six groups located at the powerhouse area. One storm drain from each group and all other outfalls will be sampled during 1994–95. Dry- and wet-weather samples are planned to be collected at continuous-flow storm drains along with water and sediment sampling to be conducted within the piping systems.

An assessment of the K-25 Site was conducted to determine which areas, activities, or materials may be contributing pollutants to the storm drain system. When a potential source was identified, management practices were reviewed to determine if there was a risk of pollutants entering storm water. If there was a risk, either corrective actions were identified or best management practices were applied. Best management practice plans were developed for the TSCA Incinerator, the CNF, the K-1501 Steam Plant, and the K-1414 Garage. These facilities were considered to be at risk because of the nature of the activities and because they are operating facilities. In the future year, best management practice plans will be developed for the K-1417 Drum Storage Yard and for construction activities

because contaminants may reach storm water. There are also three ongoing activities that are considered to be sitewide best management practices because they provide the site with information on contamination, transport of storm water, and effects of contamination. These three best management practices are the storm drain survey, radiological survey, and BMAP.

An SWPPP Site Map was developed to bring all of the site data together in a visual aid. Knowing the location of all identified potential pollutant sources in relation to the storm drain system (and sensitive environmental areas) gives the user an idea of potential pollutants that can be expected to be found at a particular outfall. By using the map, pollutants can be traced from an outfall to a source or from a potential source to its respective outfall.

Two semiannual inspections were performed in 1994. The first site inspection performed in March 1994 included a review of the effectiveness of site-specific pollution prevention measures including existing best management practices, sedimentation and erosion control measures, and visual observation of selected storm drains during a rain event. The second semiannual inspection was performed in September 1994 and included inspection of all outdoor secondary containment structures. Corrective actions were developed from the inspections, and all immediate concerns were addressed.

A "Responsibilities" section was added to the SWPPP to define the roles and responsibilities that other organizations have in storm water pollution prevention. Storm water pollution prevention is the responsibility of the entire K-25 Site. However, many organizations can have more of an impact on storm water and therefore, have more responsibilities (such as erosion control on earth-moving projects).

TOXICITY CONTROL AND MONITORING PROGRAM

Y-12 Plant Toxicity Control and Monitoring Program

In accordance with Part III of the NPDES permit issued to the Y-12 Plant, the plant is required to develop and implement a TCMP. Under the TCMP, various permitted discharges are evaluated for toxicity. Results of the toxicity tests from three wastewater treatment facilities (Central Pollution Control Facility, SPWTF, and Groundwater Treatment Facility), and one proposed permitted outfall (Outfall 201) are given in Table 4.21. For each wastewater, the table shows the date the test was initiated, the no-observed-effect concentration (NOEC) for fathead minnows and *Ceriodaphnia*, and the calculated in-stream waste concentration (IWC).

Effluent from the Groundwater Treatment Facility was tested three times in 1994 (January, April, and October) with fathead minnows and *Ceriodaphnia*. The effluent's NOECs were <6%, 3%, and 30% for fathead minnows and 12%, 3%, and 30% for *Ceriodaphnia*. The calculated IWCs (0.41% and 0.37%) were below the NOECs; therefore, it is unlikely that treated effluent from the Groundwater Treatment Facility would adversely affect the aquatic biota in East Fork Poplar Creek.

Effluent from the Central Pollution Control Facility was tested twice with fathead minnows and *Ceriodaphnia*. The fathead minnow test conducted in May was invalid and the effluent was retested in July. The treated effluent from the Central Pollution Control Facility had an NOEC of 50% for fathead minnows and 12% for *Ceriodaphnia*. The calculated IWC of Central Pollution Control Facility effluent in EFPC was 0.75% in May and 0.30% in July. Because the IWCs were less than the NOECs, it is unlikely that treated effluent from that facility would adversely affect the aquatic biota in EFPC.

Table 4.21. Y-12 Plant Toxicity Control and Monitoring Program (TCMP) summary information for 1994[a]

Site/Building	Test date	Species	NOEC[b] (%)	IWC[c] (%)
Groundwater Treatment Facility (Outfall 512)	1/27	Fathead minnow		0.41
		Ceriodaphnia	12	0.41
Steam Plant Wastewater Treatment Facility	2/3	Fathead minnow	6	7.35
		Ceriodaphnia	12	7.35
Proposed Outfall 201	3/10	Fathead minnow	100	*d*
		Ceriodaphnia	8	*d*
Groundwater Treatment Facility (Outfall 512)	4/7	Fathead minnow	3	0.37
		Ceriodaphnia	3	0.37
Central Pollution Control Facility (Outfall 501)	5/12	Fathead minnow	1	
		Ceriodaphnia	12	0.75[e]
Central Pollution Control Facility (Outfall 501)	7/14	Fathead minnow	50	0.30
		Ceriodaphnia	12	0.30
Proposed Outfall 201	7/14	Fathead minnow	<80	*d*
		Ceriodaphnia	100	*d*
Groundwater Treatment Facility (Outfall 512)	10/13	Fathead minnow	30	*f*
		Ceriodaphnia	30	*f*

[a]These 7-day toxicity tests using fathead minnows and *Ceriodaphnia* were completed in 1994 as part of the TCMP conducted for the Y-12 Plant by ORNL. Summarized are the effluents and their corresponding no-observed-effect concentrations and in-stream waste concentrations (IWCs). NOTE: Discharge from the treatment facilities is intermittent because of batch operations.

[b]No-observed-effect concentrations.

[c]The IWC based on actual flows at East Fork Poplar Creek, Station 8.

[d]This is an in stream point; therefore, an IWC is not applicable.

[e]The IWC was calculated on 5/17/94.

[f]Data not available.

Effluent from the SPWTF was tested once with fathead minnows and *Ceriodaphnia*. The NOECs for effluent from the SPWF were 6% for fathead minnows and 12% for *Ceriodaphnia*. The calculated IWC for this effluent was 7.35%.

The proposed permitted outfall (Outfall 201) was tested twice in 1994 (March and July). Water from this site reduced *Ceriodaphnia* reproduction in March (NOEC = 80%) and fathead minnow survival in July (NOEC = ≤80%).

ORNL Toxicity Control and Monitoring Program

Under the TCMP, wastewaters from the Sewage Treatment Plant, the Coal Yard Runoff Treatment Facility, and the NRWTF were evaluated for toxicity. In addition, two ambient in-stream sites were evaluated; one site is located on Melton Branch (NPDES permit point X13) and the other on White Oak Creek (permit point X14). The results of the toxicity tests of wastewaters from the three treatment facilities and the two ambient stream

sites are given in Table 4.22. This table provides, for each wastewater and ambient water, the month the test was conducted, sample treatment (if any), the wastewater's NOEC for fathead minnows and *Ceriodaphnia*, and the IWC, if appropriate. The NOEC is the concentration that did not reduce survival or growth of fathead minnows or survival or reproduction of *Ceriodaphnia*. Average water quality measurements obtained during each toxicity test are shown in Table 4.23.

During 1994, the Coal Yard Runoff Treatment Facility and the NRWTF were tested twice each, and the Sewage Treatment Plant was tested five times. The Coal Yard Runoff Treatment Facility wastewater's NOECs were 100% for fathead minnows and 50% and 12% for *Ceriodaphnia*. The corresponding wastewater's IWCs were 0.5% and 8.0%. Because the IWC was consistently lower than the NOEC, it is unlikely that wastewater from the Coal Yard Runoff Treatment Facility adversely affected the aquatic biota of White Oak Creek during 1994.

Full-strength wastewater from the NRWTF was not toxic to *Ceriodaphnia* during the April and October tests; therefore, no IWC was calculated on the NRWTF for 1994. Fathead minnow testing for this facility was discontinued as allowed in the NPDES permit guidelines. The Sewage Treatment Plant wastewater's NOEC for *Ceriodaphnia* ranged from 6% to 50% during 1994. The NOEC for the Sewage Treatment Plant was 6% in April, 12% on two occasions (April and November), 50% in July, and 25% in September. Per guidelines in the NPDES permit, no fathead minnow tests were conducted for the Sewage Treatment Plant. Because the IWC exceeded the NOEC for both tests conducted in April, a Toxicity Control Plan for the Sewage Treatment Plant was developed and implemented in July, and toxicity testing for this facility was increased to every other month.

During 1994 the Melton Branch (X13) site was tested 11 times, and the White Oak Creek (X14) site was tested 10 times. Water from X13 reduced fathead minnow survival on five occasions (April, May, October, November, and December) and *Ceriodaphnia* reproduction on two occasions (February and December). Confirmatory tests conducted in May and November again resulted in reduced fathead minnow survival. Follow-up confirmatory tests conducted in June and December showed the water to be nontoxic; thus the toxicity appeared to be transient. Confirmatory tests using *Ceriodaphnia* were conducted in February and December. Both confirmatory tests resulted in NOECs of 100%. Water from X14 reduced fathead minnow survival on two occasions (April and May) and *Ceriodaphnia* reproduction on two occasions (August and December). A confirmatory test of fathead minnows, conducted in May, again resulted in reduced fathead minnow survival. A secondary confirmatory test conducted in June showed the water to be nontoxic; thus the toxicity appeared to be transient. Confirmatory tests using *Ceriodaphnia* were conducted in September and December. Both confirmatory tests resulted in NOECs of 100%. To determine whether fathead minnow mortality in the ambient water samples might be caused by a fungal or bacterial pathogen, water from X13 and X14 was exposed to UV light for a 20-min period. Tests of water from sites X13 and X14 showed improved fathead minnow survival or growth in water treated with UV light (NOECs were 100%).

K-25 Site Toxicity Control and Monitoring Program

The NPDES permit requires that toxicity testing be performed bimonthly at Outfall 005 and Outfall 011 during the first 12 months it is in effect. If any of the toxicity tests fail at a particular location during this period, the permit requires the location to remain on a bimonthly sampling schedule; however, if a location passes every test during this time, the sampling requirement is reduced to a semiannual frequency for the remainder of the permit.

Table 4.22. 1994 toxicity test results of ORNL wastewaters and ambient waters

Outfall	Test date	Treatment[a]	Fathead minnow NOEC[b] (%)	*Ceriodaphnia* NOEC[b] (%)	IWC[c] (%)
Coal Yard Runoff Treatment Facility (X02)	May	N	100	50	0.5
	Nov	N	100	12	8.0
Sewage Treatment Plant (X01)	Apr	N	*d*	12	37.2
	Apr[e]	N	*d*	6	22.8
	July	N	*d*	50	24.5
	Sep	N	*d*	25	19.2
	Nov	N	*d*	12	15.7
Nonradiological Wastewater Treatment Plant (X12)	Apr	N	*d*	100	*f*
	Oct	N	*d*	100	*f*
Melton Branch (X13)	Feb	N	100	80	
		UV	100	*d*	
	Feb[e]	N	*d*	100	
	Apr	N	80	*g*	
		UV	100	*d*	
	May[e]	N	*g*	100	
		UV	*g*	*d*	
	May[e]	N	<80	*d*	
		UV	100	*d*	
	June	N	100	100	
		UV	100	*d*	
	Aug	N	100	100	
		UV	100	*d*	
	Oct	N	<80	100	
		UV	100	*d*	
	Nov[e]	N	<80	*d*	
		UV	100	*d*	
	Dec	N	<80	80	
		UV	100	*d*	
	Dec[e]	N	100	100	
		UV	100	*d*	
White Oak Creek (X14)	Feb	N	100	100	
		UV	100	*d*	
	Apr	N	80	*g*	
		UV	100	*d*	
	May	N	*g*	100	
		UV	*g*	*d*	
	May[e]	N	80	*d*	
		UV	100	*d*	
	June	N	100	100	
		UV	100	*d*	
	Aug	N	100	<80	
		UV	100	*d*	
	Sep[e]	N	*d*	100	
	Oct	N	100	100	
		UV	100	*d*	
	Dec	N	100	80	
		UV	100	*d*	
	Dec[e]	N	*d*	100	

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

Table 4.23. 1994 average water quality parameters measured during toxicity tests of ORNL wastewaters and ambient waters

Values are for full-strength wastewater for each test (N = 1 or 7) or averages of full-strength ambient water for each test (N = 7)

Outfall	Test date	pH (standard units)	Conductivity (µS/cm)	Alkalinity (mg/L $CaCO_3$)	Hardness (mg/L $CaCO_3$)
Coal Yard Runoff Treatment Facility (X02)	May	8.00	3240	23	1460
	Nov	7.29	3580	22	1510
Sewage Treatment Plant (X01)	Apr[a]	7.91	385	108	151
	Apr[b]	7.89	408	104	147
	July	7.91	331	81	140
	Sep	7.72	363	76	143
	Nov	7.82	450	76	168
Nonradiological Wastewater Treatment Facility (X12)	Apr	8.04	431	83	77
	Oct	7.85	626	58	108
Melton Branch (X13)	Feb[c]	7.95	392	90	184
	Feb[d]	7.07	215	71	109
	Apr	8.05	423	116	213
	May[e]	8.03	579	106	297
	May[f]	8.03	501	121	260
	June	8.04	430	101	211
	Aug	8.04	536	114	270
	Oct	7.83	680	92	335
	Nov	7.84	423	138	217
	Dec[g]	7.94	342	109	186
	Dec[h]	7.80	618	101	291
White Oak Creek (X14)	Feb	8.05	370	106	154
	Apr	8.16	308	107	139
	May[e]	8.17	322	107	146
	May[f]	8.11	337	106	145
	June	8.16	354	105	147
	Aug	8.08	367	97	161
	Sep	7.93	326	101	152
	Oct	8.00	391	105	165
	Dec[g]	8.00	368	116	181
	Dec[h]	7.97	401	117	167

[a]Data for test conducted April 7–14, 1994.
[b]Data for test conducted April 21–28, 1994.
[c]Data for test conducted February 3–10, 1994.
[d]Data for test conducted February 10–16, 1994.
[e]Data for test conducted May 12–19, 1994.
[f]Data for test conducted May 20–27, 1994.
[g]Data for test conducted December 8–15, 1994.
[h]Data for test conducted December 29–January 5, 1995.

Accordingly, toxicity testing was conducted at Outfall 005 and Outfall 011 bimonthly until October 1993. Outfall 011 passed every toxicity test during the first year of the permit; it was placed on a biannual testing schedule for 1994. It passed all toxicity tests that were conducted in 1994. Outfall 005 failed one toxicity test during 1993 and one during 1994; it will remain on a bimonthly sampling schedule.

The results of the toxicity tests of wastewaters from K-1407-J and K-1203 conducted during 1994 are given in Table 4.24. This table provides, for each wastewater, the month the test was conducted and the wastewater's no-observed-effect level (NOEL) and 96-hour lethal concentration for 50% of the test organisms (LC_{50}) for fathead minnows and *Ceriodaphnia*. Average water quality measures obtained during each toxicity test are shown in Table 4.25.

Effluent from K-1407-J (Outfall 011) was tested twice with fathead minnows and *Ceriodaphnia*. The effluent's NOELs were 75% on both occasions for fathead minnows and 7.05% and 25% for *Ceriodaphnia*. The LC_{50}s were >75% for fathead minnows and >25% and 53.49% for *Ceriodaphnia*. The toxicity tests conducted for this outfall were within the limits specified by the NPDES permit.

Table 4.24. 1994 K-25 Site NPDES Permit Number TN 0002950 toxicity test results

K-25 Site Outfall	Test date	Species	NOEL[a] (%)	LC_{50}[b] (%)	IWC[c] (%)
K-1407-J (Outfall 011)	May	Fathead minnow	75	>75	0.8
		Ceriodaphnia	7.05	53.49	0.8
	December	Fathead minnow	75	>75	0.6
		Ceriodaphnia	25	>25	0.6
K-1203 (Outfall 005)	January	Fathead minnow	100	>100	3.5
		Ceriodaphnia	100	>100	3.5
	March	Fathead minnow	<4.2	54.77	3.7
		Ceriodaphnia	100	>100	3.7
	March[d]	Fathead minnow	30	>100	N/A
	May	Fathead minnow	30	>100	1.8
		Ceriodaphnia	30	>100	1.8
	July	Fathead minnow	100	>100	2.2
		Ceriodaphnia	100	>100	2.2
	September	Fathead minnow	100	>100	2.2
		Ceriodaphnia	100	>100	2.2
	November	Fathead minnow	100	>100	2.1
		Ceriodaphnia	100	>100	2.1

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

Table 4.25. 1994 K-25 Site average water quality parameters measured during toxicity tests of the K-25 Site wastewaters
Values are averages of full-strength wastewater for each test (N = 7)

K-25 Site Outfall	Test date	pH (standard units)	Conductivity (µS/cm)	Alkalinity (mg/L $CaCO_3$)	Hardness (mg/L $CaCO_3$)
K-1407-J (011)	May	7.83	1659	51	371
	December	7.96	1554	88	614
K-1203 (005)	January	8.05	383	109	154
	March[a]	8.01	373	108	151
	March[b]	7.95	331	99	132
	May	8.03	363	86	144
	July	7.95	341	81	132
	September	7.92	382	83	153
	November	7.90	437	87	164

[a]Data are for test conducted March 3–10, 1994.
[b]Data are for test March 24–31, 1994.

Effluent from K-1203 was tested seven times with fathead minnows and six times with *Ceriodaphnia*. The effluent's NOELs were <4.2%, 30%, and 100% for fathead minnows and 30% and 100% for *Ceriodaphnia*. The LC_{50}s were 54.77% and >100% for fathead minnows and >100% for *Ceriodaphnia*. The test conducted in March resulted in a failure based on fathead minnow survival, and a confirmatory test also conducted in March showed the effluent to be nontoxic; thus the toxicity was transient. With the exception of the March fathead minnow test, all tests conducted for this outfall were within the limits specified by the NPDES permit.

BIOLOGICAL MONITORING AND ABATEMENT PROGRAM

Monitoring Contaminant Concentrations

BMAPs mandated by NPDES permits at the Y-12 Plant, ORNL, and the K-25 Site each contain tasks concerned with monitoring the accumulation of contaminants in the biota of receiving waters. The primary objectives of the contaminant accumulation studies are (1) to identify substances that accumulate to undesirable levels in biota as a result of discharges from DOE facilities, (2) to determine the significance of those discharges relative to other sources in determining contaminant concentrations in biota in receiving waters, and (3) to provide a baseline measure of biotic contamination to use in evaluating the effectiveness of any future remedial measures.

The nonradiological contaminants of most concern in biota are mercury and PCBs. Elevated concentrations (relative to local reference sites) of mercury and PCBs in biota are associated with discharges at all three facilities. Since 1985, concentrations of these substances in sunfish have been monitored at sites in EFPC downstream of the Y-12 Plant (Fig. 4.32). From 1985 to 1989, mean mercury concentrations in fish steadily decreased with distance downstream of the Y-12 Plant (Fig. 4.33). In general, this pattern was again evident in the May 1994 sampling period. However, from 1990 through December 1993 a downstream decreasing trend in EFPC was not apparent, largely as a result of lower mercury concentrations at EFK 23.4 during this period. The anomalously high mean mercury concentration at EFK 23.4 in May 1994 was influenced by the presence in the

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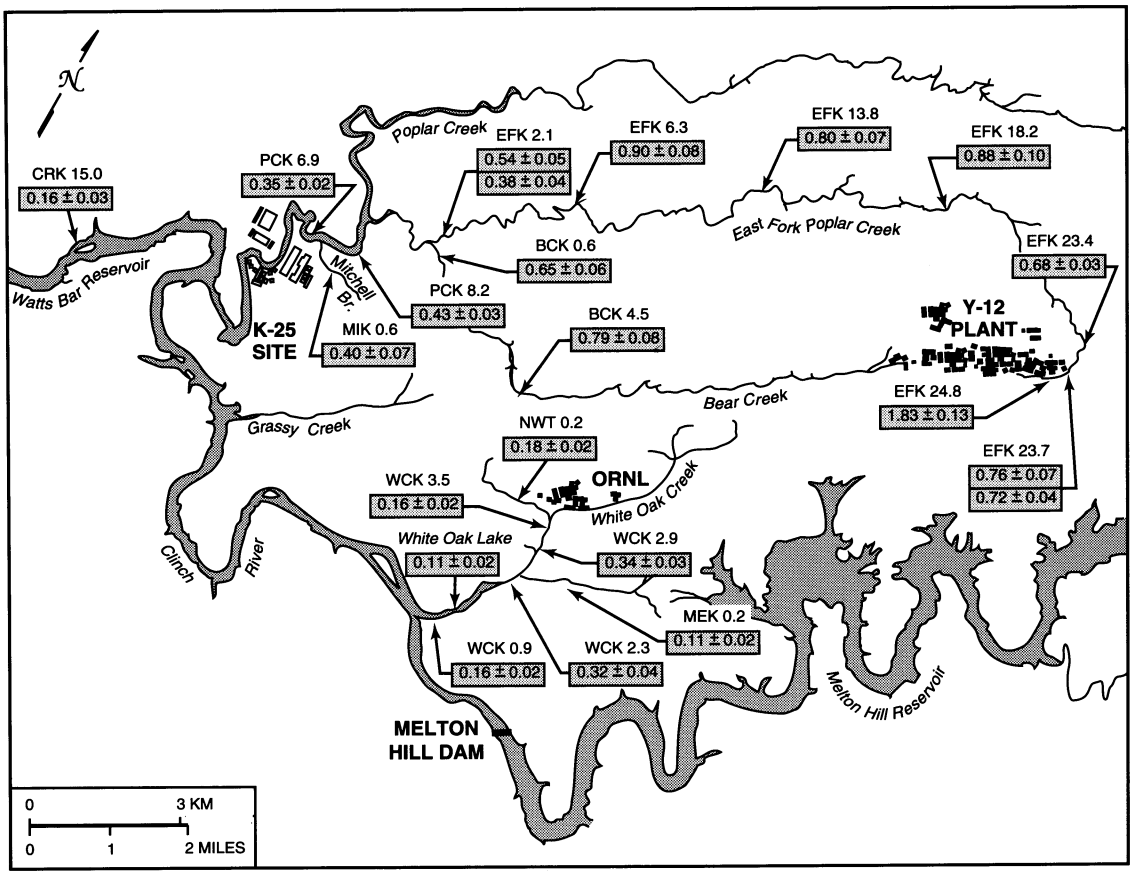

Fig. 4.32. Average concentrations (± standard error) of mercury (in micrograms per gram) in sunfish collected from November 1992 to March 1994 at sites on the ORR. Fish are redbreast sunfish (*Lepomis auritus*) at MIK 0.6, EFK sites (bottom values where two appear) and WCK 2.9, rock bass (*Ambloplites rupestris*) at BCK sites; and bluegill (*L. macrochirus*) at the remaining sites.

collection of one very highly contaminated fish that was more typical of the level of contamination in fish further upstream. The twofold to threefold higher concentrations in sunfish above Lake Reality suggest that Y-12 Plant discharges continue to be an important source of mercury in fish in the upper reaches of EFPC.

A pattern of decreasing concentration with distance downstream is apparent for PCBs in redbreast sunfish in EFPC (Fig. 4.34). Redbreast sunfish from EFK 23.4 and sites upstream (EFK 23.7, EFK 24.8) contained PCB concentrations in December 1993 substantially higher than those observed in fish from other EFPC sites. The high concentrations in fish at sites in UEFPC indicate the importance of the industrialized portion of the Y-12 Plant as a source in relation to contaminated sediment and soil downstream of Lake Reality. The mean PCB concentrations in fish increased substantially in December 1993 and May 1994 compared with concentrations observed in recent years (Fig. 4.35). At sites downstream of EFK 23.4, concentrations were similar to those observed over the period 1988 to 1992.

Sunfish collected in 1993 and 1994 again showed the presence of multiple sources of mercury and PCB contamination on the ORR. In addition to elevated concentrations in EFPC fish, elevated concentrations of mercury were clearly evident in fish from Poplar

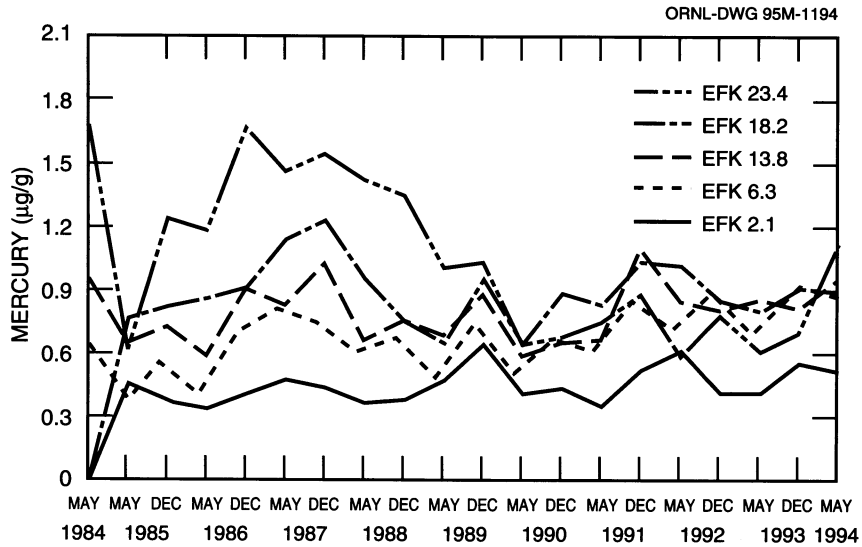

Fig. 4.33. Average concentrations of mercury in redbreast sunfish (*n* = 8) collected at sites in East Fork Poplar Creek, 1984–94. The 1984 data are from the Oak Ridge Task force study (TVA 1985).

Creek, Bear Creek, Mitchell Branch, and White Oak Creek. The highest mean concentrations continued to be in fish from EFPC and Bear Creek. Overall, mean mercury concentrations in fish sampled in 1993 and 1994 on the reservation were similar to those observed in 1992.

Mean PCB concentrations in sunfish were elevated in White Oak Creek, EFPC, Bear Creek, and Mitchell Branch. The highest PCB concentrations were found in sunfish from Bear Creek (BCK 4.5) and UEFPC. Mean PCB concentrations in sunfish increased at some White Oak Creek sites after a steady decrease at most sites over the period between 1987 and 1992. PCB concentrations in UEFPC also increased during the 1993–94 period. At most other sites on the reservation, mean PCB concentrations in sunfish in the 1993–94 period remained similar to concentrations observed in previous years.

Toxicity of Lithium Drives Need for New Waste-Acceptance Criteria

Routine compliance testing shows that effluent from the Y-12 Plant's Groundwater Treatment Facility is acutely toxic to *Ceriodaphnia dubia* (a microcrustacean) and fathead minnow larvae. Subsequent testing suggests that the toxicity is caused by the presence of lithium. Lithium is a light, strong metal (only one-third as massive as sodium) that is used in various DOE operations, including fusion weapons, fission reactors, and gamma detectors. Virtually no information exists about the toxicity of lithium to aquatic biota, despite widespread and increasing industrial use; and surprisingly little information exists about the concentrations of lithium that occur naturally in surface waters. When additional toxicity tests were conducted with lithium-spiked control water, lithium-spiked wastewaters, and lithium-spiked stream water samples, the results confirmed that lithium was acutely toxic at concentrations as low as 1 mg/L. Water type appeared to influence the toxicity of lithium; the metal was about six times more toxic in low-sodium diluted mineral water than it was in sodium-rich wastewaters. These findings are significant to waste

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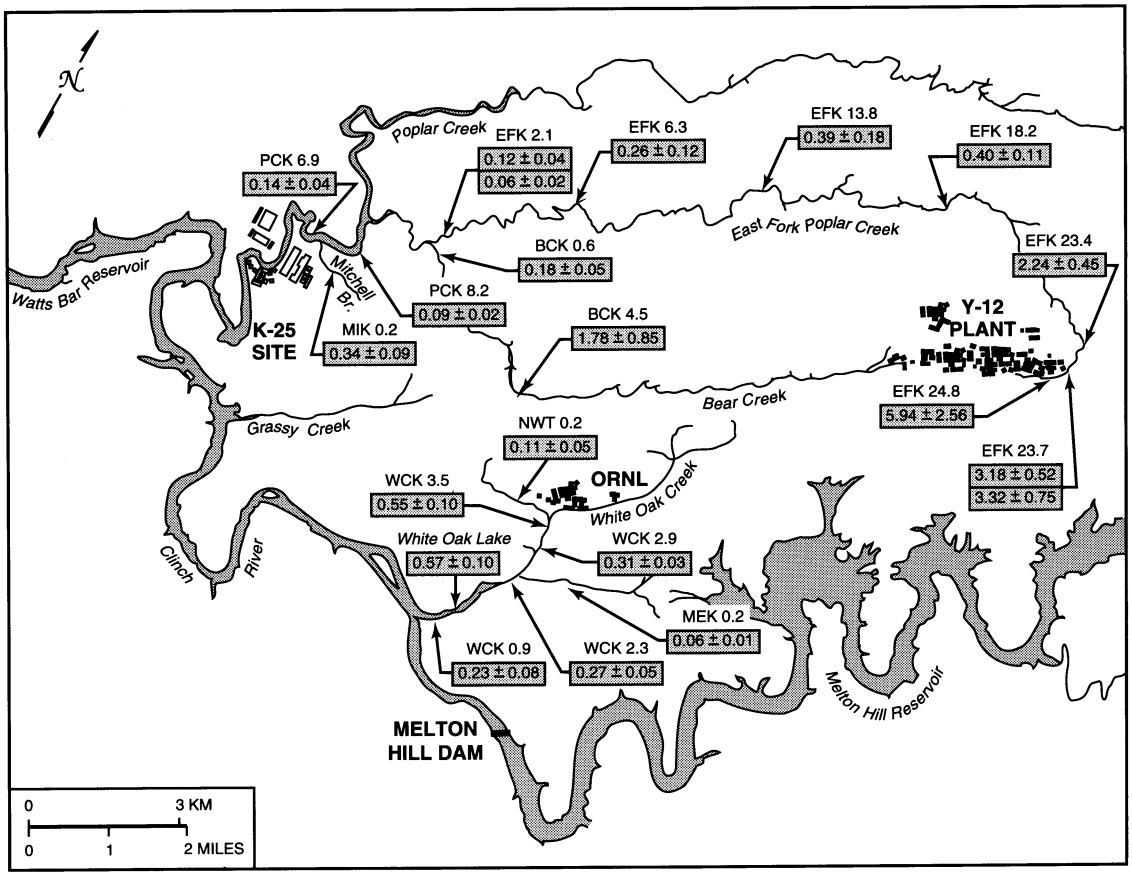

Fig. 4.34. Average concentrations (± standard error) of PCBs (in micrograms per gram) in sunfish collected from November 1993 through March 1994 at sites on the ORR. Fish are redbreast sunfish (*Lepomis auritus*) at MIK 0.6, EFK sites (bottom values where two appear), and WCK 2.9; rock bass (*Ambloplites rupestris*) at BCK sites; and bluegill (*L. macrochirus*) at the remaining sites.

treatment operations at the Y-12 Plant because (1) some batches of wastewaters treated at the Y-12 Plant's West End Treatment Facility (WETF) contain lithium at high concentrations (>5,000 mg/L), (2) lithium is exceptionally difficult to remove from solution by conventional waste treatment procedures, and (3) WETF effluent typically contains a high concentration of sodium. The results of the toxicity tests are being used to establish waste-acceptance criteria for lithium at WETF.

Temporal Trends Indicate Recovery in the Benthic Macroinvertebrate Community of a Chronically Impacted Watershed

Temporal trends in benthic macroinvertebrate community structure in five streams within a single watershed have been followed for 6 years to help assess the impact of operations and to assess the effectiveness of pollution abatement activities and remedial actions taken at ORNL. An initial characterization of the macroinvertebrate community structure determined that the sampling sites closest to one or more major effluent

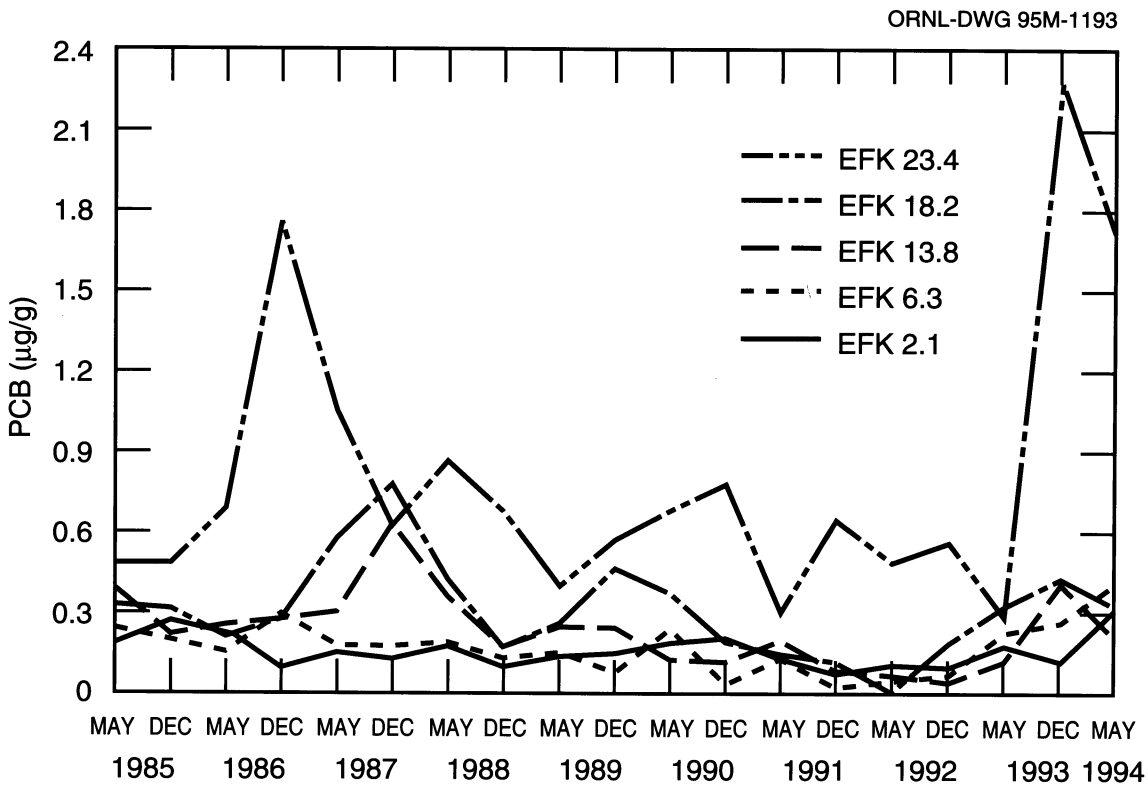

Fig. 4.35. Average concentrations of PCBs in redbreast sunfish (*n* = 8) collected at sites in East Fork Poplar Creek, 1985–94.

discharges generally exhibited the greatest evidence of impact. Invertebrate community structure at these sites also exhibited the greatest evidence of change indicative of improving conditions (e.g., significant increases in total richness) as pollution abatement projects (e.g., effluent dechlorination) were implemented or other ORNL operational changes occurred (e.g., reactor shutdown). By contrast, community structure changed little at sites located much farther downstream (far-field sites) or at sites where no abatement activities were implemented. This pattern of temporal change helps demonstrate the importance of effluents from ORNL in controlling the community structure near the point of discharge. The absence of responses at far-field sites suggests that more substantial abatement activities and remedial actions may be needed and that more time may be necessary for the communities to respond to subtle changes in water quality.

Fish Community in Upper Bear Creek Is Recovering After Remedial Actions

Ecological studies of Bear Creek, which drains the west end of the Oak Ridge Y-12 Plant, were initiated in May 1984. Surveys of the fish community have been used to identify impacts on the community and any recovery resulting from remedial actions. Assessments of the fish community have included measures of fish density (number per unit of area) and species richness (number of species) at several sites twice a year. Bear Creek is unique in that the Tennessee dace (*Phoxinus tennesseensis*), an uncommon fish, inhabits the stream in relatively high numbers. The Tennessee dace may be intolerant to

siltation, especially during the spawning season and egg and juvenile development. The uppermost site for estimating fish populations in Bear Creek is just below the S-3 Ponds, which received wastes until 1983, were neutralized and denitrified in 1984, and were capped in 1988.

Recovery of the fish community in upper Bear Creek has been slow; density increased from 0 fish/m^2 in spring 1984 to 1.79 fish/m^2 in fall 1989 and 5.23 fish/m^2 in spring 1994. Recovery of the Tennessee dace population has been slower than that of other fish populations at this site. Tennessee dace density increased from 0 fish/m^2 in spring 1984 to 0.01 in fall 1989 and 1.22 fish/m^2 in spring 1994. During the same sampling periods, blacknose dace density increased from 0 fish/m^2 to 1.68 and 2.62 fish/m^2, respectively. Species richness at this site did not stabilize until spring 1990, when four species of fish inhabited the site; these species have been found at the site in all sampling periods since 1990.

Monitoring of the fish community and the Tennessee dace population at the site below the S-3 Ponds has demonstrated the first stages of recovery following remediation of the ponds. Increased fish density and species richness suggest a decline of instream toxicity in upper Bear Creek. Stabilization of these fish densities is expected to occur in the later stages of recovery.

Evidence of Recovery in Fish Populations at Sites Located Just Downstream from Most Facility Operations

Fish density (the number of fish per square meter) and species richness (the number of species) have increased in response to remedial actions and improving water quality conditions at sites in three streams (EFPC, Mitchell Branch, and White Oak Creek) located just downstream from most facility discharges (Y-12 Plant, K-25 Site, and ORNL, respectively). Density at EFK 23.4 increased from <5 fish/m^2 in spring 1990 to a high of 18.7 fish/m^2 in fall 1993 (Fig. 4.36). While there was little change in the total number of species at this site between 1986 and 1994 (Fig. 4.37), there has been an increase in the number of species that are sensitive to pollution (two species in the last four sampling seasons). Improving water quality may in large part explain the improvements seen in the fish community.

Dramatic improvements in both fish density and species richness have occurred at MIK 0.71. Fish density was 0 fish/m^2 in spring 1991 and has continually increased to reach a high of 8.35 fish/m^2 in fall 1994 (Fig. 4.36). Species richness has increased from two to nine species over the same time period (Fig. 4.37). A series of abatement actions (e.g., dechlorination of storm drain effluents) contributed to the improvements seen at this site. A similar trend occurred at WCK 3.9, where density increased from 0.1 fish/m^2 in spring 1990 to 29.7 fish/m^2 in fall 1992 (Fig. 4.36). No fish were collected at WCK 3.9 in spring 1989, but richness has ranged from three species in spring 1990 to seven species in spring 1992 and 1994 (Fig. 4.36). Contributions of the NRWTF, which began operations in early 1990, was probably a major contributor to the improvement observed in the fish community. Similar trends in fish densities have been observed in other streams on the ORR (e.g., Fifth Creek and Bear Creek). Although species richness and fish density at these sites differ from those of reference streams, the improvements are indicative of ecological recovery.

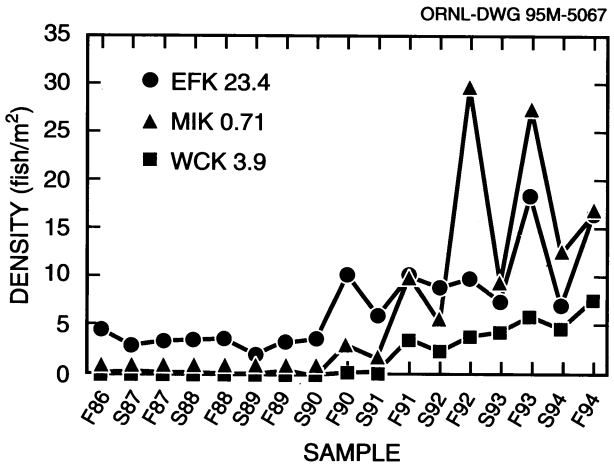

Fig. 4.36. Fish density at three sites on the Oak Ridge Reservation, 1986–94. EFK = East Fork Poplar Creek kilometer; MIK = Mitchell Branch kilometer; WCK = White Oak Creek kilometer. Sampling conducted in fall (F) and spring (S). EFK 23.4 is located downstream of most Y-12 Plant discharges; MIK 0.71 is located downstream of most K-25 Site discharges; WCK 3.9 is located downstream of most ORNL discharges.

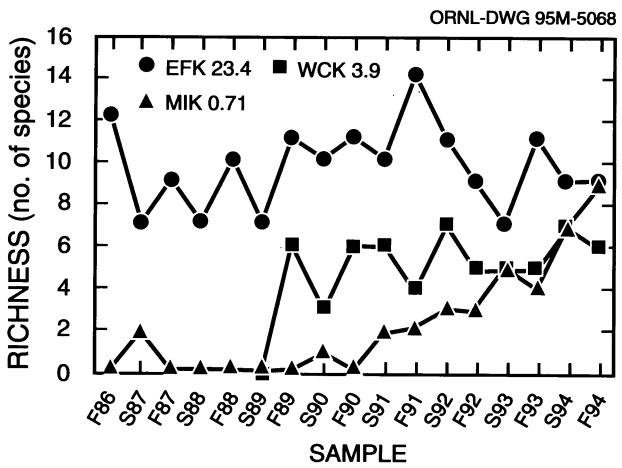

Fig. 4.37. Fish species richness at three sites on the Oak Ridge Reservation, 1986–94. EFK = East Fork Poplar Creek kilometer; MIK = Mitchell Branch kilometer; WCK = White Oak Creek kilometer. Sampling conducted in fall (F) and spring (S). EFK 23.4 is located downstream of most Y-12 Plant discharges; MIK 0.71 is located downstream of most K-25 Site discharges; WCK 3.9 is located downstream of most ORNL discharges.

5. Environmental Surveillance

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Abstract

Annual environmental surveillance is a major activity on the Oak Ridge Reservation. Environmental surveillance consists of the collection and analysis of samples of air, water, soil, foodstuffs, biota, and other media from the reservation and its surroundings. External radiation is also measured. Samples are analyzed for chemical content and for the presence of radioisotopes. Data collected during environmental surveillance activities are used to demonstrate compliance with applicable standards, to assess exposures to members of the public, and to assess effects (if any) on the local population.

METEOROLOGICAL MONITORING

Seven meteorological towers provide data on meteorological conditions and on the transport and diffusion qualities of the atmosphere on the ORR. Data collected at the towers are used in routine dispersion modeling to predict impacts from facility operations and as input to emergency response atmospheric models used in the event of accidental releases from a facility. Data from the towers are also used to support various research and engineering projects.

Description

The seven meteorological towers, depicted in Fig. 5.1, consist of one 330-ft (100-m) tower (MT5) and one 200-ft (60-m) tower (MT6) at the Y-12 Plant; one 330-ft tower (MT2) and two 100-ft towers (MT3 and MT4) at ORNL; and one 200-ft tower (MT1) and one 100-ft (MT7) tower at the K-25 Site.

Data are collected at different levels to determine the vertical structure of the atmosphere and the possible effects of vertical variations on releases from facilities. At all towers, data are collected at 32.8 ft and at the top of the tower. At the 330-ft towers, data are collected at an intermediate 100-ft level as well. At each measuring level on each tower, temperature, wind speed, and wind direction are measured. Humidity and data needed to determine atmospheric stability (a measure of the dispersive capability of the atmosphere) are also measured at each tower. Barometric pressure is measured at one tower at each facility. Precipitation is measured at MT1 and MT7 at the K-25 Site and at MT2 at ORNL; solar radiation is measured at MT2.

Data from the towers at each site are collected by a dedicated control computer at that site. The towers are polled and the data are filed on disk. Fifteen-minute and hourly values are stored at each site for a running 24-hour period, but only hourly data are routinely stored beyond 24 hours. The meteorological monitoring data from all towers are summarized quarterly at the Y-12 Plant and monthly at ORNL and the K-25 Site. Quarterly calibration of the instruments is conducted for each site by an outside contractor.

Fifteen-minute and hourly data are used directly at each site computer for emergency-response purposes such as input to dispersion models. Annual dose estimates

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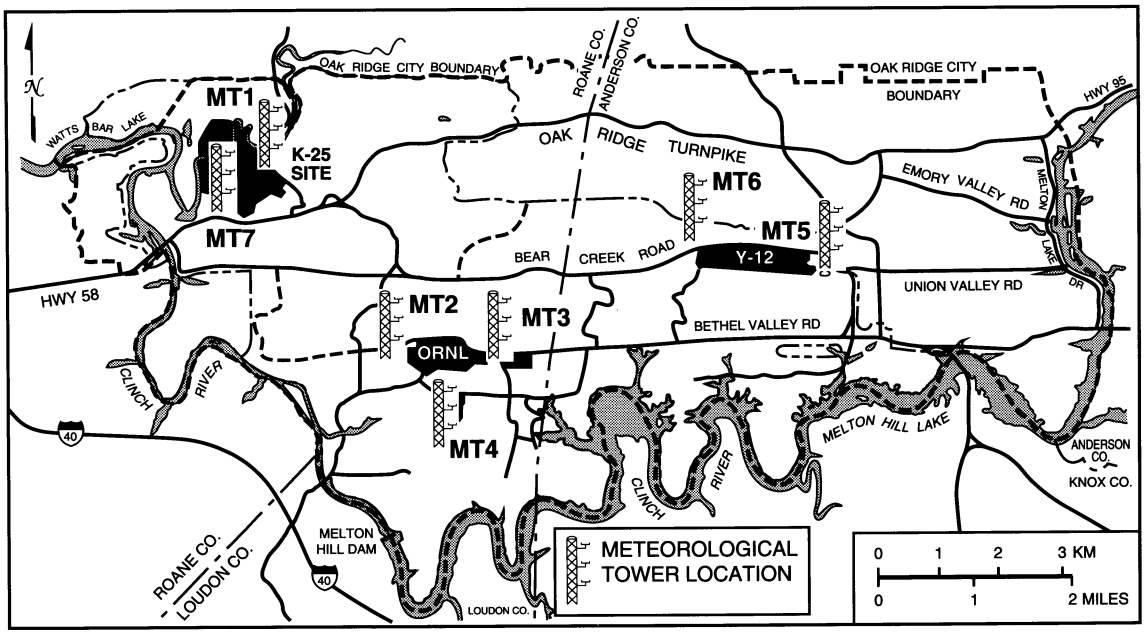

Fig. 5.1. The ORR meteorological monitoring network.

are calculated from archived data (either hourly values or summary tables of atmospheric conditions). Data quality is checked continuously against predetermined data constraints, and out-of-range parameters are marked invalid and are not input to the dispersion models.

Results

Prevailing winds are generally up-valley from the southwest and west-southwest or down-valley from the northeast and east-northeast. This pattern is the result of the channeling effect of the ridges flanking the site. Winds in the valleys tend to follow the ridges, with limited cross-ridge flow. These conditions are dominant over the entire reservation, with the exception of the K-25 Site, which is located in a relatively open area that has a more varied flow. Weaker valley flows are noted in this area, particularly in locations near the Clinch River.

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

The atmosphere over the reservation is dominated by stable conditions on most nights and in early morning hours. These conditions, coupled with the low wind speeds and channeling effects of the valleys, result in poor dilution of material emitted from the facilities. These features are captured in the data input to the dispersion models and are reflected in the modeling studies conducted for each facility.

Precipitation data from tower MT2 are used in stream-flow modeling and in certain research efforts. The data indicate the variability of regional precipitation: the high winter rainfall amounts resulting from frontal storms and the uneven, but occasionally intense, summer rainfall associated with thunderstorms.

The average data capture efficiency (a measure of acceptable data) across all locations and at the 16 tower levels was 97.7% in 1994. The maximum capture efficiency was 99.5%, and the minimum capture efficiency was 92.1%.

EXTERNAL GAMMA RADIATION MONITORING

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

Sample Collection and Analytical Procedures

External gamma measurements are recorded weekly at six ambient air stations (Fig. 5.2). In addition, measurements are collected at the American Museum of Science and Energy (Station 41).

Results

Table 5.1 presents the following data for individual stations: number of measurements, maximum value, minimum value, average value, and standard error of the mean. The median value for the ORR in 1994 was 7.7 μR/hour while the median value for cities in the United States during 1989 was 9.3 μR/hour (EPA 1990). Any contribution to the external gamma signature by the DOE facilities is not distinguishable at the ORR perimeter air monitoring (PAM) locations.

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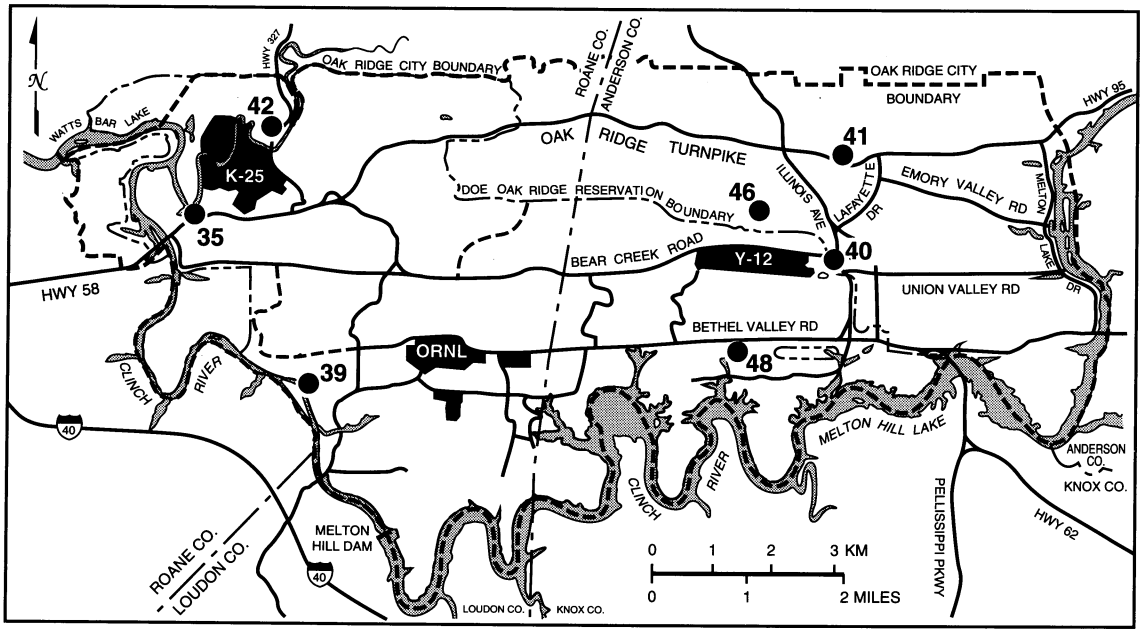

Fig. 5.2. External gamma radiation monitoring locations on the ORR.

Table 5.1. External gamma averages, 1994

Location	Number of samples	Measurement (μR/hour)			Standard error of mean
		Min	Max	Mean[a]	
39	50	8.63	10.81	9.05	0.04
40	47	7.36	77.31	10.65	2.06
41	48	8.20	11.19	9.78	0.11
42	52	6.66	7.39	6.97	0.02
46	49	6.16	12.85	8.84	0.16
48	49	1.98	11.60	6.80	0.22
51	31	7.28	8.30	7.54	0.03

[a]To convert microroentgens per hour to milliroentgens per year, multiply by 8.766.

AMBIENT AIR MONITORING

In addition to stack monitoring and sampling conducted at the DOE Oak Ridge installations, ambient air monitoring is performed to measure radiological and other selected parameters directly in the ambient air adjacent to the facilities. Ambient air monitoring provides direct measurement of airborne concentrations of radionuclides and other hazardous pollutants in the environment surrounding the facilities, allows facility personnel to determine the relative level of contaminants at the monitoring locations during an emergency, verifies that the contributions of fugitive and diffuse sources are insignificant, and serves as a check on dose-modeling calculations.

The following sections discuss the ambient air monitoring networks for the ORR, the Y-12 Plant, ORNL, and the K-25 Site.

ORR Ambient Air Monitoring

The objectives of the ORR ambient air monitoring program are (1) to perform surveillance of airborne radionuclides at the reservation perimeter and (2) to collect reference data from remote locations. The ORR PAM network associated with objective 1 includes stations 35, 37, 38, 39, 40, 42, 46, and 48 (Fig. 5.3); the remote air monitoring (RAM) network (objective 2) consists of stations 51 (Norris Dam) and 52 (Fort Loudoun Dam). Sampling was conducted at each ORR station to quantify levels of alpha-, beta-, and gamma-emitting radionuclides, tritium, beryllium, and total radioactive strontium during 1994.

Atmospheric dispersion modeling was used to select appropriate sampler locations. The locations selected are those most likely to be affected by routine releases from the Oak Ridge facilities. No residence or business is predicted to be affected routinely by significant concentrations of radioactive materials released from the ORR without being sampled by the selected locations. To provide an estimate of background radionuclide concentrations, two additional stations were located at sites not affected by releases from the ORR.

The sampling system consists of two separate instruments. The particulates are captured using a high-volume air sampler on glass fiber filters. The filters are collected weekly, composited every 4 weeks, then submitted to the laboratory for isotopic analysis. The second system is designed to collect tritiated water vapor. The sampler consists of a prefilter followed by an adsorbent trap consisting of indicating silica gel. The samples are collected weekly, composited monthly, then submitted to the laboratory for tritium analysis.

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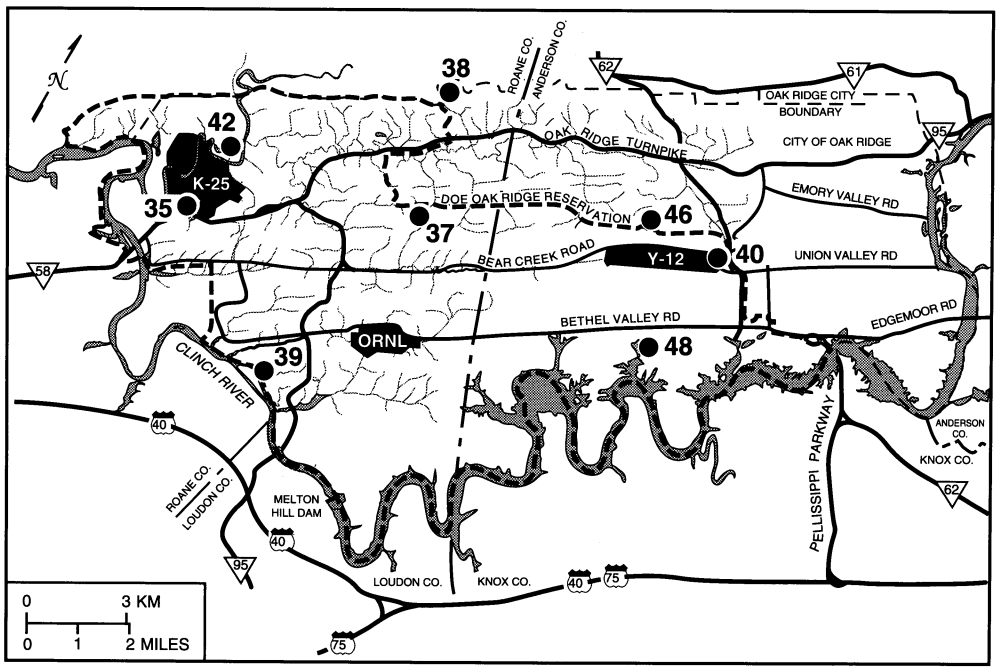

Fig. 5.3. Location of ORR perimeter air monitoring stations. Not shown are the remote air monitoring station 51 (at Norris Dam, 26 miles northeast of ORNL) and Station 52 (at Fort Loudoun Dam, 10 miles southeast of ORNL). The ORR stations also serve as soil sampling locations.

Ambient air sampling for uranium around the ORR is required by DOE order, but it is not required around a specific facility such as the Y-12 Plant. The ORR ambient air monitoring network fulfills the DOE order requirement (Fig. 5.4). As part of the ORR network, an ambient air monitoring station located in the Scarboro Community of Oak Ridge (Station 46) measures off-site impacts of Y-12 Plant operations, and is located near the theoretical area of maximum public pollutant concentrations as calculated by air-quality modeling. Station 40 of the ORR network monitors the east end of the Y-12 Plant, and Station 37 monitors the overlap of Y-12 Plant, ORNL, and K-25 Site emissions. Thus, the Y-12 Plant perimeter network of ambient uranium samplers was considered redundant and was discontinued at the end of 1994 because of its limited usefulness and high operating cost, with the exception of Stations 4, 5, and 8, which will be operated for the purpose of data trending.

Results

The ORR PAM stations assess the impact to air quality of operations on the entire reservation. The RAM stations provide information on reference concentrations of radionuclides and gross parameters for the region. A comparison of DCG percentages for the ORR PAM station sampling data with those from the RAM stations shows that ORR operations do not significantly affect local air quality (Table 5.2).

Table 5.3 represents the average concentration of three isotopes of uranium at each station for sampling years 1992, 1993, and 1994.

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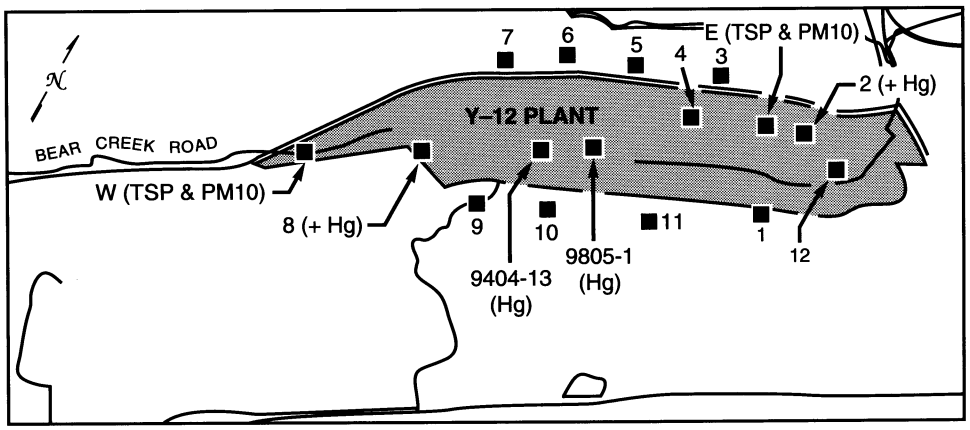

Fig. 5.4. Locations of ambient air monitoring stations at the Y-12 Plant.

Y-12 Plant Ambient Air Monitoring

The following types of ambient air monitoring systems were operated by the Y-12 Plant in 1994:

- twelve low-volume uranium particulate monitoring stations,
- eleven fluoride monitoring stations,
- two total suspended particulate (TSP) and respirable particulate [particulate matter <10 μm diam (PM10)] monitoring stations,
- four mercury monitoring stations.

The locations of these monitoring stations are shown in Fig. 5.4. Two mobile Fourier transform infrared spectroscopy (FTIR) systems, for measurement of gaseous hazardous air pollutants, were loaned out in 1994 under a cooperative research and development agreement (CRADA) for R&D with EPA. All ambient air monitoring systems at the Y-12 Plant are operated as a best management practice.

In 1994, Y-12 Plant personnel issued *Evaluation of the Ambient Air Monitoring Program at the Oak Ridge Y-12 Plant* (Energy Systems 1994a) and worked with the DOE and TDEC in reviewing the ambient air program for applicability and usefulness of the data. There are no federal regulations, state regulations, or DOE orders that require this monitoring. With the reduction of plant operations and improved emission and administrative controls, levels of measured pollutants have decreased significantly during the past several years. In addition, processes that result in the emission of enriched and depleted uranium are equipped with stack samplers that have been reviewed and approved by the EPA to meet requirements of the NESHAP regulations. ORR air sampling stations, operated by ORNL in accordance with DOE orders, are located around the reservation. Their locations ensure that areas of potentially high exposure to the public are monitored continuously for parameters of concern.

With agreement from TDEC personnel, the ambient air sampling program at the Y-12 Plant has been significantly reduced, effective at the end of 1994. All fluoride, TSP, and PM10 sampling has been discontinued, and all but 3 of the 12 uranium samplers have been shut down. The mercury sampling program will continue to monitor ambient air level

Table 5.2. ORR radionuclide concentrations in air, 1994

Determination	No. detected[a]/ No. sampled	Concentration (10^{-15} µCi/mL)[b] Min	Max	Av	Standard error	DCG (inhalation)	DCG %[c]
			PAMs				
^{241}Am	15/56	0.00E+00	4.53E–03	1.18E–03	1.53E–04	2.00E–14	5.89E–03
^{7}Be	56/56	4.11E+01	1.04E+02	7.97E+01	2.10E+00	5.00E–08	1.60E–04
^{244}Cm	1/56	0.00E+00	3.75E–03	1.68E–04	7.21E–05	4.00E–14	4.20E–04
^{60}Co	5/56	0.00E+00	7.93E–02	1.86E–02	2.93E–03	4.00E–10	4.66E–06
^{137}Cs	7/56	0.00E+00	6.95E–02	1.85E–02	2.49E–03	4.00E–10	4.62E–06
^{3}H	104/104	0.00E+00	1.73E+06	2.97E+04	1.68E+04	1.00E–07	2.97E–02
^{238}Pu	1/56	0.00E+00	1.45E–03	2.25E–04	4.79E–05	3.00E–14	7.48E–04
^{239}Pu	4/56	0.00E+00	1.16E–03	1.20E–04	3.16E–05	2.00E–14	6.00E–04
^{228}Th	47/56	0.00E+00	7.85E–03	2.25E–03	2.06E–04	5.00E–14	4.49E–03
^{230}Th	53/56	6.35E–05	5.54E–03	2.24E–03	1.83E–04	4.00E–14	5.60E–03
^{232}Th	52/56	1.26E–05	5.62E–03	2.31E–03	1.92E–04	7.00E–15	3.31E–02
Total Sr	26/56	0.00E+00	1.04E–01	1.47E–02	2.46E–03	9.00E–12	1.64E–04
^{234}U	55/56	9.40E–04	1.60E–01	3.75E–02	4.29E–03	9.00E–14	4.17E–02
^{235}U	45/56	0.00E+00	3.13E–02	4.21E–03	7.65E–04	1.00E–13	4.21E–03
^{238}U	55/56	2.60E–03	3.80E–02	1.54E–02	1.17E–03	1.00E–13	1.54E–02
			RAMs				
^{241}Am	3/14	0.00E+00	1.97E–03	6.89E–04	1.90E–04	2.00E–14	3.44E–03
^{7}Be	14/14	5.19E+01	1.11E+02	8.31E+01	3.83E+00	5.00E–08	1.66E–04
^{244}Cm	0/14	0.00E+00	8.61E–04	1.88E–04	8.61E–05	4.00E–14	4.70E–04
^{60}Co	2/14	0.00E+00	9.28E–02	2.08E–02	7.63E–03	4.00E–10	5.20E–06
^{137}Cs	2/14	0.00E+00	6.89E–02	1.68E–02	5.02E–03	4.00E–10	4.20E–06
^{3}H	26/26	2.04E+02	3.29E+04	6.85E+03	1.63E+03	1.00E–07	6.85E–03
^{238}Pu	0/14	0.00E+00	1.90E–03	2.85E–04	1.37E–04	3.00E–14	9.50E–04
^{239}Pu	0/14	0.00E+00	3.93E–04	4.16E–05	3.02E–05	2.00E–14	2.08E–04
^{228}Th	12/14	2.11E–05	4.33E–03	1.96E–03	3.45E–04	5.00E–14	3.92E–03
^{230}Th	12/14	6.34E–05	4.60E–03	2.17E–03	3.85E–04	4.00E–14	5.44E–03
^{232}Th	12/14	2.09E–05	3.93E–03	2.07E–03	3.17E–04	7.00E–15	2.95E–02
Total Sr	9/14	0.00E+00	1.81E–01	2.31E–02	1.24E–02	9.00E–12	2.57E–04
^{234}U	14/14	4.13E–03	5.10E–02	1.32E–02	3.20E–03	9.00E–14	1.46E–02
^{235}U	8/14	1.09E–04	9.88E–03	2.04E–03	6.78E–04	1.00E–13	2.04E–03
^{238}U	14/14	1.33E–03	1.07E–02	6.09E–03	8.01E–04	1.00E–13	6.09E–03

[a]Statistically significant at 95% level of confidence.

[b]1 µCi = 3.75E+04 Bq.

[c]The average is divided by the derived concentration guide (DCG) for inhalation of that isotope, multiplied by 100, and presented in the table as the percentage of the DCG.

concentrations as a result of remediation and decommissioning and decontamination activities.

Uranium

Samples for routine measurement of uranium particulate were collected by pulling ambient air through a square 14-cm (5.5-in.) filter, which was analyzed by the Y-12 Plant Analytical Services Organization for total uranium and for the percentage of ^{235}U. Prior to 1993, the samples were analyzed for gross alpha and beta and for activity levels of specific

Table 5.3. Uranium concentrations in ambient air on the ORR

Sampling station	Concentration (10^{-15} µCi/mL)		
	1992	1993	1994
35			
^{234}U	3.6E–02	4.2E–02	3.5E–02
^{235}U	0.0E+00	1.1E–02	3.0E–03
^{238}U	9.4E–03	2.2E–02	2.4E–02
37			
^{234}U	5.0E–03	5.4E–02	3.5E–02
^{235}U	8.6E–03	9.0E–03	3.0E–03
^{238}U	2.1E–02	1.8E–02	1.9E–02
38			
^{234}U	2.3E–02	3.7E–02	2.9E–02
^{235}U	0.0E+00	7.0E–03	4.0E–03
^{238}U	9.8E–03	1.7E–02	1.6E–02
39			
^{234}U	3.1E–02	4.1E–02	2.7E–02
^{235}U	4.7E–03	1.0E–02	5.0E–03
^{238}U	1.9E–02	1.6E–02	9.0E–03
40			
^{234}U	1.2E–01	1.1E–01	8.9E–02
^{235}U	8.7E–03	1.0E–03	9.0E–03
^{238}U	1.8E–02	2.1E–02	1.6E–02
42			
^{234}U	5.0E–02	2.5E–02	1.9E–02
^{235}U	0.0E+00	3.0E–03	2.0E–03
^{238}U	1.5E–03	2.2E–02	1.5E–02
46			
^{234}U	2.1E–01	1.0E–01	4.4E–02
^{235}U	5.2E–02	1.2E–02	6.0E–03
^{238}U	3.2E–02	1.8E–02	1.5E–02
48			
^{234}U	3.2E–02	5.2E–02	2.3E–02
^{235}U	5.9E–03	1.0E–02	1.0E–03
^{238}U	1.2E–02	2.1E–02	1.1E–02
51			
^{234}U	3.4E–02	4.3E–02	1.0E–02
^{235}U	2.9E–03	9.0E–03	2.0E–03
^{238}U	1.1E–02	1.4E–02	6.0E–03
52			
^{234}U	2.7E–02	3.3E–02	1.6E–02
^{235}U	5.0E–03	7.0E–03	2.0E–02
^{238}U	7.4E–03	1.6E–02	6.0E–03

uranium isotopes; however, in 1993, the analysis program for radionuclides was revised as described in the EMP to obtain total uranium particulate and the percentage of ^{235}U. In this manner, uranium concentrations in ambient air could be better correlated to stack emission data, which is also measured as total uranium. For 1994, the average 7-day concentration of uranium at the 12 monitored locations ranged from a low of 0.00004 µg/m^3 at stations 10 and 11 to a high of 0.00012 µg/m^3 at Station 4 (Table 5.4). At Station 4, the 7-day concentration ranged from 0.00001 to 0.00173 µg/m^3.

Table 5.4. Uranium in ambient air at the Y-12 Plant, 1994

Station No.	No. of samples	7-day concentration ($\mu g/m^3$)[a]		
		Max	Min	Av
1	*a*	*a*	*a*	*a*
2	51	0.00047	0.00002	0.00005
3	51	0.00014	0.00002	0.00005
4	51	0.00173	0.00001	0.00012
5	51	0.00080	0.00002	0.00009
6	46	0.00016	0.00002	0.00005
7	50	0.00025	0.00002	0.00007
8	51	0.00030	0.00003	0.00008
9	50	0.00021	0.00002	0.00005
10	44	0.00013	0.00002	0.00004
11	51	0.00013	0.00001	0.00004
12	51	0.00017	0.00002	0.00005

[a]Sampler down; no samples taken.

Fluoride

Along with uranium particulate matter, atmospheric fluoride samples were collected at 11 of the 12 sites. Atmospheric fluoride in ambient air was collected on 37-mm-diam (1.5-in.) filters that had been pretreated with potassium carbonate. The filters were analyzed by the Y-12 Plant Analytical Services Organization by selective-ion electrode method (EPA 340.2). Although the sampling method does not conform to accepted criteria, the results are compared with TDEC ambient air quality standards for interest.

The 7-day ambient air concentrations of fluorides measured during 1994 at each of the Y-12 Plant perimeter fluoride stations were well below the TDEC standard of 1.6 $\mu g/m^3$. The maximum 7-day concentration detected during the year was 0.028 $\mu g/m^3$ at Station 2 (Table 5.5). The maximum annual average 7-day concentration was 0.0102 $\mu g/m^3$ at Station 2. Figure 5.5 indicates that the measured ambient air fluoride concentrations at the perimeter of the Y-12 Plant have been well below the state of Tennessee ambient air quality standards for the 7-day average since 1987. Ambient air sampling for fluorides around the Y-12 Plant is not required by any federal, state, or DOE criteria. Dispersion modeling using Y-12 Plant meteorological data can be used to predict or estimate exposure in the event of a release, and spot sampling can be conducted to confirm model results. Ambient air sampling for fluorides was discontinued at the end of 1994.

Particulates

Monitors for TSP and PM10 in ambient air were located at the east and west ends of the Y-12 Plant. Sampling for particulate matter consisted of drawing air at a known rate through a pre-weighed filter for 24 hours every 6 days. A particle concentration can be calculated from the weight differential associated with particle accumulation on the filter during the sample period. The TSP sampling system used a glass fiber filter; the PM10 sampling system used a quartz fiber filter. TSP is no longer regulated; however, concentration values were compared with the previous Tennessee 24-hour primary ambient air quality standard of 260 $\mu g/m^3$ (Table 5.6). Sample results were used as an internal measure of area ambient air quality. The TSP concentration has not exceeded the primary

Table 5.5. Fluorides in ambient air at the Y-12 Plant, 1994

Station No.	No. of samples	7-day concentration ($\mu g/m^3$)				Percentage of standard[b]
		Max	Min	Av	Tenn. std[a]	
1	c	c	c	c	1.6	c
2	51	0.0280	0.0047	0.0102	1.6	<2
3	51	0.0144	0.0054	0.0085	1.6	<1
4	51	0.0102	0.0046	0.0081	1.6	<1
5	51	0.0126	0.0045	0.0077	1.6	<1
6	44	0.0137	0.0038	0.0088	1.6	<1
7	42	0.0140	0.0071	0.0085	1.6	<1
8	51	0.0142	0.0062	0.0084	1.6	<1
9	51	0.0112	0.0040	0.0077	1.6	<1
10	43	0.0200	0.0040	0.0090	1.6	<2
11	51	0.0102	0.0051	0.0079	1.6	<1

[a]Tennessee standard 7-day average = 1.6 $\mu g/m^3$.
[b]Percentage of standard calculated using the annual 7-day average fluoride concentration.
[c]Sampler down; no samples taken.

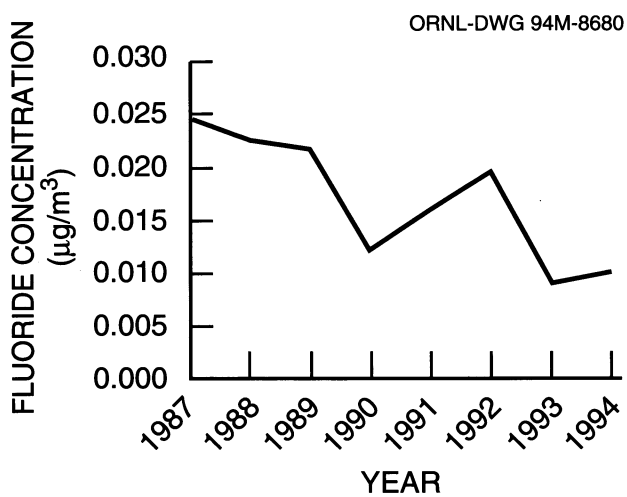

Fig. 5.5. Maximum annual average 7-day concentration for fluorides in ambient air at the Y-12 Plant. The TDEC standard for a 7-day average = 1.6 $\mu g/m^3$.

standard since 1989. During 1994, the maximum 24-hour value at the east TSP station was 148 $\mu g/m^3$, or 57.1% of the previous TDEC standard (260 $\mu g/m^3$ per 24 hours). The maximum 24-hour value at the west TSP station was 74 $\mu g/m^3$, or 28.4% of the standard. Figure 5.6 shows the Y-12 Plant 5-year TSP trend.

Three PM10 samplers were located adjacent to the existing TSP samplers, one PM10 at the west site and two PM10s at the east site. The PM10s were operated on the same schedule as the TSPs. The PM10 concentration has not exceeded the primary standard since collection of valid data began in 1992 (Table 5.7). The maximum PM10 concentration during 1994 at the west station was 20.7 $\mu g/m^3$, or 13.8% of the TDEC standard of 150 $\mu g/m^3$ per 24 hours. The maximum values at the two collocated east stations were 45.6 and 50.0 $\mu g/m^3$, or 30.4% and 33.4%, respectively, of the standard. Ambient air sampling for particulates around the Y-12 Plant is not required by any federal, state, or DOE criteria, and was discontinued at the end of 1994. Figure 5.7 shows the Y-12 Plant PM10 trend for the 3 years that they were in operation.

Table 5.6. 1994 total suspended particulates in air at the Y-12 Plant TSP monitoring stations

Station	No. of samples	Concentration ($\mu g/m^3$)					Number of exceedences
		Max	Min	Av	Tenn. std[a]	Max % of std	
East	53	148.49	6.95	41.54	260	57.11	0
West	31	73.95	5.63	24.90	260	28.44	0

[a]TSP is no longer regulated; however, the maximum measurements are still compared with the previous primary air quality standard of 260 $\mu g/m^3$ per 24 hours.

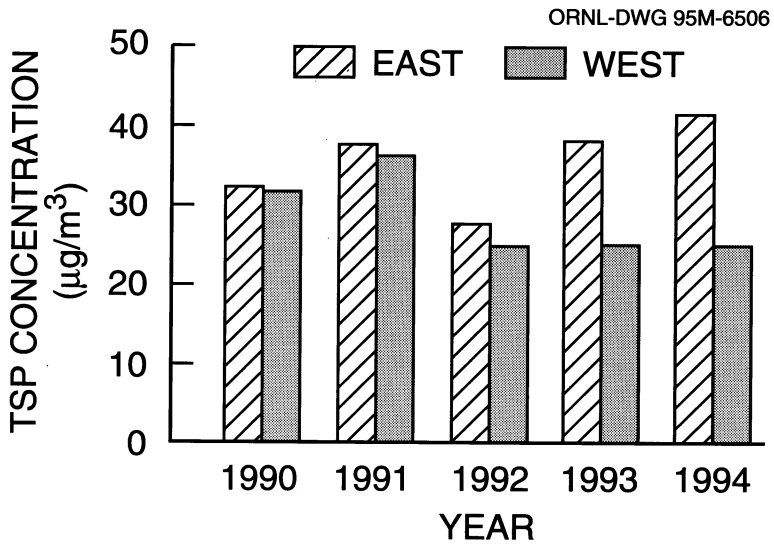

Fig. 5.6. Y-12 Plant 5-year TSP monitoring trend. TSP is no longer regulated.

Mercury

In 1986 the Y-12 Plant established an on-site monitoring program to measure mercury vapor concentrations in ambient air. The goals of the program were to establish a historical data base of mercury concentration in ambient air at the Y-12 Plant, identify spatial and temporal trends in mercury vapor concentrations at the Y-12 Plant, and demonstrate protection of the environment and human health from releases of mercury from the Y-12 Plant to the atmosphere. Outdoor airborne mercury at the Y-12 Plant results primarily from mercury vaporization from contaminated soils, burning coal at the Y-12 steam plant, and fugitive emissions from Building 9201-4 (a former lithium isotope separation facility that is contaminated with mercury).

Four outdoor ambient mercury monitoring stations (stations on the east and west ends of the plant and two stations near Building 9201-4) were established on site in 1986 and are presently still being operated. An additional site was added at New Hope Pond in August 1987 and was monitored while the pond was being closed and capped (1987–89). In February 1988, a control or reference site was established at Rain Gage No. 2 on Chestnut Ridge in the Walker Branch Watershed. This reference site was discontinued after collecting data for about 20 months to establish background concentrations and a seasonal pattern. Data for the New Hope Pond and Rain Gage No. 2 sites have been presented in earlier ORR environmental reports.

Because no established or EPA-approved methods for measuring mercury vapor in ambient air existed when the program was initiated, ESD staff developed a method to meet the needs of the monitoring program for the Y-12 Plant. At each of the monitoring sites, air

Table 5.7. 1994 PM10 concentrations in air at the Y-12 Plant PM10 monitoring stations

Station	No. of samples	Concentration (μg/m³)					Number of exceedences
		Max	Min	Av	Tenn. std[a]	Max % of std	
West	50	20.70	1.20	9.88	150	13.80	0
East	45	45.59	3.61	16.60	150	30.39	0
East collocated	60	50.03	1.02	17.81	150	33.35	0

[a]Maximum measurements are compared with the Tennessee primary air quality standard at 150 μg/m³ per 24 hours.

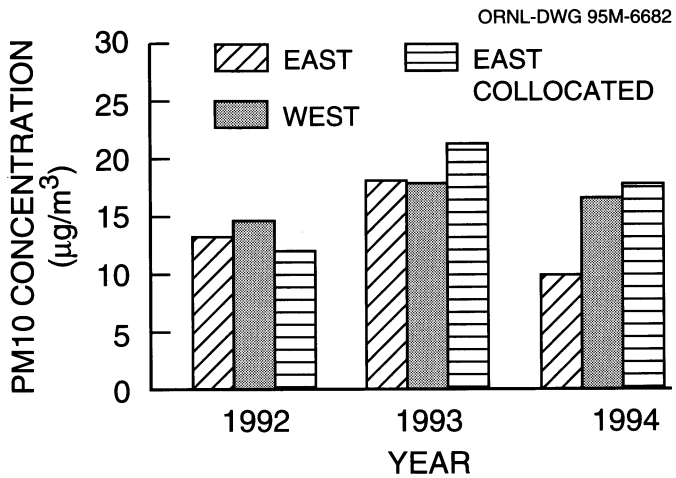

Fig. 5.7. Y-12 Plant PM10 monitoring trend. TDEC standard = 150 μg/m³ per 24 hours. (Sampling began in 1992.)

is drawn through a Teflon filter, a flow-limiting orifice, and a glass sampling tube packed with iodated charcoal, onto which airborne mercury vapor is adsorbed. Average air concentration of mercury vapor for each sampling period is calculated by dividing the total quantity of mercury collected on the charcoal by the total volume of air pulled through the tube. The charcoal sampling tubes are changed routinely every 7 days. In the latter months of 1994, however, they were changed monthly to conserve the limited inventory of sampling tubes after the manufacturer unexpectedly stopped production. The weekly schedule resumed when another manufacturer took over production of the tubes.

Table 5.8 presents mercury monitoring data for 1994, data from the 1986 through 1988 period, and data from the reference or control site. Figure 5.8 shows the trends in mercury concentrations for the four active ambient air mercury monitoring sites since the inception of the program in 1986.

With few exceptions, annual average mercury vapor concentrations have been lower in recent years than concentrations measured during the early years of the monitoring program (1986–88). This trend continues through 1994 (see Table 5.8). Three of the four monitoring sites, the exception being the Building 9805-1 site, showed significantly lower annual averages (Student's *t*-test at the 1% level) for mercury vapor concentration when compared with the 1986 through 1988 average. 1994 averages for all sites are also lower, although not significantly, than those recorded for 1993. The general decrease in ambient mercury recorded at the Y-12 Plant monitoring sites since 1989 is thought to be related to the reduction in coal burned at the Y-12 steam plant beginning in 1989 and to the completion prior to 1989 of several major engineering projects [e.g., New Hope Pond closure, the Perimeter Intrusion Detection Assessment System (PIDAS), Reduction of Mercury in Plant Effluent (RMPE), and Utility Systems Restoration] that may have caused a temporary increase in mercury air concentrations because contaminated soil and sediment

Table 5.8. 1994 results of the Y-12 Plant ambient air mercury monitoring program

Monitoring site	Number	Mercury vapor concentration ($\mu g/m^3$)			
		Max	Min	1994 av[a]	1986–88 av[a]
Station No. 2 (east end of Y-12 Plant)	37	0.017	<0.001	0.006	0.010
Station No. 8 (west end of Y-12 Plant)	36	0.026	0.003	0.009	0.033
Bldg. 9404-13 (SW of Bldg. 9201-4)	39	0.128	0.010	0.056	0.145
Bldg. 9805-1 (SE of Bldg. 9201-4)	40	0.280	0.006	0.088	0.099
Reference site, Rain Gage No. 2 (1988[b])	47	0.016	0.002	0.006	c
(1989[d])	47	0.015	<0.001	0.005	c

[a]NESHAP 30-day average standard equals 1 $\mu g/m^3$. ACGIH 8-hour day, 40-hour work week standard equals 50 $\mu g/m^3$.

[b]Data for February 9 through December 31, 1988.

[c]Not applicable.

[d]Data for January 1 through October 31, 1989.

were disturbed. The seasonal pattern of higher mercury vapor concentrations during the warmer months of the year continued through 1994 (Fig. 5.9). The smooth curve for mercury vapor concentrations in late 1994 when compared with data from earlier years is because of the reduced number of measurements during this period when the charcoal tubes were changed out monthly instead of weekly because of the supply problem.

Although ambient mercury concentrations at the Y-12 Plant were elevated above natural background in 1994, results indicate that the concentrations of mercury vapor were well below the NESHAP guideline of 1 $\mu g/m^3$ (30-day average) and the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value of 50 $\mu g/m^3$ (time-weighted average for 8-hour workday and 40-hour work week). The maximum weekly concentration measured in 1994 (0.280 $\mu g/m^3$ at Bldg. 9805-1) is less than 1% of the ACGIH limit for a 40-hour work week.

Beginning in 1995, the ambient air monitoring system for mercury will be upgraded by gradual replacement of the iodated charcoal traps with near-continuous mercury vapor monitors that can measure ambient air concentrations about every 10 minutes. These new monitors are self-calibrating and include mass flow controllers. The monitors provide data on demand that can then be averaged over much shorter time intervals than were possible in the past. When combined with synoptic meteorologic data (wind speed and direction), the data generated by this new monitoring system can be used to better understand the nature and location of fugitive mercury vapor sources at the Y-12 Plant. Initially, the new monitors will be run simultaneously with the existing monitoring system (i.e., the iodated charcoal traps) to verify comparability of the measurements.

ORNL Ambient Air Monitoring

The objectives of the ORNL ambient air monitoring program are (1) to sample at stations that are most likely to show impacts of airborne emissions from the operation of ORNL and (2) to provide for emergency response capability. The specific stations associated with these objectives are 1, 2, 3, and 7 (Fig. 5.9).

Sampling is conducted at each ORNL station to quantify levels of adsorbable gas (e.g., iodine); beryllium; and gross alpha-, beta-, and gamma-emitting radionuclides (Table 5.9).

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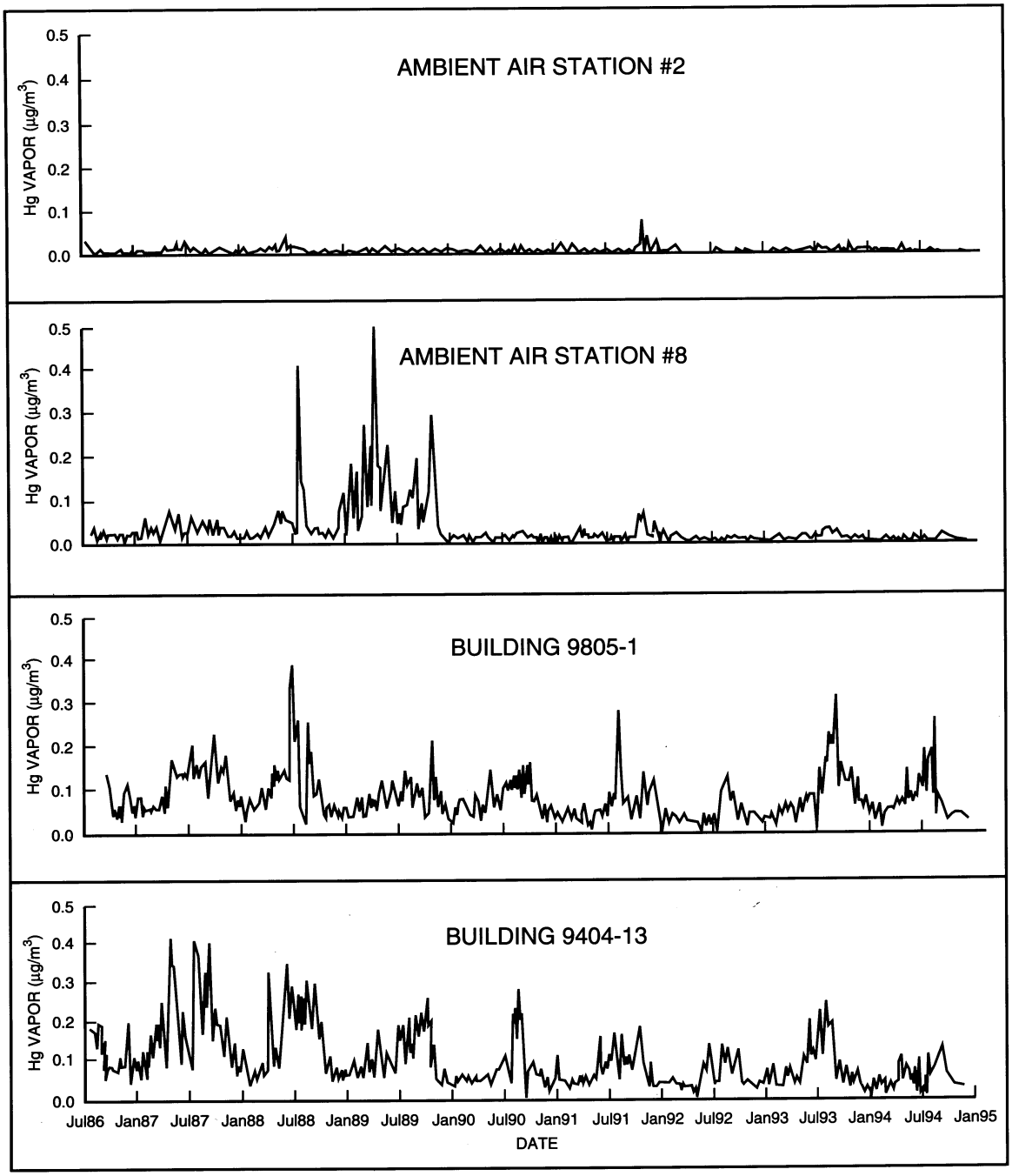

Fig. 5.8. Time trends in mercury vapor concentrations for the four active ambient air mercury monitoring sites at the Y-12 Plant.

The sampling system consists of a low-volume air sampler for particulate collection using a 47-mm glass fiber filter. The filters are collected biweekly, composited annually, then submitted to the laboratory for isotopic analysis. Following the filter is a charcoal cartridge used to collect adsorbable gases (e.g., iodine). A silica gel column is used for the collection of tritium as tritiated water (stations 3 and 7 only). The samples are collected biweekly. The silica gel is composited monthly, then submitted to the laboratory for tritium

ORNL-DWG 94M-8370

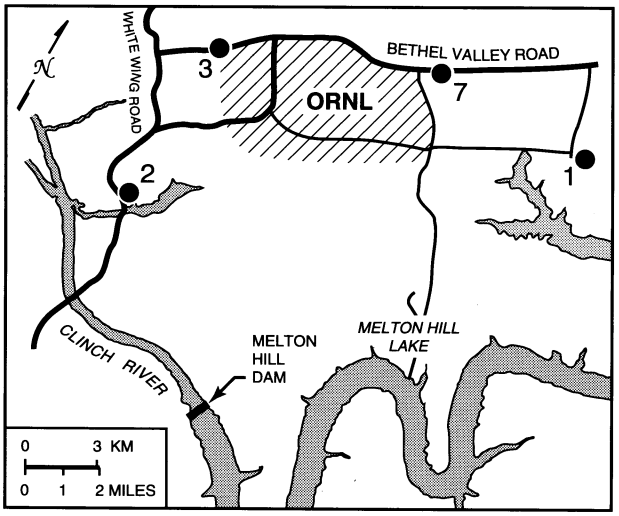

Fig. 5.9. Locations of ambient air monitoring stations at ORNL.

analysis. The charcoal cartridges are analyzed biweekly using gamma spectroscopy for adsorbable gas quantification.

Results

The ORNL PAM stations are designed to collectively assess the specific impact of ORNL operations on local air quality. Sampling data from the ORNL PAM stations (Table 5.9) is compared with air sampling data from the reference stations at Norris Dam (51) and Fort Loudoun (52) (Table 5.2). Comparison of the data in the two tables shows that ORNL has not had a significant impact on local air quality.

Table 5.9. Radionuclide concentrations measured at ORNL perimeter air monitoring stations, 1994 (10^{-15} μCi/mL)[a]
Total number of observations = 84

Parameter	Station			
	1	2	3	7
^{241}Am	0.00E+00	0.00E+00	6.70E–03[b]	0.00E+00
^{7}Be	2.68E+01[b]	2.85E+01[b]	3.50E+01[b]	2.24E+01[b]
^{244}Cm	0.00E+00	0.00E+00	4.95E–03	0.00E+00
^{60}Co	6.65E–02	3.93E–02	5.15E–02	0.00E+00
^{137}Cs	1.40E–02	4.91E–02	1.03E–02	4.66E–02
^{3}H			8.74E+04	6.30E+04
^{131}I	2.28E+00[b]	1.21E+00	2.01E+00	1.97E+00[b]
^{133}I	2.09E+00[b]	2.03E+00[b]	3.07E+00[b]	1.96E+00
^{135}I	9.85E+00	7.73E+00	1.16E+01[b]	7.57E+00[b]
^{212}Pb	2.13E+01[b]	1.15E+02[b]	6.00E+01	
^{238}Pu	0.00E+00	0.00E+00	1.03E–04	2.80E–04
^{239}Pu	0.00E+00	0.00E+00	0.00E+00	1.86E–04
Sr, total	0.00E+00	3.14E–02	2.78E–01	1.86E–03
^{228}Th	2.10E–02	4.32E–03	1.03E–02	7.74E–03
^{230}Th	1.75E–02	7.50E–03	1.34E–02	8.85E–03
^{232}Th	1.63E–02	5.30E–03	1.03E–02	4.57E–03
^{234}U	6.18E–02	4.32E–02	5.77E–02	4.47E–02
^{235}U	3.61E–03	1.77E–03	9.48E–03	4.75E–03
^{238}U	2.68E–02	2.26E–02	3.09E–02	3.08E–02

[a]1 μCi = 3.7E+4 Bq.
[b]Statistically significant at 95% level of confidence.

K-25 Site Ambient Air Monitoring

Prior to 1987, the K-25 Site ambient air monitoring program consisted of (1) sampling stations for perimeter, prevailing wind direction, nearest resident, and (2) monitoring for particulate matter, fluorides, and uranium at the maximally affected location. Uranium enrichment activities were discontinued, and the objectives of the ambient air monitoring program were reevaluated in 1986. As a result, the program adopted a five-station network for environmental surveillance of the K-25 Site. Particulate and uranium monitoring were continued and chromium, nickel, and lead monitoring were initiated. Fluoride monitoring was discontinued. This selection of measured chemical species was based on the plating and incineration operations at the K-25 Site. Each of the five stations was equipped with a high-volume sampler to collect particulate matter; in 1987 a PM10 sampler was collocated at one of the existing stations.

A program evaluation in 1993 recommended altering the list of measured chemical species according to regulations concerning hazardous air pollutants: particulate, chromium, lead, and uranium were continued and arsenic, beryllium, and cadmium were added; nickel was discontinued. This change focused on the criteria pollutants, carcinogenic hazardous air pollutant metals, and uranium. In addition, changes in analytical methods allowed for measuring up to the current total of 26 metals. All nonroutine measured metals are being measured periodically to track background levels and site impact, if any, that may demonstrate a need to adjust the list of routinely measured pollutants. During this reporting period, a new station (K6) was activated that extends perimeter monitoring to encompass increased site operations around the K-31/K-33 area (including scheduled demolition activities). The K6 site is located to the southwest side of the K-31/K-33 site and is in the direction of the modeled maximum concentration with respect to TSCA Incinerator operations. Figure 5.10 shows the location of all operational sampling stations as of the fourth quarter 1994.

Results

No standards have been exceeded since the installation of the current monitoring network. These data also support the state classification of this area including the K-25 Site as an attainment area for PM10. Standards are attained when the expected number of exceedences per year at each monitoring site averaged over a 3-year period is less than or equal to 1. Because of this classification, PM10 monitoring is not required; however, it has been a K-25 Site best management practice to maximize environmental monitoring capabilities in this area to continue to support area classification criteria designating attainment. Parameters were chosen with regard to existing and proposed regulations and the potential of K-25 Site operations to emit certain pollutants. Changes in emissions may warrant periodic reevaluation of the parameters sampled and the monitoring locations. Table 5.10 lists selected parameters measured during 1994.

In 1993 the ambient air monitors at TSCA1 and TSCA2 were modified to activate only in the event of an operational upset of the incinerator. Originally, TSCA1 and TSCA2 ran continuously, and samples were collected every 48 hours. Samples are now collected and analyzed following abnormal operations only. The sample medium is changed after an abnormal operation or a minimum of every 30 days following a monthly activation test of the system if no abnormal operation was observed. No operational upsets occurred during the 1994 reporting period.

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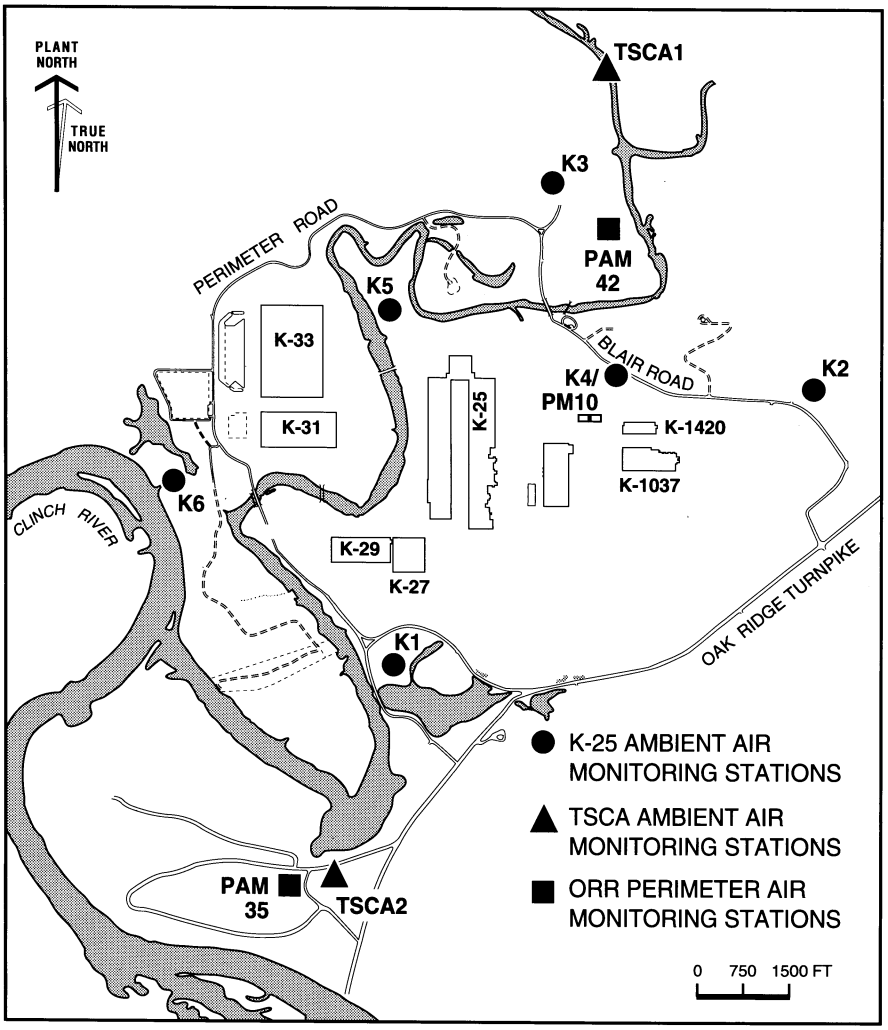

Fig. 5.10. Locations of ambient air monitoring stations at the K-25 Site.

Criteria Pollutant Levels

TSP matter analyses were performed on all high-volume 24-hour samples (Table 5.11). TSP is no longer regulated federally or by the state of Tennessee; however, data are compared with former federal and state primary and secondary standards. For 1994, the 24-hour TSP concentration for all measurement sites ranged from 5.95 to 157.52 $\mu g/m^3$. Station K4 demonstrated the highest 24-hour result because of the localized impact of the K-1407-B/C Pond Closure Project. This project included constructing a gravel parking lot and dump truck traffic carrying earthen fill onto the site via the lot and an access gate adjacent to the station. Typically all sites yield comparable TSP concentration levels during concurrent monitoring unless isolated events such as this project are in progress.

The highest measured value for all stations was 60.6% of the previous 24-hour primary standard and 105% of the secondary standard, both occurring at station K4, indicating a temporary and localized impact on TSP concentrations in the ambient air; however, the previous standards allow one exceedence per year. The next-highest concentrations were 37% of the primary standard and 64% of the secondary standard.

Table 5.10. Summary of ambient air pollutants measured at the K-25 Site, 1994

Parameter	Sampling locations	Collection frequency[a]	Analysis frequency[b]
	Criteria pollutants		
TSP[c]	K1, 2, 3, 4, 5, 6[d]	Weekly	Weekly
PM10	K4	Weekly	Weekly
Lead	K1, 2, 3, 4, 5, 6	Weekly	Monthly[e]
	Hazardous air pollutant carcinogen metals		
Arsenic	K1, 2, 3, 4, 5, 6	Weekly	Monthly[e]
Beryllium	K1, 2, 3, 4, 5, 6	Weekly	Monthly[e]
Cadmium	K1, 2, 3, 4, 5, 6	Weekly	Monthly[e]
Chromium (total)	K1, 2, 3, 4, 5, 6	Weekly	Monthly[e]
	Organic compounds		
PCBs	TSCA 1, 2[f]		
Furan	TSCA 1, 2[f]		
Dioxin	TSCA 1, 2[f]		
Hexachlorobenzene	TSCA 1, 2[f]		
	Radionuclides		
Uranium (total)	K1, 2, 3, 4, 5, 6 TSCA 1, 2[f]	Weekly	Monthly[e]

[a]24-hour sample every sixth day from midnight to midnight.

[b]"Weekly" frequency is analysis of each 24-hour sample: "Monthly" is composite sample analyses of all 24-hour samples per month for each sampler.

[c]TSP is no longer regulated by Tennessee or National Ambient Air Quality Standards (NAAQS).

[d]Sampling station K6 became operational in October of 1994.

[e]Initially, all analyses of data from station K6 are of the weekly samples.

[f]Activated automatically if a TSCA Incinerator operational upset occurs.

Table 5.11. Total suspended particulates in ambient air at the K-25 Site, 1994

Station	Number of samples	Annual summary of TSP concentrations ($\mu g/m^3$)			Max percentage of primary standard[a]	
		24-hour max	24-hour min	Annual av	Annual	24-hour
K1	59	86.78	7.41	26.53	35.37	33.38
K2	57	86.91	5.95	23.42	31.23	33.43
K3	61	80.45	6.30	24.78	33.04	30.94
K4	58	157.52[b]	6.04	34.70	46.27	60.58
K5	57	85.48	8.07	27.71	36.95	32.88
K6	9	49.90	6.71	16.73	22.31	19.19

[a]TSP is no longer regulated; however, previous Tennessee and national primary standards were 260 $\mu g/m^3$ per 24 hours and 75 $\mu g/m^3$ per year geometric mean; secondary standards were 150 $\mu g/m^3$ per 24 hours and 60 $\mu g/m^3$ per year.

[b]Exceeds previous 24-hour secondary TSP standard (1 exceedence was allowed per year).

Annual TSP geometric averages of 24-hour measurements are presented in Table 5.11. TSP is no longer regulated federally or by the state of Tennessee; however, data are compared with previous Tennessee and national primary and secondary standards. The annual TSP results range from 16.73 to 34.70 μg/m^3. The highest average TSP value was only 46.3% of the previous primary annual standard and 57.8% of the previous annual primary and secondary standards, respectively. These levels are typical of this period of the year when compared with historical data (see Fig. 5.11 for 5-year TSP trend).

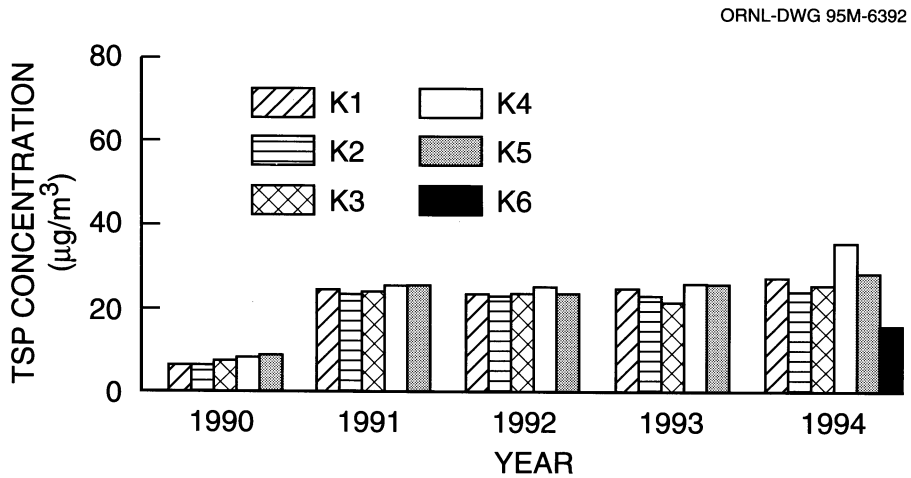

Fig. 5.11. Five-year total suspended particulate results at the K-25 Site. (Note: TSP is no longer regulated. Previously, the state and federal primary air quality standard was 75 μg/m^3; the secondary standard was 60 μg/m^3.)

Daily PM10 particulate-matter analyses were performed on all 24-hour samples (Table 5.12). For 1994, the 24-hour PM10 concentrations ranged from 3.98 to 60.32 μg/m^3. The highest measured value was 40.31% of the Tennessee 24-hour primary and secondary standards. The K-1407-B/C Pond Closure Project was being conducted near the PM10 station (K4) during the fourth quarter of 1994. The impact of PM10 levels was demonstrated by slightly elevated concentrations during this project; however, these levels indicate that the pond closure project did not have a significant impact on PM10 concentrations in the ambient air and is not an environmental concern.

Annual PM10 arithmetic average of 24-hour measurements are presented in Table 5.12. The averaged PM10 annual result was 24.30 μg/m^3. This value was only 48.6% of the Tennessee and national annual primary and secondary standards for PM10. This level is

Table 5.12. PM10 particulates in ambient air at the K-25 Site, 1994

Station	Number of samples	Annual summary of PM10 concentrations (μg/m^3)			Max percentage of standard[a]	
		24-hour max	24-hour min	Annual av	Annual	24-hour
PM10	59	60.32	3.98	24.30	48.60	40.31

[a]PM10 Tennessee and national primary and secondary standards are 150 μg/m^3 per 24 hours and 50 μg/m^3 per year arithmetic average.

slightly higher than typical levels measured during this period of the year, but it is of no environmental concern (see Fig. 5.12 for 5-year PM10 trend).

Quarterly lead results were determined from the analyses of monthly composites of 24-hour samples for each station. The total masses of lead were determined by inductively coupled plasma-mass spectrometer (ICP-MS) analytical technique. This technique was initiated in 1993, replacing a graphite furnace atomic absorption method, thus simplifying all metals analyses to one method. A summary of lead measurements is presented in Table 5.13; the data are compared with the Tennessee and national quarterly standard (1.5 μg/m^3). There are no ambient 24-hour or monthly ambient air criteria pollutant standards for lead. The maximum quarterly lead result was 0.0074 μg/m^3, only 0.5% of the quarterly standard for lead (see Fig. 5.13 for 5-year lead trend).

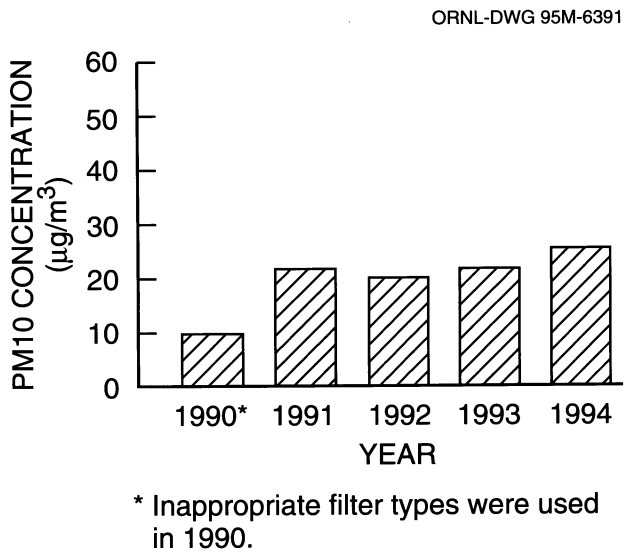

Fig. 5.12. Five-year PM10 results at the K-25 Site. (Note: 50 μg/m^3 = both the state and federal primary and secondary air quality standards for PM10.)

Hazardous Air Pollutant Carcinogen Metal Levels

Measurements of hazardous air pollutant carcinogen metals (arsenic, beryllium, cadmium, and chromium) were performed on a monthly composite of 24-hour samples from each station, although there are no Tennessee or national ambient air quality standards for hazardous air pollutant carcinogen metals. The total mass of each selected metal was determined by ICP-MS analytical technique (Table 5.14). Monthly composited arsenic concentration results for all measurement sites ranged from <0.000001 to 0.001301 μg/m^3. Monthly composited beryllium concentration results for all measurement sites was

Table 5.13. Lead concentrations in ambient air at the K-25 Site, 1994

Station	Quarterly averages of monthly composites (μg/m^3)				Max individual measures[a]	Min individual measures[a]	Percentage of quarterly standard[b]
	1	2	3	4			
K1	0.00593	0.004054	0.005048	0.002242	0.008500	0.000776	0.40
K2	0.00443	0.004119	0.003269	0.001753	0.005669	0.000784	0.30
K3	0.00513	0.003432	0.003338	0.002653	0.006860	0.000935	0.34
K4	0.00454	0.003420	0.003501	0.003222	0.006440	0.000375	0.30
K5	0.00740	0.003110	<0.003748	0.002522	0.01297	<0.000001	0.49
K6	*c*	*c*	*c*	<0.000001	0.000255	<0.000001	<0.01

[a]Maximum/minimum individual monthly composite results.

[b]Tennessee and national air quality standard for lead is 1.5 μg/m^3 quarterly arithmetic average.

[c]Not applicable.

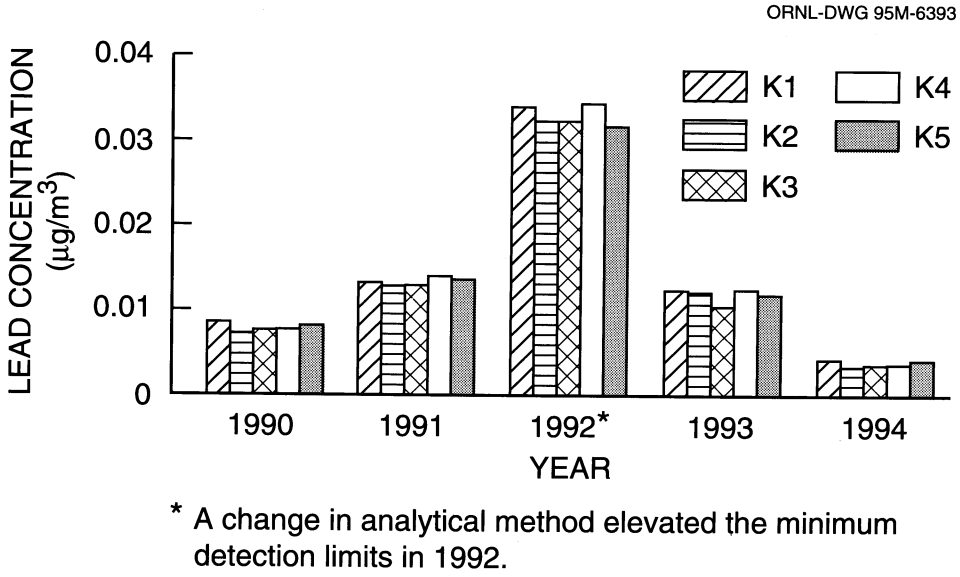

Fig. 5.13. Ambient air monitoring 5-year trend results for lead at the K-25 Site.

Table 5.14. Hazardous air pollutant carcinogen metals in ambient air[a] at the K-25 Site, 1994

Parameter	Number of samples (all stations)	Annual summary of monthly composites (μg/m^3)		
		Monthly max	Monthly min	Annual av[b]
Arsenic	309	0.001301	<0.000001	<0.000276
Beryllium	309	<0.000001	<0.000001	<0.000001
Cadmium	309	0.004676	<0.000001	0.001963
Chromium	309	0.004452	<0.000001	<0.000711

[a]There are no Tennessee or national ambient air quality standards for hazardous air pollutant carcinogen metals.

[b]This result is from the station with the highest annual average.

<0.000001 μg/m^3. Cadmium monthly composited concentration results for all measurement sites ranged from <0.000001 to 0.004676 μg/m^3. Monthly composited chromium concentration results for all measurement sites ranged from <0.000001 to 0.004452 μg/m^3.

Radionuclide Levels

Of the radionuclides, only uranium was measured on a monthly composite of 24-hour samples from each station. The total uranium mass for each composited sample was determined by ICP-MS analytical technique. The uranium concentration for all measurement sites ranged from <0.000001 to 0.001602 μg/m^3 (Table 5.15). Station K2 was the most impacted site, having a monthly maximum concentration of 0.001602 μg/m^3. Station K2 is in the prevailing downwind direction of the TSCA Incinerator. The annual average values for all stations were <1% of the DCG for naturally occurring uranium, which equates to 0.15 μg/m^3 (0.1 pCi/m^3). See Fig. 5.14 for 5-year uranium trend.

Table 5.15. Uranium in ambient air at the K-25 Site, 1994

Station	Number of samples	Annual summary of monthly composites ($\mu g/m^3$)		
		24-hour max[a]	24-hour min[a]	Annual av[b]
K1	60	0.000876	<0.000001	<0.000167
K2	59	0.001602	<0.000001	<0.000403
K3	61	0.000071	<0.000001	<0.000025
K4	60	0.000768	<0.000001	<0.000255
K5	60	0.000254	<0.000001	<0.000033
K6	9	0.000020	<0.000001	<0.000001

[a]Quarterly max/min results is of individual monthly composite analyses.

[b]The annual standard for naturally occurring uranium is 1×10^{-1} pCi/m^3, which is equivalent to 0.15 $\mu g/m^3$.

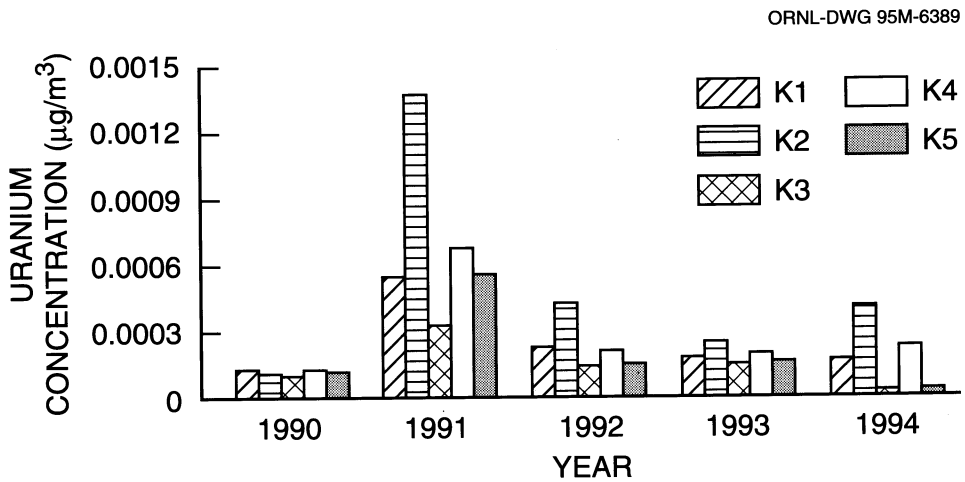

Fig. 5.14. Ambient air monitoring 5-year trend results for uranium at the K-25 Site.

Organic Compound Levels

There were no ambient air measurements of organic compounds during 1994 at the K-25 Site. Currently, measurement of organics is performed only during an operational upset of the TSCA Incinerator. No upsets occurred that activated the TSCA ambient air stations or the subsequent measurements of PCBs, furans, dioxin, and hexachlorobenzene during this reporting period.

Five-Year Trends

Five-year summaries of K-25 Site ambient air monitoring data for each National Ambient Air Quality Standards parameter and uranium are shown in Figs. 5.11 through 5.14. Monitoring results are presented for stations K1, K2, K3, K4/PM10, and K5. Five-year emission trends for PM10, TSP, and lead show insignificant variations during this time period, although program changes have affected the minimum analytical detection limits.

The 5-year trend for uranium indicates the level of work at the K-25 Site. For the 1989 to 1991 period, uranium operations at the K-25 Site were minimal, indicated by the low

detected ambient air levels. The 1991 results indicate the burning of low levels of radioactive wastes in the TSCA Incinerator, which began in the spring of 1991. Although 1991 ambient air levels for uranium increased, no level exceeded 1% of the applicable standard for natural uranium.

SURFACE WATER MONITORING

ORR Surface Water Monitoring

Under the ORR EMP, samples are collected and analyzed from 22 locations around the ORR to assess the impact of past and current DOE operations on the quality of local surface water. Sample locations are on streams downstream of ORR waste sources, at reference points on streams and reservoirs upstream of waste sources, on reference streams off site, and at public water intakes (Fig. 5.15). Sample locations include the following:

- Bear Creek downstream from Y-12 Plant inputs (BCK 0.6),
- Bear Creek downstream from Y-12 Plant burial grounds (BCK 9.4),
- Clinch River downstream from all DOE inputs (CRK 16),
- Water supply intake for the K-25 Site (CRK 23),
- Clinch River downstream from ORNL (CRK 32),
- Water supply intake for Knox County (CRK 58),
- Melton Hill Reservoir above city of Oak Ridge water intake (CRK 66),
- Melton Hill Reservoir at Oak Ridge Marina (CRK 80),

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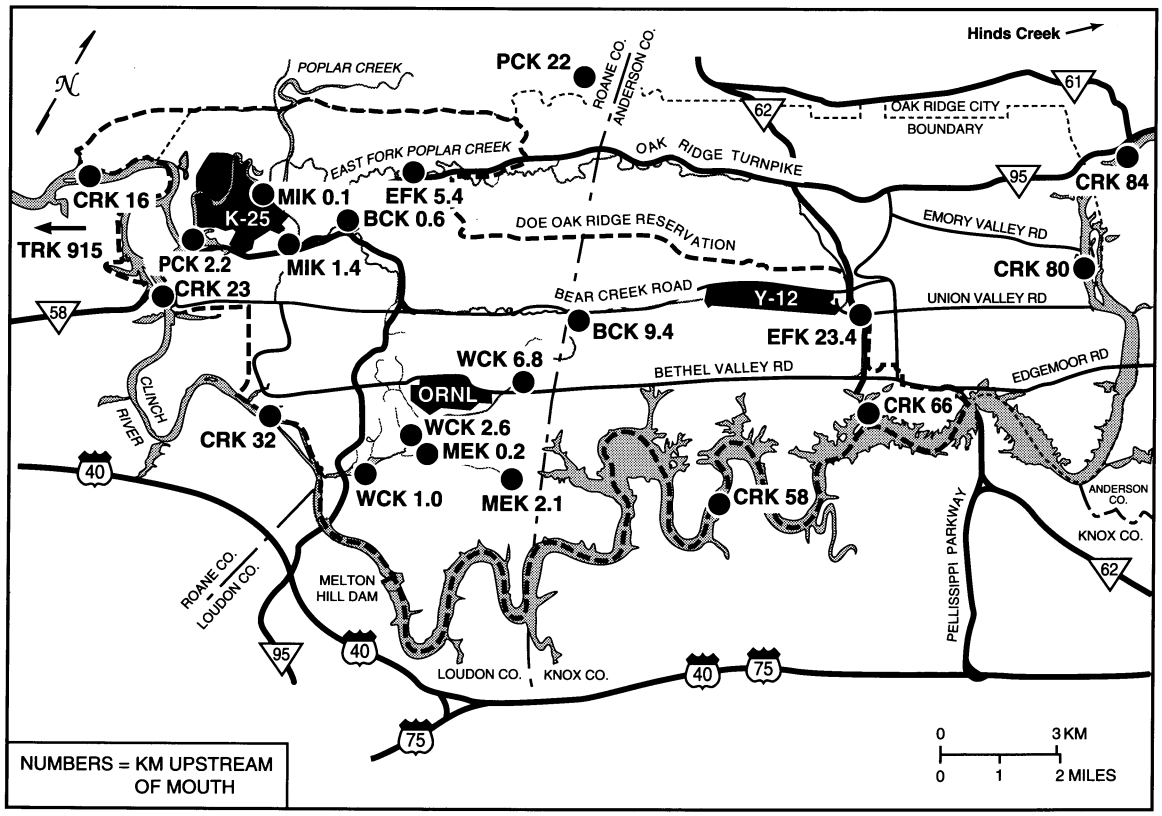

Fig. 5.15. Locations of ORR surface water sampling stations.

- Melton Hill Reservoir above all DOE inputs at the Anderson County Filtration Plant (CRK 84),
- EFPC downstream from floodplain (EFK 5.4),
- EFPC downstream from Y-12 Plant (EFK 23.4),
- Hinds Creek (reference site for EFPC) (HC),
- Melton Branch downstream from ORNL (MEK 0.2),
- Melton Branch upstream from ORNL (MEK 2.1),
- Mitchell Branch downstream from K-25 Site (MIK 0.1),
- Mitchell Branch upstream from K-25 Site (MIK 1.4),
- Poplar Creek downstream from K-25 Site (PCK 2.2),
- Poplar Creek upstream from K-25 Site and EFPC (PCK 22),
- Water supply intake for city of Kingston (TRK 915),
- White Oak Lake at White Oak Dam (WCK 1.0),
- White Oak Creek downstream from ORNL (WCK 2.6), and
- White Oak Creek upstream from ORNL (WCK 6.8).

Water quality measurements serve as guides to the general health of the environment. The sampling and analysis in this program are conducted in addition to requirements mandated in NPDES permits for individual ORR DOE facilities. Although there is some overlap of sampling sites in the NPDES and environmental monitoring plan programs, frequency and analytical parameters vary.

Sampling frequency under the environmental monitoring plan is bimonthly, with half of the sites being sampled one month and the other half in the following month. Grab samples are collected and analyzed for general water quality parameters, total metals, and volatile organics. They are also screened for radioactivity and analyzed for specific radionuclides when appropriate.

In 1994 the collection of semiannual composite samples from White Oak Creek at White Oak Dam (WCK 1.0) and the Clinch River downstream from all DOE inputs (CRK 16) was implemented. These samples are analyzed for isotopic uraniums, thoriums, and transuranics.

Tennessee water quality criteria for domestic water supplies and for freshwater fish and aquatic life are used as references for locations where they are applicable. Out of the 79 parameters sought at each of the 22 locations, silver and chromium at White Oak Dam (WCK 1.0) and copper at White Oak Creek downstream from ORNL (WCK 2.6) on the ORR are the only parameters that exceeded a reference value.

The results for the semiannual composites at CRK 16 and WCK 1.0 are consistent with the bimonthly samples collected from these locations.

Y-12 Plant Surface Water Monitoring

Routine surface water monitoring that is not required by the NPDES permit is performed at the Y-12 Plant site for a variety of reasons, and various radiological and nonradiological parameters are monitored. Monitoring results are compared with state water quality criteria and with DOE order requirements. Data collected for nonradiological parameters are compared with Tennessee water quality criteria if a criterion exists for a given parameter. The most restrictive of either the fresh water fish and aquatic life criterion maximum concentration or the "recreation concentration for organisms only" standard (10^{-5} risk factor for carcinogens) was used.

The water quality monitoring is done as a best management practice. In some instances the water quality criteria are below the reported analytical detection limits (examples are

mercury, selenium, and silver). On some occasions, interferences with the analytical instrumentation, such as high levels of suspended solids after a rainfall, may result in a laboratory reporting a detection limit that is higher than normal and above a water quality criterion. This monitoring serves as a record of water quality criteria as an informal comparison. Of all the parameters measured in the surface water as a best management practice, mercury is the only demonstrated contaminant of concern. Continued reductions of mercury in plant effluent and monitoring for mercury discharge at Station 17 will be a requirement of the new NPDES permit.

Radiological data are compared with DCGs published in DOE Order 5400.5. The DCG for water is the concentration of a given radionuclide that, if the water were ingested at the rate of 730 L/year, would result in an effective dose equivalent of 100 mrem/year to "reference man," as defined by ICRP Publication 23. Radiological data are reported as percentages of the DCGs for given radionuclides. If the sum of DCG percentages for a location ever exceeds 100%, an analysis of the best available technology to reduce the sum of the percentages of the radionuclide concentrations to their respective DCGs to less than 100% would be required as specified in DOE Order 5400.5.

Station 17, located near the junction of Bear Creek and Scarboro roads, is used to monitor EFPC downstream of Lake Reality but prior to its leaving the easternmost Y-12 Plant boundary (Fig. 5.16). Discharges from Y-12 Plant processes affect water quality and flow in EFPC before it enters the Clinch River. Samples were obtained for radiological and nonradiological parameters and grab samples for mercury and volatile organics were obtained daily at Station 17. With the exception of holidays, 24-hour composite samples were obtained every day of the week; a 72-hour composite was collected on weekends for a variety of chemical parameters.

More than 200 samples were collected in 1994 at Station 17 for analysis of nonradiological parameters, resulting in more than 15,000 measurements. Comparisons with Tennessee water quality criteria, for parameters where there was an exceedence, are shown in Table 5.16. All 245 measurements for silver, selenium, mercury, and acrylonitrile

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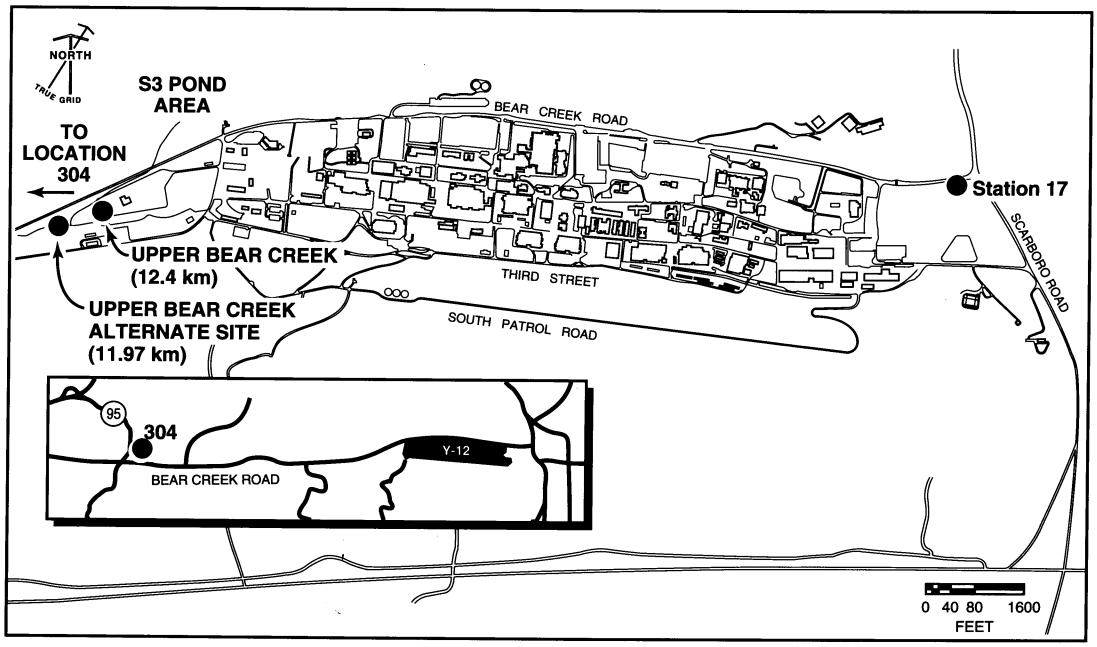

Fig. 5.16. Locations of Y-12 Plant surface water sampling stations.

were above those criteria because the detection limits of the analytical method are above the water quality criteria (see Table 5.16). Of the remaining measurements, some measurements for beryllium, copper, lead, cadmium, and chromium exceeded the criteria because the detection limits were sometimes higher than the water quality criteria. On five occasions the measured value for zinc exceeded the water quality criteria.

Table 5.16. Surface water sampling measurements exceeding Tennessee water quality criteria at the Y-12 Plant, 1994

Parameter	Location	Number of samples	Concentration (mg/L)			Water quality criteria (mg/L)	Number of measurements exceeding criteria
			Detection limit	Max	Av		
Acryloinitrile	Station 17	245	0.010	<0.010	<0.010	0.0067	245
Beryllium	Station 17	245	0.0004	<0.002	<0.0004	0.0013	1
Copper	Station 17	245	0.006	<0.03	<0.007	0.018	2
Lead	Station 17	245	0.02	<0.1	<0.02	0.082	1
Selenium	Station 17	245	0.1	<0.5	<0.1	0.020	245
Silver	Station 17	245	0.006	<0.03	<0.006	0.004	245
Mercury	Station 17	245	0.0002	0.0090	0.0012	0.00015[a]	245
Chromium	Station 17	245	0.006	<0.03	<0.006	0.016	1
Cadmium	Station 17	245	0.0004	<0.02	<0.004	0.004	1
Zinc	Station 17	245	0.01	0.22	<0.01	0.117	5
Mercury	Rogers Quarry (Outfall 302)	52	0.0002	<0.0002	<0.0002	0.00015	52
Selenium	Rogers Quarry (Outfall 302)	52	0.1	<0.1	<0.1	0.020	52

[a]The Tennessee water quality standard for recreation is 0.00015 mg/L. The freshwater fish and aquatic life standards are 0.024 mg/L for maximum concentrations and 0.000012 mg/L for continuous concentrations.

Mercury data are used for long- and short-term trending of mercury concentrations in plant effluents. The legacy of contamination resulting from the use and storage of mercury at the Y-12 Plant has been previously acknowledged and has prompted a series of remedial measures. In the late 1950s, the average annual concentration of mercury in EFPC peaked at about 2.3 mg/L (2,300 μg/L) (Fig. 5.17). Recent annual average concentrations ranged from 0.0014 to 0.0016 mg/L (1.4 to 1.6 μg/L) (Fig. 5.18). Because of mercury abatement activities and decreases in water flow, mercury loading to EFPC from the Y-12 Plant has decreased significantly. Average daily values were about 60 g/day in the early 1980s, whereas recent values are nearly 15 g/day, representing a 75% decrease in mercury releases during the past decade.

All radiological measurements at Station 17 were well below the DCGs. The summed percentage of DCGs for measured radionuclides at Station 17 was 1.94%. The largest single contributor to this total was ^{238}U. The median value for ^{238}U at this location for 1994 was 6.7 pCi/L, which represents 1% of the DCG. In 1994, the total uranium and associated curies released from the Y-12 Plant, as measured at Station 17 on UEFPC, was 185 kg, or 0.11 Ci (4.1×10^9 Bq).

NPDES sampling locations 302 (Rogers Quarry) and 304 on Bear Creek (km 4.55) are considered instream sampling points for McCoy Branch and Bear Creek. In past years, coal bottom ash slurry was discharged to the McCoy Branch Watershed from the Y-12 Steam Plant. Bear Creek water quality is affected by area source runoff and groundwater discharges from waste disposal sites. Of measurements collected and comparisons made to

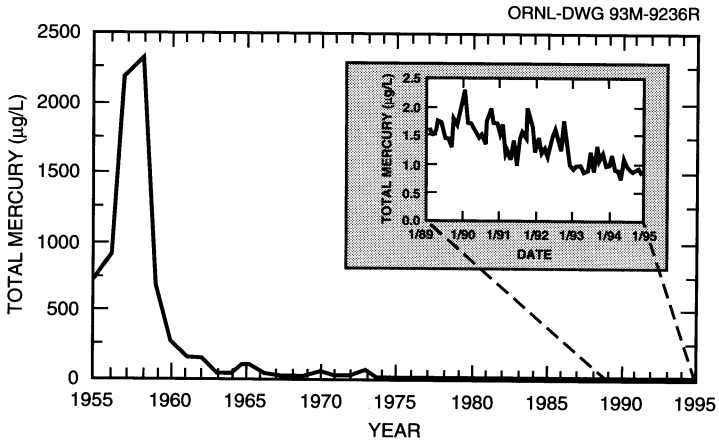

Fig. 5.17. Mercury concentrations in surface water leaving the Y-12 Plant, 1955–95. Values plotted in large graph are annual averages. Values in inset are monthly averages.

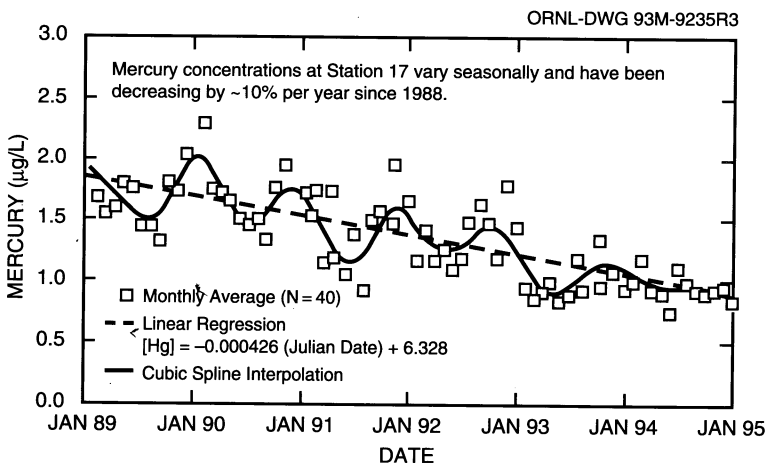

Fig. 5.18. Monthly average (n = 40) mercury concentrations in East Fork Poplar Creek at Station 17 near the eastern end of the Y-12 Plant, January 1989–December 1994. Straight and sinusoidal lines fitted to data represent long-term and seasonal trends, respectively.

state water quality criteria for surface water surveillance, only mercury and selenium exceeded the criteria at Outfall 302. This was because the analytical-method detection limits for mercury (0.0002 mg/L) and selenium (0.1 mg/L) exceed the water quality criterion (0.00015 mg/L). At Outfall 304, no measurements made as part of the surface water program exceeded water quality criteria.

Additional surface water sampling is conducted at Outfall 304 by the Y-12 Plant groundwater protection program to monitor trends throughout the Bear Creek Hydrogeologic Regime (see Sect. 7).

In addition to surveillance monitoring via conventional surface water sampling, the Y-12 Plant has established a series of monitoring stations on the storm sewer collection system and EFPC. These stations are officially known as the Surface Water Hydrological Information Support System (SWHISS). The SWHISS network is designed to monitor and record various surface water parameters to aid in spill tracking and water quality determination. Ten stations are currently operational (Fig. 5.19).

Telemetry delivers real-time monitoring data to the Utilities Monitoring Station 9 and the SWHISS house central computer in Building 9704-1. Real-time monitoring parameters vary for each site but typically include pH, temperature, conductivity, dissolved oxygen, and flow. Two locations on EFPC also measure chlorine.

ORNL Reference Surface Water Monitoring

The net impact of ORNL activities on surface waters is evaluated by comparing data from samples collected at reference locations with information from samples collected

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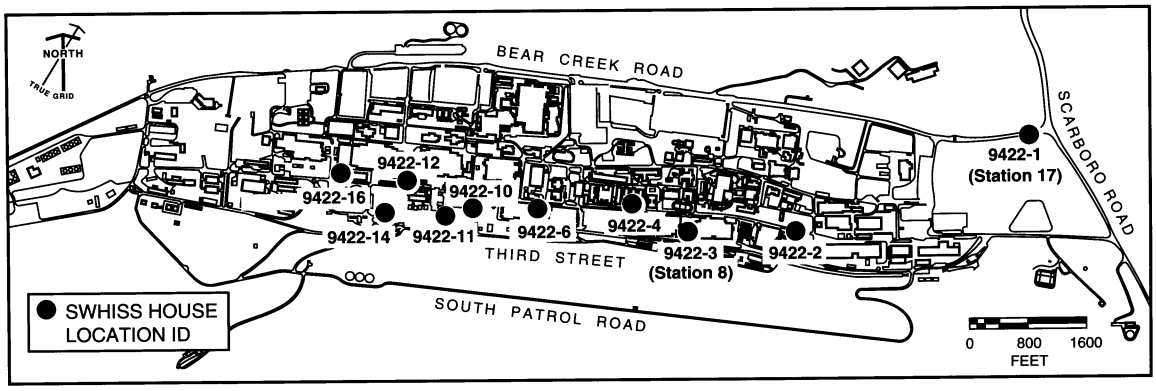

Fig. 5.19. Operating Surface Water Hydrological Information Support System monitoring locations.

downstream of the facility. Monthly surface water samples are collected at two sampling locations to determine contamination levels before the influence of White Oak Creek, the primary discharge point into Watts Bar Lake from the ORNL plant site. One sampling location is Melton Hill Dam above ORNL's main discharge point into the Clinch River. The other sampling location is White Oak Creek headwaters above any ORNL discharge points to White Oak Creek (Fig. 4.14).

Analyses were performed to detect radioactivity and conventional, inorganic, and organic pollutants in the water. Conventional pollutants are indicated by conductivity, temperature, turbidity, pH, total dissolved solids, total suspended solids, and oil and grease. Inorganic parameters are indicated by analyses for metals and anions. The presence of organic pollutants is indicated by results from total organic carbon analysis. If the total organic carbon result is greater than 2.5 mg/L, analyses for volatile and semivolatile organic compounds will be conducted.

There were no high levels of organic compounds detected by the total organic carbon analysis at either location, as indicated by the maximum value of 2.3 mg/L at Melton Hill Dam and by the maximum value of 1.8 mg/L at White Oak Creek headwaters.

In an effort to provide a basis for evaluation of analytical results and for assessment of surface water quality, drinking water standards (DWSs) from 40 CFR Parts 141 and 143, and the Tennessee General Water Quality Criteria for Domestic Water Supply have been used. Although DWSs are used, it is unrealistic to assume that members of the public are going to drink untreated water from Melton Hill Dam and White Oak Creek headwaters.

There is reasonably good agreement between parameters measured at White Oak Creek headwaters and those at Melton Hill Dam. Aluminum, iron, and manganese were the only average concentrations that exceeded the DWSs at both White Oak Creek headwaters and Melton Hill Dam. Concentrations of these magnitudes are commonly associated with the hydrogeology of the Clinch River.

Radiological data are compared with DOE DCGs. The average concentration for a radionuclide is expressed as a percentage of its DCG when a DCG exists and when the average concentration is significantly greater than zero. At the reference locations, none of the averages for 1994 were significantly greater than zero.

ORNL Radiological Liquid Effluent Monitoring Program Under the EMP

In 1994 monitoring for gamma activity and tritium was added at the ORNL NPDES Category I and Category II outfalls. Category I outfalls are storm drains; Category II outfalls are storage area drains, once-through cooling water, cooling-tower blowdown, and condensate drains. Samples are collected at these outfall locations at the same time as samples are collected for the ORNL NPDES program. Radionuclides detected at these outfalls were <1% of the DCG for the respective radionuclide.

K-25 Site Surface Water Monitoring

In addition to the ORR surface water surveillance program, surface water surveillance is conducted at six locations at the K-25 Site (Fig. 5.20) as a best management practice. The West Fork Poplar Creek and K-1710 sampling locations provide information representative of surface water conditions upstream of the K-25 Site. Station K-716 is located downstream of most K-25 Site operations and provides information on the cumulative effects of the operations of the K-25 Site as well as those upstream. The remaining sampling locations are at points where drainage in the major surface water basins converges before discharging to Poplar Creek (K-1007-B and K-1700) or to the Clinch River (K-901-A).

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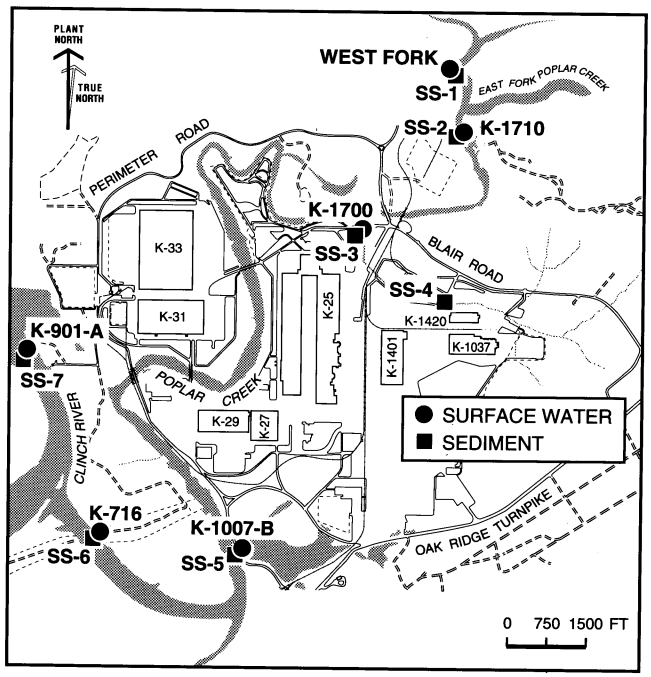

Fig. 5.20. Monitoring locations for surface water and sediment at the K-25 Site.

Samples are analyzed monthly for radionuclides. Quarterly samples from the six locations are collected and analyzed for general water quality parameters, selected metals, and organic compounds. In addition, samples from K-901-A and K-1007-B are analyzed monthly for PCBs. Samples from the remaining locations are analyzed quarterly for PCBs. Radionuclide results are compared with the DCGs. Nonradiological results are compared with Tennessee water quality standards for fish and aquatic life, where such standards are published. Many monitored parameters have no published standards.

In most instances, results of the analyses for nonradiological parameters are well below the applicable standards. Zinc, which occurs naturally in the soil of the area, was detected at just above the limit in one sample from K-1700. Lead, nickel, silver, and mercury were occasionally detected but always in very low concentrations. For iron and manganese, DWSs are sometimes exceeded, but the DWSs are below the level present in ambient waters. Both elements are abundant in the soil of East Tennessee, and water samples collected upstream of K-25 Site operations often show results above the standards. In

addition, natural conditions cause periodic exceedences of DWSs for dissolved oxygen and pH.

Dissolved oxygen measurements regularly fall below the minimum water quality standard during the summer months because of increased temperature (and therefore lower solubility of the gas) and increased biological activity. Similarly, increased photosynthesis during the summer months causes an increase in the pH of area waterways, sometimes exceeding the maximum water quality standard. Water bodies in the vicinity of the K-25 Site are regularly inspected for signs of stress on aquatic organisms during these periods. No evidence that these conditions have a negative impact on the aquatic communities was discovered during 1994. For most of the analyses, results are below detection limits for the instrument and method. Moreover, analytical results for samples collected upstream of the K-25 Site are chemically similar in most respects to those collected below the K-25 Site.

The sum of the fractions of the DCGs for all six sampling locations remained below 1.0 for the year, as is required by DOE Order 5400.5 (Fig. 5.21). The highest sum of the fractions, 0.058, or 5.8% of the allowable DCG, was reported for sampling location K-1700. These results are still well below the conservative limits established by the order. The 1994 radiological data do not indicate any significant radiological effects from K-25 Site operations on perimeter surface waters.

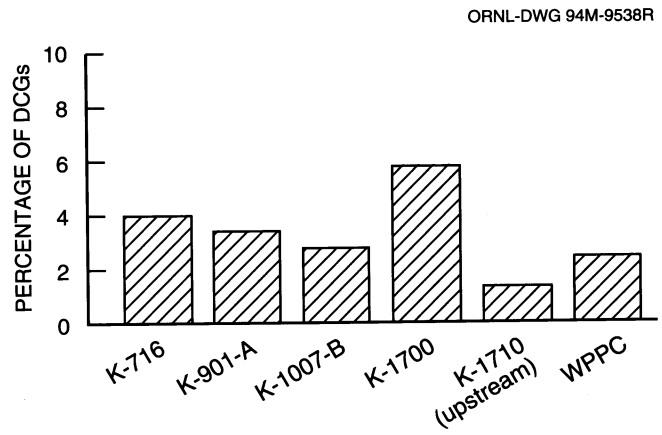

Fig. 5.21. Percentage of DCGs for K-25 Site surface water monitoring locations.

Off-Site Spring and Residential Well Monitoring

In 1989, ORNL implemented a long-term program to monitor off-site residential drinking water quality. The objective of the program as described in the ORR environmental monitoring plan is to document water quality from groundwater sources near the ORR and to monitor the potential impact of DOE-ORO operations on the quality of these groundwater sources.

Currently, 3 springs and 16 wells are included in the program. These locations were selected because of their proximity to the ORR and because they are located on a representative distribution of sources from the different geologic formations of the area. They are sampled semiannually, subject to access availability, and the results are provided in individual reports to the owners. Eighteen locations were sampled in February 1994, and 17 were sampled in August 1994, for a total of 35 sets of samples.

Parameters monitored include volatile organics, metals, anions, and the radioactive parameters: gross alpha activity, gross beta activity, total radioactive strontium, technetium-99, tritium, and radionuclides observed in a gamma scan. In past years, sampling has not indicated any contaminant movement to these sites, and results from sampling in 1994 continue to support this finding.

The federal DWS for fluoride was exceeded during both sampling events at one well, and the standard for nitrate was exceeded at another well during both events. The concentrations measured were consistent with the historical behavior of the individual wells. The well exceeding fluoride limits is located deep in the Conasauga formation; the high fluoride concentration most likely results from natural chemical reactions that can occur in deep wells that penetrate the Conasauga geologic group.

Off-Site Treated Water Monitoring

The ORNL program for assessing impacts to the Clinch and Tennessee rivers uses empirical data from samples taken at the Kingston and Gallaher potable water treatment plants (Fig. 5.22). In 1994, composite samples of treated water samples were collected weekly and analyzed quarterly for total uranium and specific radionuclides.

Federal and state DWSs (40 CFR Parts 141 and 143 and the Tennessee General Water Quality Criteria for Domestic Water Supply) were used as reference values. If a DWS for a radionuclide has not been established, then 4% of the DOE DCG for that radionuclide is used as the reference value. The average radionuclide concentration is expressed as a percentage of the reference value when a reference exists and when the average is significantly greater than zero. In 1994, there were no average radionuclide concentrations greater than 3.1% of reference values at the Kingston Water Treatment Plant and none greater than 3.8% of reference values at the Gallaher Water Treatment Plant. The laboratory method used for total uranium does not permit a test of significance for the maximum and minimum, but the average concentrations of uranium at both Gallaher and Kingston were <0.9% of the gross alpha standard (15 pCi/L). The total uranium measurement is converted to an activity by assuming natural abundance of uranium isotopes ^{234}U, ^{235}U, and ^{238}U.

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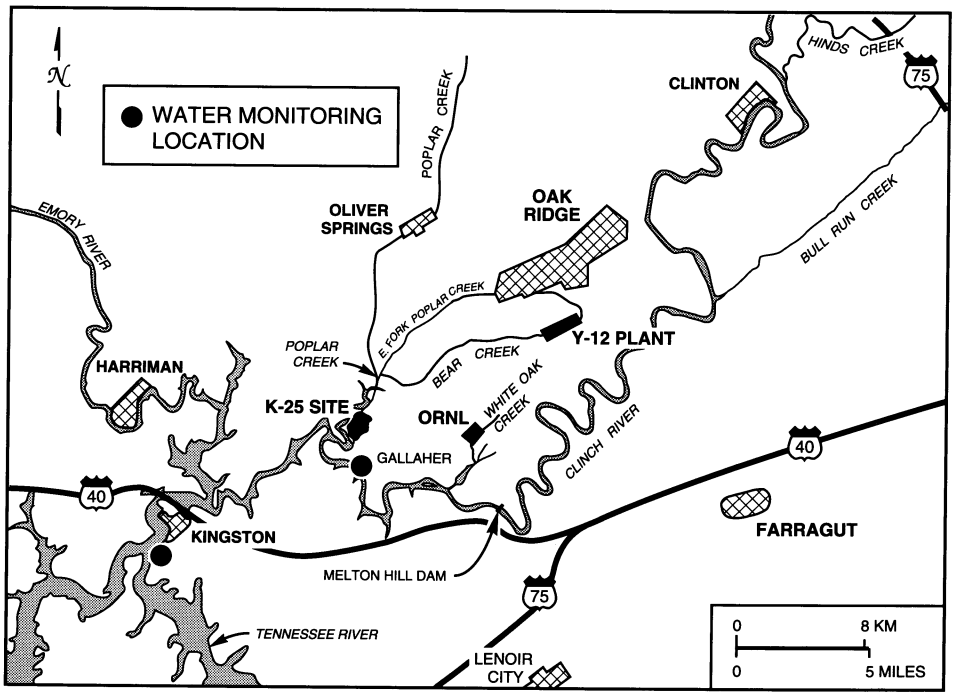

Fig. 5.22. Sampling locations for off-site treated water.

SOIL

Soil is an integrating medium that can contain pollutants originally released to the air and can thus provide a measure of pollutant deposition from the atmosphere. Soil sampling and analysis is used to evaluate long-term accumulation trends.

Soil plots consisting of a known mixture of soil were erected at nine of the ambient air stations in the fall of 1992 (eight perimeter stations and the remote station at Norris Dam; see Fig. 5.4). These soil plots eliminate the differences in the mechanics of transport in the different types of soil found naturally on the ORR. The soil plot program is described in detail in the environmental monitoring plan for the ORR. Additionally, soil samples are collected at the K-25 Site as a best management practice.

Vertical composite samples were collected at the nine stations once during 1994. Samples were analyzed for gross alpha and beta activity; gamma emitters; total radiological strontium; and uranium, thorium, beryllium, and plutonium isotopes.

Results

Concentrations for the ORR are summarized in Table 5.17. These values do not differ significantly from previous soil data.

In addition to the ORR soil sampling program, soil samples are collected at the K-25 Site as a best management practice. Soil samples taken at points coinciding with K-25 Site ambient air monitoring stations are analyzed for both nonradiological concentrations and radiological activity once per calendar year. The selection of sampling locations in this manner integrates the overall environmental sampling program to allow for comparability of data between the soil and ambient air media in evaluating long-term accumulation trends. Soil sampling locations at the K-25 Site are shown in Fig. 5.23.

Metals such as cadmium, lead, nickel, mercury, and silver were detected in all soil sampling locations; however, the concentrations were always very low. PCBs were

Table 5.17. Results of radiological analysis of ORR soil samples, 1994 (pCi/g)[a]

Parameter	Station								
	35	37	38	39	40	42	46	48	51
^{241}Am	*b*	0.02	*b*	0.01	0.03	*b*	0.02	*b*	*b*
^{7}Be	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*
^{244}Cm	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*
^{60}Co	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	0.07
^{137}Cs	*b*	0.76	0.12	0.13	0.13	*b*	0.08	*b*	*b*
Gross alpha	1.82	1.59	2.42	2.08	1.74	1.39	1.55	1.42	0.86
Gross beta	3.78	2.65	4.19	3.92	3.38	3.24	2.84	3.78	1.84
^{40}K	2.33	2.74	3.51	3.38	2.43	4.05	2.5	3.92	3.38
^{238}Pu	*b*	*b*	*b*	*b*	0.01	0.01	0.02	*b*	*b*
^{239}Pu	*b*	*b*	*b*	0.02	*b*	*b*	*b*	*b*	*b*
Sr, total	0.74	0.77	0.66	0.59	0.61	0.66	0.68	0.43	0.22
^{228}Th	0.29	0.27	0.29	0.18	0.3	0.27	0.23	0.22	0.27
^{230}Th	0.08	0.08	0.12	0.08	0.08	0.1	0.09	0.08	0.06
^{232}Th	0.84	0.08	0.11	0.07	0.83	0.1	0.05	0.08	0.06
^{234}U	0.22	0.19	0.19	0.24	0.1	0.24	0.21	0.13	0.1
^{235}U	0.03	0.01	0.01	0.01	0.005	*b*	*b*	0.01	0.03
^{238}U	0.11	0.06	0.09	0.07	0.06	0.09	0.07	0.06	0.04

[a]1 pCi = 3.7E–02 Bq.
[b]Not detected.

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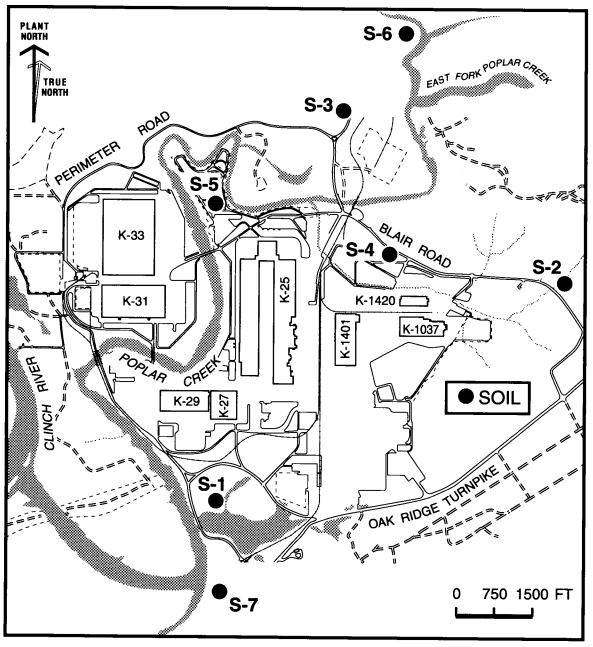

Fig. 5.23. Soil sampling locations at the K-25 Site.

detected at three K-25 soil sampling locations: on the northwest peninsula, near the K-1209 meteorological tower, and near the old powerhouse area. In all instances, the concentrations were estimated values because the levels were below the normal limit of detection for the method. Semivolatile organic compounds and chlorinated pesticides were not detected in any K-25 soil sample.

Radionuclides detected in the soil samples include ^{137}Cs, ^{234}U, ^{235}U, ^{238}U, ^{237}Np, ^{238}Pu, ^{239}Pu, and ^{99}Tc. The activity levels measured in 1994 were comparable to those of 1993. In all but two instances, activity levels for those isotopes were <1 pCi/g. The two exceptions were ^{234}U activities of 1.05 pCi/g and 1.57 pCi/g, both of which were from samples collected along the northern edge of the K-25 Site, where most of the industrial and waste management and storage activities have occurred.

In addition to the requested isotopes, ^{234m}Pa, ^{228}Th, ^{234}Th, and ^{40}K were detected in some of the samples. The measured activities were low, and in many cases were below the minimum detectable activity for a 95% confidence level.

SEDIMENT

ORR Sediment

Stream and lake sediments act as a record of some aspects of water quality by concentrating and storing certain contaminants. Annually, under the ORR environmental monitoring plan, sediment samples are collected at 16 sites near surface water and biological monitoring locations in and around the reservation (Fig. 5.24). The sampling sites are as follows:

- Bear Creek downstream from all DOE inputs (BCK 0.6),
- Bear Creek downstream from Y-12 Plant burial grounds (BCK 9.4),
- Clinch River downstream from all DOE inputs (CRK 16),
- Clinch River downstream from ORNL (CRK 32),
- Melton Hill Reservoir at Oak Ridge Marina (CRK 80),
- Melton Hill Reservoir above all DOE inputs at Anderson County Filtration Plant (CRK 84),
- EFPC downstream from floodplain (EFK 5.4),
- EFPC downstream from Y-12 Plant (EFK 23.4),
- Hinds Creek (reference site for EFPC) (HC),
- Melton Branch upstream from ORNL (MEK 2.1),
- Mitchell Branch downstream from K-25 Site (MIK 0.1),
- Mitchell Branch upstream from K-25 Site (MIK 1.4),

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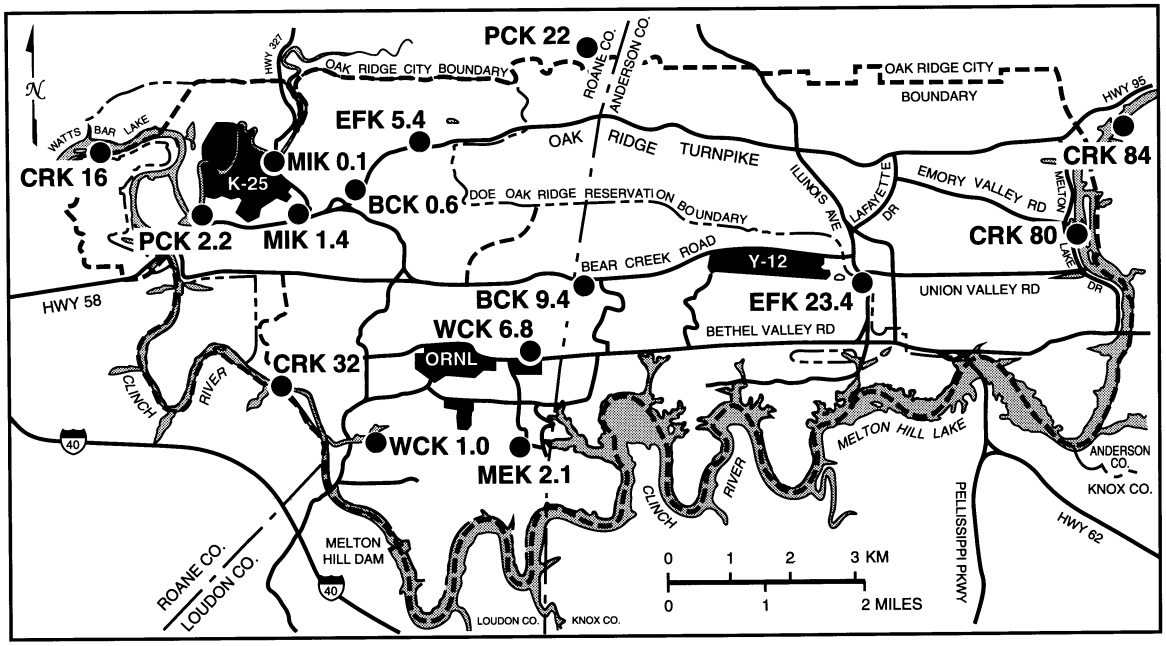

Fig. 5.24. ORR environmental monitoring plan sediment sampling locations.

- Poplar Creek downstream from K-25 Site (PCK 2.2),
- Poplar Creek upstream from K-25 Site and EFPC (PCK 22),
- White Oak Lake at White Oak Dam (WCK 1.0), and
- White Oak Creek upstream from ORNL (WCK 6.8).

Sediments are effective at concentrating and storing contaminants that have a high affinity for organic and inorganic surfaces, but they also contain naturally occurring organic and inorganic chemicals. In analytical measurements, the naturally occurring chemicals in sediment lead to higher backgrounds and less sensitivity than those found in water samples. Sediments are best analyzed for substances that are concentrated and retained in the sediment, resulting in sensitive, time-integrated measurements of contamination. The program was initiated in 1993, and the locations are sampled annually. Samples were analyzed for total metals, chlorinated pesticides, PCBs, semivolatile organic compounds, and selected radionuclides. Comparison of 1994 data with historical data is difficult because the program was initiated in 1993. The data are insufficient to distinguish any patterns or trends. In addition, sediments in stream environments are highly variable, and the variability is reflected in the data collected to date.

K-25 Site Sediment

In addition to the ORR sediment sampling program, sediment samples are taken at some locations near the K-25 Site as a best management practice; they are taken at points coinciding with the K-25 Site surface water sampling locations and are analyzed for radiological activity and other parameters once per calendar year. This activity is part of

environmental surveillance monitoring, which assesses the impact of the site's operations on the public and environment as required by DOE Order 5400.1.

Sediment samples are collected at the points that coincide with surface water sampling points, away from the turbulent area of the discharges, when applicable (Fig. 5.21). Samples are collected and analyzed for radiological activity and nonradiological parameters such as metals, pesticides, PCBs, and semivolatiles. K-25 Site sediment sampling is consistent with the DOE order requirements and is designed to complement the ORR surveillance program.

Results

Analyses for nonradiological parameters indicate that the geology of the K-25 Site is the dominant factor in determining the composition of sediment samples.

Metals such as cadmium, lead, mercury, nickel, and silver were detected in several samples. Interestingly, the samples having the highest concentrations of both cadmium and lead as well as the second-highest concentration of silver were collected from the West Fork Poplar Creek location, which is above the area of the stream expected to be affected by any ORR or K-25 Site activity.

Cadmium, lead, and mercury were also present at K-716 in concentrations greater than those of most other sampling locations. Overall, concentrations of these metals were similar to or slightly less than concentrations in samples taken in 1993.

No pesticides were detected; however, a number of semivolatile organic compounds were detected. In all cases, the values were estimated because the concentrations were below the normal detection limits for the method. The West Fork Poplar Creek site produced the highest results for several of the compounds. As in 1993, the concentrations of most semivolatile organic compounds at most locations were undetectable.

PCB (Aroclor 1254) was detected on Mitchell Branch at K-1700 and on Poplar Creek at K-716. In both instances, reported concentrations were estimated values below the recognized detection limit.

Radionuclides detected in sediment samples from the K-25 Site include ^{109}Cd, ^{137}Cs, ^{237}Np, ^{238}Pu, ^{239}Pu, ^{40}K, ^{234m}Pa, ^{99}Tc, ^{228}Th, ^{234}Th, ^{234}U, ^{235}U, ^{236}U, and ^{238}U. In general, activity levels for 1994 were similar to those obtained in 1993. In almost all cases, the activity for an individual isotope at a specific location was below (sometimes well below) 1 pCi/g.

FOOD

Collection and analysis of vegetation samples serves three purposes: to evaluate potential radiation doses received by people consuming food crops; to predict possible concentrations in meat, eggs, and milk from animals consuming grains; and to monitor trends in environmental contamination and possible long-term accumulation of radionuclides.

Hay

Hay is cut on the ORR and sold to area farmers for fodder. Six areas from which hay is cut have been identified as potential depositional areas for airborne materials from ORR sources (Fig. 5.25). Areas 1, 2, and 3 are within the predicted air plume for an ORNL source and could also be affected by the K-25 Site. Baled hay was collected from each of the three sites and composited. Areas 2, 4, 5, and 6 are within the predicted air plume for a

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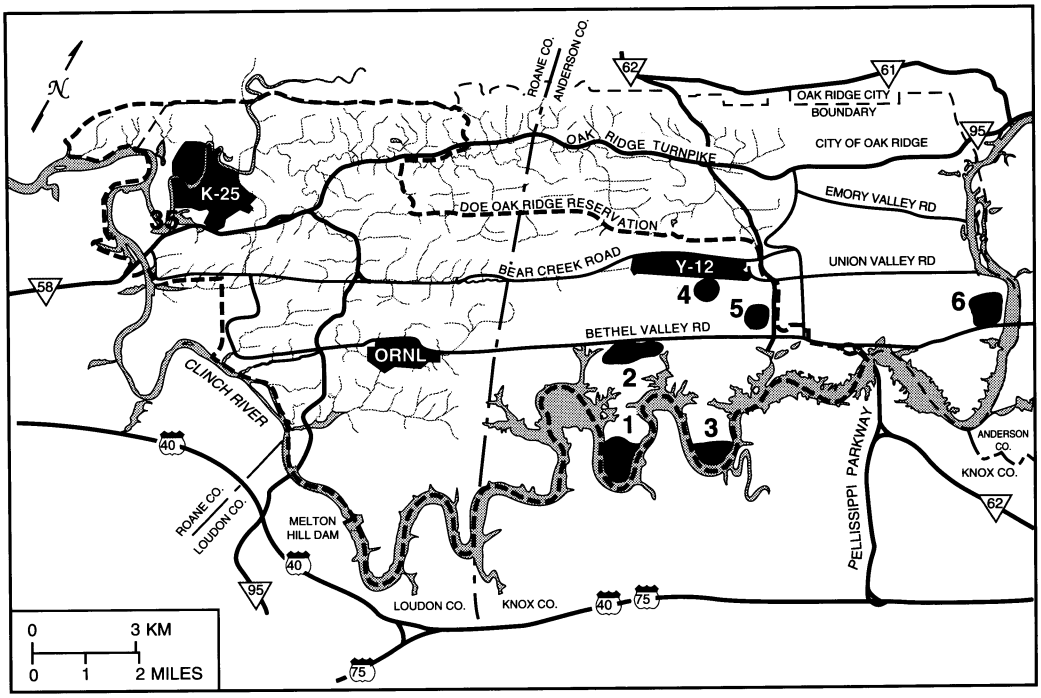

Fig. 5.25. Hay sampling locations on the ORR.

K-25 Site, an ORNL, and a Y-12 Plant source. Baled hay was collected from each of these sites and composited. Area 6 best represents the combined plumes from all three sites; baled hay was collected from this site. A reference site has been added to this program; reference data will be available in 1995.

Results

Hay samples were collected during June 1994, and samples were analyzed for gross alpha and beta, gamma emitters, iodine, and fluorides. Table 5.18 summarizes the results of the sampling effort; note that ^{7}Be and ^{40}K are naturally occurring isotopes found throughout the area.

Vegetables

Tomatoes were grown in nine soil plots established at ambient air stations (Fig. 5.4). Lettuce was harvested from seven soil plots (crops failed at Stations 39 and 42). Turnips were harvested from two plots (46 and 51) and were purchased from private gardens near Stations 35, 39, and 40. Turnip crops failed at Stations 37, 38, 42, and 48. Tomatoes were harvested in August; lettuce, in June; and turnips, in December.

Results

Samples were analyzed for gross alpha and beta, gamma emitters, and isotopic uranium. Table 5.19 summarizes the results of the sampling effort.

The analytical results indicate that radionuclide concentrations in tomatoes, lettuce, and turnips do not vary significantly when comparing samples collected at the reference

Table 5.18. Concentrations of radionuclides and fluoride in hay from the ORR, 1994[a]

Analyte	Area		
	1, 2, 3	2, 4, 5	6
^{7}Be	1.3E–08	1.4E–08	6.2E–11
^{60}Co	5.2E–11	1.7E–12	2.7E–12
^{137}Cs	2.7E–11	5.9E–11	6.7E–12
^{129}I	1.4E–11	2.7E–11	4.0E–12
^{40}K	6.0E–09	3.3E–09	1.5E–08
^{3}H	3.7E–10	6.8E–09	4.4E–10
Gross alpha	4.4E–10	4.7E–10	1.4E–10
Gross beta	4.1E–09	4.7E–09	1.3E–08
Fluoride	1.0E+00	1.2E+00	7.1E–01

[a]All radionuclide data are given in curies per kilogram (1 pCi = 3.7E–02 Bq). Fluorine data are given in micrograms per gram.

station (51) with those obtained from the ORR plots or purchased from representative gardens near ORR plots.

Milk

Ingestion is one of the pathways of exposure to radioactivity for humans. Radionuclides can be transferred from the environment to people via food chains such as the grass-cow-milk pathway. Milk is a potentially significant source to humans of some radionuclides deposited from airborne emissions because of the relatively large surface area that a cow can graze daily, the rapid transfer of milk from producer to consumer, and the importance of milk in the diet.

The 1994 milk sampling program consisted of monthly grab samples collected from five locations in the vicinity of the ORR (Fig. 5.26). Milk samples are analyzed at ORNL for radioactive iodine (^{131}I) by gamma spectrometry and for total radioactive strontium (^{89}Sr + ^{90}Sr) by chemical separation and low-background beta counting. Liquid scintillation is used to analyze for tritium (^{3}H).

Results

Radioactivity measurements are reported as the net activity (the difference between the gross activity and instrument background). A value is considered to be a detected value if it exceeds 1.645 times its estimated standard error. Concentrations of total radioactive strontium were detected in milk (Table 5.20). There were no detected concentrations of ^{131}I or ^{3}H. Average values for radioactive strontium were converted to EDEs and are presented in Section 6 of this report. Results are consistent with data from previous years.

Fish

Members of the public potentially could be exposed to contaminants originating from DOE-ORO activities through consumption of fish caught in area waters. This exposure pathway is monitored under the ORR environmental monitoring plan by collecting fish from 14 locations annually and analyzing edible fish flesh. Sampling locations are located

Table 5.19. Results of radiological samples of vegetables grown on the ORR, 1994 (pCi/g)[a]

Parameter	Station								
	35	37	38	39	40	42	46	48	51
					Tomatoes				
^{60}Co	6.8E–05	0	1.5E–04	2.6E–04	2.3E–04	2.6E–04	0	3.8E–04	0
^{137}Cs	8.1E–05	0	3.2E–04	0	9.5E–05	0	2.7E–05	1.2E–04	1.5E–04
Gross alpha	1.3E–03	0	1.4E–03	0	0	6.2E–04	4.9E–04	3.0E–04	2.8E–03
Gross beta	1.8E–01	1.5E–01	1.7E–01	1.5E–01	1.5E–01	1.5E–01	1.8E–01	1.5E–01	1.5E–01
^{40}K	2.7E–01	2.0E–01	2.4E–01	2.2E–01	2.7E–01	2.8E–01	2.2E–01	2.8E–01	2.0E–01
^{234}U	7.6E–05	6.9E–05	4.7E–05	6.2E–06	8.4E–05	6.4E–05	2.7E–05	4.5E–05	3.1E–05
^{235}U	1.8E–05	1.5E–05	6.8E–06	9.5E–06	2.7E–06	3.4E–05	3.1E–06	2.7E–05	6.1E–06
^{238}U	1.5E–05	2.7E–05	5.0E–05	1.9E–05	1.1E–05	2.0E–05	1.2E–05	3.6E–05	1.1E–05
					Lettuce				
^{7}Be	1.4E–02	2.7E–03	3.3E–02	*b*	1.3E–03	*b*	7.5E–03	1.0E–02	1.3E–03
^{60}Co	4.0E–04	0.0E+00	2.1E–03	*b*	3.5E–03	*b*	1.0E–03	9.4E–04	9.4E–04
^{137}Cs	5.1E–03	3.7E–03	5.1E–03	*b*	1.4E–03	*b*	2.9E–03	5.2E–03	1.0E–03
Gross alpha	1.0E–01	6.0E–02	1.4E–01	*b*	1.2E–01	*b*	1.3E–01	1.9E–01	5.9E–02
Gross beta	4.5E+00	4.0E+00	3.7E+00	*b*	3.6E+00	*b*	3.6E+00	3.9E+00	4.4E+00
^{40}K	3.5E+00	3.3E+00	4.0E+00	*b*	3.5E+00	*b*	2.8E+00	3.9E+00	3.2E+00
^{234}U	3.7E–03	4.8E–03	1.5E–02	*b*	1.0E–02	*b*	1.2E–02	1.2E–02	1.2E–02
^{235}U	3.1E–04	1.0E–03	3.6E–03	*b*	2.7E–03	*b*	0.0E+00	6.7E–04	4.3E–03
^{238}U	4.6E–03	3.2E–03	9.7E–03	*b*	3.5E–03	*b*	8.2E–03	7.1E–03	8.1E–04
					Turnips				
^{7}Be	2.7E–03	*b*	*b*	2.2E–02	1.6E–02	*b*	2.2E–02	*b*	7.3E–02
^{60}Co	3.2E–03	*b*	*b*	6.8E–03	1.6E–03	*b*	–2.7E–04	*b*	–2.2E–03
^{137}Cs	5.4E–04	*b*	*b*	3.0E–03	–2.2E–03	*b*	5.4E–04	*b*	2.2E–03
Gross alpha	1.1E–02	*b*	*b*	1.1E–02	–2.4E–03	*b*	–4.3E–02	*b*	1.6E–02
Gross beta	1.8E+00	*b*	*b*	1.7E+00	1.5E+00	*b*	1.5E+00	*b*	1.8E+00
^{40}K	6.5E–01	*b*	*b*	2.6E+00	2.3E+00	*b*	1.4E+00	*b*	2.3E+00
^{234}U	–3.2E–04	*b*	*b*	5.1E–03	4.1E–03	*b*	–7.6E–04	*b*	2.4E–03
^{235}U	–1.0E–03	*b*	*b*	4.1E–03	–1.1E–03	*b*	–2.7E–04	*b*	–7.6E–04
^{238}U	–1.0E–03	*b*	*b*	1.6E–03	3.0E–03	*b*	–6.2E–04	*b*	–1.1E–03

[a]1 pCi = 3.7E–02 Bq.
[b]Crop failure.

downstream of DOE activities, at upstream reference locations, and at one off-site reference location. Sampling sites are divided into six larger river locations and eight smaller creek locations. Because of the limited number and size of fish available for sampling on the creek locations, different fish-processing and analytical procedures are used. Only results from sampling at river locations are presented in this report.

The river locations include five sites on the Clinch River and one location on Poplar Creek (Fig. 5.27):

- Melton Hill Reservoir above all DOE inputs at Anderson County Filtration Plant (CRK 84),
- Melton Hill Reservoir at Oak Ridge Marina (CRK 80),
- Melton Hill Reservoir above city of Oak Ridge water intake (CRK 66),
- Clinch River downstream from ORNL (CRK 32),
- Clinch River downstream from all DOE inputs (CRK 16), and
- Poplar Creek downstream from K-25 Site (PCK 2.2).

Additional monitoring of wildlife on the ORR, both aquatic and terrestrial, is conducted under BMAP, a requirement of facility NPDES permits. The eight creek locations for fish collection are included in this effort, the results of which do not appear in this report.

ORNL-DWG 85M-9421R10

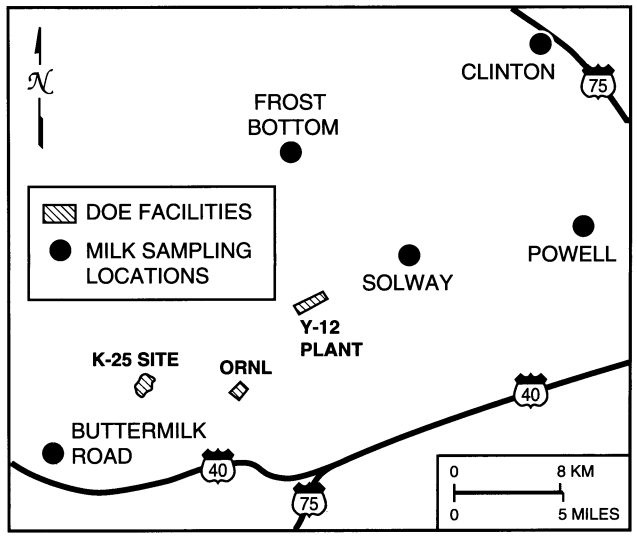

Fig. 5.26. Milk sampling locations in the vicinity of the ORR.

Table 5.20. Concentrations of total radioactive strontium (^{89}Sr + ^{90}Sr) in raw milk, 1994 (pCi/L)[a]

Station	No. Detected/ No. of samples	Detected concentration			Standard error of mean
		Max	Min	Av	
Buttermilk Road	12/12	2.27	0.84	1.43[b]	0.13
Powell	12/12	2.59	0.59	1.67[b]	0.19
Clinton	11/11	4.32	0.59	2.01[b]	0.34
Frost Bottom	12/12	3.24	0.92	2.08[b]	0.18
Solway	6/6	5.94	0.70	3.33[b]	0.71
Network summary	53/53	5.94	0.59	2.10[b]	0.28

[a]1 pCi = 3.7E-02 Bq.

[b]Average is significantly greater than zero at the 95% confidence level. The average value for EPA Region IV is 1.8 pCi/L (U.S. EPA 1993a).

Sunfish (*Lepomis macrochirus*, *L. auritus*, and *Ambloplites rupestris*) are collected from each of the six river locations, filleted, and frozen. When enough fish have been collected (typically 150 to 200 per location), the samples are thawed and fillets from six of the largest are analyzed for selected metals, pesticides, and PCBs. The rest (separated into three composite samples) are ashed and analyzed for ^{60}Co, ^{137}Cs, and total radioactive strontium. To provide data from a second species, six to ten catfish are also collected at the CRK 16 and CRK 32 locations, and a composite sample is analyzed for selected metals, pesticides, and PCBs. A composite sample is also ashed and analyzed for ^{60}Co, ^{137}Cs, and total radioactive strontium.

ORNL-DWG 93M-5468R

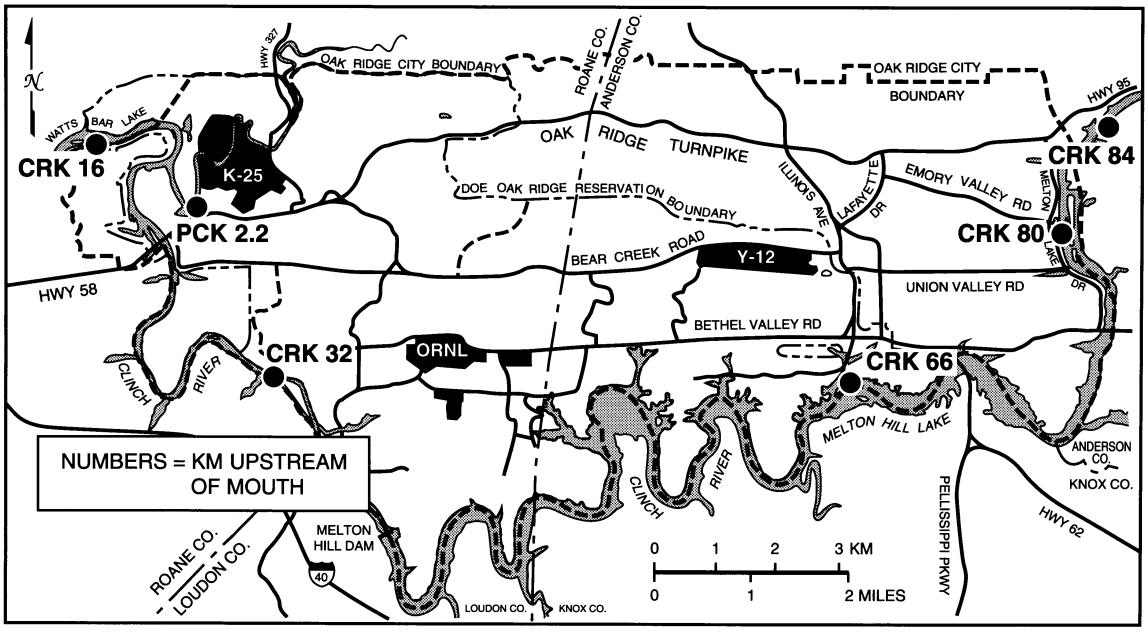

Fig. 5.27. Fish sampling locations along the Clinch River.

Results

For all six locations, most parameters analyzed for in sunfish were undetected. Most parameters analyzed for in catfish collected at CRK 16 and CRK 32 were undetected. Catfish sampling was initiated in 1993, and the locations are sampled annually. Given that this is the second year of catfish sampling and the third year of sunfish sampling, there are sparse historical data that can be used for comparison with the 1994 results. Some comparisons have been made, but it is difficult to draw any conclusions. (See Tables 6.8 and 6.11 for EDEs associated with fish consumption.)

For PCBs, reported values for sunfish and catfish were below the federal Food and Drug Administration (FDA) tolerance of 2 ppm; for mercury, all reported values were below the FDA action level of 1 ppm. This has been true for all 3 years of the program. Information regarding potential health impacts associated with the sunfish and catfish data is provided in Section 6.

White-Tailed Deer

The tenth annual deer hunts managed by DOE and the TWRA were held on the ORR during the final quarter of 1994. ORNL staff, TWRA, and student members of the Wildlife Society (University of Tennessee Chapter) performed most of the necessary operations at the checking station.

The 1994 deer hunt varied from previous years. All three hunts this year were gun hunts; however, during the November 12–13 hunt, an archery hunt was conducted in a designated area separate from the gun-hunt areas. An archery-only hunt area was established on the northeast side of ORNL, which allowed archery hunting during all three hunt periods.

From the total harvest of 495 animals, 309 (62.4%) were bucks and 186 (37.6%) were does. The heaviest buck had 8 antler points and weighted 185 lb. The greatest number of

points (11) were found on three bucks, weighing 123, 132, and 136 lb. The heaviest doe weighted 123 lb.

Results

Of the 495 deer harvested, 8 were confiscated because they exceeded established release limits (5 pCi/g for ^{137}Cs and 20 pCi/g for ^{90}Sr). Concentrations of ^{90}Sr in bone exceeded the confiscation limit in all eight of the deer confiscated. Concentrations of ^{137}Cs in the deer released to the public did not exceed 2.2 pCi/g. Elevated ^{137}Cs concentrations were also detected in two of the eight confiscated deer, which is unlike results from recent years. The deer confiscated during the 1994 hunt represent 1.6% of the total deer harvested.

Resident Canada Geese

One objective of the ORR waterfowl program is to determine concentrations of gamma-emitting radionuclides accumulated by waterfowl associated with waste disposal areas. Radioactive elements found in waste material are the primary types of contaminants associated with the ORR. The annual roundup of Canada geese for leg banding and collaring took place on June 28 and 29, 1994. During the roundup, whole-body gamma scans were conducted on 105 geese at the deer-checking station: 20 geese each from ORNL, the K-25 Site, Melton Hill Dam, Oak Ridge Marina, and Clark Center Park and 5 from the Y-12 Plant were analyzed. Afterward, the geese were returned to their original areas.

The sampling areas are chosen because the geese congregate there. The geese are highly mobile animals that range freely to sites on and off the reservation. For that reason, the results in this report should be taken as an indication of the possible overall impact that the reservation has on the geese rather than as an evaluation of the collection sites.

Results

Of the 105 geese counted in 1994, 66 had concentrations of ^{137}Cs that were considered to be statistically greater than zero. Of these, the highest concentration, 1.2 pCi/g, was found in a goose collected at ORNL. The average ^{137}Cs concentration in the 66 geese was estimated to be 0.12 pCi/g.

6. Dose

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Abstract

The interaction of radiation emitted by radionuclides with human tissue accounts for most of the doses from radionuclides in the environment. Radionuclides can be taken into the body through ingestion, inhalation, and skin absorption. Humans can also be exposed directly to radiation sources outside the body, which can include radionuclides. Radiation dose can be estimated based on type of radiation, route and length of exposure, and organs exposed. This section presents estimates of the radiation from the small quantities of radionuclides released to air and water as a result of operations at the Oak Ridge Reservation facilities during 1994 and describes the methods used to make these estimates.

RADIATION DOSE

Small quantities of radionuclides were released to the environment from operations at the ORR facilities during 1994. Those releases are quantified and characterized in Sects. 4, 5, and 7. This section presents estimates of the potential radiation doses to the public from the releases and describes the methods used to make the estimates.

Terminology

Most doses associated with radionuclide releases to the environment are caused by interactions between radiation emitted by the radionuclides and human tissue. These interactions involve the transfer of energy from the radiation to tissue, a process that may damage the tissue. The radiation may come from radionuclides located outside the body (in or on environmental media or objects) or from radionuclides deposited inside the body (by inhalation, ingestion, and, in a few cases, absorption through the skin).

Exposures to radiation from nuclides located outside the body are called external exposures; exposures to radiation from nuclides deposited inside the body are called internal exposures. This distinction is important because external exposures occur only when a person is near or in a radionuclide-containing medium; internal exposures continue as long as the radionuclides remain inside the person. Also, external exposures may result in uniform irradiation of the entire body and all its components; internal exposures usually result in nonuniform irradiation of the body. (When taken into the body, most radionuclides deposit preferentially in specific organs or tissues and thus do not irradiate the body uniformly.)

A number of the specialized terms and units used to characterize exposures to ionizing radiation are defined in Appendix A. One of these is used repeatedly in this section and is defined as the effective dose equivalent (EDE), a risk-based dose equivalent that can be used to estimate health-effects risks to exposed persons. It is a weighted sum of dose equivalents to specified organs, expressed in rem or sieverts (1 rem = 0.01 Sv).

Methods of Evaluation

Airborne Radionuclides

Characterization of the radiological consequences of radionuclides released to the atmosphere from ORR operations during 1994 was accomplished by calculating, for each plant and for the entire ORR, EDEs to maximally exposed off-site individuals and to the entire population residing within 80 km (50 miles) of the center of the ORR. The dose calculations were made using the CAP-88 package of computer codes (Beres 1990), which was developed under EPA sponsorship to demonstrate compliance with Rad-NESHAP 40 CFR 61, Subpart H. This package contains the most recent, approved version of the AIRDOS-EPA and DARTAB computer codes and the ALLRAD88 radionuclide data file. The AIRDOS-EPA computer code implements a steady-state Gaussian plume atmospheric dispersion model to calculate concentrations of radionuclides in the air and on the ground. It also uses Regulatory Guide 1.109 (NRC 1977) food chain models to calculate radionuclide concentrations in foodstuffs (vegetables, meat, and milk) and subsequent intakes by humans.

The concentrations and human intakes are used by EPA's latest version of the DARTAB computer code to calculate EDEs from radionuclides released to the atmosphere. The dose calculations use the dose conversion factors (DCFs) contained in the ALLRAD88 data file (Beres 1990).

Three types of radionuclide releases were reported in the ORR Rad-NESHAP report for 1994: monitored, sampled, and calculated. Monitored releases are quantified using data from continuous sampling systems. Monitored sources during 1994 included the combined monitored stacks at the Y-12 Plant; stacks associated with buildings 2026, 2523, 3020, 3039, 7830, 7877, and Stack 7911 at ORNL; and the K-25 Site TSCA Incinerator (K-1435) stack.

Sampled releases are calculated from measured radionuclide contents of various media (e.g., grab samples of room air concentrations and sections of filters) and measured flow rates through the sampled media. Sampled sources during 1994 include room exhausts at the Y-12 Plant; stacks associated with buildings 2000, 2523, 3018, 3074, 3544, 7025, and 7512 at ORNL; and discharge points associated with the K-1015 laundry, the K31/K33 R114 transfer project and purging operation, and the K-31 cascade equipment removal project at the K-25 Site.

Calculated releases are determined from source inventories (e.g., hot cell, hood, and storage area) using EPA-approved emission factors. Therefore, these calculated releases are conservative and largely hypothetical. Their purpose is to determine whether source monitoring or sampling is required. All doses (including those derived from these hypothetical releases) must be reported in the annual site environmental report and in the Rad-NESHAP report; however, it is important to realize that radiation doses associated with calculated releases, which may be hypothetical, are added to the doses associated with monitored and sampled releases.

Monitored and sampled radionuclide releases were modeled for 1 combined release point at the Y-12 Plant, for 13 release points at ORNL, and for 4 release points at the K-25 Site. Table 6.1 lists the source parameter values used in the calculations.

Meteorological data used in the calculations were in the form of joint frequency distributions of wind direction, wind speed class, and atmospheric stability category. These data were derived from data collected during 1994 at the 60-m height on MT6 for the Y-12 Plant; at the 100-m height on meteorological tower 2 (MT2) for stacks 2000, 2026, 2523, 3018, 3020, 3039, 3074, 3544, and 7025 and at the 30-m height on MT4 for stacks 7512,

Table 6.1. Monitored and sampled release point parameters and receptor locations used in the dose calculations

Source name	Type	Release height (m)	Inner diameter (m)	Gas exit velocity (m/s)	Gas exit temperature (°C)	Distance (m) and direction to maximally exposed individual	
						Plant	ORR
				Y-12 Plant			
All	Point	20	0	0	Ambient	1080 NNE	1080 NNE
				ORNL			
2026	Point	22.9	1.05	10.4	Ambient	5450 E	9300 NE
3020	Point	61.0	1.96	5.6	Ambient	5450 E	9300 NE
3039	Point	76.2	5.68	2.6	Ambient	5450 E	9300 NE
7025	Point	4.0	0.3	13.6	Ambient	5710 SW	7550 NNE
7512	Point	30.5	0.91	8.8	Ambient	3720 SW	9640 NNE
7911	Point	76.2	3.43	2.7	Ambient	3720 SW	9640 NNE
7830	Point	4.6	0.21	6.7	Ambient	2350 SW	10990 NNE
7877	Point	13.9	0.51	10.6	Ambient	2350 SW	10990 NNE
2000	Point	15.2	0.66	8.9	Ambient	4060 SSW	9300 NE
3018	Point	61.0	4.11	0.2	Ambient	5450 E	9300 NE
3074	Point	4.0	0.26	10.2	Ambient	5450 E	9300 NE
3544	Point	9.5	0.27	16.6	Ambient	5450 E	9300 NE
2523	Point	7.0	0.3	5.1	57.2	5450 E	9300 NE
				K-25 Site			
K-1435	Point	30.5	1.37	5.6	79.1	5180 WSW	13000 ENE
K-1015	Point	3.7	0	0	Ambient	4340 WSW	14000 ENE
K-31/K-33	Point	25.9	0	0	Ambient	3330 WSW	14800 ENE
K-31	Point	19.8	0	0	Ambient	3330 WSW	14800 ENE

7830, 7877, and 7911 at ORNL; and at the 60-m height on MT1 for the K-25 Site. Rainfall on the ORR during 1994 was 166 cm (65.5 in.), the average air temperature was 14°C (57°F), and the average mixing layer height was 1000 m.

When calculating dose, it is assumed that each person remained at home (actually, outside the house), unprotected, during the entire year and obtained food according to the rural pattern defined in the NESHAP background documents (EPA 1989). This pattern specifies that 70% of the vegetables and produce, 44.2% of the meat, and 39.9% of the milk consumed by each person are produced in the local area (e.g., a home garden). The remaining portion of each food is assumed to be produced within 80 km (50 miles) of the ORR. For collective EDE estimates, production of beef, milk, and crops within 80 km of the ORR was calculated using the state-specific production rates provided with CAP-88.

Results

Calculated EDEs from radionuclides emitted to the atmosphere from the ORR are listed in Tables 6.2 (maximum individual) and 6.3 (collective). The EDE received by the hypothetical, maximally exposed individual for the ORR was calculated to be about 1.7 mrem (0.017 mSv), which is below the NESHAP standard of 10 mrem (0.10 mSv) and well below the 300 mrem (3 mSv) that the average individual receives from natural sources

Table 6.2. Calculated radiation doses to maximally exposed off-site individuals from airborne releases during 1994

Plant	Total effective dose equivalents [mrem (mSv)]	
	Plant max	ORR max
ORNL	1.0E–01 (1.0E–03)[a]	3.0E–02 (3.0E–04)
K-25 Site	1.0E–01 (1.0E–03)[b]	2.0E–02 (2.0E–04)
Y-12 Plant	1.7E+00 (1.7E–02)[c]	1.7E+00 (1.7E–02)
Entire ORR	*d*	1.7E+00 (1.7E–02)[e]

[a]The maximally exposed individual is located 4060 m (2.5 miles) SSW of the 3039 stack and 3720 m (2.3 miles) SW of the 7911 stack.

[b]The maximally exposed individual is located 5180 m (3.2 miles) WSW of the K-1435 stack.

[c]The maximally exposed individual is located 1080 m (0.7 miles) NNE of the Y-12 Plant release point.

[d]Not applicable.

[e]The maximally exposed individual for the entire ORR is the Y-12 Plant maximally exposed individual.

Table 6.3. Calculated collective EDEs from airborne releases during 1994

Plant	Effective dose equivalents	
	Person-rem[a]	Person-Sv
ORNL	3	0.03
K-25 Site	4	0.04
Y-12 Plant	13	0.13
ORR	19	0.19

[a]The collective effective dose equivalents to the 879,546 persons residing within 80 km (50 miles) of the ORR.

of radiation. About 0.2 mrem (0.002 mSv) of the 1.7 mrem is from calculated emissions. The maximally exposed individual is located about 9300 m (5.8 miles) northeast of the 3039 stack at ORNL, about 13,000 m (8.1 miles) east-northeast of the K-1435 (TSCA Incinerator) stack at the K-25 Site, and about 1080 m (0.7 miles) north-northeast of the Y-12 Plant release point. The calculated collective EDE to the entire population within 80 km (50 miles) of the ORR (about 879,546 persons) was about 19 person-rem (0.19 person-Sv), which is 0.007% of the 264,000 person-rem that this population could have received from natural sources of radiation. About 4 of the 19 person-rem are from calculated emissions.

The EDE received by the hypothetical, maximally exposed individual for the Y-12 Plant was calculated to be 1.7 mrem (0.017 mSv). This individual is located about 1080 m (0.7 miles) north-northeast of the Y-12 Plant release point. Essentially, all (99%) of this dose is from ingestion and inhalation of uranium, primarily ^{234}U, ^{235}U, and ^{238}U. The contribution of Y-12 Plant emissions to the 50-year committed collective EDE to the

population residing within 80 km of the ORR was calculated to be about 13 person-rem (0.13 person-Sv), which is approximately 66% of the collective EDE for the ORR.

The EDE received by the hypothetical, maximally exposed individual for ORNL was calculated to be 0.14 mrem (0.0014 mSv). This individual is located 4060 m (2.5 miles) south-southwest of the 3039 stack and 3720 m (2.3 miles) southwest of the 7911 stack. About 7% of this dose is from ingestion and inhalation of tritium, about 34% is from immersion in noble gases, and about 33% is from ingestion and inhalation of ^{138}Cs. Calculated source terms account for about 17% of the dose. The contribution of ORNL emissions to the collective EDE to the population residing within 80 km of the ORR was calculated to be about 3 person-rem (0.03 person-Sv), which is approximately 16% of the collective EDE for the ORR.

The EDE received by the hypothetical, maximally exposed individual for the K-25 Site was calculated to be 0.12 mrem (0.0012 mSv). This individual is located about 5180 m (3.2 miles) west-southwest of the TSCA Incinerator (K-1435) stack. About 80% of this dose is from ingestion and inhalation of uranium, about 6% is from thorium, and about 9% is from neptunium-237. The contribution of K-25 Site emissions to the collective EDE to the population residing within 80 km of the ORR was calculated to be about 4 person-rem (0.04 person-Sv), which is approximately 19% of the collective EDE for the reservation.

The reasonableness of the calculated radiation doses can be inferred by examining the radiation doses that could be received from measured air concentrations of radionuclides at the ORR PAMs and RAMs (Fig. 5.4). Hypothetical individuals assumed to reside at the PAMs have the potential to receive EDEs between 0.13 and 1.2 mrem/year (0.0013 and 0.012 mSv/year); these EDEs include contributions from naturally occurring (background) radionuclides, from radionuclides released from the ORR, and radionuclides released from any other sources. An indication of doses from sources other than those on the ORR can be obtained from the EDEs calculated at the two RAMs, which averaged 0.10 mrem/year (0.0010 mSv/year). Between 30 and 90% of the calculated EDEs at the PAMs are attributable to tritium.

Of particular interest is a comparison of doses calculated using measured air concentrations at PAMs located near the maximally exposed individuals for each plant and doses calculated to those individuals using CAP-88 and measured emissions. PAM 46 is located near the maximally exposed individual for the Y-12 Plant and the entire ORR. The EDE calculated at PAM 46 was 0.17 mrem/year (0.0017 mSv/year), which is 10% of the 1.7 mrem/year (0.017 mSv/year) to the maximally exposed individual modeled by the CAP-88 code. PAM 39 is located near the maximally exposed individual for ORNL. The EDE calculated at PAM 39 was 0.15 mrem/year (0.0015 mSv/year), which is essentially the same as the 0.14 mrem/year (0.0014 mSv/year) based on CAP-88 code modeling. PAM 35 is located near the maximally exposed individual for the K-25 Site. The EDE calculated at PAM 35 was 0.36 mrem/year (0.0036 mSv/year), which is three times higher than the 0.12 mrem/year (0.0012 mSv/year) modeled value to the maximally exposed individual.

Waterborne Radionuclides

Radionuclides discharged to surface waters from the ORR enter the Tennessee River system by way of the Clinch River and various feeder streams. Discharges from the Y-12 Plant enter the Clinch River by way of Bear Creek and East Fork Poplar Creek, both of which enter Poplar Creek before it enters the Clinch River. Discharges from ORNL enter the Clinch River by way of White Oak Creek and White Oak Lake. Discharges from the K-25 Site enter the Clinch River by way of Poplar Creek. This section discusses the potential radiological impacts of these discharges to persons who drink water, eat fish,

swim, boat, and use the shoreline at various locations along the Clinch and Tennessee rivers.

Measured, annual-average concentrations of radionuclides in water samples taken at the K-25 Site (Gallaher) water plant and at the Kingston municipal water plant were used to calculate potential maximum individual EDEs from drinking water. A person who drank 365 L of K-25 Site water during 1994 could have received an EDE of about 0.3 mrem (0.003 mSv); a person who drank 730 L of Kingston water could have received about 0.04 mrem (0.0004 mSv).

A program initiated during 1993 involves collecting samples of water and fish at selected locations along the Clinch River, Poplar Creek, and near the intake of the Kingston city water plant on the Tennessee River (Fig. 5.22). The results of this sampling program were used to illustrate potential radiation doses from radionuclides found in waters above and below inputs from the ORR.

Measured concentrations of radionuclides in water at the selected locations were input to the LADTAP XL computer code to calculate potential EDEs to maximally exposed individuals who are assumed to eat 21 kg of fish/year, to swim for 27 hours/year, to boat for 63 hours/year, and to use the shoreline for 67 hours/year at the sampled location. Also, fish sampling data were used to calculate maximum individual EDEs from eating 21 kg of fish. Table 6.4 is a summary of the potential EDEs. Eating fish and shoreline usage are the only significant contributors to potential EDEs. Doses attributable to swimming and boating are negligibly small.

The two methods of calculating EDEs from eating fish, using measured concentrations of radionuclides in water and using measured concentrations of radionuclides in fish, gave very different results, largely because of differences in the radionuclides reported as present by the two approaches. In many instances, doses calculated using concentrations in water exceeded those calculated using concentrations in fish tissue. Both sets of results are presented in Table 6.4.

Calculated EDEs ranged from 0.05 to 1.9 mrem (0.0005 to 0.019 mSv) per year. High and low dose estimates are found both above and below DOE inputs. Doses that result from eating fish range from 0.001 to 1.6 mrem (0.00001 to 0.016 mSv) per year, and doses resulting from shoreline exposures ranged from 0.0007 to 0.4 mrem (0.000007 to 0.004 mSv) per year.

When all pathways are considered, the maximum EDE resulting from waterborne radionuclide discharges could have been about 2.2 mrem (0.022 mSv): 1.9 mrem (0.019 mSv) from use of off-site waters plus 0.3 mrem (0.003 mSv) from drinking K-25 Site water. The collective EDE to the 50-mile population was estimated to be about 4 person-rem (0.04 person-Sv). These are small percentages of individual and collective doses attributable to natural background radiation, 0.7% and 0.002%, respectively.

Radionuclides in Other Environmental Media

The CAP-88 computer codes calculate radiation doses from ingestion of meat, milk, and vegetables that contain radionuclides released to the atmosphere. The doses are included in the dose calculations for airborne radionuclides.

Milk

One environmental pathway for ingestion, drinking milk, also was evaluated using concentrations of strontium, tritium, and ^{131}I measured in milk collected from nearby farms. If, during the year, an individual drank 310 L of milk containing the highest

Table 6.4. Potential maximum individual EDEs from use of off-site waters (mrem)[a,b]

Location	Eating fish	Swimming	Boating	Using shoreline	Total
Clinch River above all DOE input (CRK 84)	6.0E–03 3.0E–01	6.0E–05	3.0E–05	5.0E–02	5.0E–02/4.0E–01
Clinch River at Oak Ridge Marina (CRK 80)	1.0E–03 1.2E+00	4.0E–04	2.0E–04	4.0E–01	4.0E–01/1.6E+00
Clinch River above Oak Ridge city water intake (CRK 66)	1.0E–02 2.0E–01	2.0E–04	5.0E–05	9.0E–02	1.0E–01/3.0E–01
Clinch River at Knox County water intake (CRK 58)	*c* 1.0E+00	1.0E–04	3.0E–05	6.0E–02	*c*/1.1E+00
Clinch River below ORNL (CRK 32)	6.0E–01 2.0E–01	7.0E–05	6.0E–08	7.1E–04	6.0E–01/2.0E–01
Clinch River at K-25 Site water intake (CRK 23)	*c*	5.0E–05	3.0E–08	4.0E–03	*c*/1.0E–01
Clinch River below all DOE inputs (CRK 16)	6.0E–02 5.0E–01	1.0E–04	5.0E–05	1.0E–01	2.0E–01/7.0E–01
Tennessee River at Kingston Water Plant intake (TRK 915)	*c* 2.0E–01	1.0E–07	7.0E–08	8.0E–04	*c*/2.0E–01
Poplar Creek above union with East Fork Poplar Creek (PCK 22)	*c* 5.0E–01	8.0E–05	4.0E–05	1.0E–01	*c*/6.0E–01
Poplar Creek below the K-25 Site (PCK 2.2)	1.0E–01 1.6E+00	8.0E–05	4.0E–05	3.0E–01	4.0E–01/1.9E+00

[a]To convert mrem to mSv, divide the given values by 100.

[b]All values are based on measured concentrations of radionuclides in water except the first set of values for eating fish, which are based on measured concentrations of radionuclides in fish.

[c]Not sampled.

detectable quantity of the three radionuclides, the individual could have received an EDE of about 0.2 mrem (0.002 mSv). No tritium or ^{131}I was detected in milk samples during 1994.

Honey

Several bee colonies are located on the ORR. The honey produced in these hives was sampled, and the sampling results are used to give an indication of potential EDEs to persons who eat honey produced by bees that may have collected pollen on the ORR. If an adult consumed 1 kg (2.2 lb) of the sampled honey during the year, the resulting EDE could be about 0.2 mrem. The average adult likely consumes less than 1 kg of honey per year.

The total production of honey in Anderson, Loudon, and Roane counties during 1992 (the latest available data) was approximately 1500 kg (3200 lb). In the extremely unlikely event that all the honey produced in the three counties contained the sampled concentrations of radionuclides, the resulting collective dose could be 0.3 person-rem.

Crops

Another environmental pathway for ingestion that was evaluated separately is eating vegetables. In 1994, three types of vegetables were sampled: tomatoes, lettuce, and turnips. These vegetable types were chosen as representative of fruit-bearing, leafy, and root vegetables. Tomatoes, lettuce, and turnips were sampled from nine, seven, and five plots located at the ORR PAMs respectively. Hay grown on the ORR also was sampled.

To calculate potential EDEs from eating the sampled vegetables, it was assumed that a person ate 9.4 kg of homegrown tomatoes, 13 kg of leafy vegetables, and 55 kg of root vegetables during the year. These ingestion rates also assume that about 70% of the produce consumed was grown locally. Based on these assumptions, the maximum individual's EDE from eating all three vegetable types could be about 2.7 mrem (0.027 mSv): about 0.04 mrem (0.0004 mSv) from fruit-bearing vegetables, about 0.87 mrem (0.0087 mSv) from leafy vegetables, and about 1.7 mrem (0.017 mSv) from root vegetables (Table 6.5). If the contribution of ^{40}K, which is strictly a naturally occurring radionuclide to this dose [about 96% or 2.6 mrem (0.026 mSv)] is excluded, the maximum individual EDE could have been about 0.1 mrem (0.001 mSv). This 0.1 mrem was from the other radionuclides detected in the vegetables. Detected isotopes include uranium (^{234}U, ^{235}U, and ^{238}U), ^{137}Cs, and ^{60}Co. Although these radionuclides are measured in emissions from the ORR, uranium isotopes occur naturally in soil and fertilizers that are spread on gardens. Therefore, most of the radioactivity found in the vegetables and the associated radiation doses are not attributable to ORR operations.

Table 6.5. Average EDEs from ingesting vegetables grown at ORR ambient air monitoring stations

Vegetable	EDE [mrem (mSv)]	
	All reported radionuclides	Excluding ^{40}K
Tomatoes	4.0E–02 (4.0E–04)	3.0E–04 (3.0E–06)
Lettuce	8.7E–01 (8.7E–03)	6.0E–02 (6.0E–04)
Turnips	1.7E+00 (1.7E–02)	4.0E–02 (4.0E–04)
Total	2.7E+00 (2.7E–02)	1.0E–01 (1.0E–03)

Hay samples were collected from six locations and were combined into 3 samples. These samples were analyzed for ^{7}Be, ^{60}Co, ^{137}Cs, ^{129}I, ^{3}H, and ^{40}K. Essentially all of the dose to humans (about 96%) from eating beef and drinking milk from cattle that eat hay was from the naturally occurring ^{40}K. Including the contribution from ^{40}K, the EDE from drinking milk and eating beef was estimated to be 16.4 mrem (0.164 mSv); excluding ^{40}K, the EDE was estimated to be about 0.6 mrem (0.006 mSv).

White-Tailed Deer

Several deer hunts were held on the ORR during 1994. A total of 495 deer were killed, of which 8 were confiscated because their radionuclide content exceeded the release limit (20 pCi/g ^{90}Sr in bone). The remaining 487 deer had an average field-dressed weight of about 40.8 kg (90 lb). Assuming 55% of the dressed weight is edible, the average deer would yield about 22.45 kg (49.5 lb) of meat. Therefore, based on the average weight, the total harvest of edible meat was about 10,930 kg (24,100 lb).

All deer were surveyed at the TWRA inspection station to determine the ^{137}Cs content in tissue and total strontium in bone. Based on field measurements, the average ^{137}Cs concentration in the 487 released deer was 0.24 pCi/g (0.009 Bq/g).

The EDE for an individual consuming one deer with the average concentration of ^{137}Cs was estimated to be 0.27 mrem (0.0027 mSv). The collective EDE from eating all the harvested deer meat with an average ^{137}Cs concentration of 0.24 pCi/g could have been about 0.13 person-rem (0.0013 person-Sv).

To estimate the EDE to the maximally exposed individual, it was assumed that one person consumed a hypothetical deer that could give the highest individual EDE because of its radionuclide content and weight. The maximum ^{137}Cs concentration found in a released deer was 2.2 pCi/g (0.08 Bq/g) and the maximum weight was 83.9 kg (185 lb). If one person consumed the hypothetical deer with the highest ^{137}Cs concentrations and maximum weight, that person could have received an EDE of about 5.1 mrem (0.051 mSv). No individual should receive a dose higher than 5.1 mrem by eating deer from the ORR.

Canada Geese

During the annual roundup of Canada geese for leg banding and collaring, whole-body gamma scans were conducted on 105 geese at the deer-checking station. The geese were collected from the Y-12 Plant (5 geese), ORNL (20 geese), the K-25 Site (20 geese), Clark Center Park (20 geese), Melton Hill Dam (20 geese), and the Oak Ridge Marina (20 geese). Only 66 geese had concentrations of ^{137}Cs that were considered to be statistically greater than zero. From these 66 results, the average ^{137}Cs concentration was 0.126 pCi/g (0.0047 Bq/g). The maximum ^{137}Cs concentration, surveyed in a goose collected from the ORNL swan pond, was 1.2 pCi/g (0.044 Bq/g).

The total number of goose-hunting days in 1994 was about 45 days. The daily bag limit was two Canada geese. It is possible but unlikely that of all the Canada geese harvested from Anderson, Loudon, Roane, and Knox counties, approximately 198 of them could have spent time on the ORR.

The average weight of the Canada geese scanned during the roundup was about 3.9 kg (8.6 lb), half of which is assumed to be edible. A person eating a Canada goose with the average ^{137}Cs concentration could have received an EDE of about 0.01 mrem (0.0001 mSv). If this person consumed 90 geese (maximum allowable number of Canada geese one hunter could harvest) the estimated EDE would be about 1.1 mrem (0.01 mSv). A person eating a Canada goose with the highest ^{137}Cs concentration, could receive an EDE of about 0.1 mrem (0.001 mSv). The collective EDE from eating 198 geese harvested in 1994 could have been about 0.0024 person-rem (2.4E–5 person-Sv), assuming all were contaminated at the average level.

Direct Radiation

External exposure rates from background sources in the state of Tennessee average about 6.4 μR/hour and range from 2.9 to 11 μR/hour. These exposure rates translate into

annual EDE rates that average 42 mrem/year (0.42 mSv/year) and range between 19 and 72 mrem/year, or 0.19 and 0.72 mSv/year (Myrick et al. 1981). External radiation exposure rates are measured at a number of locations on and off the ORR. The average exposure rate at PAMs around the ORR during 1994 was about 8.5 μR/hour. This equals a dose rate of about 55 mrem/year (0.55 mSv/year). Except for two locations, all measured exposure rates beyond the ORR boundaries are near background levels. The two exceptions are a stretch of bank along the Clinch River and a section of Poplar Creek that flows through the K-25 Site.

During 1987, external exposure rate measurements were taken along a 1.7-km (1.1-mile) length of Clinch River bank. Measured exposure rates along this stretch of bank averaged 13 μR/hour and ranged between 3.5 and 18 μR/hour. These measured exposure rates are attributable to radiation emanating from a nearby field that contains the remnants of a ^{137}Cs seeding experiment. The experimental plots were remediated during 1994, but measurements to confirm that the exposure rate along the Clinch River has decreased were not performed. Therefore, we assume the exposure rate along the Clinch River caused by the cesium plots was the same as reported last year, about 8 μR/hour (0.006 mrem/hour) above background.

A potential maximally exposed individual is a hypothetical fisherman who was assumed to spend 5 hours/week (250 hours/year) near the point of average exposure. This hypothetical, maximally exposed individual could have received an EDE of about 1 mrem (0.01 mSv) during 1994. This dose estimate is high because most of the ^{137}Cs was removed from the experimental fields in 1994.

The radiation field along Poplar Creek emanates from storage areas within the K-25 Site. The section of the creek affected by this area runs through the plant and is used at times by fishermen. Exposure rate measurements, corrected for background, taken along the creek during 1994 ranged between 3.9 and 8.3 μR/hour, which is equivalent to an EDE rate from 0.003 to 0.006 mrem/hour (between 0.00003 and 0.00006 mSv/hour). The average exposure rate was about 5.1 μR/hour, which corresponds to an EDE rate of 0.004 mrem/hour. A 4-hour fishing trip could have resulted in reception of an EDE between 0.01 to 0.02 mrem (0.0001 to 0.0002 mSv). If the hypothetical Clinch River fisherman is used, the 250-hour/year exposure time could have resulted in reception of an EDE of about 1 mrem (0.01 mSv).

Actual fishing activity on the affected stretch of Poplar Creek needs to be determined to obtain a more realistic assessment of this exposure pathway. It is extremely unlikely that anyone would fish this stretch of Poplar Creek for 250 hours/year.

Doses to Aquatic Biota

DOE Order 5400.5, Chapter II, sets an interim absorbed dose rate limit of 1 rad/day (0.01 Gy/day) to native aquatic organisms. To demonstrate compliance with this limit, absorbed dose rates to fish, crustacea (e.g., crayfish), and muskrats were calculated using the computer code CRITR2 (Baker and Soldat 1993). Fish and crustacea are considered to be primary aquatic organisms, those that reside in the aquatic ecosystem. Muskrats are considered to be secondary organisms, those that subsist on aquatic plants. Maximum and average concentrations of radionuclides measured in surface waters on and around the ORR are used to estimate dose rates from internal and external exposures. Internal dose rates are calculated using organism- and nuclide-specific bioaccumulation factors and absorbed energy fractions. External dose rates are calculated for submersion in water and irradiation from bottom sediments. Exposure to sediments is particularly meaningful for crawling or

fixed organisms (such as crayfish and mollusks). Direct radiation doses from sediment are estimated from water concentrations using factors such as a geometry roughness factor, sediment deposition transfer factor, and nuclide-specific ground-surface irradiation dose factors.

Table 6.6 lists average and maximum total dose rates to aquatic organisms from waterways at the Y-12 Plant, ORNL, and the K-25 Site for ORNL. The doses for ORNL are based on water concentrations associated with nine different sampling locations: Melton Branch (Outfalls X-13 and 2), White Oak Creek (Outfall X-14), White Oak Dam (Outfall X-15), First Creek, Fifth Creek, Raccoon Creek, Northwest Tributary, and at the 7500 Bridge. The results from these calculations indicate that absorbed dose rates to aquatic biota are much less than 1 rad/day (0.01 Gy/day).

The highest dose rates, which were associated with maximum concentrations of radionuclides in water, occurred at Melton Branch (X-13): 4.1E–3 rad/day (4.1E–5 Gy/day) to fish, 1.9E–3 rad/day (1.9E–5 Gy/day) to crustacea, and 1.2E–2 rad/day (1.2E–4 Gy/day) to muskrats. Even with maximum radionuclide concentrations at these locations, the absorbed doses were significantly less than the limit of 1 rad/day (0.01 Gy/day).

At the Y-12 Plant, aquatic organism doses were estimated from radionuclide water concentrations obtained at Bear Creek (Outfall 304), East Fork Poplar Creek (Station 17) and Rogers Quarry (Outfall 302). At Bear Creek (Outfall 340) the maximum dose rates to fish and muskrats were ascertained: 6.4E–04 rad/day (6.4E–06 Gy/day) and 1.8E–01 rad/day (1.8E–03 Gy/day). The maximum estimated dose rate to crustacea [2.6E–03 rad/day (2.6E–05 Gy/day)] was located at Rogers Quarry; however, the dose rate to crustacea was not much greater than dose rates estimated at EFPC or Bear Creek.

Similar analyses were conducted at the K-25 Site. The waterways evaluated were Mitchell Branch (K-1700), Poplar Creek at the sewage treatment plant (K-1203), and in the holding pond that discharges into the Clinch River (K-901-A). The highest estimated absorbed dose to fish was 2.7E–3 rad/day (2.7E–5 Gy/day) at Mitchell Branch (K-1700). The highest dose rate for crustacea, 3.3E–3 rad/day (3.3E–5 Gy/day), was also at K-1700. The maximum dose rate to muskrats of 1.9E–3 rad/day (1.9E–5 Gy/day) was at the holding pond (K-901-A). Absorbed doses estimated from maximum radionuclide water concentrations determined on the ORR resulted in doses far less than the 1 rad/day (0.01 Gy/day) limit prescribed in DOE Order 5400.5.

Current-Year Summary

A summary of the maximum EDEs to individuals by several pathways of exposure is given in Table 6.7. It is unlikely (if not impossible) that any real person could have been irradiated by all of these sources and pathways for a period of 1 year; however, if the resident who received the highest EDE [1.7 mrem (0.017 mSv)] from gaseous effluents, also drank water from the Gallaher plant [0.3 mrem (0.003 mSv)], ate fish from PCK 2.2 [1.6 mrem (0.016 mSv), and fished the Clinch River near the cesium field or Poplar Creek inside the K-25 Site [1 mrem (0.01 mSv), he or she could have received a total EDE of about 4.6 mrem (0.046 mSv), or about 1.5% of the annual dose [300 mrem (3 mSv)] from background radiation. If a person ate the entire, most contaminated deer, that person would have received a committed EDE of about 5.1 mrem (0.051 mSv).

DOE Order 5400.5 limits to no more than 100 mrem (1 mSv) the EDE that an individual may receive from all exposure pathways from all radionuclides released from the ORR during 1 year. As described in the preceding paragraph, the 1994 maximum EDE

Table 6.6. 1994 total dose rate for aquatic organisms (rad/day)[a,b]

Measurement location	Fish		Crustacea		Muskrat	
	Average	Maximum	Average	Maximum	Average	Maximum
			ORNL			
Melton Branch (X13)	1.7E–3	4.1E–3	4.6E–4	1.9E–3	5.8E–3	1.2E–2
White Oak Creek (X14)	8.0E–4	1.6E–3	1.5E–4	2.9E–4	1.5E–3	2.5E–3
White Oak Dam (X15)	9.5E–4	1.7E–3	2.6E–4	5.9E–4	2.5E–3	3.3E–3
7500 Road Bridge	6.5E–4	1.5E–3	1.2E–4	1.1E–3	1.0E–3	1.7E–3
First Creek	7.4E–4	1.7E–3	1.2E–4	7.2E–4	2.7E–3	5.3E–3
Fifth Creek	1.5E–4	5.3E–4	1.6E–4	7.9E–4	2.8E–4	4.9E–4
Melton Branch 2	5.6E–5	2.2E–4	8.9E–5	3.7E–4	4.1E–5	1.3E–4
Northwest Tributary	3.3E–4	1.0E–3	2.2E–4	9.1E–4	6.3E–4	1.2E–3
Raccoon Creek	4.6E–5	9.8E–4	7.6E–6	8.0E–4	1.7E–4	6.9E–4
			Y-12 Plant			
East Fork Poplar Creek (Station 17)	5.4E–05	3.9E–04	3.2E–04	2.5E–03	9.9E–04	2.3E–02
Bear Creek (Outfall 304)	5.2E–05	6.4E–04	3.0E–04	2.5E–03	1.2E–03	1.8E–01
Rogers Quarry (Outfall 302)	3.2E–05	3.3E–04	2.9E–04	2.6E–03	7.4E–04	3.8E–02
			K-25 Site			
Mitchell Branch (K-1700)	2.3E–04	2.7E–03	1.1E–04	3.3E–03	1.7E–04	7.3E–04
Poplar Creek (Sewage Treatment Plant, K-1203)	1.3E–04	9.9E–04	8.4E–05	2.0E–03	2.9E–04	1.9E–03
Clinch River (Holding Pond, K-901-A)	3.0E–05	3.7E–04	5.0E–05	1.3E–03	1.2E–04	5.2E–04

[a]Total dose rate includes the contribution of internally deposited radionuclides, sediment exposure (derived from water concentrations), and water immersion.

[b]To convert from rad/day to Gy/day divide by 100.

Table 6.7. Summary of estimated radiation dose equivalents to an adult during 1994 at locations on the ORR of maximum exposure

Pathway	Location	Effective dose equivalent	
		mrem	mSv
Gaseous effluents	Maximally exposed resident to		
Inhalation plus direct radiation from air, ground, and food chains	Y-12 Plant	1.7	0.017
	ORNL	0.1	0.001
	K-25 Site	0.1	0.001
	ORR	1.7	0.017
Liquid effluents			
Drinking water	Gallaher Water Plant	0.3	0.003
Eating fish	Poplar Creek, PCK 2.2	1.6	0.016
Other activities	Clinch River	0.4	0.004
Eating deer		5.1	0.051
Direct radiation	Clinch River shoreline	1[a]	0.01
	Poplar Creek (K-25 Site)	1	0.01

[a]This likely is an overestimate of the potential dose because the source of direct radiation was remediated during 1994.

could have been about 5 mrem (0.05 mSv), or about 5% of the limit given in DOE Order 5400.5.

Five-Year Trends

Dose equivalents associated with selected exposure pathways for the years from 1990 to 1994 are given in Table 6.8. The variations in values over this 5-year period likely are not statistically significant. The dose estimates for direct irradiation along the Clinch River have been corrected for background.

Table 6.8. Trends in total effective dose equivalent for selected pathways

Pathway	Effective dose equivalent (mrem)[a]				
	1990	1991	1992	1993	1994
All air	2	2	1.3	1.4	1.7
Fish consumption	0.3	0.3	0.4	0.2	1.6
Drinking water (Kingston)	0.04	0.1	0.05	0.07	0.04
Direct radiation (Clinch River)	1[b]	1[b]	1[b]	1[b]	1[c]
Direct radiation (Poplar Creek)			11[b]	1	1

[a]To convert mrem to mSv, divide by 100.

[b]These values have been corrected by removing the contribution of natural background radiation and by using International Commission on Radiological Protection recommendations for converting external exposure to effective dose equivalent.

[c]This is an overestimate of the potential dose because the source of the direct radiation was remediated during 1993 and 1994.

Potential Contributions from Off-Site Sources

Four off-site facilities were identified as potential contributors to radiation exposure of the public around the ORR. These facilities include a waste processing facility located on Bear Creek Road, a depleted uranium processing facility located on Illinois Avenue, a decontamination facility located on Flint Road in Oak Ridge, and a waste processing facility located on Gallaher Road in Kingston.

Airborne emissions from these facilities (based on information supplied by the facilities) and their radiological impacts are negligibley small, and when combined with impacts caused by emissions from the ORR, are not expected to cause any individual to receive an EDE in excess of EPA or DOE limits. No information was obtained about waterborne releases, if any, from these facilities.

Findings

The maximally exposed off-site individual could have received a 50-year committed EDE of about 1.7 mrem (0.017 mSv) from airborne effluents from the ORR. This dose is within the limit specified in the Clean Air Act for DOE facilities. The estimated collective committed EDE to the about 880,000 persons living within 80 km (50 miles) of the ORR was about 19 person-rem (0.19 person-Sv) for 1994 airborne emissions. This represents about 0.007% of the 260,000 person-rem (2,600 person-Sv) that the surrounding population would receive from all sources of natural radiation.

CHEMICAL DOSE

Terminology

The following terms are pertinent to the understanding of chemical exposure. See Appendix B for further explanation of terms and methodology.

- Slope factor (SF). A plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor is used to estimate an upper-bound probability of an individual developing cancer as a result of lifetime exposure to a particular level of a potential carcinogen. Units are expressed as mg kg^{-1} day^{-1}.
- Maximum contaminant level (MCL). EPA National Interim Primary and National Primary Drinking Water regulations that apply to all community or public water systems.
- Reference dose (RfD). An estimate of the daily exposure to the human population, including sensitive individuals, that is likely to be without an appreciable risk of deleterious effects during a lifetime.
- Secondary maximum contaminant level (SMCL). EPA National Secondary Drinking Water regulations that apply to public water systems. The EPA SMCLs are unenforceable criteria that apply to aesthetic water quality; however, Tennessee SMCLs, which are the same as the federal SMCLs, are enforceable.

RfDs, which are used to evaluate potential health effects from noncarcinogens, are derived from doses of chemicals that result in no adverse effect or the lowest dose that showed an adverse effect on humans or laboratory animals (See Appendix B). The EPA maintains the Integrated Risk Information System (IRIS) data base, which contains verified RfDs and slope factors and up-to-date health risk and EPA regulatory information for numerous chemicals.

For chemicals for which RfDs are not available, national primary (MCL) and secondary drinking water regulation (SMCL) concentrations, expressed in milligrams per liter, are converted to RfD values by multiplying by 2 L (the average daily adult water intake) and dividing by 70 kg (the reference adult body weight). The result is a dose expressed in mg kg^{-1} day^{-1}. Table 6.9 lists the RfD and SFs used in this analysis.

SFs are used to evaluate carcinogenic impacts. The SF converts the estimated daily intake averaged over a lifetime exposure to the incremental risk of an individual developing cancer. Because it is unknown whether a threshold (a dose below which no adverse effect occurs) exists for carcinogens, units for carcinogens are set in terms of risk. For potential carcinogens at the ORR, a risk of developing cancer over a human lifetime of 1 in 100,000 (10^{-5}) was used to establish acceptable levels of exposure. That is, the EPA estimates that a certain concentration of a chemical, if ingested, could cause a risk of one additional cancer case for every 100,000 exposed persons.

Table 6.9. Chemical reference doses and slope factors used in drinking water and fish intake analysis

Chemical	Reference dose or slope factor	Reference[a]
Acetone	1.00E–01	RfD
Aluminum	6.00E–03	SMCL
Antimony	4.00E–04	RfD
Arsenic	3.00E–04	RfD
Barium	7.00E–02	RfD
Beryllium	5.00E–03	RfD
2–Butanone	6.00E–01	RfD
Cadmium	5.00E–04	RfD
Chloride	7.14E+00	SMCL
Chromium (VI)	5.00E–03	RfD
Copper	4.00E–02	MCL
4,4′–DDE	3.40E–01	SF
Dieldrin	1.60E+01	SF
Fluoride	6.00E–02	RfD
Iron	9.00E–03	SMCL
Lead	4.00E–04	MCL
Manganese	5.00E–03	RfD
Mercury	5.70E–05	MCL
Nickel	2.00E–02	RfD
PCBs	7.70E+00	SF
Selenium	5.00E–03	RfD
Silver	5.00E–03	RfD
Sulfate	7.14E+00	SMCL
Thallium	8.00E–05	RfD
Toluene	2.00E–01	RfD
Uranium	3.00E–03	RfD
Vanadium	7.00E–03	RfD
Zinc	3.00E–01	RfD

[a]RfD: reference dose (mg kg^{-1} day^{-1}); SMCL: secondary maximum contaminant level; MCL: maximum contaminant level; SF: slope factor (kg mg^{-1} day^{-1}).

Methods of Evaluation

Airborne Chemicals

Air permits issued by TDEC allow release of permitted quantities of chemicals. Sampling or monitoring is required only at the ORNL Steam Plant. No air monitoring data amenable to human exposure analysis were available. (See Section 4, "Airborne Discharges.")

Waterborne Chemicals

Prior to the 1993 annual environmental report, calculated daily intakes, based on chemical concentrations in water or fish, were divided by the acceptable daily intake, which is based on the RfD. Current risk assessment methodologies use the term hazard quotient (HQ) to evaluate noncarcinogenic health effects. Therefore, in this environmental report the HQ methodology is used. Intakes, calculated in mg kg^{-1} day^{-1} in the HQ methodology, are expressed in terms of dose. For carcinogens, the estimated dose (I) from ingestion of water or fish is divided by the chronic daily intake (CDI), which corresponds to a 10^{-5} lifetime risk of developing cancer. See Appendix B for a more detailed discussion.

Drinking Water

HQs and I/CDI ratios for chemicals concentrations found in surface water are summarized in Table 6.10. Some of the sampling data for individual chemicals are reported as less than ("<") values, indicating that concentrations are below the limit of detection of the analytical instrumentation. These data were used in the analysis only if one or more samples had values above the detection limits. The tilde "~" indicates that estimated values and/or detection limits were used in estimating the average concentration of a chemical. This symbol is listed beside the estimated HQ or I/CDI ratios to indicate the type of data used.

To evaluate the drinking water pathway, HQs and I/CDIs were estimated at current drinking water supply locations (CRK 23 and 58) both above and below the ORR. The Gallaher Water Station (CRK 23) is located near the water intake for the K-25 Site and is below the ORNL effluent discharge point. The Knox county water supply intake (CRK 58) is located above the ORR discharge points. In addition, the drinking water pathway was evaluated at the Anderson County Filtration Plant (CRK 84) which is above all DOE inputs, and at CRK 16, which is a location downstream of all DOE inputs.

With the exception of aluminum, iron, and thallium, the HQ values were less than 1. Elevated aluminum and iron HQs were estimated both upstream and downstream of the ORR. At CRK 58, upstream of ORR discharge points, an HQ greater than one was estimated for thallium.

Fish Consumption

Chemicals in water can be accumulated by aquatic organisms that may be eaten by humans. Bluegill (sunfish) and catfish (at two locations) collected from the Clinch River and Poplar Creek were analyzed for a number of metals, pesticides, and PCBs. Table 6.11 summarizes the HQ and I/CDI ratios derived on average chemical concentrations in fish samples found both upstream and downstream locations from the ORR. Arsenic, lead, mercury, and thallium concentrations in fish tissue resulted in HQs greater than 1. Arsenic and lead were found in sunfish samples collected upstream of the ORR (CRK 84, 80, and

Table 6.10. Chemical hazard quotients for drinking water

Chemical	Hazard quotient			
	CRK 84[a]	CRK 58[b]	CRK 23[c]	CRK 16[d]
		Metals		
Aluminum	~1.90E+00	~1.95E+00	9.05E–01	3.67E+00
Barium	1.22E–02	1.18E–02	1.22E–02	2.82E–02
Beryllium	~5.71E–03			
Cadmium				~3.03E–01
Chromium	~2.74E–02			
Iron	1.49E+00	1.40E+00	9.84E–01	2.63E+00
Manganese	5.37E–01	3.26E–01	5.71E–01	4.63E–01
Mercury	~2.81E–02	~3.96E–02	~4.21E–02	~4.41E–02
Thallium		~6.79E+01		
Uranium	~1.24E–03	~1.43E–03	~2.48E–03	2.10E–03
Vanadium	~2.37E–02	~8.25E–03	~6.67E–03	~7.62E–03
Zinc	~4.95E–04	~5.05E–05	~5.43E–04	~6.67E–04
		Anions		
Chloride	1.20E–02	1.28E–02	1.32E–02	1.32E–02
Fluoride	~5.71E–02	~5.24E–02	~5.71E–02	~5.24E–02
Nitrate	3.93E–02	6.25E–02	4.11E–02	3.04E–02
Sulfate	7.20E–02	7.20E–02	7.60E–02	6.40E–02
		Volatile organics		
2-Butanone	~2.83E–04	~2.31E–04	2.63E–04	~2.29E–04
Acetone	~2.86E–03			
Toluene			~6.14E–04	

[a]Melton Hill Reservoir above all DOE inputs.
[b]Water supply intake for Knox County.
[c]Water supply intake for K-25 Site.
[d]Clinch River downstream of all DOE inputs.

66). HQs greater than one for mercury were found both upstream and downstream of the ORR and in sunfish collected from Poplar Creek (PCK 2.2). An HQ greater than one also was observed for thallium in fish collected from Poplar Creek (PCK 2.2).

For carcinogens, I/CDI ratios greater than 1 indicate a risk greater than 10^{-5}. Chemicals for which I/CDIs were greater than one were PCBs (Aroclor 1248, 1254, and 1260), 4,4′-DDE and dieldrin. I/CDIs greater than one were found for PCBs and 4,4′-DDE in fish collected up and downstream of the ORR. An I/CDI ratio greater than one was found in catfish collected downstream of the ORR (CRK 16). In many cases, the tissue concentrations of PCBs,

4,4′-DDE, and dieldrin were estimated at or below the analytical detection limit. Because of analytical detection limitations, the actual fish tissue concentrations are unknown (an exception is the Aroclor-1260 concentration in catfish tissue sample from CRK 32).

Table 6.11. Chemical hazard quotients (HQs) for metals and estimated dose/chronic daily intake (I/CDIs) for carcinogens in fish[a]

Parameters	Sunfish						Catfish	
	CRK 84[b]	CRK 80[c]	CRK 66[d]	CRK 32[e]	CRK 16[f]	PCK 2.2[g]	CRK 32[e]	CRK 16[f]
HQs for metals								
Antimony		~8.70E–01						
Arsenic	~1.36E–03	~1.16E+00	1.74E+00					
Chromium	4.31E–02	3.65E–02	4.47E–02	~8.12E–03		~7.13E–03		
Copper	4.56E–03	4.97E–03	5.39E–03	1.02E–02	4.97E–03	5.18E–03	6.84E–03	7.04E–03
Lead	~1.55E+00	1.55E+00	1.64E+00					
Mercury	1.05E+00	8.87E–01	7.12E–01	~4.07E–01	~1.32E+00	1.06E+00	1.13E+00	1.89E+00
Nickel				~8.29E–03	~5.80E–03	~5.39E–03		
Selenium	1.99E–01	1.99E–01	2.32E–01					
Silver	~1.09E–02	~1.47E–02					1.59E–02	1.51E–02
Thallium						~1.66E+01		
Uranium				~8.84E–04		~8.84E–02		
Zinc	3.31E–02	3.31E–02	3.59E–02	3.04E–02	3.59E–02	3.31E–02	1.71E–02	1.38E–02
I/CDIs for carcinogens (pesticides and PCBs)								
4,4′-DDE	~1.18E+00					~1.55E+00		
Dieldrin								J5.57E+00
Aroclor-1248							J5.49E+00	
Aroclor-1254	~3.25E+02			~1.53E+02	~3.38E+02	~1.66E+02	J1.08E+02	J6.38E+01
Aroclor-1260	~2.68E+02				~3.38E+02		2.49E+02	J1.21E+02

[a]A tilde "~" indicates that estimated values and/or detection limits were used in the calculation. A "J" indicates that the laboratory estimated the value at or below the analytical detection limit.

[b]Melton Hill Reservoir, above all DOE inputs, Anderson Country Filtration Plant.

[c]Melton Hill Reservoir, Oak Ridge Marina, above ORNL.

[d]Melton Hill Reservoir, above the city of Oak Ridge intake.

[e]Clinch River, downstream of ORNL.

[f]Clinch River, downstream of all DOE inputs.

[g]Poplar Creek, downstream of the K-25 Site.

7. Groundwater

W. K. Jago, R. S. Loffman, and C. A. Motley

Abstract

Most residents in the Oak Ridge area do not rely on groundwater for potable supplies although suitable water is available. Local groundwater provides some domestic, municipal, farm, irrigation, and industrial uses, however, and must be viewed as both a potential pathway for exposure to hazardous wastes and as a means for contaminant transport. Statutes codified into regulations by the U.S. Environmental Protection Agency specifically target the protection of groundwater from contamination by hazardous wastes. The regulations guide groundwater monitoring at the U.S. Department of Energy plants in Oak Ridge. Monitoring programs established on the Oak Ridge Reservation assess groundwater contamination and transport on and off the reservation and are intended to comply with established regulatory requirements.

INTRODUCTION

The groundwater monitoring programs at the ORR gather information to determine the effects of DOE operations on groundwater quality in compliance with all applicable requirements.

The location and movement of groundwater must be determined to identify the extent of contamination in groundwater and to predict the possible fate of contaminants. To make this determination, an understanding is required of how groundwater moves in general and how that movement will be influenced by the geological setting.

Geological Setting

The ORR is located in the Tennessee portion of the Valley and Ridge Province, which is part of the southern Appalachian fold and thrust belt. As a result of thrust faulting and differential erosion, a series of valleys and ridges have formed parallel to the thrust faults.

Geologic units designated as the Knox Group and the Maynardville Limestone of the Conasauga Group, both consisting of massive carbonate rocks, constitute the Knox Aquifer. A combination of fractures and solution conduits in this aquifer control flow over substantial areas, and relatively large quantities of water may move relatively long distances. Active groundwater flow occurs at greater depth in the Knox Aquifer and the water flows farther than in the aquitards. The Knox Aquifer is the primary source of base flow in many streams, and most large springs on the ORR discharge from the Knox Aquifer. Yields of some wells penetrating larger solution conduits are reported to exceed 1000 gal/min.

The remaining geologic units (the Rome Formation, the Conasauga Group below the Maynardville Limestone, and the Chickamauga Group) constitute the aquitards, which consist mainly of siltstone, shale, sandstone, and thinly bedded limestone of low to very low permeability. Nearly all groundwater flow in the aquitards occurs through fractures. The typical yield of a well in the aquitards is less than 1 gal/min, and the base flows of streams draining areas underlain by the aquitards are poorly sustained because of such flow rates.

Hydrogeological Setting

Groundwater Hydrology

When rain falls, a portion of the rainwater accumulates as groundwater by soaking into the ground, infiltrating soil and rock. The accumulation of groundwater in pore spaces of sediments creates sources of useable water, which flows in response to external forces. Groundwater eventually reappears at the surface in springs, swamps, stream and river beds, or pumped wells. Thus, groundwater is a reservoir for which the primary input is recharge from rainwater infiltrating the soil and whose output is discharge to springs, swamps, rivers, streams, and wells.

Water from the surface moving down into the soil makes its way by percolating downward through the pore spaces between sediment grains and also through fractures in bedrock. The smaller the pore spaces or fractures, the slower the flow of water through the subsurface. The physical property that describes the ease with which water may move through the pore spaces and fractures in a given material is called permeability, and it is largely determined by the volume and size of these features and how well they are connected.

As water infiltrates the earth, it travels down through the unsaturated zone, where the pore spaces and fractures are partly filled with water and partly filled with air. Water moving down through the unsaturated zone will eventually reach the saturated zone, where the pore spaces and fractures are completely filled with water. The boundary between the

GLOSSARY

aquiclude—a saturated geologic unit that does not transmit significant quantities of water. Although the transmissive capabilities of the aquiclude on the ORR are poorly known, the term is used in this report to denote the zone below active circulation.

aquifer—a saturated permeable geologic unit that transmits significant quantities of groundwater. The common definition is that an aquifer yields usable quantities of water to wells, but that definition is relaxed in this report (see *aquitard*).

aquitard—less permeable geologic units. In this report the term is used in contrast to *aquifer*, which contains more permeable flow networks.

base flow—the sustained, or "fair weather" flow of a stream.

flux—a state of flow change or fluctuation.

regolith—all subsoils (nonlithified, less cohesive materials) above bedrock, either formed in place or transported.

saprolite—weathered bedrock that has not been transported and that retains some of the original structure.

stormflow zone—aproximately corresponds to the root zone of vegetation and is observed to be thickest in fertile, well-developed, and densely vegetated soils.

thrust fault—a low-angle fault that results in surface compression.

unsaturated zone—limited above by the land surface and below by the water table.

saturated zone—area beneath the water table bearing as much water as it can hold.

unsaturated and the saturated zones is known as the water table, which generally follows, in subtle form, the contour of the surface topography. Springs, swamps, and beds of streams and rivers are the outcrops of the water table, where groundwater is discharged to the surface.

Because the earth's permeability varies greatly, groundwater flowing through subsurface strata does not travel at a constant rate or without impediment. Strata that transmit water easily (such as those composed primarily of sand) are called aquifers, and strata that restrict water movement (such as clay layers) are called aquitards. An aquifer with an aquitard lying above and beneath it is termed a confined aquifer. Groundwater moves through aquifers toward natural exits, or discharge points, to reappear at the surface.

The direction of groundwater flow through an aquifer system is determined by the permeability of the strata containing the aquifer and by the hydraulic gradient, which is a measure of the difference in hydraulic head over a specified distance. Differences in hydraulic head compare the driving force for groundwater movement through the saturated zone. The hydraulic head at any given point in an aquifer is a function of the energy associated with the water's elevation above sea level and the pressures exerted on it by surrounding water. Because hydraulic head is not solely a function of elevation, downgradient is not necessarily synonymous with downhill. The downgradient direction will have a horizontal and vertical component, just as a household drain moves wastewater both horizontally and vertically, seeking the lowest point of exit. Aquitards deflect groundwater movement just as drain pipe walls control the direction of wastewater movement. In an aquifer constrained by aquitards such as horizontal clay layers, the downgradient direction tends to be more horizontal than vertical.

Groundwater on the ORR occurs both in the unsaturated zone as transient, shallow subsurface stormflow and as an underlying unconfined water-table aquifer. An unsaturated zone of variable thickness separates the stormflow zone and water-table aquifer. Near surface water features, the water-table aquifer is found at shallow depths; along the ridge tops or near other high topographic areas, the water-table aquifer is continuous to depths of several hundred meters. In low-lying areas where the water table occurs near the surface, the stormflow zone and saturated zone are indistinguishable.

Several distinct flow intervals occur within the water-table aquifer the uppermost water table interval, the intermediate interval, the deep interval, and the aquiclude, which is defined by a transition to saline water (Fig. 7.1). The divisions within the saturated zone grade into one another vertically and are not separated by distinct boundaries but reflect an overall decrease in the rate of flow with depth. Within the ORR aquitards, the greatest flux is associated with the stormflow zone and the smallest with the deep zone. Water does not flow in the aquiclude. In the Knox Aquifer, the greatest flux is in the water table and intermediate intervals.

Two broad hydrologic units are identified on the ORR: the Knox Aquifer and the aquitards, which consist of less permeable geologic units. Figure 7.2 is a generalized map showing surface distribution of the Knox Aquifer and the ORR aquitards. Many waste areas on the ORR are located in areas underlain by the aquitards.

Unsaturated Zone Hydrology

The unsaturated zone exists throughout the ORR except where the water table is near land surface (such as along perennial stream channels). The thickness of the unsaturated zone is greatest beneath ridges, and thins toward valley floors. Beneath ridges underlain by the Knox Aquifer, the unsaturated zone commonly is greater than 30 m (100 ft) thick, whereas beneath ridges underlain by an aquitard, the unsaturated zone is typically less than

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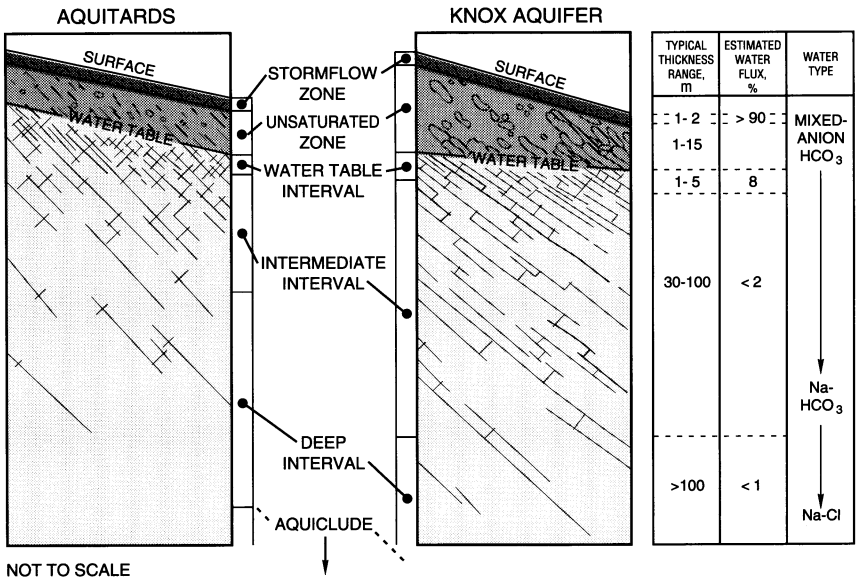

Fig. 7.1. Vertical relationships of flow zones of the ORR: estimated thicknesses, water flux, and water types.

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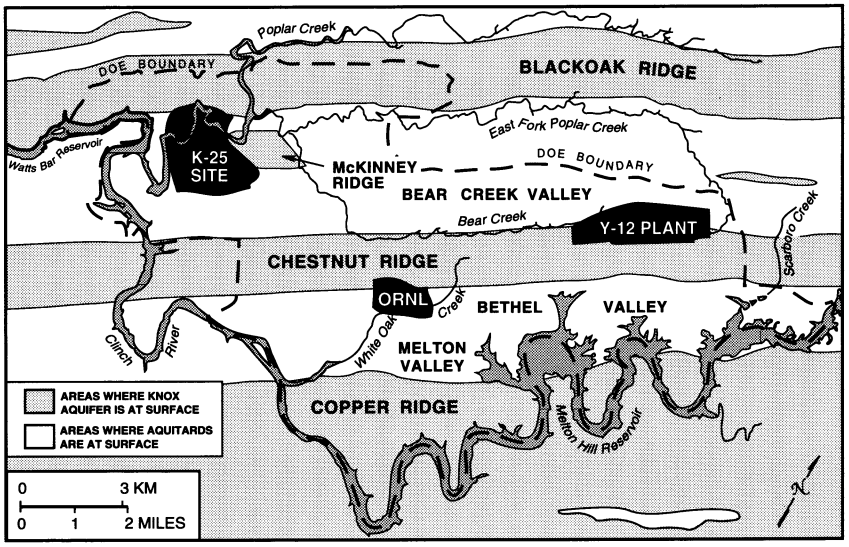

Fig. 7.2. The Knox Aquifer and the aquitards on the Oak Ridge Reservation.

15 m (50 ft) thick. The materials above the bedrock consist of clay and silt derived from the weathering of bedrock materials and have significant water storage capability.

Most recharge through the unsaturated zone occurs along fractures and large pores that may become saturated during rain events, even though surrounding small pores remain unsaturated and contain trapped air.

Groundwater occurs in the unsaturated zone as (1) transient water of limited extent separated from the water table and located above it (particularly in the areas of the Knox Aquifer) and (2) as transient, shallow, subsurface stormflow.

In undisturbed, naturally vegetated areas on the ORR, about 90% of the infiltrating precipitation does not reach the water table but travels through the 1- to 2-m-deep stormflow zone, which approximately corresponds to the root zone. Because of the permeability contrast between the stormflow zone and the underlying unsaturated zone, the stormflow zone partially or completely saturates during rainfall events, and then water flows laterally, following very short flow paths to adjacent streams. When the stormflow zone becomes completely saturated, flow of water over the land occurs. Between rainfall events, as the stormflow zone drains, flow rates decrease dramatically and water movement becomes nearly vertical toward the underlying water table.

The rate at which groundwater is transmitted through the stormflow zone is attributed to large pores (root channels, worm bores, and relict fractures). Stormflow is primarily a transport mechanism in undisturbed or vegetated areas, where it intersects shallow waste sources. Most buried wastes are below the stormflow zone; however, in some trenches a commonly observed condition known as "bathtubbing" can occur, in which the excavation fills with water and may overflow into the stormflow zone. All stormflow ultimately discharges to streams on the ORR.

Saturated Zone Hydrology

As shown in Fig. 7.1, the saturated zone on the ORR can be divided into four vertically distinct flow zones an uppermost water table interval, an intermediate zone, a deep zone, and an aquiclude. Available evidence indicates that most water in the saturated zone in the aquitards is transmitted through a 1- to 6-m-thick layer of closely spaced, well-connected fractures near the water table (the water table interval) as shown on Fig. 7.3.

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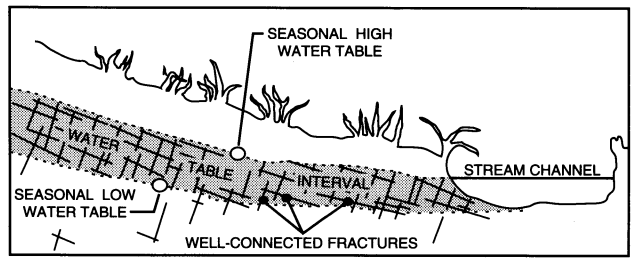

Fig. 7.3. Water table interval.

The range of seasonal fluctuations in depth to the water table and in rates of groundwater flow vary significantly across the reservation. In the areas of the Knox Aquifer, seasonal fluctuations in water levels average 5.3 m (17 ft), and mean discharge from the active groundwater zone is typically 85 gal/min per square mile. In the aquitards of Bear Creek Valley, Melton Valley, East Fork Valley, and Bethel Valley, seasonal fluctuations in water levels average 5 ft and typical mean discharge is 26 gal/min per square mile.

As in the stormflow zone, the bulk of water mass in the groundwater zone resides within the micropores of blocks of the rock matrix, which are bounded by fractures. Diffusive exchange between water in matrix pores and water in fractures reduces contaminant migration rates relative to water velocities in the fractures. For example, the leading edge of a geochemically nonreactive contaminant mass such as tritium migrates along fractures at a typical rate of 3 ft/day; however, the center of mass of a contaminant plume typically migrates at a rate less than 0.2 ft/day.

In the intermediate interval, groundwater flow paths are a product of fracture density and orientation. In this interval, groundwater movement occurs primarily in permeable fractures that are poorly connected. In the Knox Aquifer a few cavity systems and fractures control groundwater movement in this zone, but in the aquitards the bulk of flow is through fractures along which permeability may be increased by weathering.

In the aquitards, chemical characteristics of groundwater change from mixed-cation-HCO_3 water type at shallow depth to a Na-HCO_3 water type at deeper levels. This transition, not marked by a distinct change in rock properties, serves as a useful marker and can be used to distinguish the more active intermediate groundwater interval from the sluggish flow of the deep interval. There is evidence of similar change with depth in the chemical characteristics of water in the Knox Aquifer. Although the mechanism responsible for this change in water types is not quantified, it most likely is related to the amount of time the water is in contact with a specific type of rock.

Hydrologically active fractures in the deep interval are significantly fewer in number and shorter in length than in the other intervals and the spacing is greater. Wells finished in the deep interval of the ORR aquitards typically yield less than 0.3 gal/min and thus are barely adequate for water supply.

In the aquitards, saline water characterized by total dissolved solids ranging up to 2.75×10^5 mg/L and chlorides generally in excess of 5×10^4 mg/L (ranging up to 1.63×10^5 mg/L) lies beneath the deep interval of the groundwater zone, delineating an aquiclude. Chemically, this water resembles brines typical of major sedimentary basins, but its origin is not known. The chemistry suggests extremely long residence times (i.e., very low flow rates) and little or no mixing with shallow groundwater.

The aquiclude has been encountered at depths of 125 and 244 m (400 and 800 ft) in Melton and Bethel valleys, respectively (near ORNL), and it is believed to approach 305 m (1000 ft) in portions of Bear Creek Valley (near the Y-12 Plant) underlain by aquitard formations. Depth to the aquiclude in areas of the Knox Aquifer is not known but is believed to be greater than 366 m (1200 ft); depth to the aquiclude has not been established in the vicinity of the K-25 Site.

Groundwater Flow

Many factors influence groundwater flow on the ORR. Topography, surface cover, geologic structure, and rock type exhibit especially strong influence on the hydrogeology. Variations in these features result in water flux variations. (Average flux rates for the aquitards and the Knox Aquifer formations are shown in Fig. 7.1.) As an example, the overall decrease in open fracture density with depth results in a decreased groundwater flux with depth.

The topographic relief characteristic of the ORR is sufficient to most active subsurface flow to remain shallow on the ORR. U.S. Geological Survey modeling (Tucci 1992) suggests that 95% of all groundwater flow occurs in the upper 15 to 30 m (50 to 100 ft) of the saturated zone in the aquitards. As a result, flow paths in the active-flow zones (particularly in the aquitards) are relatively short, and nearly all groundwater discharges to local surface water drainages on the ORR. Conversely, in the Knox Aquifer, it is believed that a few solution conduit flow paths may be considerably longer, perhaps as much as 1.6 km (2 miles) long in the along-strike direction. No evidence at this time substantiates the existence of any deep, regional flow off the ORR or between basins within the ORR in either the Knox Aquifer or the aquitards. Recent evidence, however, has indicated that contaminant transport occurs off of the ORR in the intermediate interval through the Knox Aquifer, near the east end of the Y-12 Plant.

Migration rates of contaminants transported in groundwater are strongly influenced by natural chemical and physical processes in the subsurface (including diffusion and adsorption). Peak concentrations of solutes, including contaminants such as tritium moving from a waste area, for instance, can be delayed for several to many decades in the

aquitards, even along flow paths as short as a few hundred feet. The processes that naturally retard contaminant migration and store contaminants in the subsurface are likely to be less effective in the Knox Aquifer than in the aquitards because of flow along solution features.

Groundwater Monitoring Considerations

Because of the complexity of the hydrogeologic framework on the ORR, groundwater flow and, therefore, contaminant transport are largely unpredictable on a local scale. Consequently, individual plume delineation is not feasible on the ORR. Stormflow and most groundwater discharge to the surface water drainages on the ORR. For that reason, monitoring surface water quality is one of the best ways to assess the extent to which groundwater from a large portion of the ORR transports contaminants; however, contaminant transport may occur at depth as well. The center of mass of the volatile organic compound (VOC) plume in the Maynardville Limestone east of the Y-12 Plant lies at a depth of 300 ft. Transport of the highest VOC concentrations occurs in this interval because VOCs are more dense than water and there is little dilution.

Off-Site Spring and Residential Well Monitoring

Groundwater monitoring of residential wells and springs in the vicinity of the ORR is summarized in Sect. 5.

Groundwater Monitoring Program on the ORR

The groundwater surveillance monitoring programs implemented at the DOE facilities have been designed to obtain full compliance with regulatory requirements and to meet objectives. Site-specific regulatory monitoring programs are supported technically by site characterization and regional studies of the geohydrologic and chemical aspects of the flow system. Quality control procedures for every aspect of data collection and analysis have been established, and data bases are used to organize and report analytical results.

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

GROUNDWATER MONITORING AT THE Y-12 PLANT

Background and Regulatory Setting

Most of the groundwater monitoring at the Y-12 Plant is conducted within the scope of a single, comprehensive groundwater monitoring program, which includes the following elements:

- monitoring to comply with requirements of RCRA interim status assessment and detection monitoring,
- compliance with RCRA post-closure monitoring requirements,
- monitoring to support CERCLA RI/FS efforts and records of decision,
- compliance with TDEC solid waste management (SWM) regulations,

- monitoring to support DOE Order 5400.1 requirements (exit pathway and grid monitoring programs),
- monitoring to support various elements of the Y-12 Plant Environmental Restoration (ER) Program,
- compliance with regulatory monitoring requirements for petroleum USTs, and
- monitoring to support best management practices.

Through incorporation of these multiple considerations, the comprehensive monitoring program at the Y-12 Plant addresses multiple regulatory considerations and technical objectives. It eliminates redundancy between different resulting programs and ensures consistent data collection and evaluation.

Additional groundwater monitoring activities are conducted under two broad categories: (1) groundwater investigations that use multiport-instrumented core holes and (2) short-term monitoring activities conducted under specific CERCLA OU RIs. The specific data requirements, technical approaches, or technologies applied by these two areas of investigation result in their being outside the scope of direct implementation by the comprehensive monitoring program. Data generated as a result of these activities, however, is incorporated into evaluations of groundwater flow, contaminant migration, and proposed changes to the comprehensive program.

More than 200 contaminated units have been identified at the Y-12 Plant resulting from past waste management practices. Many of these sites have been grouped into OUs under CERCLA based on priority and common assessment and remediation requirements (DOE 1993) (Fig. 7.4). Eleven OUs made up of 31 units have been established.

The remaining units have been grouped into Y-12 Plant study areas and constitute lower-priority units that will be investigated under CERCLA as preliminary assessments/ site investigations (PA/SIs). New OUs or additions to existing OUs will be made if the degree of contamination determined by the PA/SI warrants further study under an RI/FS. In addition to source OUs, two RIs are being pursued within Bear Creek Valley for groundwater, surface water, and stream sediments that have received contaminants from source OUs.

An agreed order was signed by DOE, TDEC, and Energy Systems in April 1993 that resolved a number of regulatory conflicts between CERCLA and RCRA. Under the agreed order, RCRA will be applied as an ARAR to the extent that post-closure maintenance and care of former interim-status units will be conducted in compliance with the terms of RCRA post-closure permits. Groundwater monitoring will be integrated with CERCLA programs, and corrective actions will be deferred to CERCLA. Groundwater monitoring data reporting will comply with RCRA post-closure permit conditions as well as CERCLA requirements.

Two additional primary regulatory drivers for groundwater monitoring at the Y-12 Plant are the TDEC SWM regulations for nonhazardous solid waste management facilities and the TDEC regulations governing USTs. Two facilities (Centralized Sanitary Landfill II and Industrial Landfill IV) have been subject to groundwater monitoring under the TDEC SWM regulations for several years, and one new facility (Construction/Demolition Landfill VI) was completed in December 1993. Construction of two additional landfill units was completed in 1994 (Industrial Landfill V in April and Construction/Demolition Landfill VII in December). Baseline groundwater monitoring was initiated for the three new facilities late in 1993 and was completed during the first quarter of 1995. Groundwater monitoring to support UST programs have progressed past the assessment phase and into corrective actions, which require only limited monitoring.

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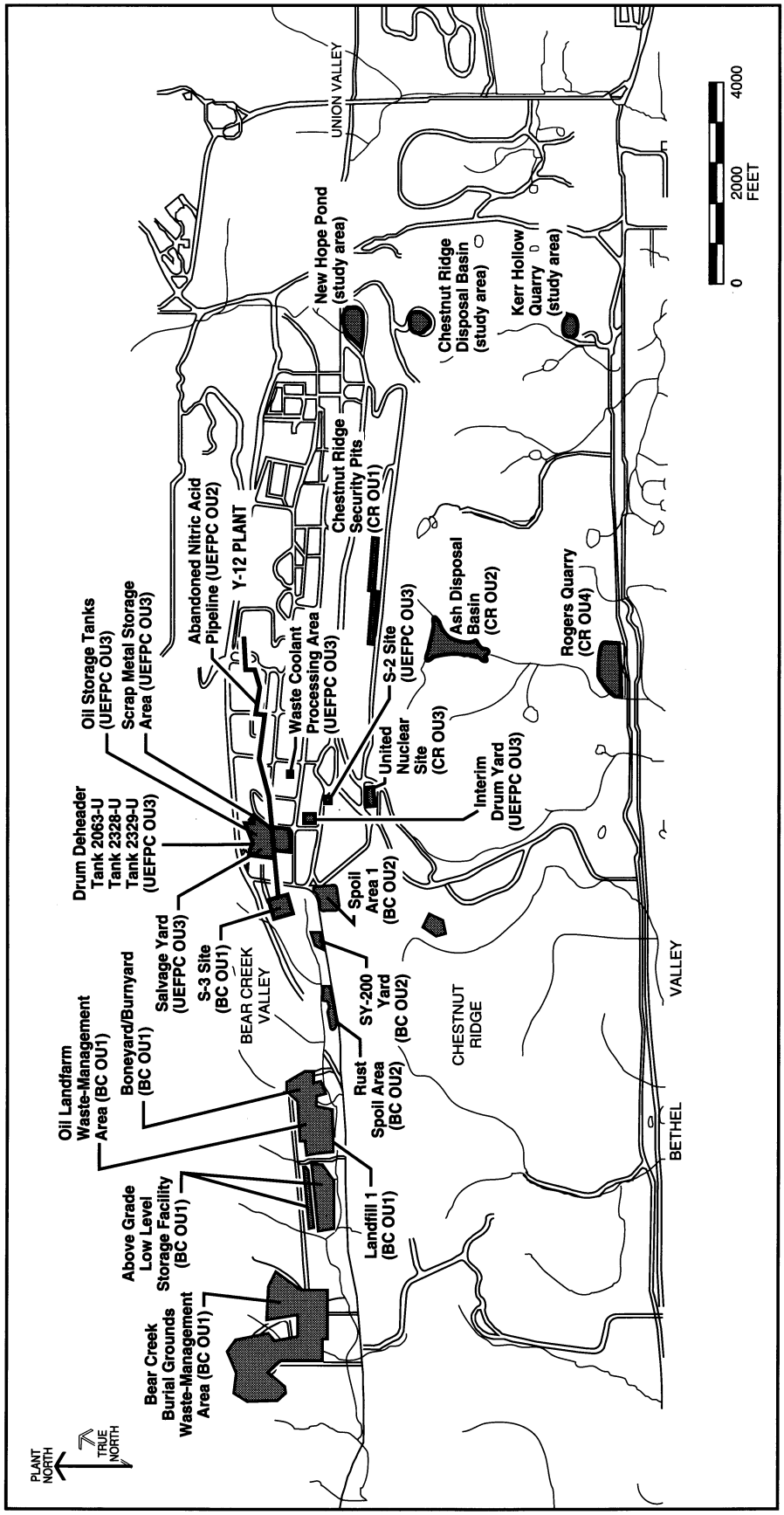

Fig. 7.4. Y-12 Plant source operable units and study areas regulated as RCRA interim-status sites.

Hydrogeologic Setting and Summary of Groundwater Quality

In the comprehensive monitoring program, the Y-12 Plant is divided into three hydrogeologic regimes delineated by surface water drainage patterns, topography, and groundwater flow characteristics. The regimes are further defined by the waste sites they contain. These regimes include the Bear Creek Hydrogeologic Regime (Bear Creek regime), the Upper East Fork Poplar Hydrogeologic Regime (East Fork regime), and the Chestnut Ridge Hydrogeologic Regime (Chestnut Ridge regime) (Fig. 7.5). Most of the Bear Creek and East Fork regimes are underlain by the ORR aquitards. The extreme southern portion of these two regimes is underlain by the Maynardville Limestone, which is part of the Knox Aquifer. The entire Chestnut Ridge regime is underlain by the Knox Aquifer.

In general, groundwater flow in the water table interval follows topography. Shallow groundwater flow in the Bear Creek and East Fork regimes is divergent from a topographic and groundwater table divide located near the western end of the Y-12 Plant. Shallow groundwater flow directions east and west of the divide are predominantly easterly and westerly, respectively. This divide defines the boundary between the Bear Creek and Chestnut Ridge regimes. In addition, flow converges toward the primary surface streams from Pine Ridge to the north and Chestnut Ridge to the south of the Y-12 Plant. In the Chestnut Ridge regime, a groundwater table divide exists that approximately coincides with the crest of the ridge. Shallow groundwater flow, therefore, tends to be toward either flank of the ridge, with discharge primarily to surface streams and springs located in Bethel Valley to the south and Bear Creek Valley to the north.

In Bear Creek Valley, groundwater in the intermediate and deep intervals moves predominantly through fractures in the ORR aquitards, converging toward and moving through fractures and solution conduits in the Maynardville Limestone. Karst development in the Maynardville Limestone has a significant impact on groundwater flow paths in the water table and intermediate intervals. In general, groundwater flow parallels geologic strike. Groundwater flow rates in Bear Creek Valley vary widely; they are very slow within the deep interval of the ORR aquitards but can be quite rapid within solution conduits in the Maynardville Limestone. The rate of groundwater flow perpendicular to geologic strike from the ORR aquitards to the Maynardville Limestone has not been well established. Several investigations are currently under way or planned to attempt to identify how quickly groundwater beneath waste sites over the ORR aquitards moves to the

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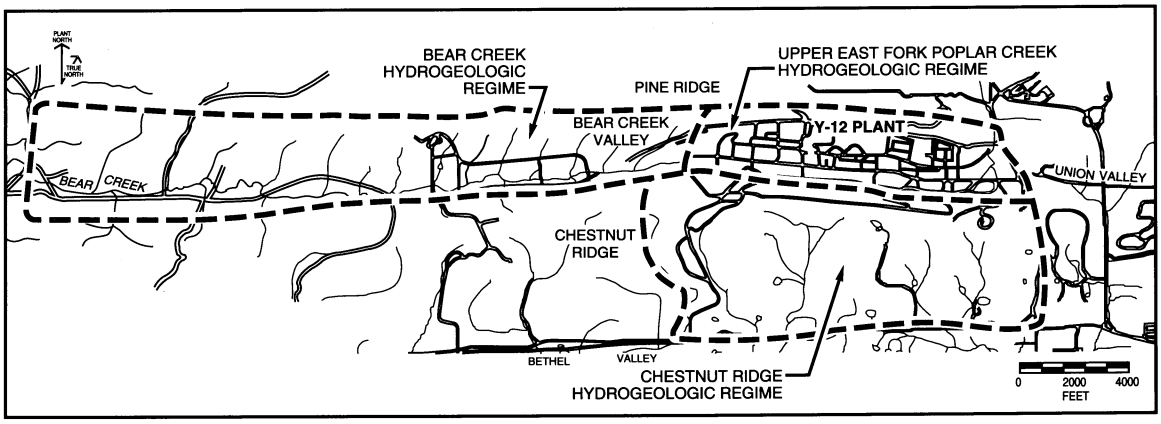

Fig. 7.5. Hydrogeologic regimes at the Y-12 Plant.

Maynardville Limestone. Recent data obtained as part of hydrologic studies in the Bear Creek regime suggest that strike-parallel transport of some contaminants can occur within the ORR aquitards for significant distances. Continuous elevated levels of nitrate within the ORR aquitards are now known to extend west from the S-3 Site for a distance of about 3000 ft, approximately twice the previous estimates. VOCs at source units in the ORR aquitards, however, tend to remain close to source areas because they tend to adsorb to bedrock matrix, diffuse into pore spaces within the matrix, and degrade prior to migrating to exit pathways, where rapid transport for long distances can occur.

Groundwater flow in the Chestnut Ridge regime is almost exclusively through fractures and solution conduits in the Knox Group. Discharge points for intermediate and deep flow are not well known. Groundwater is currently presumed to flow primarily toward Bear Creek Valley to the north and Bethel Valley to the south. Groundwater from intermediate and deep zones may discharge at certain spring locations along the flanks of Chestnut Ridge. Along the crest of the ridge, water table elevations decrease from west to east, implying an overall easterly trend in groundwater flow.

Historical monitoring efforts have shown that groundwater quality at the Y-12 Plant has been affected by four types of contaminants: nitrate, VOCs, metals, and radionuclides. Of these, nitrate and VOCs are the most widespread, although data obtained since 1988 suggest that the extent of some radionuclides may also be significant, particularly in the Bear Creek regime. Trace metals, the least extensive groundwater contaminants, generally occur in a small area of low-pH groundwater at the west end of the Y-12 Plant, in the vicinity of the S-3 Site. Data obtained as a result of previous monitoring efforts show that contaminant plumes from multiple source units have mixed with one another and that contaminants (other than nitrate) are no longer easily associated with a single source.

1994 Well Installation and Plugging and Abandonment Activities

The monitoring objectives for the wells at the Y-12 Plant are divided into four categories: Category I wells, to obtain additional data to delineate the extent of groundwater contamination; Category II wells, to monitor potential exit pathways for groundwater contamination; Category III wells, as new or replacement wells for compliance monitoring; and Category IV wells, under the direction of the Y-12 Plant ER Program, to obtain specific data required for CERCLA RIs. In 1994, two new groundwater monitoring wells were installed in the East Fork regime. Monitoring wells were installed by the Y-12 Plant Groundwater Protection Program (GWPP). Both new wells are Category II. In addition, two methane monitoring probes were installed by the Y-12 Plant GWPP in support of closure activities at Centralized Sanitary Landfill II.

The Y-12 Plant GWPP conducts well plugging and abandonment activities as part of an overall program to maintain the Y-12 Plant monitoring well network. Wells that are damaged beyond rehabilitation, interfere with planned construction activities, or for which no useful data can be obtained, are selected for plugging and abandonment. In 1994, 67 wells were plugged and abandoned. All of the wells (located in the extreme western portion of the Bear Creek regime) were plugged and abandoned because of poor condition, historical lack of security or identity, or no identifiable future use.

1994 Monitoring Programs

Groundwater monitoring in 1994 addressed multiple requirements from regulatory drivers, DOE orders, Y-12 Plant ER programs, and best management practices. In addition,

monitoring efforts that used multiport monitoring systems continued under both exit-pathway and the Y-12 Plant ER Program dense nonaqueous phase liquid (DNAPL) studies. One round of sampling at 20 spring, seep, and surface water stations was conducted by the Y-12 Plant ER program as part of a focused study in the Union Valley area east of the Y-12 Plant. Table 7.1 contains a summary of monitoring activities conducted by the Y-12 Plant GWPP, as well as the programmatic requirements that apply to each site.

Figure 7.6 shows the locations of multiport wells, exit-pathway wells, and ORR perimeter wells, as specified in the EMP.

Detailed data reporting for monitoring activities conducted by the Y-12 Plant GWPP is contained within the 1994 annual groundwater quality reports for each hydrogeologic regime (HSW, Inc. 1995a, 1995b, 1995c). Details of multiport monitoring activities through part of 1993 have been formally reported (Dreier et al. 1993), although additional work has been conducted that has not been formally published. Details of small-scale monitoring efforts performed by organizations other than the Y-12 Plant GWPP specifically for CERCLA OUs are published in RI reports.

Y-12 Plant Groundwater Quality

Upper East Fork Poplar Creek Hydrogeologic Regime

The East Fork regime encompasses the Y-12 Plant complex, extending west from Scarboro Road. It is separated from the Bear Creek regime by a topographic and hydrologic boundary located near the west end of the plant. The 1994 monitoring locations, waste management sites, and petroleum fuel USTs in the East Fork regime that are addressed in this document are shown in Fig. 7.7. One integrator OU (UEFPC) and two source OUs (UEFPC OU 2 and OU 3) lie within the regime. The CERCLA source OUs that encompass these sites are shown in Fig. 7.4 and summarized in Table 7.2. Detailed operational histories of these sites have been published in previous ORR annual site environmental reports.

UEFPC OU 1 consists of both surface water and groundwater components of the hydrogeologic system within the East Fork regime. Numerous sources of contamination to both the surface water and groundwater flow systems exist within the plant area. Chemical constituents from the S-3 Ponds Waste Management Area dominate groundwater contamination in the western portion of the hydrologic regime. In addition to potential surface water and groundwater contamination sources identified in UEFPC OUs 1, 2, and 3, most of the potentially contaminated units making up the Y-12 study areas are within the East Fork regime. Potential surface-water contamination associated with the storm sewer system and East Fork mercury use areas is of primary interest and will be addressed in the UEFPC OU 1 RI/FS.

The administrative boundary of UEFPC OU 1 was expanded in 1994 to include portions of Union Valley to the east of the ORR. A focused study was initiated to investigate the extent of VOCs in groundwater east of the ORR and to attempt to identify springs, seeps, or surface water in which contaminants may be discharging (see "Union Valley Interim Study" section). Focus study and RI work plans for UEFPC OU 1 are scheduled to be submitted to EPA in late 1995.

Table 7.1. Summary of the comprehensive groundwater monitoring program at the Y-12 Plant, 1994

Hydrogeologic regime/waste disposal site	Requirements[a]	Number of wells	Analytical parameters[b]
	Bear Creek Hydrogeologic Regime		
Bear Creek Springs	EXP	3	Standard + (beta for SS-1 and SS-4)
Bear Creek surface water	EXP	6	Standard + (beta for NT-1, BCK-9.40, and BCK-11.97)
Exit pathway—Traverse A	EXP	5	Standard + (beta for GW-683 and GW-684)
Exit pathway—Traverse B	EXP	6	Standard + (beta for GW-694 and GW-706)
Exit pathway—Traverse C	EXP	8	Standard
Exit pathway—Traverse W	EXP/RCRA-CM	6	COMP and T-DCE
Oil Landfarm	RCRA-AM/SMP	10	Standard + (U and beta at GW-085, GW-537; MET at GW-537; COMP at GW-43, GW-44, GW-84)
Rust Spoil Area	RCRA-AM	2	Standard
S-3 Site	RCRA-CM/SMP	10	T-DCE + COMP + (STD for GW-345, GW-347, GW-348; MET at GW-347)
Spoil Area I	RCRA-AM/SMP	2	Standard + (beta for GW-315)
Y-12 Burial Grounds	RCRA-AM/SMP	19	Standard + (CMP for GW-40, GW-42, GW-47, GW-79, GW-80, GW-162, GW-372, GW-373, GW-642; MET at GW-053; beta at GW-061)
Above-Grade Low-Level Storage Facility	BMP	3	Standard + ^{234}U, ^{235}U, ^{238}U
	East Fork Poplar Creek Hydrogeologic Regime		
Surface water	BMP	2	Standard
Beta-4 Security Pit	GRID	4	Standard
Exit pathway—Traverse J	EXP	5	Standard
Grid B-2	GRID	2	Standard
Grid C-1	GRID	2	Standard
Grid D-1	GRID	2	Standard
Grid D-2	GRID	2	Standard
Grid E-1	GRID	2	Standard
Grid E-2	GRID	2	Standard
Grid E-3	GRID	3	Standard
Grid F-2	GRID	2	Standard
Grid F-3	GRID	2	Standard
Grid G-1	GRID	2	Standard
Grid G-2	GRID	2	Standard
Grid G-3	GRID	2	Standard
Grid H-2	GRID	2	Standard
Grid H-3	GRID	2	Standard
Grid I-1	GRID	2	Standard
Grid I-2	GRID	2	Standard + TPH
Grid J-3	GRID	2	Standard
Grid J-4	GRID	2	Standard
Grid K-1	GRID	3	Standard
Grid K-2	GRID	3	Standard
Grid K-3	GRID	1	Standard
New Hope Pond	RCRA-AM/BMP	15	Standard
Rust Garage Area	UST	6	Standard + TPH

Table 7.1 (continued)

Hydrogeologic regime/waste disposal site	Requirements[a]	Number of wells	Analytical parameters[b]
S-2 Site	GRID	3	Standard
U.S. Geological Survey Sites/ exit pathway/Union Valley	EXP	14	Standard + (RAD, BNA at GW-169, GW-170, GW-171, GW-172, GW-230, GW-232)
Waste Coolant Facilities/ Salvage Yard/Fire Training Facility	GRID	8	Standard
Chestnut Ridge Hydrogeologic Regime			
Springs	BMP	1	Standard + AOC + ORP + OMP
Ash Disposal Basin	BMP	4	Standard + TOX + TOC
Chestnut Ridge Security Pits	RCRA-AM	10	Standard
East Chestnut Ridge Waste Pile	BMP	4	Standard
Kerr Hollow Quarry	RCRA-DM	7	Standard + REP + PHEN
Landfill II	SWDF	3	Standard + AOC + ORP + (U and OMP at GW-539)
Chestnut Ridge Borrow Area Waste Pile	BMP	7	Standard + AOC + ORP + (U and beta at GW-295)
Landfill IV	SWDF	5	Standard + AOC + ORP + (RAD at GW-521)
Landfill V	SWDF	5	Standard + AOC + ORP + U + OMP
Landfill VI	SWDF	7	Standard + AOC + ORP
Landfill VII	SWDF	4	Standard + AOC + ORP + OMP + U + TPH
Rogers Quarry	BMP	4	Standard + BNA
Sediment Disposal Basin	RCRA-DM	8	Standard + REP + BNA
United Nuclear Site	ROD	6	Standard + U + Ra

[a]BMP = best management practices monitoring; EXP = exit-pathway monitoring under DOE Order 5400.1; RCRA-AM = RCRA Assessment Monitoring at interim status units; RCRA-DM = RCRA Detection Monitoring at interim status units; RCRA-CM = RCRA post-closure corrective action monitoring; SMP = Y-12 Plant Environmental Restoration Program's Surveillance and Maintenance Program; GRID = grid well monitoring locations under DOE Order 5400.1; UST = petroleum underground storage tank locations; SWDF = monitoring for solid waste disposal facilities under TDEC Rule 1200-1-7-.04; ROD = CERCLA record of decision post-closure monitoring.

[b]Standard = ICP metals scan; Cd, Cr, Pb by atomic absorption spectroscopy; Hg; U (total); VOCs; major anions; gross alpha; gross beta; pH; conductance; TSS; TDS; turbidity; standard field parameters, including dissolved oxygen, water level, pH, temperature, conductance, and redox potential. COMP = RCRA corrective action monitoring parameters, including Standard plus ^{241}Am, ^{129}I, ^{237}Np, ^{238}Pu, total radium, total strontium, ^{99}Tc, ^{3}H, ^{234}U, ^{235}U, and ^{238}U. Beta = beta-emitting isotopes, including total strontium, ^{99}Tc, and ^{3}H. TPH = total petroleum hydrocarbons. REP = four replicate analyses for pH, conductance, TOC, and TOX. PHEN = phenols. TOX = total organic halides. TOC = total organic carbon. ORP = other parameters required by TDEC Rule 1200-1-7-.04, including chemical oxygen demand, cyanide, TOC, and TOX. U = isotopic uranium analysis, including ^{234}U, ^{235}U, and ^{238}U. OMP = other miscellaneous permit-required parameters including ammonia (as N), gamma activity, and *trans*-1,2-dichloroethene. Ra = total radium. BNA = base/neutral/acid extractable organic compounds (semivolatile organics). AOC = additional VOC list required by TDEC Rule 1200-1-7-.04. T-DCE = *trans*-1,2-dichloroethene.

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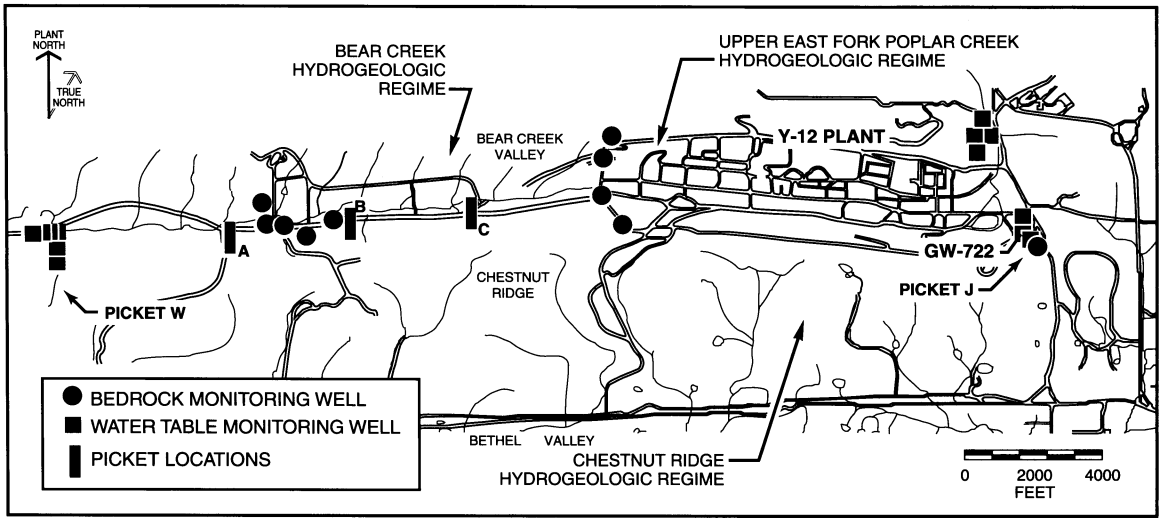

Fig. 7.6. Locations of exit-pathway monitoring pickets, ORR perimeter surveillance wells, and multiport monitoring wells. Well GW-722 is a multiport monitoring well that is also designated as a perimeter surveillance well.

Discussion of Monitoring Results

The objectives of the 1994 groundwater monitoring program in the East Fork regime were (1) to further define contaminant plume boundaries and (2) to evaluate potential contaminant exit pathways by using the existing monitoring well network in the Maynardville Limestone. Locations of monitoring wells are shown in Fig. 7.7.

Plume Delineation

The primary groundwater contaminants in the East Fork regime are nitrate, VOCs, trace metals, and radionuclides. Sources of nitrate, trace metals, and radionuclides are the S-2 Site, the Abandoned Nitric Acid Pipeline, and the S-3 Site. Although it is located west of the hydrologic divide that separates the East Fork regime from the Bear Creek regime, the S-3 Site has contributed to groundwater contamination in the western part of the regime. A mound in the water table created by disposal of large volumes of liquid wastes during operation of the S-3 Site (formerly the S-3 Ponds) allowed contaminants to move into areas east of the current hydrologic divide.

Sources of VOCs in the East Fork regime include the S-3 Site, several sites located within the Y-12 Salvage Yard, the Waste Coolant Processing Area, petroleum USTs, and process/production buildings in the plant. Concentrations of VOCs in most of the East Fork regime have remained relatively constant since 1988 (Fig. 7.8). Some monitoring locations (e.g., GW-220 and GW-733) on the eastern end of the regime, east of New Hope Pond, have shown increasing VOC concentrations, indicative of an easterly movement of the center of mass of part of the plume (Fig. 7.9). Data show that VOCs are the most extensive laterally in the shallow groundwater; however, recent data indicate that, once contaminants migrate into the Maynardville Limestone, they tend to concentrate at depths between 100 and 500 ft. The highest VOC concentrations appear to be between 200 and 500 ft, as exemplified by vertical carbon tetrachloride distribution (Fig. 7.10).

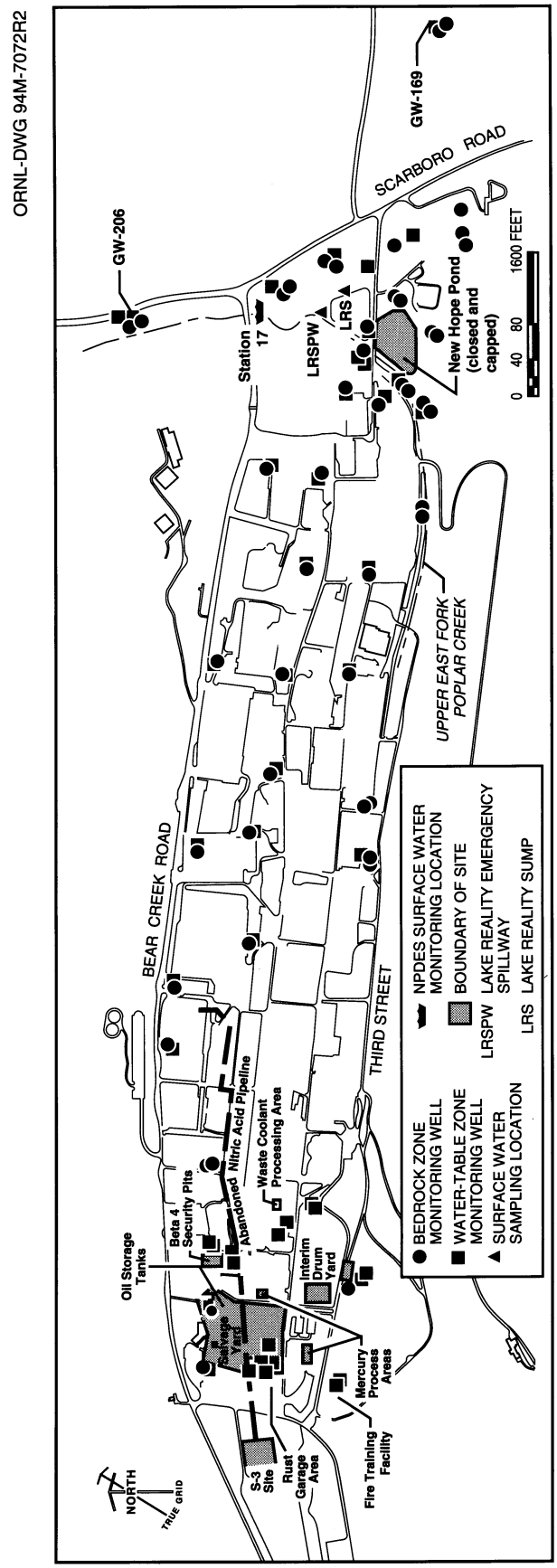

Fig. 7.7. Locations of waste management sites and monitoring wells sampled during 1994 in the Upper East Fork Poplar Creek Hydrogeologic Regime.

Table 7.2. History of CERCLA operable units, waste management units, and underground storage tanks included in the 1994 Comprehensive Groundwater Monitoring Program; Upper East Fork Poplar Creek Hydrogeologic Regime

Site	Historical regulatory classification[a]	Historical data
New Hope Pond	TSD unit	Built in 1963. Regulated flow of water in UEFPC before exiting the Y-12 Plant grounds. Sediments include PCBs, mercury, and uranium but not hazardous according to toxicity characteristic leaching procedure. Closed under RCRA in 1990
Abandoned Nitric Acid Pipeline	SWMU	Used from 1951 to 1983. Transported liquid nitric acid wastes and dissolved uranium from Y-12 Plant process areas to the S-3 Site. Leaks were the release mechanisms to groundwater
Salvage Yard Scrap Metal Storage Area	SWMU	Used from 1950 to present for scrap metal storage. Some metals contaminated with low levels of depleted or enriched uranium. Runoff and infiltration are the principal release mechanisms to groundwater
Salvage Yard Oil/Solvent Drum Storage Area	SWMU	Primary wastes included waste oils, solvents, uranium, and beryllium. Both closed under RCRA. Leaks and spills represent the primary contamination mechanisms for groundwater
Salvage Yard Oil Storage Tanks	SWMU	Used from 1978 to 1986. Two tanks used to store PCB-contaminated oils, both within a diked area
Salvage Yard Drum Deheader Facility	SWMU	Used from 1959 to 1989. Sump tanks 2063-U, 2328-U, and 2329-U received residual drum contents. Sump leakage is a likely release mechanism to groundwater
S-2 Site	SWMU	Used from 1945 to 1951. An unlined reservoir received liquid wastes. Infiltration is the primary release mechanism to groundwater
Waste Coolant Processing Area	SWMU	Former biodegradation facility used to treat waste coolants from various machining processes. Closed under RCRA in 1988
Building 81-10 Area	NA	Staging facility. Potential historical releases to groundwater from leaks and spills of liquid wastes or mercury
Coal Pile Trench	SWMU	Located beneath the current steam plant coal pile. Disposals included solid materials (primarily alloys). Trench leachate is a potential release mechanism to groundwater
Interim Drum Yard	SWMU	Diked outdoor storage area once used to store drums of liquid and solid wastes. Partially closed under RCRA in 1988
Beta-4 Security Pits	SWMU	Used from 1968 to 1972 for disposal of classified materials, scrap metals, and liquid wastes. Site is closed and capped. Primary release mechanism to groundwater is infiltration
Rust Garage Area	SWMU/UST	Former vehicle and equipment maintenance area, including four former petroleum USTs. Petroleum product releases to groundwater are documented
Garage Underground Tanks	SWMU/UST	Fuel USTs used from 1944 to 1978. Converted to waste oil storage in 1978; removed in 1989. Petroleum and waste oil leaks represent probable releases to groundwater

[a]Regulatory status before the 1992 Federal Facility Agreement: TSD Unit—RCRA-regulated, land-based treatment, storage, or disposal unit; SWMU—RCRA-regulated solid waste management unit; and UST—petroleum underground storage tank.

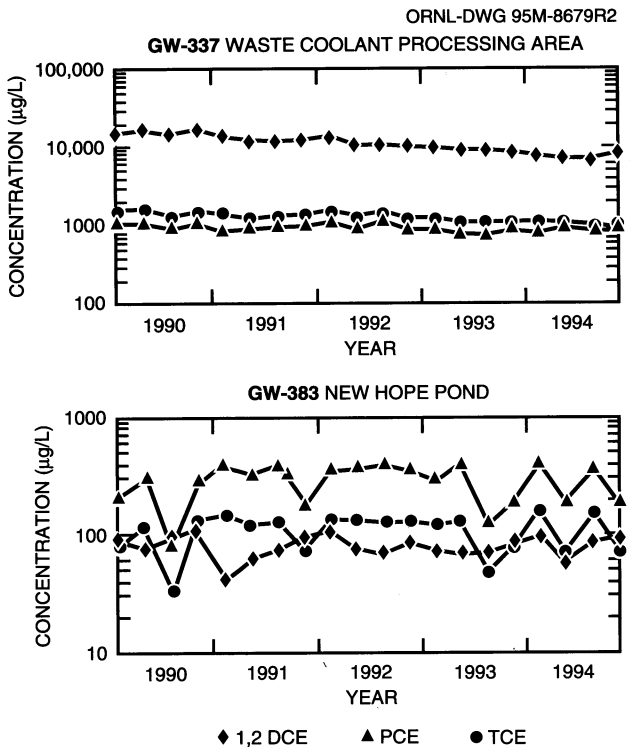

Fig. 7.8. Quarterly volatile organic compound concentrations in groundwater in selected wells in the East Fork regime.

Nitrate

Nitrate concentrations exceeded the 10 mg/L maximum contamination level during 1994 in a large part of the western portion of the East Fork regime (Fig. 7.11). (A complete list of DWSs is presented in Appendix D.) Groundwater containing nitrate concentrations as high as 10,000 mg/L occur in the unconsolidated zone and at shallow bedrock depths just east of the S-3 Site. In 1994, the highest observed annual average nitrate value was in well GW-251, about 2000 ft southeast of the S-3 site (Fig. 7.11).

The real extent of the nitrate plume is essentially defined in the unconsolidated zone and the shallow bedrock zone. In both zones, the nitrate plume extends about 2500 ft eastward from the S-3 Site to just downgradient of the S-2 Site. Nitrate has traveled farthest in groundwater in the Maynardville Limestone.

Trace Metals

Concentrations of barium, cadmium, chromium, and lead exceeded maximum contamination levels during 1994 in samples collected from monitoring wells at the S-2 Site, the Y-12 Salvage Yard, the Waste Coolant Processing Area, the 9754 and 9754-2 Fuel facilities, Rust Garage, two exit-pathway wells, and New Hope Pond. Elevated concentrations of these metals were most commonly reported for groundwater samples collected from wells monitoring the unconsolidated zone. Groundwater at shallow bedrock depths contained elevated metals concentrations near the Y-12 Salvage Yard, the S-2 Site, and at New Hope Pond. A definable plume of elevated metals contaminants is not present; metals above maximum contaminant levels tend to occur adjacent to the source units. A rigorous statistical evaluation was conducted as part of the RCRA post-closure permit application for the East Fork regime to determine whether New Hope Pond was a source of metals contamination. The analysis showed that New Hope Pond was not a statistically discernable source of metals, gross alpha activity, or gross beta activity.

Volatile Organic Compounds

Because of the many source areas, VOCs are the most widespread groundwater contaminants in the East Fork regime (Fig. 7.12). Dissolved VOCs in the regime generally consist of two types of compounds: chlorinated solvents and petroleum hydrocarbons. The highest concentrations of dissolved chlorinated solvents (about 12 mg/L) are found at the Waste Coolant Processing Area, and the highest dissolved concentrations of petroleum

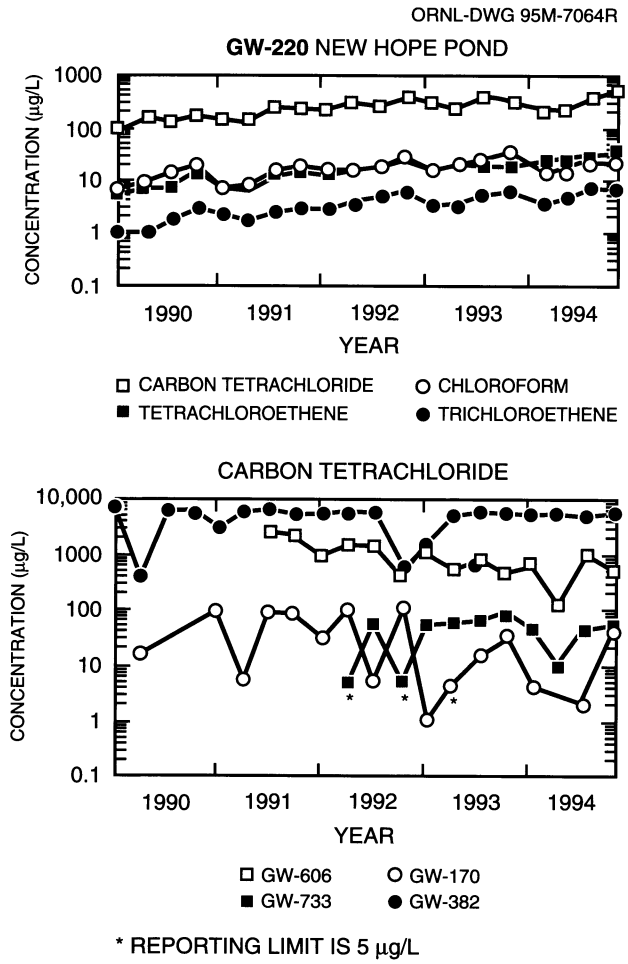

Fig. 7.9. Quarterly volatile organic compound concentrations in selected wells near New Hope Pond and exit-pathway wells.

hydrocarbons (about 60 mg/L) occur in groundwater in the Y-12 Salvage Yard near the Rust Garage Area.

The 1994 monitoring results generally confirm findings from the previous 3 years of monitoring. A continuous dissolved VOC plume in groundwater in the bedrock zone extends eastward from the S-3 Site over the entire length of the regime. Additionally, the 1994 data confirm previous results identifying the Waste Coolant Processing Facility area as a VOCs source area. Pockets of VOCs also are present in groundwater at the Building 9754 and 9754-2 fuel facilities and New Hope Pond. New data from the East Fork regime grid well monitoring network show that a major source area also lies within process areas in the central portion of the plant.

Results obtained during previous years suggest that New Hope Pond is not a source of VOCs in the wells at the east end of the Y-12 Plant (Fig. 7.10). Data obtained during 1994 support this observation. Groundwater sampled from wells installed upgradient of the site (wells GW-382 and GW-606) contains the same VOCs found in wells downgradient of the site (Well GW-220). The upgradient sources of these VOCs have not been pinpointed beyond process and maintenance facilities located in central and eastern portions of the Y-12 Plant.

Radionuclides

As in the Bear Creek regime, the primary alpha-emitting radionuclides found in the East Fork regime are uranium, isotopes of radium, neptunium, and americium. The primary beta-emitting radionuclide is technetium.

Groundwater with gross alpha activity greater than 15 pCi/L occurs in scattered points within the East Fork regime (Fig. 7.13). Gross alpha activity exceeding the maximum contamination level is most extensive in groundwater in the unconsolidated zone. Gross alpha activity greater than 15 pCi/L occurs consistently only in one well (GW-204) at Tank 0134-U and one well west of New Hope Pond (GW-605). Previous data have also suggested an area of elevated gross alpha activity west of New Hope Pond. Sporadic gross alpha activity was observed in several shallow wells scattered across the East Fork regime, notably in exit-pathway wells GW-206 and GW-169 (Fig. 7.13). Erratic data distribution,

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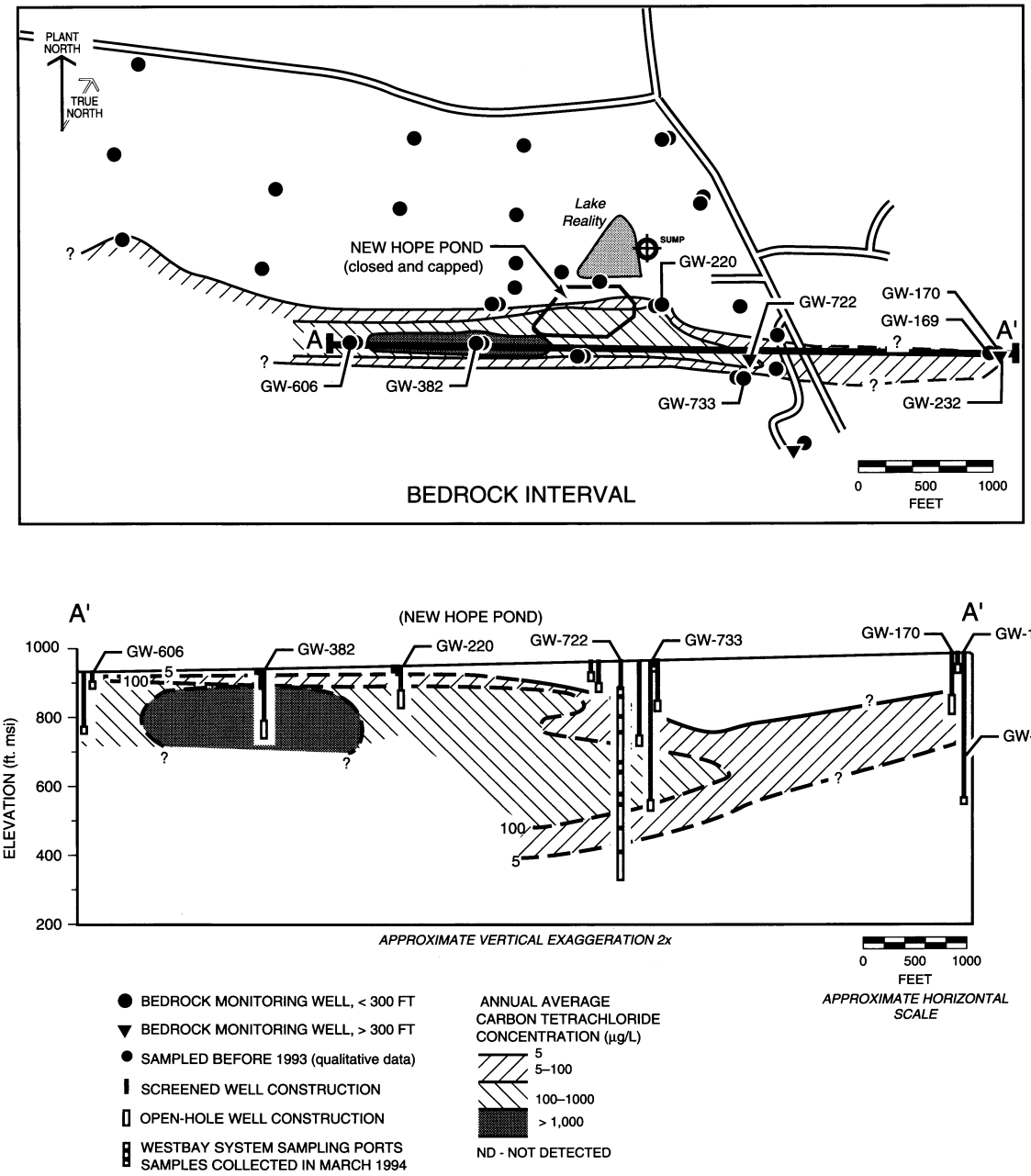

Fig. 7.10. Volatile organic compound concentrations in Maynardville Limestone, at depths between 200 and 500 ft.

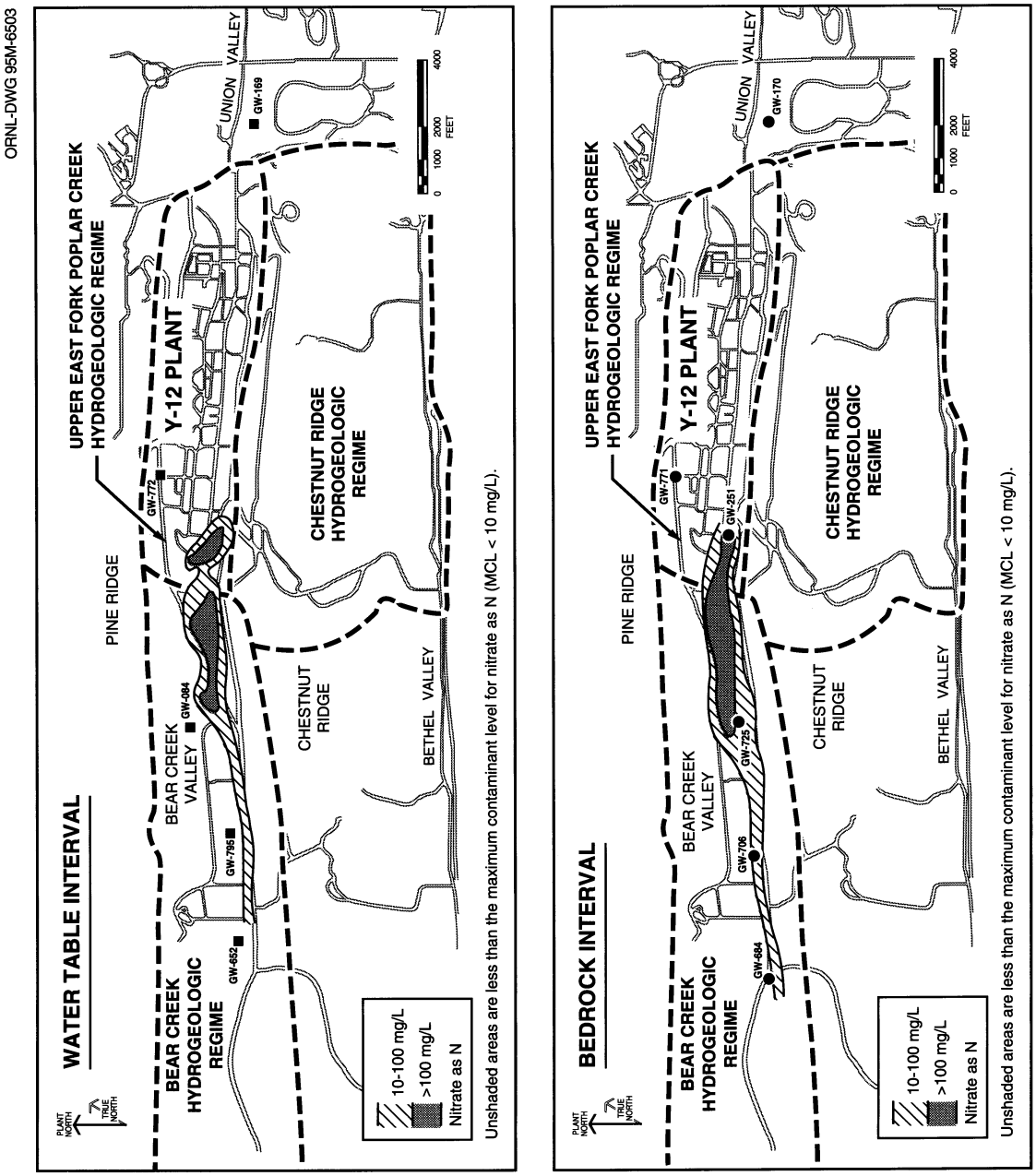

Fig. 7.11. Nitrate (as N) observed in groundwater at the Y-12 Plant.

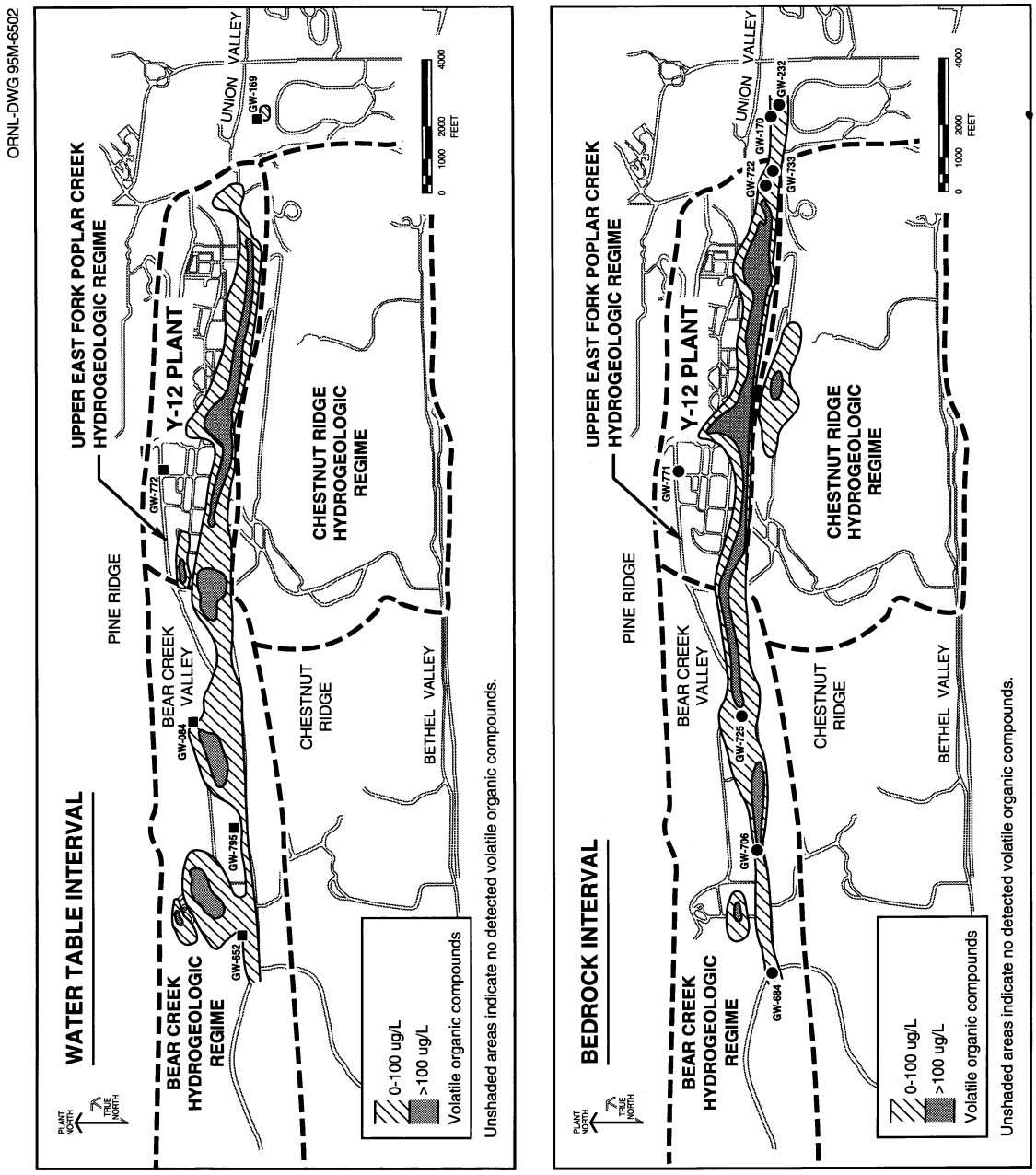

Fig. 7.12. Summed volatile organic compounds in groundwater at the Y-12 Plant.

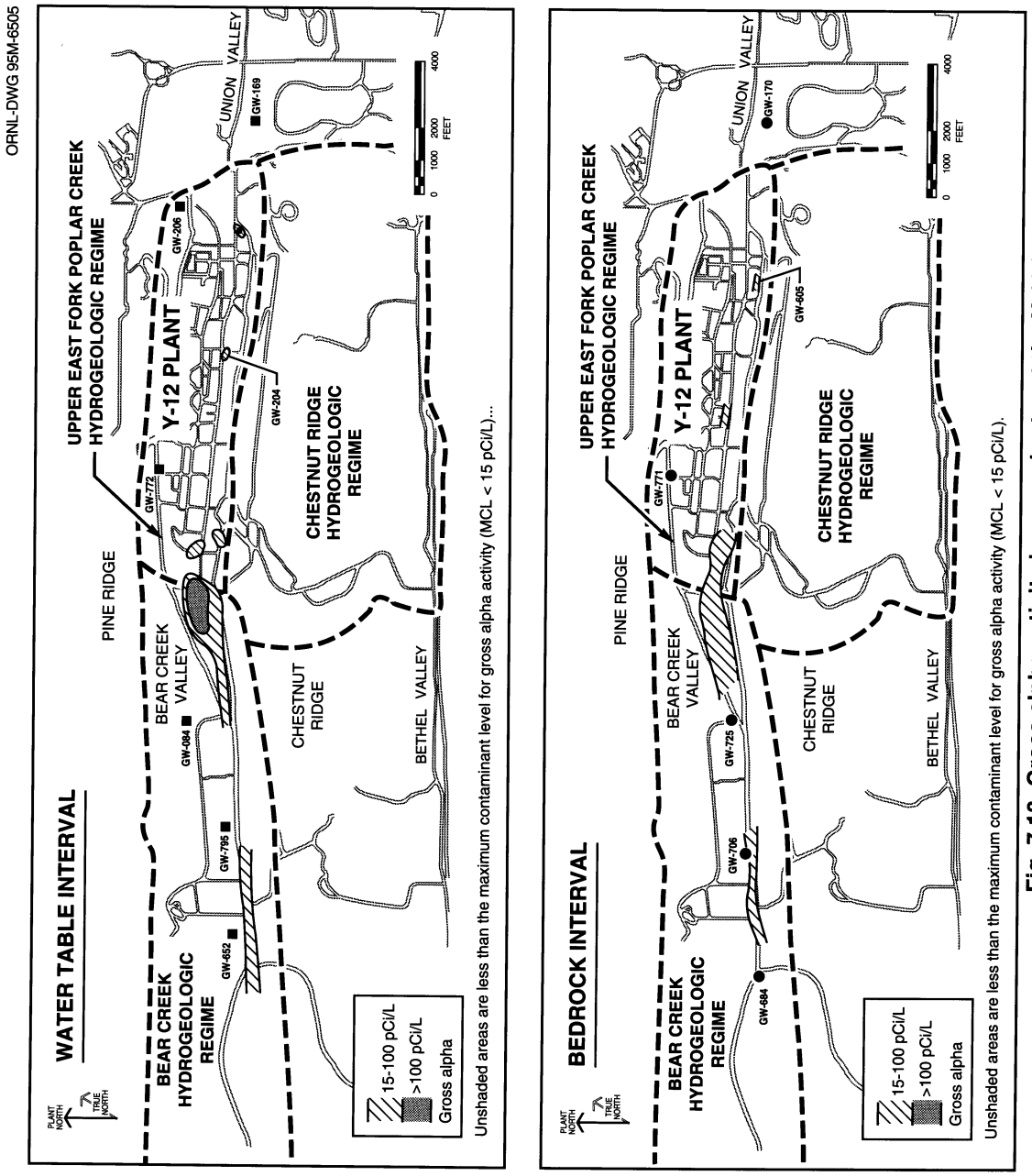

Fig. 7.13. Gross alpha activity in groundwater at the Y-12 Plant.

coupled with high turbidity and total suspended solids content in samples from most of the wells, indicate that these values are false positives.

Elevated gross beta activity in groundwater in the East Fork regime shows a pattern similar to that observed for gross alpha activity (Fig. 7.14). In general, gross beta activity exceeds 50 pCi/L in groundwater in scattered locations throughout the regime. Gross beta activity consistently greater than the 50-pCi/L annual average occurred only in the western part of the regime, near the Salvage Yard and Rust Garage and in wells GW-154 and GW-605, located west of New Hope Pond, within the Maynardville Limestone (Fig. 7.14).

Exit-Pathway and Perimeter Monitoring

Exit-pathway groundwater monitoring activities in the East Fork regime in 1994 involved ongoing monitoring and evaluation of data from exit-pathway wells installed in 1992. The 1992 ORR environmental report contained a detailed discussion of the new exit-pathway monitoring network. Surface water quality in UEFPC is regularly monitored in accordance with NPDES permits, and the results are summarized in Sect. 4. In addition, monitoring of the entire East Fork grid well network commenced in 1994.

Chemical water quality data from exit-pathway wells monitored in 1993 provided the first strong indication that VOCs are being transported off the ORR through the Maynardville Limestone at depths of approximately 100 to 300 ft. Sporadic occurrences of common chlorinated solvents, carbon tetrachloride and tetrachloroethene, above DWSs were confirmed at a depth of 160 ft in an off-site well (Well GW-170, Figs. 7.10 and 7.12). This off-site well is located approximately 1500 ft east of the eastern ORR boundary. This off-site well also contained chloroform and trichloroethene, although below the MCLs for these two compounds. Two additional wells at the same location as Well GW-170 have been sampled. Well GW-169 is approximately 40 ft deep. Only trace levels of VOCs have been observed in this well; one sample for trichloroethene was slightly above the MCL in 1991. Carbon tetrachloride and chloroform have not been present above detection levels in the shallow well. Well GW-232 is approximately 400 ft deep. No VOCs have been detected in this well.

In 1993, VOCs were confirmed to exist in Well GW-733 located along the eastern edge of the ORR. Well GW-733 also monitors the Maynardville Limestone and is approximately 260 ft deep. The compositions of the VOCs seen in this well were the same as those observed in Well GW-170. The concentration trend for carbon tetrachloride, the primary contaminant of concern, in both wells GW-170 and GW-733 is illustrated in Fig. 7.9. An areal distribution of VOCs is shown in Fig. 7.12. The data to date indicate that VOC transport is occurring at depth within the Maynardville Limestone and is restricted to that formation. A vertical profile of VOC contamination was obtained from a multipart monitoring well (GW-722), near the eastern boundary of the ORR (Fig. 7.6). The data show that the highest VOC concentrations occurred at depths between 200 and 500 ft below ground surface (Fig. 7.10). VOC concentrations are highest at these depths because most dilution and mixing with rainwater occurs in the shallow portions of the Maynardville Limestone. VOCs have not been observed in exit-pathway wells drilled to a variety of depths in the ORR aquitards north of Well GW-733. Conversely, VOCs have not been observed at concentrations exceeding MCLs in several wells located south of Well GW-733 in the Knox Aquifer.

VOC data were obtained for the first time from two sampling points near Lake Reality: a dewatering sump located just east of the site and groundwater seeps north of the site within the emergency overflow spillway. These samples contained VOCs, indicating that groundwater may be moving preferentially through permeable fill zones beneath a

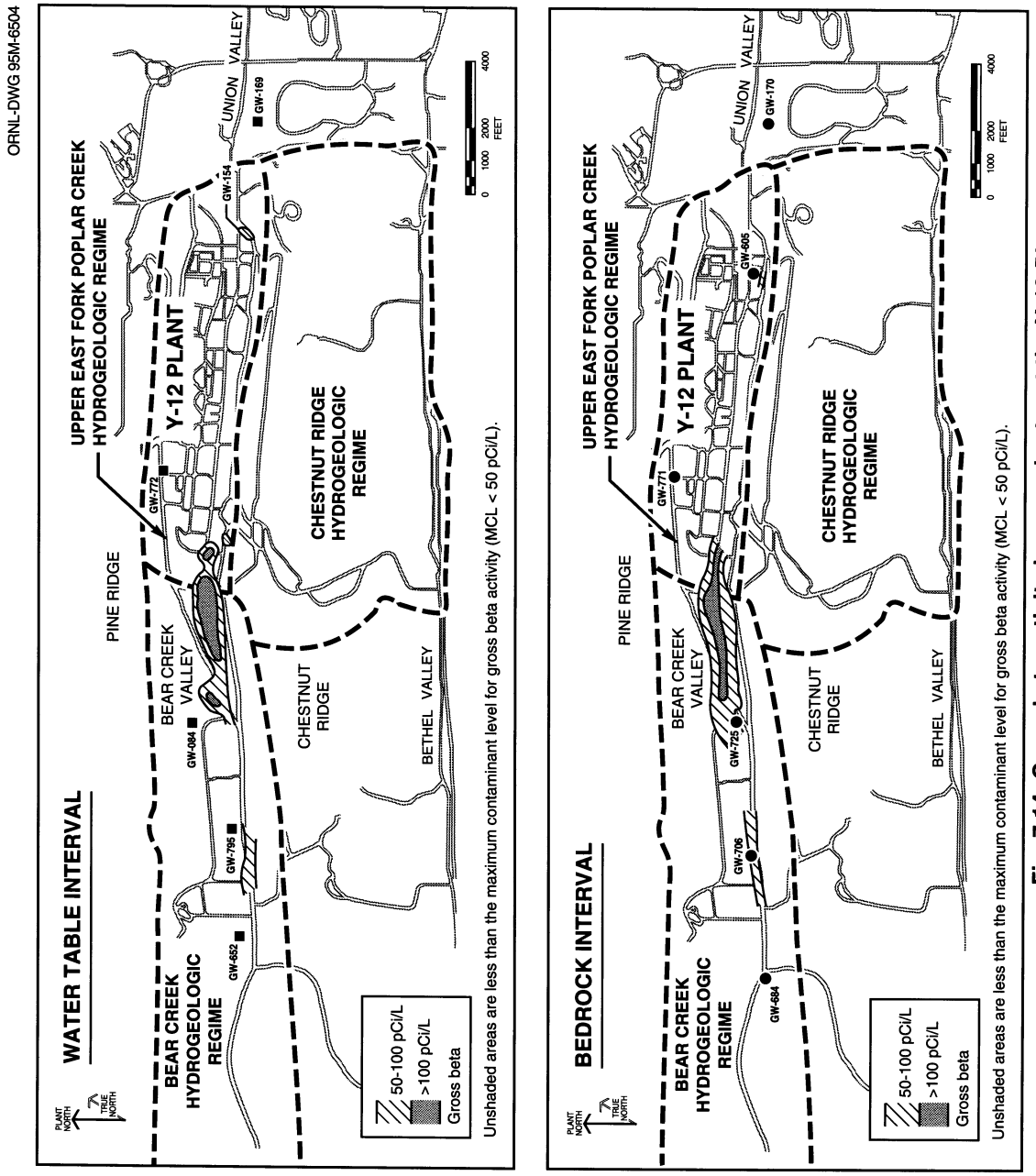

Fig. 7.14. Gross beta activity in groundwater at the Y-12 Plant.

concrete-lined diversion channel for UEFPC. The sump was originally installed in 1990 to prevent the bottom liner for Lake Reality from floating as a result of upward hydrostatic pressure. The sump was only intermittently active during 1992 and 1993, and was deactivated in mid-1994 because of concerns that it was inducing shallow groundwater flow to the north. Monitoring of the groundwater seepage in the overflow spillway is continuing to determine whether any trends in VOC levels result from deactivation of the sump. Source areas for the VOCs are not well defined. Historical data have shown significant VOC contamination within and immediately east of the Y-12 Plant. Multiple sources are likely to include process areas where large quantities of solvents, particularly carbon tetrachloride, were used in the early and mid-1940s. Operations and maintenance facilities, such as the Waste Coolant Processing Area, also represent probable historical source areas.

Union Valley Interim Study

Upon confirmation by the exit-pathway and perimeter monitoring programs that VOCs were migrating off of the ORR, the Y-12 Plant Environmental Restoration Program was assigned as the lead organization for future actions using CERCLA criteria. Immediate notifications were made to appropriate local, state, and EPA agencies through the DOE occurrence reporting process. A public meeting was held in March 1994 to present the data obtained to date, address any concerns by stakeholders, and describe both short-term and long-term actions that would be taken to investigate the problem, determine if any risk to public health and the environment existed, and develop interim corrective measures, if required. Short-term actions included the following:

- obtain property access agreements,
- conduct a survey for potential groundwater use,
- continue existing groundwater monitoring efforts in the Union Valley area,
- complete a focused study to determine the extent and adverse impacts (if any) of VOC contamination, and
- evaluate the need for immediate corrective actions.

A survey of area property owners, completed in April 1994, confirmed that groundwater is not a drinking-water or process-water source in Union Valley. An interim study was conducted during the last calendar quarter of 1994 to identify potential discharge locations for groundwater (i.e., springs, seeps, and surface streams), conduct appropriate sampling of optimal locations, and determine whether human health or environmental risks exist from any discharging contaminants (CDM 1995).

Six existing groundwater monitoring wells in Union Valley and 20 spring, seep, and surface water locations were sampled as part of the interim study (Fig. 7.15). Groundwater monitoring well results from the interim study confirmed the presence of VOCs in groundwater about 1500 ft off the ORR. Several metals were also detected above primary or secondary DWSs or background levels in two wells (GW-169 and GW-232). The elevated levels in GW-169 may be considered suspect because of the high amounts of suspended content (mud) in the samples that had elevated metals. Well GW-232 is approximately 400 ft deep, and the elevated metals may represent natural concentrations at those depths. One sample from Well GW-171 showed strontium activity in excess of its reference standard, although the gross beta activity measured in the same sample was less than drinking water criteria. Validation of the result is currently ongoing.

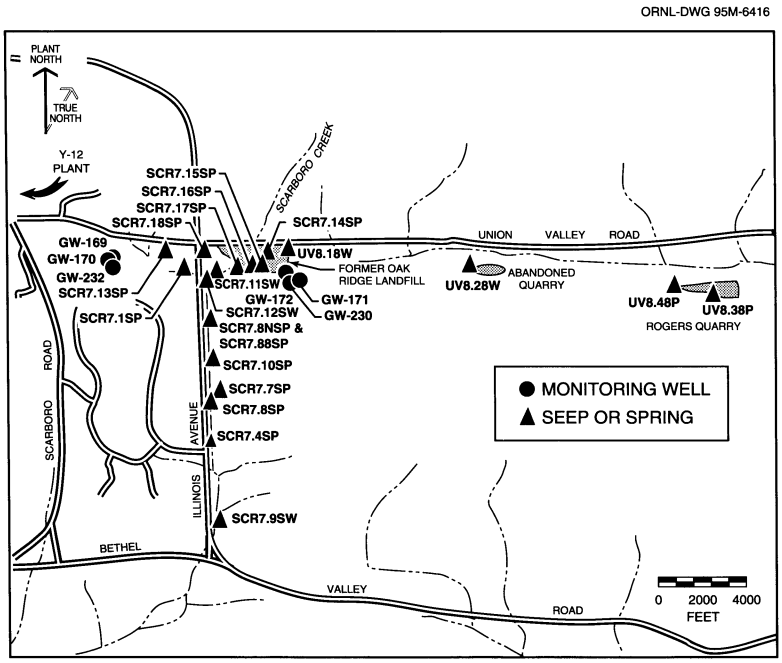

Fig. 7.15. Sampling locations for the Union Valley interim study. (*Source:* CDM Federal Program, Inc., 1995.)

Spring, seep, and surface water data obtained during the interim study indicated that one spring (SCR7.1SP) contained carbon tetrachloride in excess of the U.S. EPA primary DWS, along with trace levels of other VOCs, and appears to be a discharge point for groundwater that has been affected by historical operations at the Y-12 Plant. Estimated levels of VOCs below reporting limits were identified at several scattered locations in the study area, particularly SCR7.8SP. The types and concentrations of VOCs identified at these stations indicate that they are not likely attributable to Y-12 Plant historical operations, with the possible exception of SCR7.8SP. Iron and manganese exceeded secondary and primary DWSs, respectively, at SCR7.16SP and SCR7.14SP. Arsenic was elevated above anticipated levels at SCR7.16SP, and elemental strontium slightly exceeded background levels at UV8.4SP. These metals (with the exception of strontium) appear to be associated with drainage from the old municipal landfill located in the study area. The strontium levels in UV8.4SP may be a natural geochemical condition within the Knox Aquifer.

A risk assessment was also conducted as part of the interim study. The risk assessment concluded that, although some contaminants exceeded the risk levels for drinking water, an incomplete exposure pathway exists because groundwater is not used as a drinking water source in Union Valley. In addition, no health risks were identified in association with surface water or springs. Based upon the data obtained to date and the results of the risk assessment, an immediate interim action to remediate or intercept groundwater contamination was deemed unwarranted. TDEC and EPA retain regulatory authority to restrict or post advisories concerning exposure to groundwater or surface water in Union Valley. Any additional investigations in this area will be addressed in conjunction with DOE, TDEC, and EPA as the RI/FS for UEFPC OU 1 progresses.

Bear Creek Hydrogeologic Regime

Located west of the Y-12 Plant in Bear Creek Valley, the Bear Creek regime is bounded to the north by Pine Ridge and to the south by Chestnut Ridge. The regime encompasses the portion of Bear Creek Valley extending from the west end of the Y-12 Plant to Highway 95. Figure 7.16 shows the Bear Creek regime, locations of wells sampled in 1994, and the locations of its waste management sites. One integrator OU (Bear Creek OU 4) and two source OUs (Bear Creek OU 1 and OU 2) lie within the regime. The sites

contained within the CERCLA source OUs are shown in Fig. 7.4 and are summarized in Table 7.3.

Bear Creek OU 4 originally addressed stream channel deposits from the coupled groundwater–surface water system/stream channel deposits within the Bear Creek regime. As part of the ongoing redefinition of Y-12 Plant operable units, floodplain sediments along Bear Creek were incorporated into the scope of the RI/FS. Floodplain sediments were originally classified as a source OU; however, recent data increasingly showed that contaminant contributions from these media could not be separated from the stream system or the shallow groundwater system. In addition, groundwater data collection under the scope of Bear Creek OU 4 was eliminated from the RI scope. Data obtained from approximately 6 years of monitoring under the comprehensive groundwater monitoring program is to be used as the primary data set for conceptual model development and risk assessment. Data gaps, as they are discovered, will be addressed as focused studies with limited scopes and short durations.

All RI field activities under the redefined scope of Bear Creek OU 4 were completed in February 1995. Field activities associated with Bear Creek OU 1 (Fig. 7.4) are scheduled to be completed in March 1995. All of the RI-generated results and conclusions will be integrated into the RI report for Bear Creek Valley.

Discussion of Monitoring Results

Groundwater monitoring efforts in the Bear Creek regime during 1994 were the same as those for the East Fork regime: (1) to delineate contaminant plume boundaries and (2) to evaluate potential contaminant exit pathways in the Maynardville Limestone by using the existing monitoring well network. In addition, RCRA corrective action monitoring was conducted to comply with requirements of the S-3 Site post-closure permit.

Plume Delineation

The primary groundwater contaminants in the Bear Creek regime are nitrate, trace metals, VOCs, and radionuclides. The S-3 Site is the primary source of nitrate, radionuclides, and trace metals. Sources of VOCs include the S-3 Site, the Rust Spoil Area, Oil Landfarm waste management area, and the Bear Creek Burial Grounds waste management area; the latter two sites are the principal sources. DNAPLs have been discovered at a depth of 270 ft below the Bear Creek Burial Grounds. The DNAPLs consist primarily of tetrachloroethene, trichloroethene, 1,1-dichloroethene, 1,2-dichloroethene, and high concentrations of PCBs.

Contaminant plume boundaries are essentially defined in the bedrock formations that directly underlie many waste disposal areas in the Bear Creek regime, particularly the Nolichucky Shale. The elongated shape of the contaminant plumes in the Bear Creek regime is the result of preferential transport of the contaminants parallel to strike in both the Knox Aquifer and the ORR aquitards. A review of historical data suggests that, in general, contaminant concentrations in the Bear Creek regime, within the ORR aquitards, have remained relatively constant since 1986. Certain contaminants at specific sites, however, have shown non-steady-state concentration patterns, as detailed in the 1992 ORR environmental report (Energy Systems 1993b). The same trends have been observed in exit-pathway wells located in the Bear Creek regime (Figs. 7.6 and 7.17), with slight increases or decreases observed for selected contaminants.

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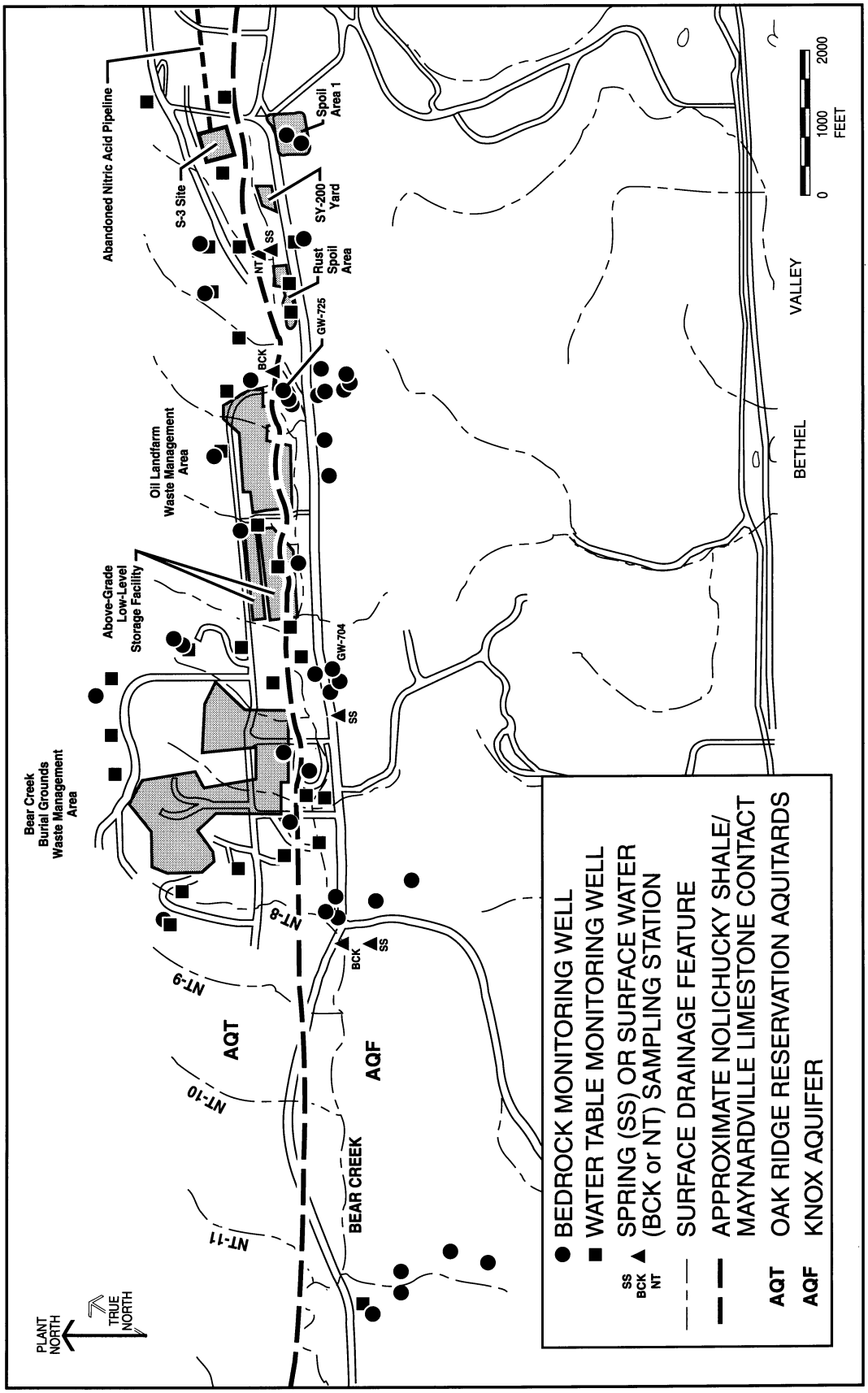

Fig. 7.16. Locations of waste management sites and monitoring wells sampled during 1994 in the Bear Creek Hydrogeologic Regime.

Table 7.3. History of CERCLA operable units and waste management units included in the 1994 Comprehensive Groundwater Monitoring Program; Bear Creek Hydrogeologic Regime

Site	Historical regulatory classification[a]	Historical data
S-3 Site	TSD unit	Four unlined surface impoundments constructed in 1951. Received liquid nitric acid/uranium-bearing wastes via the Nitric Acid Pipeline until 1984. Closed and capped under RCRA in 1988. Infiltration was the primary release mechanism to groundwater
Oil Landfarm	TSD unit	Operated from 1973 to 1982. Received waste oils and coolants tainted with metals and PCBs. Closed and capped under RCRA in 1989. Infiltration was the primary release mechanism to groundwater
Boneyard	SWMU	Unlined shallow trenches used to dispose of construction debris and to burn magnesium chips and wood
Burnyard	SWMU	Used from 1943 to 1968. Wastes, metal shavings, solvents, oils, and laboratory chemicals were burned in two unlined trenches
Hazardous Chemical Disposal Area	SWMU	Built over the burnyard. Handled compressed gas cylinders and reactive chemicals. Residues placed in a small
Sanitary Landfill I	SWMU	Used from 1968 to 1982. TDEC-permitted, nonhazardous industrial landfill. May be a source of certain contaminants to groundwater. Closed and capped under TDEC requirements in 1983
Bear Creek Burial Grounds Waste-Management Area	Burial Grounds A and C and Walk-in Pits—TSD units	A and C received waste oils, coolants, beryllium and uranium, various metallic wastes, and asbestos into unlined trenches and standpipes. Walk-in Pits received chemical wastes, shock-sensitive reagents, and uranium saw fines. Activities ceased in 1981. Final closure certified for A (1989), C (1990), and the Walk-in Pits (1994). Infiltration is the primary release mechanism to groundwater
Bear Creek Burial Grounds Waste-Management Area (continued)	Burial Grounds B, D, E, J, and Oil Retention Pond Nos. 1 and 2—SWMUs	Burial Grounds B, D, E, and J, unlined trenches, received depleted uranium metal and oxides and minor amounts of debris and inorganic salts. Ponds 1 and 2, built in 1971 and 1972, respectively, captured waste oils seeping into two Bear Creek tributaries. The ponds were closed and capped under RCRA in 1989. Certification of closure and capping of Burial Grounds B and part of C was granted 2/95
Rust Spoil Area	SWMU	Used from 1975 to 1983 for disposal of construction debris, but may have included materials bearing solvents, asbestos, mercury, and uranium. Closed under RCRA in 1984. Site is a source of VOCs to shallow groundwater according to CERCLA RI
Spoil Area I	SWMU	Used from 1980 to about 1987 for disposal of construction debris and other stable, nonrad wastes. Permitted under TDEC solid waste management regulations in 1986; closure began shortly thereafter. Soil contamination is of primary concern
SY-200 Yard	SWMU	Used from 1950s to 1986 for equipment and materials storage. No documented waste disposal at the site occurred. Leaks, spills, and soil contamination are concerns
Above-Grade LLW Storage Facility	NA	Constructed in 1993. Consists of six used to store inert, low-level radioactive debris and solid wastes packaged in steel containers

[a]Regulatory status before the 1992 Federal Facilities Agreement: TSD Unit—RCRA regulated, land-based treatment, storage, or disposal unit; SWMU—RCRA-regulated solid waste management unit.

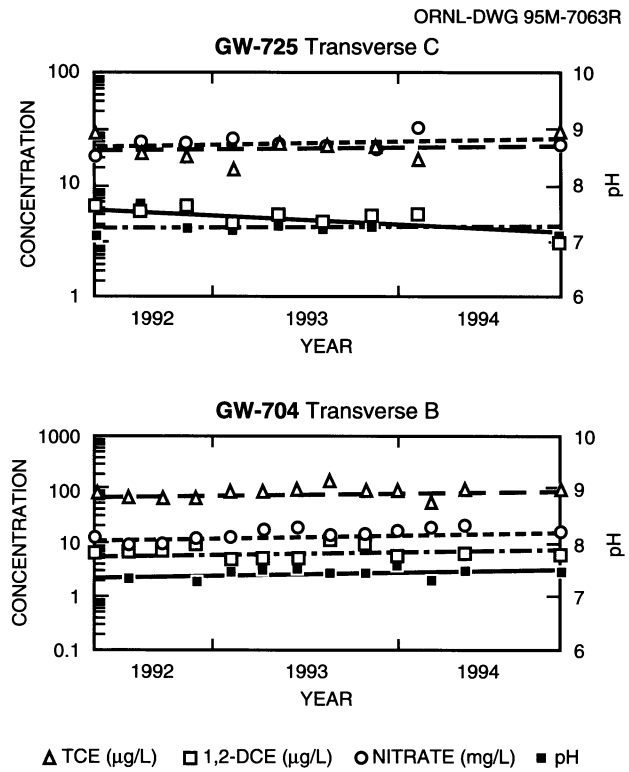

Fig. 7.17. Quarterly concentrations of selected contaminants in exit-pathway monitoring wells GW-725 and GW-704 in the Bear Creek Hydrogeologic Regime.

Nitrate

Unlike most of the other groundwater contaminants, nitrate moves easily with the groundwater. The limits of the nitrate plume probably define the maximum extent of subsurface contamination in the Bear Creek regime.

Data obtained during 1994 indicate that nitrate concentrations exceed the 10 mg/L MCL in an area that extends west from the S-3 Site for several thousand feet down Bear Creek Valley (Fig. 7.11). Nitrate concentrations greater than 100 mg/L extend about 3000 ft west of the S-3 Site. During 1994 the highest nitrate concentrations continued to be seen adjacent to the S-3 Site in groundwater in the unconsolidated zone and at shallow depths (less than 100 ft below the ground surface) in the Nolichucky Shale. A separate source area was thought to exist in the vicinity of the Oil Landfarm; however, recent data show that significant strike-parallel transport of nitrate has occurred within the Nolichucky Shale. The hypothesized source area is now known to be an extension of the S-3 Site plume.

The horizontal extent of the nitrate plume is essentially defined in groundwater in the upper part of the aquifer (less than 200 ft below the ground surface). Data obtained from exit-pathway monitoring wells installed during 1991 and 1992 suggest that the nitrate plume in groundwater within bedrock in the Maynardville Limestone extends farther west along Bear Creek Valley than previously thought (about 12,000 ft).

Vertical plume boundaries are not so well defined. Typically, nitrate concentrations exceed the MCL in groundwater in the upper 300 ft of the Maynardville Limestone. Below this depth nitrate concentrations exceed 10 mg/L in an area immediately down-dip (south) of the S-3 Site. Data obtained since 1986 suggest that the nitrate plume extends more than 600 ft below the ground surface within the ORR aquitards at the S-3 Site.

Trace Metals

Barium, cadmium, chromium, lead, and mercury have been identified from previous monitoring as the principal trace metal contaminants in groundwater in the Bear Creek regime. Historically, the concentrations of these metals exceeded maximum contamination levels or natural (background) levels primarily in low-pH groundwater at shallow depths near the S-3 Site. Disposal of acidic liquid wastes at this site reduced the pH of the groundwater, which allows the metals to remain in solution. Elsewhere in the Bear Creek

regime, where relatively high pH conditions prevail, only sporadic occurrences of elevated trace metal concentrations are evident.

Based on the 1994 data, the highest concentrations of barium were reported for samples from NT-1 and wells at the S-3 Site. Barium, chromium, and cadmium were detected above maximum contaminant levels in filtered samples from two monitoring wells in the Bear Creek Burial Grounds and Oil Landfarm waste management areas.

Other trace metal contaminants in the Bear Creek regime are beryllium, boron, cobalt, copper, nickel, strontium, and uranium. Concentrations of these metals have commonly exceeded background levels in groundwater near the S-3 Site, Bear Creek Burial Grounds, and Oil Landfarm waste management areas. Selected stream and spring locations and exit-pathway study wells also have exhibited total uranium and strontium concentrations above background values.

Volatile Organic Compounds

Like nitrate, VOCs are widespread in groundwater in the Bear Creek regime (Fig. 7.12). The primary compounds are tetrachloroethene, trichloroethene, 1,2-dichloroethene, 1,1,1-trichloroethane, and 1,1-dichloroethane. In most areas the VOCs are dissolved in the groundwater, but nonaqueous phase accumulations of tetrachloroethene and trichloroethene occur in bedrock more than 250 ft below the Bear Creek Burial Grounds waste management area.

Groundwater in the unconsolidated zone that contains detectable levels of VOCs occurs primarily within about 1000 ft of the source areas. The highest VOC concentrations (greater than 10,000 mg/L) in the unconsolidated zone occur at the Bear Creek Burial Grounds waste management area.

The extent of the dissolved VOC plumes is slightly greater in the underlying bedrock. Although the plumes generally do not extend more than 1000 ft from the source areas in groundwater in the low-permeability formations that underlie many waste sites, significant transport of the VOCs has occurred in the Maynardville Limestone.

Data obtained from exit-pathway monitoring wells installed during 1991 and 1992 show that in the vicinity of the water table, an apparently continuous dissolved VOC plume extends for about 7000 ft westward from the S-3 Site to just west of the Bear Creek Burial Grounds waste management area. The highest levels of VOCs in the Bear Creek regime occur in bedrock, just south of the Bear Creek Burial Grounds Waste Management Area. Historical levels have been as high as 7000 mg/L in groundwater.

Radionuclides

Uranium, neptunium, americium, and naturally occurring isotopes of radium have been identified as the primary alpha-particle emitting radionuclides in the Bear Creek regime. Technetium is the primary beta-particle emitting radionuclide in the regime, but tritium and isotopes of strontium also may be present in groundwater near the S-3 Site.

Evaluations of the extent of these radionuclides in groundwater in the Bear Creek regime during 1994 were based primarily on measurements of gross alpha activity and gross beta activity. If the annual average gross alpha activity in groundwater samples from a well exceeded 15 pCi/L (the MCL for gross alpha activity), then one or more of the alpha-emitting radionuclides were assumed to be present in the groundwater monitored by the well. A similar rationale was used for annual average gross beta activity that exceeded 50 pCi/L.

As shown in Fig. 7.13, groundwater with elevated levels of gross alpha activity occurs in the water table interval in the vicinity of the S-3 Site, the Bear Creek Burial Grounds, and the Oil Landfarm waste management areas. In the bedrock interval, gross alpha activity exceeds 15 pCi/L in groundwater in the Nolichucky Shale near the S-3 Site, the southern sides of the Bear Creek Burial Grounds, and east of the Oil Landfarm waste management areas. Data obtained from exit-pathway wells installed in 1991 and 1992 show that gross alpha activity in groundwater in the Maynardville Limestone exceeds the maximum contamination level for 12,000 ft west of the S-3 Site. Elevated gross alpha activities were observed in five exit-pathway spring and stream monitoring locations.

The distribution of gross beta radioactivity in groundwater in the unconsolidated zone is similar to that of gross alpha radioactivity (Fig. 7.14). During 1994 gross beta activity exceeded 50 pCi/L within the water table interval in the Maynardville Limestone from south of the S-3 Site to the Oil Landfarm waste management area. Within the intermediate bedrock interval in the Maynardville Limestone, the elevated gross beta activity extends as far west as does gross alpha activity, just to the west of the Bear Creek Burial Grounds waste management area. Elevated gross beta activity was observed in four springs and one stream monitoring station that also exhibited elevated gross alpha activity.

Exit-Pathway and Perimeter Monitoring

Exit-pathway monitoring began in 1990 to provide data on the quality of groundwater and surface water exiting the Bear Creek regime. The Maynardville Limestone is the primary exit pathway for groundwater. Bear Creek, which flows across the Maynardville Limestone in much of the Bear Creek regime, is the principal exit pathway for surface water. Various studies have shown that surface water in Bear Creek and groundwater in the Maynardville Limestone are hydraulically connected. The western exit-pathway well transect (Picket W) serves as the perimeter wells for the Bear Creek Regime (Fig. 7.6).

Most exit-pathway study activities in 1994 consisted of continued monitoring at four well transects (pickets). The 1992 ORR environmental report and Shevenell et al. (1992) contain detailed information about the construction of these pickets and the rationale for their construction. Other related investigations initiated as part of exit-pathway studies have included evaluation of the geologic characteristics of the Maynardville Limestone, geochemical characterization of groundwater types in Bear Creek Valley, analysis of controlling variables for development of preferred groundwater flow paths, and cross-borehole testing. Studies are ongoing of the transport of contaminants adsorbed to colloidal particles and of the depth of active responses to rainfall events within the Maynardville Limestone.

Groundwater quality data obtained during 1994 from the exit-pathway monitoring wells confirmed previous data that contaminated groundwater does not seem to occur much beyond the western side of the Bear Creek Burial Grounds waste management area.

Surface water samples were collected semiannually from a northern tributary of Bear Creek (the background location), from three springs that discharge groundwater to the creek, and from four points along the main creek channel (Fig. 7.18). A preliminary review of the 1994 data indicates that spring discharges and water in upper reaches of Bear Creek contain many of the compounds found in the groundwater; however, the concentrations in the creek and spring discharges decrease rapidly with distance downstream of the waste disposal sites. This assessment is consistent with data from previous years.

Nitrate concentrations in Bear Creek exceeded the MCL during 1994 from south of the S-3 Site to west of the Bear Creek Burial Grounds at BCK 9.40. Nitrate concentrations at BCK 4.55 (NPDES Outfall 304), at the junction of Bear Creek Road and Highway 95,

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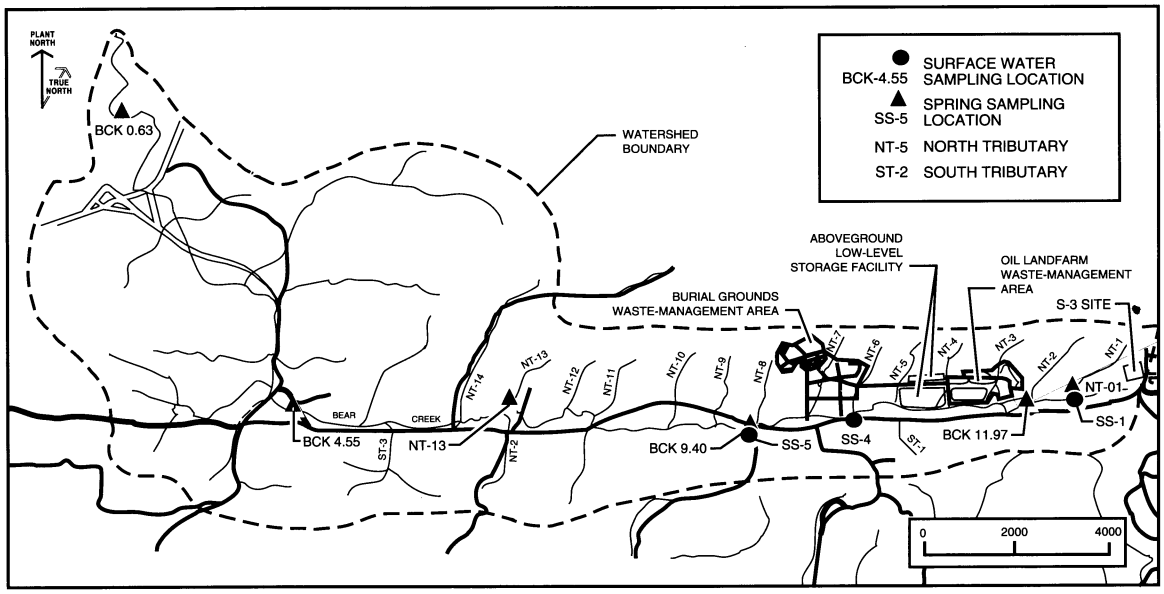

Fig. 7.18. Surface water and spring stations sampled during 1994 in the Bear Creek Hydrogeologic Regime.

averaged 2.7 mg/L. The average nitrate concentration in surface water samples collected from the farthest downstream point (BCK 0.63), which is located just upstream of the confluence of Bear Creek and EFPC, was 2.5 mg/L, below the maximum contamination level but above background. (Background is about 0.2 mg/L.) Average nitrate concentrations in spring discharges decreased from an average of 23.9 mg/L at SS-1 to 8.8 mg/L at SS-5.

Low concentrations of VOCs (<10 μg/L) were detected in surface-water samples and spring discharge samples collected from the upper reaches of Bear Creek (at NT-1 and BCK 9.40). Compounds detected in samples from the creek were trichloroethene, 1,2-dichloroethene, and tetrachloroethene. Spring discharges at SS-1 and SS-4 also contained trace amounts of VOCs. Each of these compounds is a primary component of the VOC plumes in groundwater in the regime.

Based on the 1994 data, uranium is again the most common trace metal contaminant in Bear Creek. Concentrations of uranium exceeded background levels throughout reaches of the creek upstream of BCK 9.40. Moreover, uranium concentrations in the creek slightly exceeded background levels at the farthest downstream sampling point (BCK 0.63). Uranium concentrations in spring effluents exceed background levels as far west as the SS-5 location.

Annual average gross alpha activity in 1994 mirrored the results of previous years. Gross alpha was above 15 pCi/L only at BCK 11.97 and BCK 9.40 along Bear Creek. Spring discharges west as far as SS-5 had annual average gross alpha above 15 pCi/L. Gross beta activity exceeded 50 pCi/L at BCK 11.97, BCK 9.40, and NT-01. Annual average gross beta exceeded 50 pCi/L at SS-1 and SS-4.

Chestnut Ridge Hydrogeologic Regime

The Chestnut Ridge regime is south of the Y-12 Plant and is flanked to the north by Bear Creek Valley and to the south by Bethel Valley Road. The regime encompasses the portion of Chestnut Ridge extending from a gap in the ridge located southeast of the eastern end of the Y-12 Plant to a drainage basin on the ridge located just west of Centralized Sanitary Landfill II. Figure 7.19 shows the locations of waste management units and monitoring wells sampled in 1994. CERCLA OUs in the regime are shown in Fig. 7.4 and detailed in Table 7.4.

Four categories of sites are located within the Chestnut Ridge regime: (1) RCRA interim-status units, (2) RCRA 3004(u) SWMUs and solid waste disposal units, (3) TDEC-permitted solid waste disposal facilities, and (4) CERCLA OUs. No integrator OU has been established for the regime because contamination from the Security Pits is distinct and is not mingled with plumes from other sources. Groundwater media will be addressed as part of the RI/FS for each source OU. Of the waste disposal sites located in the Chestnut Ridge regime, only the Chestnut Ridge Security Pits have been confirmed as a source of groundwater contamination. Table 7.4 summarizes the operational history of waste management units in the regime. Detailed discussions of these sites have been included in previous annual site environmental reports.

Discussion of Monitoring Results

Groundwater quality data obtained in the Chestnut Ridge regime during 1994 support conclusions drawn from previous monitoring results. A more comprehensive suite of analytical tests is applied to most sites in the Chestnut Ridge regime because of various permitting requirements; however, volatile organics and trace metals are the only categories in which findings currently consistently exceed background levels. Gross alpha and beta activities have sporadically exceeded screening levels in the past in samples taken from wells at the Chestnut Ridge Sediment Disposal Basin, United Nuclear Site, Industrial Landfill III, and Kerr Hollow Quarry. No discernable pattern or consistency to the data has been determined. Annual average gross alpha or gross beta did not exceed DWSs at any monitoring location in 1994.

In late 1994, a detailed review of groundwater results from Kerr Hollow Quarry was conducted in response to the identification of total strontium and total uranium levels in three wells at the site that were consistently elevated above background concentrations (GW-142, GW-145, and GW-146; Fig. 7.19). The data review indicated that no elevated gross alpha or gross beta was associated with the elevated metals values. Hence, the elevated metals concentrations may reflect natural geochemical variations in groundwater at the site or possibly the impacts of waste disposal operations. As a best management practice, isotopic uranium and strontium analyses will be conducted in 1995. In addition to the metals evaluation, VOC occurrences were examined. The evaluation demonstrated that low levels of tetrachloroethene and carbon tetrachloride were sporadically observed in wells GW-142 and GW-144. The occurrences of these compounds were first detected in 1990. The frequency of occurrence increased during 1991 and 1992 and then began to decrease in 1993. The only detectable VOC in 1994 was carbon tetrachloride in one sample from well GW-144 in the second calendar quarter. The occurrences of these VOCs appears to correlate with underwater debris removal and shredding corrective actions at the quarry, which were conducted between August 1990 and October 1993.

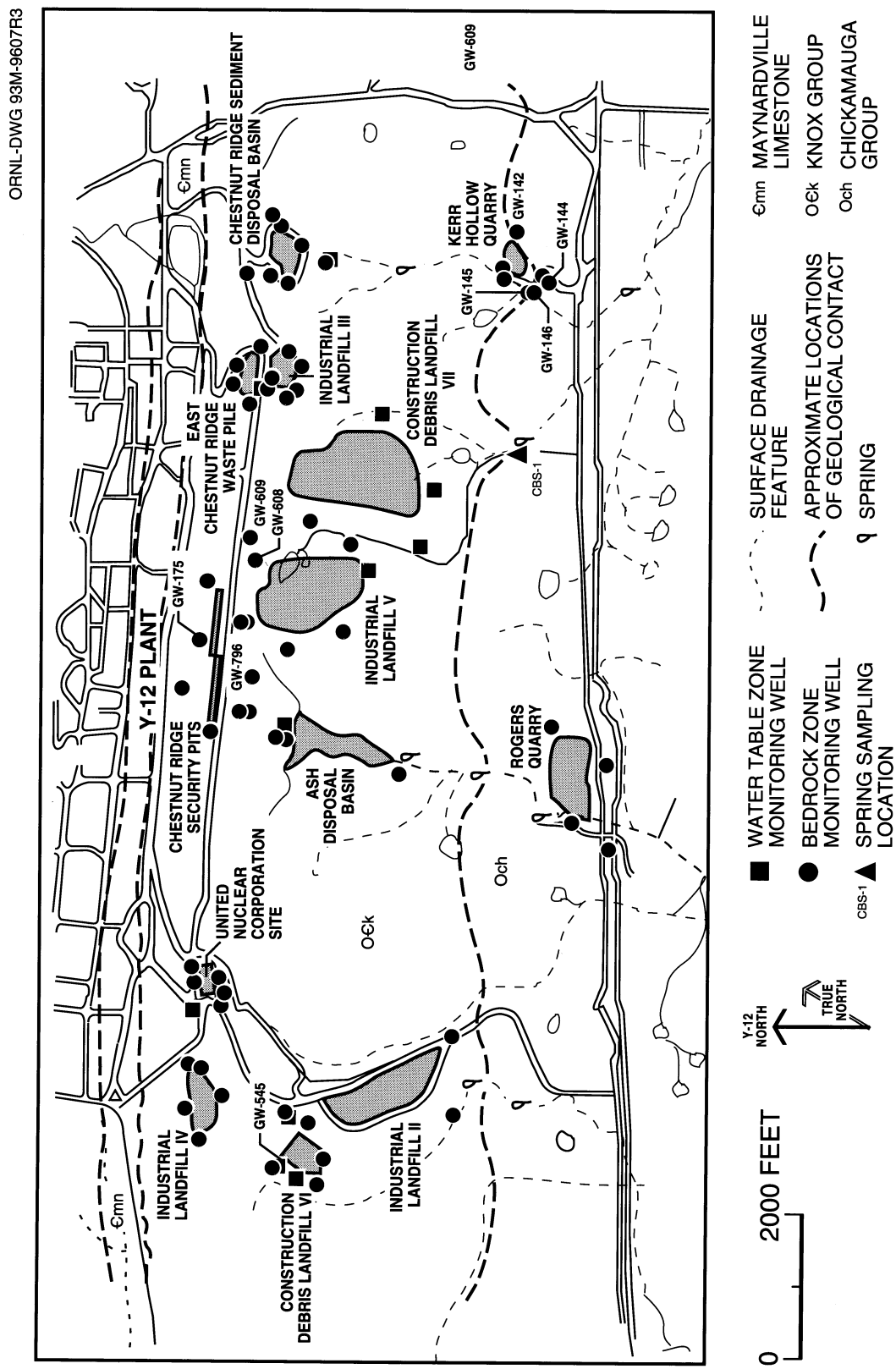

Fig. 7.19. Locations of waste management sites and monitoring wells sampled during 1994 in Chestnut Ridge Hydrogeologic Regime.

Table 7.4. History of CERCLA operable units and waste management units included in the 1994 Comprehensive Groundwater Monitoring Program; Chestnut Ridge Hydrogeologic Regime

Site	Historical regulatory classification[a]	Historical data
Chestnut Ridge Sediment Disposal Basin	TSD unit	Operated from 1973 to 1989. Received soil and sediment from New Hope Pond and mercury-contaminated soils from the Y-12 Plant. Site was closed under RCRA in 1989. Not a documented source of groundwater contamination
Kerr Hollow Quarry	TSD unit	Operated from 1940s to 1988. Used for the disposal of reactive materials, compressed gas cylinders, and various debris. RCRA closure (waste removal) was conducted between 1990 and 1993. Certification of closure with some wastes remaining in place was approved by TDEC 2/95
Chestnut Ridge Security Pits	TSD unit	Operated from 1973 to 1988. Series of trenches for disposal of classified materials, liquid wastes, thorium, uranium, heavy metals,, and various debris. Closed under RCRA in 1989. Infiltration is the primary release mechanism to groundwater
East Chestnut Ridge Waste Pile	TSD unit	A lined, RCRA-permitted hazardous waste storage facility for contaminated soils from the Y-12 Plant
Ash Disposal Basin	SWMU	Used until 1967. Site received Y-12 Steam Plant coal ash slurries. Leaching of metals to groundwater are of concern
United Nuclear Corporation Site	SWMU	Received about 29,000 drums of cement-fixed sludges and soils,, demolition materials, and low-level radioactive contaminated soils. Closed in 1992 under CERCLA and RCRA
Rogers Quarry	SWMU	Used from 1960s until 1993 for disposal of steam-plant coal ash and process debris. Metals contaminants are of primary concern
Chestnut Ridge Borrow Area Waste Pile	Not regulated	Contains soils from off-site locations in Oak Ridge bearing low levels of mercury and other metals
Centralized Sanitary Landfill II	TDEC-permitted Class I industrial SWDF	Central sanitary landfill for the ORR. Detection monitoring under TDEC-SWM regulations has been ongoing since 1986
Industrial Landfill IV	TDEC-permitted Class II industrial SWDF	Permitted to receive only, nonhazardous industrial solid wastes. Detection monitoring under TDEC-SWM regulations has been ongoing since 1988
Industrial Landfill V	TDEC-permitted Class II industrial SWDF	New facility completed 4/94. Baseline groundwater monitoring began 5/93 and was completed 1/95. Currently under TDEC-SWM detection monitoring
Construction/ Demolition Landfill VI	TDEC-permitted Class IV construction/ demolition SWDF	New facility completed 12/93. Baseline groundwater quality monitoring began 5/93 and was completed 12/93. Waste disposal began 4/94. Currently under permit-required detection monitoring per TDEC
Construction/ Demolition Landfill VI	TDEC-permitted Class IV construction/ demolition SWDF	New facility, construction completed in 12/94. TDEC granted approval to operate 1/95. Baseline groundwater quality monitoring began in 5/93 and was completed in 1/95. Currently under permit-required detection monitoring per TDEC

[a]Regulatory classification before the 1992 Federal Facilities Agreement: TSD Unit—RCRA regulated, land-based treatment, storage, or disposal facility; SWDF—solid waste disposal facility (landfill); SWMU—RCRA-regulated solid waste management unit.

Plume Delineation

The horizontal extent of the VOC plume at the Chestnut Ridge Security Pits is reasonably well defined in the water table and shallow bedrock zones (Fig. 7.12). Groundwater quality data obtained during 1994 suggest that the lateral extent of the VOC plume at the site may have increased slightly, as evidenced by slightly increased VOCs in Wells GW-608, GW-609, and GW-175, and by the presence of VOCs in well GW-796, located upgradient of Landfill V.

There are two distinct VOCs in groundwater at the security pits. In the western portion of the site, the VOC plume is characterized by high concentrations of 1,1,1-trichloroethane. Tetrachloroethene is a principal component of the VOC plume in the eastern portion of the site. The distinct difference in the composition of the plume is probably related to differences in the types of wastes disposed of in the eastern and western trench areas.

Nitrate

Nitrate concentrations were well below the DWS of 10 mg/L in all wells.

Trace Metals

Chromium concentrations in unfiltered samples sporadically exceeded DWSs in five wells. Elevated turbidity and suspended solids were also observed in most of these samples, indicating a high probability for false positives. Lead and cadmium levels exceeded DWSs in one sample from GW-545. Associated suspended-solid levels were 1200 mg/L, indicating that the results are suspect.

Volatile Organic Compounds

Efforts to delineate the extent of VOCs in groundwater at the security pits (previously discussed) have been in progress since 1987. A review of historical data suggests that VOC concentrations in groundwater at the site have generally decreased since 1988 (Table 7.5). Low levels of VOCs were observed at a few additional scattered locations in 1994. Trace levels of carbon tetrachloride were observed in one sample from Well GW-144.

Radionuclides

Annual average gross alpha and gross beta activities were below DWSs of 15 pCi/L and 50 pCi/L, respectively, in 1994.

Exit-Pathway and Perimeter Monitoring

Exit-pathway monitoring in the Chestnut Ridge regime has followed a different approach from that used for the other two regimes. Contaminant and groundwater flow paths in the karst bedrock underlying the regime are not best identified through conventional monitoring techniques. The comprehensive groundwater monitoring plan, therefore, presented a rationale for using dye-tracer studies to identify exit pathways. Based on the results of dye-tracer studies, springs and surface streams that represent discharge points for groundwater can be identified for water quality monitoring.

A dye-tracer study was initiated and completed in 1992 (SAIC 1993), primarily to confirm results of an initial study conducted in 1990 (Geraghty and Miller, Inc. 1990). The 1992 study used the same dye injection well near the Chestnut Ridge Security Pits and many of the same monitoring points as did the 1990 study. The primary differences

Table 7.5. Annual average summed VOC concentrations in groundwater at the Chestnut Ridge Security Pits

Well number	Summed average VOCs (μg/L)						Percentage decrease
	1989	1990	1991	1992	1993	1994	
GW-173	17.0	13.5	11.8	11.7	*a*	*a*	31
GW-174	47.8	48.5	43.7	34.0	*a*	*a*	29
GW-175	31.8	38.5	31.0	29.5	17.0	25.3	20
GW-176	285.3	233.5	170.5	139.7	*a*	*a*	51
GW-177	66.7	18.8	26.3	25.5	33.0	28.3	58
GW-178	43.4	40.0	34.0	29.0	*a*	*a*	32
GW-179	838.0	455.0	328.3	262.3	*a*	*a*	69
GW-180	145.8	99.5	74.2	52.3	*a*	*a*	64
GW-322	696.0	730.3	633.0	538.3	*a*	*a*	23
GW-607	*a*	16.9	*b*	*b*	*b*	*a*	100
GW-608	*a*	14.8	15.5	4.5	4.0	4.5	70
GW-609	*a*	78.0	67.5	35.5	28.4	54.5	49
GW-610	*a*	1.0	0.5	*b*	*b*	0.3	70
GW-611	*a*	16.0	9.0	13.5	10.5	12.3	23
GW-612	*a*	505.8	451.3	358.3	*a*	*a*	29

[a]Not sampled.
[b]Not detected.

included an expanded monitoring network and the use of two fluorescent dyes to verify dye detection.

Results of the second tracer-dye study showed no conclusive occurrences of dyes at the monitoring points and did not corroborate data for detection points in the first study. The 1992 study also showed that the injection well was inappropriate because dye-uptake rates by the formation were inadequate. It is likely that the dye-uptake rates are inadequate because the source well is not screened in a flow conduit interconnected to the rest of the system. A formal comparison report has been completed that examines results of both studies to provide recommendations for improvements for future dye-tracer studies in this regime. Future dye-tracer studies are possible. The TDEC DOE Oversight Division is currently planning a small-scale tracer study east of the Sediment Disposal Basin.

Monitoring of one large spring located south of Industrial Landfill V and Construction/Demolition Landfill VII was conducted in 1994 as a best management practice. It is likely that other spring locations will be monitored in 1995, also as a best management practice.

Special Studies

Two research investigations continued in 1994 involving groundwater at the Y-12 Plant. These investigations included (1) a continuation of groundwater and contaminant studies in which multiport-instrumented wells were used (Fig. 7.6) and (2) of an evaluation of contaminant transport via colloidal particles in groundwater.

Efforts with regard to multiport-instrumented wells continued for both exit-pathway–related studies and for the Y-12 Plant Environmental Restoration Program DNAPL investigation in the Bear Creek regime. Multiport-instrumented wells provide detailed, three-dimensional hydraulic conductivity, potentiometric, and chemical data. These wells, therefore, provide greatly enhanced resolution of the hydraulic and hydrochemical properties of the groundwater flow system. Details regarding installation and background

information for these wells was presented in the 1992 ORR environmental report (Energy Systems 1993b).

Monitoring of six multiport wells continued as part of exit-pathway studies in 1994. Ongoing data collection included hydraulic conductivity and potentiometric measurements to evaluate changes over time. In addition, samples for volatile constituents and helium analyses were collected. Helium analyses were conducted to examine relative age of groundwater from various depth intervals. In general, groundwater with a long residence time in the subsurface will have a higher helium content. A longer residence time implies slow groundwater movement. Thus, comparisons of helium concentrations allow a determination to be made about the depths of active groundwater flow. In addition, these data and information gathered from analysis of other wells were used to initiate an evaluation of groundwater transport across the geologic boundary between the ORR aquitards and the Maynardville Limestone. Because most of the waste sites in Bear Creek Valley overlie the ORR aquitards, identification of groundwater flow zones across the geologic boundary is critical to understanding how contamination moves to the exit pathway (Maynardville Limestone). A good understanding of these introduction points to the exit-pathway system is critical for appropriate selection and development of future remedial measures.

Sampling of all five core holes used as part of the DNAPL study was initiated, as was some hydraulic conductivity testing. Geologic data obtained during installation of these particular wells have been evaluated to characterize the density and magnitude of fractures, which are the primary flow pathways for DNAPLs in the subsurface. The information obtained to date indicates that fracture density greatly decreases within the lower portions of the Nolichucky Shale in the ORR aquitards. A corresponding change in potentiometric pressure in this geologic interval suggests that a lower boundary may exist for downward DNAPL migration in the subsurface. Additional sampling and analysis activities for these multiport wells are planned for 1995 and include sampling for volatile constituents.

An investigation into contaminant transport via colloidal particles was initiated in 1993. The study focuses on major ions and metals because these constituent types are the most likely to adsorb onto colloids being transported within the active flow system. The study includes about 30 wells located within the ORR aquitards, Maynardville Limestone, and Knox Group within the Bear Creek and Chestnut Ridge regimes. A wide range of geologic units and depths was selected to examine how colloidal transport of contaminants is related to these variables. Very slow pumping rates are used to sample groundwater. Various sizes of filters are used to filter the samples to obtain aliquots for analysis. The various aliquots are analyzed to determine what size range of colloidal particles adsorb and transport contaminants. Approximately half of the subject wells have been sampled to date, and preliminary results are being compiled. In addition, the study was amended in 1994 to include sampling of selected wells in conjunction with storm events. The data obtained will provide insight regarding how constituents may be mobilized in the shallow karst system as a result of high-precipitation events.

GROUNDWATER MONITORING AT THE OAK RIDGE NATIONAL LABORATORY

Background

The groundwater monitoring program at ORNL consists of a network of wells of two basic types and functions: (1) water quality monitoring wells built to RCRA specifications

and used for site characterization and compliance purposes and (2) piezometer wells used to characterize groundwater flow conditions. ORNL has established an ER Program to provide comprehensive management of sites where past and current research, development, and waste management activities may have resulted in residual contamination of the environment. Individual monitoring and assessment is assumed to be impractical for each of these sites because their boundaries are indistinct and because there are hydrologic interconnections between many of them. Consequently, the concept of waste area groupings (WAGs) was developed to facilitate evaluation of potential sources of releases to the environment. A WAG is a grouping of multiple sites that are geographically contiguous and/or that occur within hydrologically defined areas. WAGs allow establishment of a suitably comprehensive groundwater and surface water monitoring system in a far shorter time than that required to deal with every facility, site, or SWMU individually. Some WAGs share boundaries, but each WAG represents a collection of distinct small drainage areas, within which similar contaminants may have been introduced. Monitoring data from each WAG are used to direct further groundwater studies aimed at addressing individual sites or units within a WAG as well as contaminant plumes that extend beyond the perimeter of a WAG.

At ORNL, 20 WAGs were identified by the RCRA facilities assessment conducted in 1987. Thirteen of these have been identified as potential sources of groundwater contamination. Additionally, there are a few areas where potential remedial action sites are located outside the major WAGs. These individual sites have been considered separately (instead of expanding the area of the WAG). Water quality monitoring wells are established around the perimeters of the WAGs determined to have a potential for release of contaminants. Figure 7.20 shows the location of each of the 20 WAGs.

ORNL-DWG 87M-9552AR2

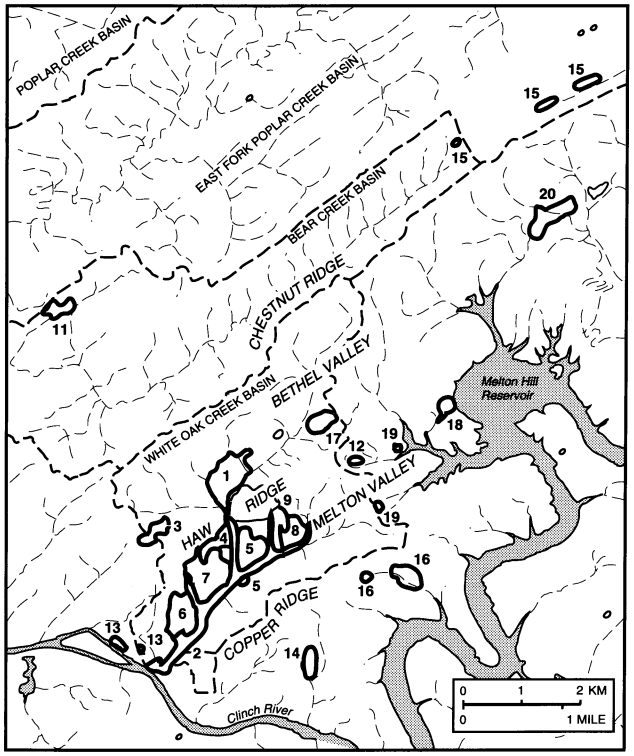

Fig. 7.20. Locations of ORNL waste area groupings (WAGs). (WAG 10 sites are underground, beneath WAG 5.)

For discussion purposes the WAGs are grouped by the valley in which they are located; i.e., Bethel Valley WAGs include 1, 3, and 17; Melton Valley WAGs include 2, 4, 5, 6, 7, 8, and 9; and WAG 11 (the White Wing Scrapyard).

The ORNL plant perimeter surveillance monitoring is discussed in this section. The ORNL program monitors groundwater at four general locations that are thought to be likely exit pathways for groundwater affected by activities at ORNL (Fig. 7.21).

Table C.3 (continued)

K-25 source number	Emission source reference number	Permit number	Source description	Permit type
K1202ST1	73-1106-20	033203P	Tank stores waste oils and solvents for incinerator	Operating
K1202ST2	73-1106-41	034392P	Tank stores waste oils and solvents for incinerator	Operating
K1401275029PL	73-0106-38	012506P	Plastic shop curing oen	Operating
K1401MSMC1	73-0106-32	017337P	Motor curing oven	Operating
K1401JIGANDFIXT	73-0106-71	029898P	Vacuum exhaust for parts fabrication in the jig and fixture shop	Operating
K1401PLS1,4,6	73-0106-72	029899P	Ovens 1, 4, and 6 used for curing plastic parts in the plastic shop	Operating
K1401CARPENTERSHOP	73-1106-40	032930P	Miscellaneous wood and acrylic plastic working operations with cyclone control	Operating
K25BULBCRUSHER	73-1106-43	934193P	Flourescent lamp disposers with fabric/carbon filters	Operating
K1414UNLGAS	73-1106-39	035063P	20,000-gal unleaded gasoline underground storage tank	Operating
K1414UG	73-0106-28	037113P	Methanol, unleaded gasoline storage tank	Operating
K1420PHILLIPSVA	73-0106-70	023798P	Phillips vapor degreaser, perchloroethylene	Operating
K1420DISASSEMBL	73-0106-74	032344P	Disassembly stand for dismantling parts	Operating
K1420A1	73-0106-82	034619P	Flammable materials storage tank	Operating
K1425WOSC	73-0106-11	029895P	Waste oil and solvent storage tanks	Operating
K1425WOSA	73-0106-11	029895P	Waste oil and solvent storage tanks	Operating
K1425WOSD	73-0106-11	029895P	Waste oil and solvent storage tanks	Operating
K1425WOSB	73-0106-11	029895P	Waste oil and solvent storage tanks	Operating
K1435TSCAINCIN	73-0106-78	032449I	TSCA Incinerator	Operating
K1435CTANKFARM	73-0106-75	024105P	Tank farm for hazardous liquid wastes	Operating
K15012720FO	73-0106-28	016312P	K-1501 613,000-gal fuel oil tank	Operating
K15012810FO	73-0106-28	016312P	K-1501 15,228-gal fuel oil tank	Operating
K1501BOILER4	73-0106-04	029902F	Natural gas boiler	Operating
K1501BOILER7	73-0106-07	029902F	Gas/oil boiler	Operating
K1501BOILER8	73-0106-12	937114F	Gas/oil boiler	Permit to construct

Table C.3 (continued)

K-25 source number	Emission source reference number	Permit number	Source description	Permit type
K1501BOILER9	73-0106-12	937114F	Gas/oil boiler	Permit to construct
K1600TTFL	73-0106-59	017053P	Development lab with two hoods and one small oven	Operating
K1652FECS	73-1106-42	733774P	Fire extinquisher charging station	Operating
K-25-B-1	73-0106-19	016309P	Heat exchange medium freon for plant	Operating

Appendix D: Drinking Water Standards

Table D.1. Reference standards for water

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish and aquatic life[c]	Tennessee water quality criteria—recreation "organisms-only" values[c]	4% of DOE DCG[d]	DOE DCG
Anions (mg/L)							
Chloride		250					
Fluoride	4	2					
Nitrate	10						
Nitrite	1						
Sulfate, as SO_4		250					
Base/neutral/acid extractable organics (μg/L)							
1,2-Dichlorobenzene	600				17,000		
1,2,4-Trichlorobenzene	70						
1,3-Dichlorobenzene					2,600		
1,4-Dichlorobenzene (para)	75	5	75		2,600		
2,4-Dinitrophenol					14,000		
2,4-Dinitrotoluene					91		
2,4,6-Trichlorophenol					65		
2-Methyl-4,6-Dinitrophenol					765		
3,4-Benzofluoranthene					0.49		
Benzo(k)fluoranthene					0.49		
Acenaphthylene					0.3		
Anthracene					110,000		
Benzo(a)anthracene					0.3		
Benzo(a)pyrene	0.2				0.3		
bis-(2-chloroethyl)ether					14		
bis-(2-ethylhexyl)phthalate					59		

Table D.1 (continued)

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish and aquatic life[c]	Tennessee water quality criteria—recreation "organisms-only" values[c]	4% of DOE DCG[d]	DOE DCG
Di-n-butyl phthalate					12,000		
Diethyl phthalate					120,000		
Dimethyl phthalate					2,900,000		
Fluoranthene					32		
Fluorene					14,000		
Hexachlorobenzene	1				0.007		
Hexachlorocyclopentadiene	50				17,000		
Hexachloroethane					89		
Nitrobenzene					1,900		
Pentachlorophenol	1			20			
Phenathrene					0.03		
Pyrene					11,000		
			Field measurements				
Dissolved oxygen, mg/L				5			
Temperature, °C			30.5		30.5		
Turbidity, JTU[e]	1						
pH, standard units		(6.5, 8.5)	(6.0, 9.0)	(6.5, 8,5)	(6.0, 9.0)		
			Metals (mg/L)				
Aluminum		0.2					
Antimony	0.006				4.31		

Table D.1 (continued)

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish and aquatic life[c]	Tennessee water quality criteria—recreation "organisms-only" values[c]	4% of DOE DCG[d]	DOE DCG
Arsenic	0.05		0.05	0.36			
Barium	2						
Beryllium	0.004				0.0013		
Cadmium	0.005		0.005	0.0039			
Chromium (hexavalent)	0.1		0.100	0.016	670		
Copper	1.3[f]	1		0.018			
Cyanide	0.2			0.022			
Iron		0.3					
Lead	0.015[f]		0.05	0.082			
Manganese		0.05					
Mercury	0.002		0.002	0.0024	0.00015		
Nickel	0.1			1.418	4.6		
Selenium	0.05		0.050	0.02			
Silver		0.1	NA	0.004			
Thallium	0.002						
Zinc		5		0.117			
			Others				
Asbestos (fibers/L)	7,000,000						
Coliform Bacteria (mL)	0.01						
Color (color units)		15					
Cyanide (mg/L)				0.022			
Odor (T.O.N.)		3					
Total dissolved solids, mg/L		500	500				

Table D.1 (continued)

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish and aquatic life[c]	Tennessee water quality criteria—recreation "organisms-only" values[c]	4% of DOE DCG[d]	DOE DCG
Pesticides/herbicides/PCBs (μg/L)							
2,3,7,8-TCDD (Dioxin)	0.00003				0.000001		
2,4-D	70						
2,4,5-TP (Silvex)	50						
4,4′-DDT				1.1	0.006		
4,4′-DDE					0.006		
4,4′-DDD					0.008		
Alachlor	2						
Aldicarb sulfoxide	4						
Aldrin				3	0.014		
Atrazine	3						
Carbofuran	40						
Chlordane	2			2.4	0.006		
Dalapon	200						
Dibromochloropropane	0.2						
Di(ethylhexyl)adipate	400						
Di(ethylhexyl)phthalate	7						
Dinoseb	7						
Diquat	20						
a-Endosulfan				0.22	159		
b-Endosulfan				0.22	159		

Table D.1 (continued)

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish and aquatic life[c]	Tennessee water quality criteria—recreation "organisms-only" values[c]	4% of DOE DCG[d]	DOE DCG
Endothall	100						
Endrin	2			0.18			
Ethylene dibromide	0.05						
Glyphosate	700						
Heptachlor	0.4			0.52	0.002		
Heptachlor epoxide	0.2			0.52	0.001		
g-BHC (Lindane)	0.2			2	0.63		
Methoxychlor	40						
Oxamyl (Vydate)	200						
PCB-1242					0.0005		
PCB-1254					0.0005		
PCB-1221					0.0005		
PCB-1232					0.0005		
PCB-1248					0.0005		
PCB-1260					0.0005		
PCB-1016					0.0005		
PCB, total	0.5				0.00045		
Picloram	500						

Table D.1 (continued)

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish and aquatic life[c]	Tennessee water quality criteria—recreation "organisms-only" values[c]	4% of DOE DCG[d]	DOE DCG
Simazine	4						
Toxaphene	3			0.73	0.008		
Radionuclides (pCi/L)[g]							
^{241}Am						1.2	30
^{214}Bi						24,000	600,000
^{109}Cd						400	10,000
^{143}Ce						1,200	30,000
^{60}Co						200	5,000
^{51}Cr						4,000	100,000
^{137}Cs						120	3,000
^{155}Eu						4,000	100,000
Gross alpha	15						
Gross beta	50[h]						
^{3}H	20,000					80,000	2,000,000
^{131}I						120	3,000
^{40}K						280	7,000
^{237}Np						1.2	30
^{234m}Pa						2,800	70,000
^{238}Pu						1.6	40
$^{239/240}$Pu						1.2	30
^{226}Ra	5					4	100

Table D.1 (continued)

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish and aquatic life[c]	Tennessee water quality criteria—recreation "organisms-only" values[c]	4% of DOE DCG[d]	DOE DCG
^{228}Ra	5					4	100
^{106}Ru						240	6000
Sr, total rad	8					40	1,000
^{99}Tc						4,000	100,000
^{228}Th						16	400
^{230}Th						12	300
^{232}Th						2	50
^{234}Th						400	10,000
Thorium, natural						2	50
^{234}U						20	500
^{235}U						24	600
^{238}U						24	600
Uranium, natural						24	600
Uranium, total[i]						20	500
			Volatile organics (μg/L)				
1,1,1-Trichloroethane	200		200		170,000		
1,1-Dichloroethene	7		7		32		
1,1,2-Trichloroethane	5				420		
1,1,2,2-Tetrachloroethane					110		
1,2-Dichloroethane	5		5		990		
1,2-Dichloroethene	70						

Table D.1 (continued)

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish and aquatic life[c]	Tennessee water quality criteria—recreation "organisms-only" values[c]	4% of DOE DCG[d]	DOE DCG
cis-1,2-Dichloroethene	70						
trans-1,2-Dichloroethene	100						
1,2-Dichloropropane	5						
cis-1,3-Dichloropropane					1,700		
trans-1,2-Dichloropropane					1,700		
Acrolein					780		
Acrylonitrile					6.7		
Benzene	5		5		710		
Bromodichloromethane	100[j]						
Bromoform	100[j]				4,700		
Carbon tetrachloride	5		5		44		
Chlorobenzene	100						
Chloroethane	200						
Chloroform	100[j]				4,700		
Dibromochloromethane	100[j]				4,700		
Ethylbenzene	700				29,000		
Methylene chloride					16,000		
Styrene	100						
Tetrachloroethene	5				88		
Toluene	1,000				300,000		
Trichloroethene	5		5		807		

Table D.1 (continued)

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish and aquatic life[c]	Tennessee water quality criteria—recreation "organisms-only" values[c]	4% of DOE DCG[d]	DOE DCG
Trihalomethanes, total	100				100		
Vinyl chloride	2		2		5,250		
Xylene, total	10,000						

[a]40 CFR Part 141—National Primary Drinking Water Regulations, Subparts B and G, as amended.
[b]40 CFR Part 143—National Secondary Drinking Water Regulations, as amended.
[c]Rules of Tennessee Department of Environment and Conservation, Division of Water Pollution Control, Chapter 1200-4-3, General Water Quality Criteria, as amended.
[d]DOE Order 5400.5, Chapter III, Derived Concentration Guides for Air and Water. Four percent of the DOE DCG to represent the DOE criterion of 4 mrem effective dose equivalent from ingestion of drinking water.
[e]JTU an NTU are roughly equivalent in the range of 25 to 1000 JTU.
[f]Action level, which is applicable to community water systems and non-transient, non-community water systems.
[g]Only the radiounuclides that were sought at the Oak Ridge Reservation are listed.
[h]Regulatory guide for assessing compliance without further analysis.
[i]Minimum of uranium isotopes.
[j]Limit for total trihalomethanes (bromodichloromethane + bromoform + chloroform + dibromochloromethane).

Appendix E: Underground Storage Tank Data

Table E.1. Underground storage tanks (USTs) at the Y-12 Plant

Location	Tank identification number	Installation date	Out-of-service date	Capacity (gallons)	Contents	Status	Preliminary investigation(s)	Environmental assessment ( ) date to regulatory agency	Corrective action
						Petroleum USTs			
9722-6	2312-U	1987	1994	550	Diesel	Inert filled 2/95	CR (4/95)	NA	NA
9722-5	2313-U	1987	1994	550	Diesel	Inert filled 2/95	CR (4/95)	NA	NA
9999-7	2316-U	1986	1994	550	Diesel	Inert filled 2/95	CR (4/95)	NA	NA
9999-5	2320-U	1986	1994	550	Diesel	Removed 2/95	CR (4/95)	NA	NA
9722-4	2333-U	1988	1994	550	Diesel	Inert filled 3/95	CR (4/95)	NA	NA
9714	2334-U	1987	In use	6,000	Gasoline	Full compliance	Site check	NA	NA
9714	2335-U	1987	In use	10,000	Diesel	Full compliance	Site check	NA	NA
9754-3	2396-U	1993	In use	10,000	Diesel	Full compliance	NA	NA	NA
9754-3	2397-U	1993	In use	20,000	Gasoline	Full compliance	NA	NA	NA
9712	0084-U	1958	1988	500	Used oil	Removed 6/88	CERCLA	TBD	TBD
9204-2	0134-U	1966	1982	117	Gasoline	Removed 8/88	ISCR, FPRR	SIR (3/92)	EAR/CAP (8/92), CAP approval (5/93), CR (4/94), SRF (1/95)
9754-2	0439-U	1978	1989	20,000	Gasoline	Removed 9/89	IAR, ISCR, FPRR	SIR/CAP (3/91)	CAP (7/92), CAP approval (5/93), BMR (3/94), SSSR (4/94)
9754-2	0440-U	1978	1989	10,000	Diesel	Removed 9/89	IAR, ISCR, FPRR	SIR/CAP (3/91)	CAP (7/92), CAP approval (5/93), BMR (3/94), SSSR (4/94)
9754	2073-U	1944	1979	1,000	Gasoline	Removed 10/93	SI	SIR/CAP (3/91)	CAP (7/92), CAP approval (5/93), BMR (3/94), SSSR (4/94)
9754	2074-U	1944	1979	1,000	Gasoline	Removed 10/93	SI	SIR/CAP (3/91)	CAP (7/92), CAP approval (5/93), BMR (3/94), SSSR (4/94)
9754	2075-U	1944	1979	1,000	Diesel	Removed 10/93	SI	SIR/CAP (3/91)	CAP (7/92), CAP approval (5/93), BMR (3/94), SSSR (4/94)
9754-1	1219-U	1964	1988	12,000	Diesel	Removed 12/89	EA	SIR (3/91)	CAP (5/92), SRF (2/94), SRF approval (3/94), SSSR (9/94), SSSR revised (1/95)
9754-1	1222-U	1968	1988	12,000	Gasoline	Removed 12/89	EA	SIR (3/91)	CAP (5/92), SRF (2/94), SRF approval (3/94), SSSR (9/94),

Table E.1 (continued)

Location	Tank identification number	Installation date	Out-of-service date	Capacity (gallons)	Contents	Status	Preliminary investigation(s)	Environmental assessment ( ) date to regulatory agency	Corrective action
9720-15	2068-U	1968	1980	1,000	Gasoline	Removed 2/90	EA/FPRR	SIR (3/91)	CAP (5/92), SRF (2/94), SRF approval (3/94), SSSR (9/94), SSSR revised (1/95)
9754-1	2082-U	1981	1988	8,000	Gasoline	Removed 12/89	EA	SIR (3/91)	CAP (5/92), SRF (2/94), SRF approval (3/94), SSSR (9/94), SSSR revised (1/95)
PRW	2310-U	1975	1989	200	Gasoline	Removed 11/89	ISCR	SIR/CAP (7/91)	EAR/CAP (3/93), CAP approval (12/93), OE (4/94, 5/94), CR (7/94)
9201-1	2331-U	1973	1988	560	Gasoline	Removed 12/88	ISCR, FPRR	SIR (3/92)	EAR/CAP (7/92), CAP approval (12/93), BMR (3/94), SRF (4/94), SRF approval (5/94)
9401-3	0713-U	1955	1988	10,500	No. 2 fuel oil	Removed 11/88	NI	NA	NA
9754	0836-U	1944	1989	10,000	Used oil	Removed 10/89	RCRA	RCRA	RCRA
9204-3	0928-U	1966	1989	200	Gasoline	Removed 5/89	RIR, closure approved 8/92	NA	NA
9995	2078-U	1965	1979	110	Gasoline	Inert filled 1979	CERCLA	TBD	TBD
9995	2079-U	1965	1979	55	Gasoline	Inert filled 1979	CERCLA	TBD	TBD
9996	2080-U	1971	1987	560	Gasoline	Removed 12/88	RIR	NA	NA
9212	2081-U	1958	1970	280	Gasoline	Removed 4/91	ISCR	NA	OE/CR (12/91)
9201-5	2099-U	1971	1989	560	Gasoline	Removed 7/89	IAR, RIR, closure approved 3/90	NA	NA
9929-1	2117-U	1971	1983	550	No. 2 fuel oil	Removed 10/88	NI	NA	NA
9204-4	2130-U	1960	1992	550	Gasoline	Removed 12/92	RIR	NA	NA
9999	2293-U	1954	1974	58	Gasoline	Removed 1974	NI	NA	NA
9999	2294-U	1954	1974	58	Gasoline	Removed 1974	NI	NA	NA
9998	2305-U	1956	1990	55	Diesel	Removed 10/90	RIR, closure approved 1/95	NA	NA

Table E.1 (continued)

Location	Tank identification number	Installation date	Out-of-service date	Capacity (gallons)	Contents	Status	Preliminary investigation(s)	Environmental assessment ( ) date to regulatory agency	Corrective action
PRE	2315-U	1960	1988	64	Gasoline	Removed 11/89	ISCR	EAR/CAP (2/91)	OE/CAR (12/92), closure approval 1/95
9769	2330-U	1949	1988	5,000	No. 2 fuel oil	Inert filled 4/88	NI	NA	NA
Chestnut Ridge	2336-U	1981	1991	550	Gasoline	Removed 5/91	RIR, closure approved 1/95	NA	NA
Buff. Mtn.	2337-U	1972	1990	250	Gasoline	Removed 3/90	IAR, ISCR	SIR (5/91), SIR Phase II (1/92)	Closure approval 2/95
9720-13	2338-U	1970	1984	200	Used oil	Removed 7/90	RIR	TBD	TBD
9219	2395-U	1964	1977	2,000	No. 2 fuel oil	Removed 6/93	NI	NA	NA
SYDD	2063-U	1959	1989	130	Oil/solvent	Removed 7/89	IAR, ISCR/FPRR	CERCLA	CERCLA
SYDD	2328-U	1959	1989	475	Oil/solvent	Removed 7/89	IAR, ISCR/FPRR	CERCLA	CERCLA
SYDD	2329-U	1959	1989	475	Oil/solvent	Removed 7/89	IAR, ISCR/FPRR	CERCLA	CERCLA
					Hazardous Substance USTs				
9767-13	2102-U	1987	1992	7,500	Methanol	Removed 1/93	CR	NA	NA
9418-3	2072-U	1943	1960	45,000	Solid uranium oxide	Exempt	CERCLA	CERCLA	CERCLA
9825-1	2129-U	1984	In use	240,000	Solid uranium oxide	Exempt	NA	NA	NA

Notes

- BMR baseline monitoring report
- CAP corrective action plan
- CAR corrective action report
- CERCLA conducted under the Comprehensive Environmental Response, Compensation and Liability Act
- CR closure report
- EA environmental assessment
- EAR environmental assessment report
- FPRR free product removal report
- IAR initial abatement report
- ISCR initial site characterization report
- NA not applicable
- NI not investigated
- OE overexcavation
- RCRA conducted under Resource Conservation and Recovery Act, Subtitle C
- RIR release investigation report
- TBD to be determined
- SIR site investigation report
- SRF site ranking form
- SSSR site-specific standard request
- SYDD salvage yard drum deheader

Appendix F: Errata

Appendix F: Errata

The following corrections pertain to the *Oak Ridge Reservation Annual Site Environmental Report for 1993* (Energy Systems 1994b).

Page	For	Read
4-6, Table 4.3, ^{239}Pu at Stack 3018	3.10E–01	3.1E–11
4-24, Table 4.13, K-1203 Sewage Treatment Plant, ^{228}Th		
Average	2.91E+02	2.50E+03
Percentage of DCG	7.27E+01[c]	5.21E+01[c]
All listed isotopes	8.61E–01[c]	6.55E–01[c]
5-8, Fig. 5.6, caption	Weekly averages for fluorides in ambient air at the Y-12 Plant, 1987–93.	Maximum annual average 7-day concentration for fluorides in ambient air at the Y-12 Plant.
5-21, "ORNL Reference Surface Water Monitoring," line 6	Fig. 4.15	Fig. 4.14

Glossary

AA — See atomic absorption spectrometry.

absorption — The process by which the number and energy of particles or photons entering a body of matter is reduced by interaction with the matter.

accuracy — The closeness of the result of a measurement to the true value of the quantity.

aliquot — The quantity of sample being used for analysis.

alkalinity — Alkalinity is a measure of the buffering capacity of water, and because pH has a direct effect on organisms as well as an indirect effect on the toxicity of certain other pollutants in the water, the buffering capacity is important to water quality.

alpha particle — A positively charged particle emitted from the nucleus of an atom having the same charge and mass as that of a helium nucleus (two protons and two neutrons).

ambient air — The surrounding atmosphere as it exists around people, plants, and structures.

analytical detection limit — The lowest reasonably accurate concentration of an analyte that can be detected; this value varies depending on the method, instrument, and dilution used.

analyte — A constituent or parameter that is being analyzed.

anion — A negatively charged ion.

aquifer — A saturated, permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients.

aquitard — A geologic unit that inhibits the flow of water.

ash — Inorganic residue remaining after ignition of combustible substances.

assimilate — To take up or absorb into the body.

atom — Smallest particle of an element capable of entering into a chemical reaction.

atomic absorption spectrometry (AA) — Chemical analysis performed by vaporizing a sample and measuring the absorbance of light by the vapor.

Atomic Energy Commission (AEC) — A federal agency created in 1946 to manage the development, use, and control of nuclear energy for military and civilian application. It was abolished by the Energy Reorganization Act of 1974 and succeeded by the Energy Research and Development Administration (now part of the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission).

base/neutral and acid extractables (BNA) — A group of organic compounds analyzed as part of Appendix IX of 40 CFR 264 and the EPA list of priority pollutants.

beta particle — A negatively charged particle emitted from the nucleus of an atom. It has a mass and charge equal to those of an electron.

biomass — The weight of any specific or general kind of organic matter, usually expressed per area or volume.

biota — The animal and plant life of a particular region considered as a total ecological entity.

blank — A control sample that is identical, in principle, to the sample of interest, except that the substance being analyzed is absent. In such cases, the measured value or signal for the substance being analyzed is believed to be a result of artifacts. Under certain circumstances, that value may be subtracted from the measured value to give a net result reflecting the amount of the substance in the sample. EPA does not permit the subtraction of blank results in EPA-regulated analyses.

calibration — Determination of variance from a standard of accuracy of a measuring instrument to ascertain necessary correction factors.

carcinogen — A cancer-causing substance.

cation — Positively charged ion.

CERCLA-reportable release — A release to the environment that exceeds reportable quantities as defined by CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act).

chain-of-custody — A form that documents sample collection, transport, analysis, and disposal.

chemical oxygen demand — Indicates the quantity of oxidizable materials present in a water and varies with water composition, concentrations of reagent, temperature, period of contact, and other factors.

chlorocarbons — Compounds of carbon and chlorine, or carbon, hydrogen, and chlorine, such as carbon tetrachloride, chloroform, tetrachloroethylene, etc. They are among the most significant and widespread environmental contaminants. Classified as hazardous wastes, chlorocarbons may have a tendency to cause detrimental effects, such as birth defects.

closure — Control of a hazardous waste management facility under RCRA requirements.

compliance — Fulfillment of applicable requirements of a plan or schedule ordered or approved by government authority.

concentration — The amount of a substance contained in a unit volume or mass of a sample.

conductivity — A measure of water's capacity to convey an electric current. This property is related to the total concentration of the ionized substances in water and the temperature at which the measurement is made.

confluence — The point at which two or more streams meet; the point where a tributary joins the main stream.

contamination — Deposition of unwanted material on the surfaces of structures, areas, objects, or personnel.

cosmic radiation — Ionizing radiation with very high energies, originating outside the earth's atmosphere. Cosmic radiation is one source contributing to natural background radiation.

count — The signal that announces an ionization event within a counter; a measure of the radiation from an object or device.

curie (Ci) — A unit of radioactivity. One curie is defined as 3.7×10^{10} (37 billion) disintegrations per second. Several fractions and multiples of the curie are commonly used:

kilocurie (kCi) — 10^3 Ci, one thousand curies; 3.7×10^{13} disintegrations per second.

millicurie (mCi) — 10^{-3} Ci, one-thousandth of a curie; 3.7×10^7 disintegrations per second.

microcurie (μCi) — 10^{-6} Ci, one-millionth of a curie; 3.7×10^4 disintegrations per second.

picocurie (pCi) — 10^{-12} Ci, one-trillionth of a curie; 0.037 disintegrations per second.

daughter — A nuclide formed by the radioactive decay of a parent nuclide.

decay, radioactive — The spontaneous transformation of one radionuclide into a different radioactive or nonradioactive nuclide, or into a different energy state of the same radionuclide.

dense nonaqueous phase liquid (DNAPL) — The liquid phase of chlorinated organic solvents. These liquids are denser than water and include commonly used industrial compounds such as tetrachloroethylene and trichloroethylene.

derived concentration guide (DCG) — The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air or inhalation), would result in either an effective dose equivalent of 0.1 rem (1 mSv) or a dose equivalent of 5 rem (50 mSv) to any tissue, including skin and lens of the eye. The guides for radionuclides in air and water are given in DOE Order 5400.5.

desorption — The process of removing a sorbed substance by the reverse of adsorption or absorption.

dilution factor — The mathematical factor by which a sample is diluted to bring the concentration of an analyte in a sample within the analytical range of a detector (e.g., 1 mL sample + 9 mL solvent = 1:10 dilution, or a dilution factor of 10).

disintegration, nuclear — A spontaneous nuclear transformation (radioactivity) characterized by the emission of energy and/or mass from the nucleus of an atom.

dissolved oxygen — A desirable indicator of satisfactory water quality in terms of low residuals of biologically available organic materials. Dissolved oxygen prevents the chemical reduction and subsequent leaching of iron and manganese from sediments.

dose — The energy imparted to matter by ionizing radiation. The unit of absorbed dose is the rad, equal to 0.01 joules per kilogram in any medium.

absorbed dose — The quantity of radiation energy absorbed by an organ, divided by the organ's mass. Absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 Gy).

dose equivalent — The product of the absorbed dose (rad) in tissue and a quality factor. Dose equivalent is expressed in units of rem (or sievert) (1 rem = 0.01 sievert).

committed dose equivalent — The calculated total dose equivalent to a tissue or organ over a 50-year period after known intake of a radionuclide into the body. Contributions from external dose are not included. Committed dose equivalent is expressed in units of rem (or sievert).

committed effective dose equivalent — The sum of the committed dose equivalents to various tissues in the body, each multiplied by the appropriate weighting factor. Committed effective dose equivalent is expressed in units of rem (or sievert).

effective dose equivalent — The sum of the dose equivalents received by all organs or tissues of the body after each one has been multiplied by an appropriate weighting factor. The effective dose equivalent includes the committed effective dose equivalent from internal deposition of radionuclides and the effective dose equivalent attributable to sources external to the body.

collective dose equivalent/collective effective dose equivalent — The sums of the dose equivalents or effective dose equivalents of all individuals in an exposed population within a 50-mile (80-km) radius, and expressed in units of person-rem (or person-sievert). When the collective dose equivalent of interest is for a specific organ, the units would be organ-rem (or organ-sievert). The 50-mile distance is measured from a point located centrally with respect to major facilities or DOE program activities.

dosimeter — A portable detection device for measuring the total accumulated exposure to ionizing radiation.

dosimetry — The theory and application of principles and techniques involved in the measurement and recording of radiation doses. Its practical aspect is concerned with using various types of radiation instruments to make measurements.

downgradient — In the direction of decreasing hydrostatic head.

downgradient well — A well that is installed hydraulically downgradient of a site and may be capable of detecting migration of contaminants from a site.

drinking water standards (DWS) — Federal primary drinking water standards, both proposed and final, as set forth by EPA.

duplicate samples — Two or more samples collected simultaneously into separate containers.

duplicate result — A result derived by taking a portion of a primary sample and performing the identical analysis on that portion as is performed on the primary sample.

effluent — A liquid or gaseous waste discharge to the environment.

effluent monitoring — The collection and analysis of samples or measurements of liquid and gaseous effluents for purposes of characterizing and quantifying the release of contaminants, assessing radiation exposures of members of the public, and demonstrating compliance with applicable standards.

Environmental Restoration — A DOE program that directs the assessment and cleanup of its sites (remediation) and facilities contaminated with waste as a result of nuclear-related activities.

exposure (radiation) — The incidence of radiation on living or inanimate material by accident or intent. Background exposure is the exposure to natural background ionizing radiation. Occupational exposure is that exposure to ionizing radiation that takes place during a person's working hours. Population exposure is the exposure to the total number of persons who inhabit an area.

external radiation — Exposure to ionizing radiation when the radiation source is located outside the body.

fecal coliform — The coliform group comprises all of the aerobic, non-spore-forming, rod-shaped bacteria. The test determines the presence or absence of coliform organisms.

formation — A mappable unit of consolidated or unconsolidated geologic material of a characteristic lithology or assemblage of lithologies.

friable asbestos — Asbestos that is brittle or readily crumbled.

gamma ray — High-energy, short-wavelength electromagnetic radiation emitted from the nucleus of an excited atom. Gamma rays are identical to X rays except for the source of the emission.

gamma spectrometry — A system consisting of a detector, associated electronics, and a multichannel analyzer that is used to analyze samples for gamma-emitting radionuclides.

genotoxicology — The study of the effects of chemicals or radioactive contaminants on the genetics of individual animals or plants.

grab sample — A sample collected instantaneously with a glass or plastic bottle placed below the water surface to collect surface water samples (also called dip samples).

groundwater, unconfined — Groundwater exposed to the unsaturated zone.

half-life, biological — The time required for a biological system, such as that of a human, to eliminate by natural processes half the amount of a substance (such as a radioactive material) that has entered it.

half-life, radiological — The time required for half of a given number of atoms of a specific radionuclide to decay. Each nuclide has a unique half-life.

halogenated compound — An organic compound bonded with one of the five halogen elements (astatine, bromine, chlorine, fluorine, and iodine).

halomethane — Any compound that includes a methane group (CH_3) bonded to a halogen element (astatine, bromine, chlorine, fluorine, or iodine).

hardness — Water hardness is caused by polyvalent metallic ions dissolved in water. In fresh water, these are mainly calcium and magnesium, although other metals such as iron, strontium, and manganese may contribute to hardness.

heavy water — Water in which the molecules contain oxygen and deuterium, an isotope of hydrogen that is heavier than ordinary hydrogen.

herbaceous — Having little or no woody tissue.

hydrology — The science dealing with the properties, distribution, and circulation of natural water systems.

hydrogeology — Hydrolic aspects of site geology.

in situ — In its original place; field measurements taken without removing the sample from its origin; remediation performed while groundwater remains below the surface.

internal dose factor — A factor used to convert intakes of radionuclides to dose equivalents.

internal radiation — Internal radiation occurs when natural radionuclides enter the body by ingestion of foods, milk, and water, and by inhalation. Radon is the major contributor to the annual dose equivalent for internal radionuclides.

ion — An atom or compound that carries an electrical charge.

ion exchange — Process in which a solution containing soluble ions is passed over a solid ion exchange column that removes the soluble ions by exchanging them with labile ions

from the surface of the column. The process is reversible so that the trapped ions are removed (eluted) from the column and the column is regenerated.

irradiation — Exposure to radiation.

isotopes — Forms of an element having the same number of protons in their nuclei but differing in the number of neutrons.

> **long-lived isotope** — A radionuclide that decays at such a slow rate that a quantity of it will exist for an extended period (half-life is greater than 3 years).
>
> **short-lived isotope** — A radionuclide that decays so rapidly that a given quantity is transformed almost completely into decay products within a short period (half-life is 2 days or less).

lower limit of detection (LLD) — The smallest concentration/amount of analyte that can be reliably detected in a sample at a 95% confidence level.

maximally exposed individual — A hypothetical individual who remains in an uncontrolled area and would, when all potential routes of exposure from a facility's operations are considered, receive the greatest possible dose equivalent.

mercury — A silver-white, liquid metal solidifying at –38.9°C to form a tin-white, ductile, malleable mass. It is widely distributed in the environment and biologically is a nonessential or nonbeneficial element. Human poisoning from this highly toxic element has been clinically recognized.

microbes — Microscopic organisms.

migration — The transfer or movement of a material through the air, soil, or groundwater.

millirem (rem) — The dose equivalent that is one one-thousandth of a rem.

milliroentgen (mR) — A measure of X-ray or gamma radiation. The unit is one-thousandth of a roentgen.

minimum detectable activity — The smallest activity of a radionuclide that can be distinguished in a sample by a given measurement system at a preselected counting time and at a given confidence level.

monitoring — Process whereby the quantity and quality of factors that can affect the environment and/or human health are measured periodically in order to regulate and control potential impacts.

natural radiation — Radiation arising from cosmic and other naturally occurring radionuclide sources (such as radon) present in the environment.

nuclide — An atom specified by its atomic weight, atomic number, and energy state. A radionuclide is a radioactive nuclide.

outfall — The point of conveyance (e.g., drain or pipe) of wastewater or other effluents into a ditch, pond, or river.

parts per million (ppm) — A unit measure of concentration equivalent to the weight/volume ratio expressed as milligrams per liter.

parts per billion (ppb) — A unit measure of concentration equivalent to the weight/volume ratio expressed as grams per liter or nanograms per milliter.

person-rem — Collective dose to a population group. For example, a dose of 1 rem to 10 individuals results in a collective dose of 10 person-rem.

pH — A measure of the hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH from 0 through 6, basic solutions have a pH > 7, and neutral solutions have a pH = 7.

piezometer — An instrument used to measure the potentiometric surface of the groundwater. Also, a well designed for this purpose.

precision — The closeness of approach of a value of similar or replicate results to a common value in a series of measurements.

priority pollutants — A group of approximately 130 chemicals (about 110 are organics) that appear on a U.S. Environmental Protection Agency list because they are toxic and relatively common in industrial discharges.

process water — Water used within a system process.

process sewer — Pipe or drain, generally located underground, used to carry off process water and/or waste matter.

purge — To remove water prior to sampling, generally by pumping or bailing.

quality assurance (QA) — Any action in environmental monitoring to ensure the reliability of monitoring and measurement data.

quality control (QC) — The routine application of procedures within environmental monitoring to obtain the required standards of performance in monitoring and measurement processes.

quality factor — The factor by which the absorbed dose (rad) is multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiation, the biological damage to exposed persons. It is used because some types of radiation, such as alpha particles, are more biologically damaging than others.

rad — The unit of absorbed dose deposited in a volume of material.

radioactivity — The spontaneous emission of radiation, generally alpha or beta particles or gamma rays, from the nucleus of an unstable isotope.

radioisotopes — Radioactive isotopes.

radionuclide — An unstable nuclide capable of spontaneous transformation into other nuclides by changing its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.

reclamation — Recovery of wasteland, desert, etc., by ditching, filling, draining, or planting.

reference material — A material or substance with one or more properties that is sufficiently well established and used to calibrate an apparatus, to assess a measurement method, or to assign values to materials.

regression analysis — A collection of statistical techniques that serve as a basis for drawing inferences about relationships among quantities in a scientific system.

release — Any discharge to the environment. Environment is broadly defined as any water, land, or ambient air.

rem — The unit of dose equivalent (absorbed dose in rads × the radiation quality factor). Dose equivalent is frequently reported in units of millirem (mrem) which is one-thousandth of a rem.

remediation — The correction of a problem. See Environmental Restoration.

RFI Program — RCRA Facility Investigation Program; EPA-regulated investigation of a solid waste management unit with regard to its potential impact on the environment.

RFI/RI Program — RCRA Facility Investigation/Remedial Investigation Program; On the ORR, the expansion of the RFI Program to include CERCLA and hazardous substance regulations.

roentgen — A unit of exposure from X or gamma rays. One roentgen equals 2.58×10^{-4} coulombs per kilogram of air.

screened interval — In well construction, the section of a formation that contains the screen, or perforated pipe, that allows water to enter the well.

seepage basin — An excavation that receives wastewater. Insoluble materials settle out on the floor of the basin, and soluble materials seep with the water through the soil column where they are removed partially by ion exchange with the soil. Construction may include dikes to prevent overflow or surface runoff.

self-absorption — Absorption of radiation by the sample itself, preventing detection by the counting instrument.

sensitivity — The capability of methodology or instruments to discriminate between samples with differing concentrations or containing varying amounts of analyte.

settleable solids — Material settling out of suspension within a defined period.

settling basin — A temporary holding basin (excavation) that receives wastewater, which is subsequently discharged.

sievert (Sv) — The SI (International System of Units) unit of dose equivalent, 1 Sv = 100 rem.

slurry — A suspension of solid particles (sludge) in water.

specific conductance — The ability of water to conduct electricity; this ability varies in proportion to the amount of ionized minerals in the water.

spike — The addition of a known amount of reference material containing the analyte of interest to a blank sample.

spiked sample — A sample to which a known amount of some substance has been added.

split sample — A sample that has been portioned into two or more containers from a single sample container or sample-mixing container.

stable — Not radioactive or not easily decomposed or otherwise modified chemically.

stack — A vertical pipe or flue designed to exhaust airborne gases and suspended particulate matter.

standard deviation — An indication of the dispersion of a set of results around their average.

standard reference material (SRM) — A reference material distributed and certified by the National Institute of Standards and Technology.

storm water runoff — Surface streams that appear after precipitation.

strata — Beds, layers, or zones of rocks.

substrate — The substance, base, surface, or medium in which an organism lives and grows.

surface water — All water on the surface of the earth, as distinguished from groundwater.

temperature — The thermal state of a body considered with its ability to communicate heat to other bodies.

terrestrial radiation — Ionizing radiation emitted from radioactive materials, primarily potassium-40, thorium, and uranium, in the earth's soils. Terrestrial radiation contributes to natural background radiation.

total activity — The total quantity of radioactive decay particles that are emitted from a sample.

total dissolved solids — Dissolved solids and total dissolved solids are terms generally associated with freshwater systems and consist of inorganic salts, small amounts of organic matter and dissolved materials.

total organic halogens — A measure of the total concentration of organic compounds that have one or more halogen atoms.

total solids — The sum of total dissolved solids and suspended solids.

total suspended particulates — Refers to the concentration of particulates in suspension in the air irrespective of the nature, source, or size of the particulates.

transect — A line across an area being studied. The line is composed of points where specific measurements or samples are taken.

transmissive zone — A zone of sediments sufficiently porous and permeable to allow the flow of groundwater through the zone.

transuranic waste — Solid radioactive waste containing primarily alpha-emitting elements heavier than uranium.

transuranium elements — Elements with higher atomic weights than uranium; all 13 known transuranic elements are radioactive and are produced artificially.

trip blank — A sample container of deionized water that is transported to the well sample location, treated as a well sample, and sent to the laboratory for analysis; trip blanks are used to check for contamination resulting from transport, shipping, and site conditions.

tritium (^3H) — The hydrogen isotope with one proton and two neutrons in the nucleus. It emits a low-energy beta particle (0.0186 MeV maximum) and has a half-life of 12.5 years.

t-test — Statistical method used to determine if the means of groups of observations are equal.

turbidity — A measure of the concentration of sediment or suspended particles in solution.

unconsolidated zone — Soil zone located above the water table.

uncontrolled area — Any area to which access is not controlled for the purpose of protecting individuals from exposure to radiation and radioactive materials.

upgradient — In the direction of increasing hydrostatic head.

volatile organic compounds — Used in many industrial processes, the levels of these carcinogenic compounds must be kept to a minimum. They are measured by volatile

organic analyses content. Common examples include trichloroethane, tetrachloroethylene, and trichloroethylene.

watershed — The region draining into a river, river system, or body of water.

wetlands — Lowland areas, such as a marshes or swamps, inundated or saturated by surface water or groundwater sufficiently to support hydrophytic vegetation typically adapted for life in saturated soils.

wind rose — A diagram in which statistical information concerning direction and speed of the wind at a location is summarized.

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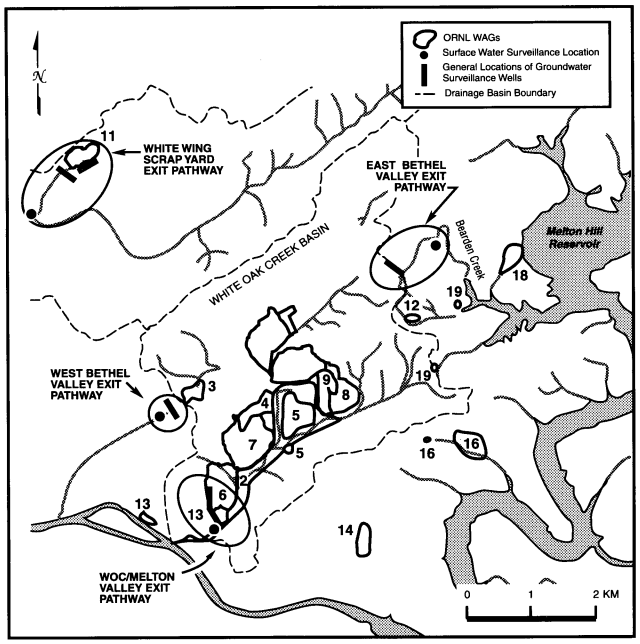

Fig. 7.21. Groundwater exit pathways on the Oak Ridge Reservation that are likely to be affected by ORNL operations.

Bethel Valley

WAG 1

WAG 1, the ORNL main plant area, contains about one-half of the remedial action sites identified to date by the ER Program. WAG 1 lies within the Bethel Valley portion of the White Oak Creek drainage basin. The boundaries of the basin extend to the southeast and northeast along Chestnut Ridge and Haw Ridge. The WAG boundary extends to the water gap in Haw Ridge. The total area of the basin in Bethel Valley is about 2040 acres. Bedrock beneath the main plant area is limestone, siltstone, and calcareous shale facies of the Ordovician Chickamauga Group.

Most of the WAG 1 sites were used to collect and to store LLW in tanks, ponds, and waste treatment facilities, but some also include landfills and spill and leak sites during the last 50 years. Because of the nature of cleanup and repair, it is not possible to determine which spill or leak sites still represent potential sources of release. Most of the SWMUs are related to ORNL's solid and liquid radioactive waste management operations. Recent ER activities within WAG 1 include several RIs associated with sources of contamination; e.g., Surface Impoundments OU, a treatability study associated with the Gunite and Associated Tank OU, and two removal actions (Corehole 8 and WC-14).

WAG 3

WAG 3 is located in Bethel Valley about 1 km (0.6 mile) west of the main plant area. WAG 3 is composed of three SWMUs: SWSA 3, the Closed Scrap Metal Area (1562), and the currently operating Contractors Landfill (1554).

SWSA 3 and the Closed Scrap Metal Area are inactive landfills known to contain radioactive solid wastes and surplus materials generated at ORNL from 1946 to 1979. Burial of solid waste ceased at this site in 1951; however, the site continued to be used as an aboveground scrap metal storage area until 1979. Sometime during the period from 1946 to 1949, radioactive solid wastes removed from SWSA 2 were buried at this site. In 1979, most of the scrap metal stored above ground at SWSA 3 was either transferred to other storage areas or buried on site in a triangular-shaped disposal area immediately south of SWSA 3.

Records of the composition of radioactive solid waste buried in SWSA 3 were destroyed in a fire in 1961. Sketches and drawings of the site indicate that alpha and beta-gamma wastes were segregated and buried in separate areas or trenches. Chemical wastes were probably also buried in SWSA 3 because there are no records of disposal elsewhere. Although the information is sketchy, the larger scrap metal equipment (such as

tanks and drums) stored on the surface at this site was also probably contaminated. Because only a portion of this material is now buried in the Closed Scrap Metal Area, it is not possible to estimate the amount of contamination that exists in this solid SWMU.

The Contractors' Landfill was opened in 1975 and is used to dispose of various uncontaminated construction materials. No contaminated waste or asbestos is allowed to be buried at the site. ORNL disposal procedures require that only non-RCRA, nonradioactive solid wastes are to be buried in the Contractors' Landfill.

WAG 17

WAG 17 is located about 1.6 km (1 mile) directly east of the ORNL main plant area. This area has served as the major craft and machine shop area for ORNL since the late 1940s. The area includes the receiving and shipping departments, machine shops, carpenter shops, paint shops, lead-burning facilities, garage facilities, welding facilities, and material storage areas that are needed to support ORNL's routine and experimental operations. It is composed of eight SWMUs, a former septic tank now used as a sewage collection/pumping station for the area, and seven tanks used for waste oil collection and storage and for storage of photographic reproduction wastes.

Melton Valley

WAG 2

WAG 2 is composed of White Oak Creek discharge points and includes the associated floodplain and subsurface environment. It represents the major drainage system for ORNL and the surrounding facilities. WAG 2 consists of two SWMUs: one is the area encompassed by the stream channels of White Oak Creek and Melton Branch, and the other includes White Oak Lake, White Oak Dam, and the embayment.

In addition to natural drainage, White Oak Creek has received treated and untreated effluents and reactor cooling water from ORNL activities since 1943. Controlled releases include those from the NRWTF, the sewage treatment plant, and a variety of process waste holdup ponds throughout the ORNL main plant area (WAG 1). It also receives groundwater discharge and surface drainage from WAGs 1, 4, 5, 6, 7, 8, and 9.

There is little doubt that WAG 2 represents a source of continuing contaminant release (radionuclides and/or hazardous chemicals) to the Clinch River. Although it is known that WAG 2 receives groundwater contamination from other WAGs, the extent to which WAG 2 may be contributing to groundwater contamination has yet to be determined. Recent ER activities include continued RI and support of the WAG 5 seeps removal action.

WAG 4

WAG 4 is located in Melton Valley about 0.8 km (0.5 mile) southwest of the main ORNL plant site. It comprises the SWSA 4 waste disposal area, LLLW transfer lines, and the experimental Pilot Pit Area (Area 7811).

SWSA 4 was opened for routine burial of solid radioactive wastes in 1951. From 1955 to 1963, Oak Ridge was designated by the Atomic Energy Commission as the Southern Regional Burial Ground; as such, SWSA 4 received a wide variety of poorly characterized solid wastes (including radioactive waste) from about 50 agencies. These wastes consisted of paper, clothing, equipment, filters, animal carcasses, and related laboratory wastes. About 50% of the waste was received from sources outside of Oak Ridge facilities. Wastes

were placed in trenches, shallow auger holes, and in piles on the ground for covering at a later date.

From 1954 to 1975, LLLW was transported from storage tanks at the main ORNL complex to waste pits and trenches in Melton Valley (WAG 7), and later to the hydrofracture site, through underground transfer lines. The Pilot Pit Area (Area 7811) was constructed for use in pilot-scale radioactive waste disposal studies from 1955 to 1959; three large concrete cylinders containing experimental equipment remain embedded in the ground. A control building and asphalt pad have been used for storage through the years.

WAG 5

WAG 5 contains 28 sites, 13 of which are tanks that were used to store LLLW prior to disposal by the hydrofracture process. WAG 5 also includes the surface facilities constructed in support of both the old and new hydrofracture facilities. The largest land areas in WAG 5 are devoted to SWSA 5 and the Transuranic Waste Storage Area. The remaining sites are support facilities for ORNL's hydrofracture operations, two LLW pipeline leak/spill sites, and an impoundment in SWSA 5 used to dewater sludge from the original Process Waste Treatment Facility. Currently, LLW tanks at the new hydrofracture facility are being used to store evaporator concentrates pending a decision regarding ultimate disposal of these wastes.

SWSA 5 was used to dispose of solid LLW generated at ORNL from 1959 to 1973. From 1959 to 1963 the burial ground served as the Southeastern Regional Burial Ground for the Atomic Energy Commission. At the time SWSA 5 burial operations were initiated, about 10 acres of the site was set aside for the retrievable storage of transuranic wastes.

The WAG 5 boundary includes the old and new hydrofracture installations. Because Melton Branch flows between the old and new hydrofracture facilities, the new hydrofracture facility has a separate boundary.

The WAG 5 RI field activities have been completed and the RI report is currently being written. A CERCLA removal action was initiated in 1994 to remove ^{90}Sr from two seeps emanating from WAG 5.

WAG 6

WAG 6 consists of three SWMUs: (1) SWSA 6, (2) the emergency waste basin, and (3) the explosives detonation trench. SWSA 6 is located in Melton Valley, northwest of White Oak Lake and southeast of Lagoon Road and Haw Ridge. The site is about 2 km (1.2 miles) south of the main ORNL complex. Waste burials at the 68-acre site were initiated in 1973 when SWSA 5 was closed. Various radioactive and chemical wastes were buried in trenches and auger holes. SWSA 6 is the only currently operating disposal area for LLW at ORNL. The emergency waste basin was constructed in 1961 to provide storage of wastes that could not be released from ORNL to White Oak Creek. The basin is located northwest of SWSA 6 and has a capacity of 15 million gal. Radiological sampling of the small drainage from the basin has shown the presence of some radioactivity. The source of this contamination is not known.

WAG 6 was among the first to be investigated at ORNL by the ER Program. WAG 6 is an interim-status RCRA unit because of past disposal of RCRA-regulated hazardous waste. Environmental monitoring is carried out under CERCLA and RCRA. A proposed alternate approach, which involved capping WAG 6, was abandoned after a public meeting in which members of the community objected to the high cost of capping.

WAG 7

WAG 7 is located in Melton Valley about 1.6 km (1 mile) south of the ORNL main plant area. The major sites in WAG 7 are the seven pits and trenches used from 1951 to 1966 for disposal of LLLW. WAG 7 also includes a decontamination facility, three leak sites, a storage area containing shielded transfer tanks and other equipment, and seven fuel wells used to dispose of acid solutions primarily containing enriched uranium from Homogeneous Reactor Experiment fuel.

WAGs 8 and 9

WAG 8 is located in Melton Valley, south of the main plant area, and is composed of 35 SWMUs that are associated with the reactor facilities in Melton Valley. The SWMUs consist of active LLLW collection and storage tanks, leak/spill sites, a contractors' soils area, radioactive waste ponds and impoundments, chemical and sewage waste treatment facilities, a chemical waste SWSA, and a mixed waste SWSA. WAG 8 includes the Molten Salt Reactor Experiment facility, the High Flux Isotope Reactor, and the Radiochemical Engineering Development Center.

Radioactive wastes from these facilities are collected in on-site LLLW tanks and periodically pumped to the main plant area (WAG 1) for storage and treatment. The waste includes demineralizer backwash, regeneration effluents, decontamination fluids, experimental coolant, and drainage from the compartmental areas of filter pits.

WAG 9 is located in Melton Valley about 1 km (0.6 miles) southeast of the ORNL main plant area and northeast of WAG 8. WAG 9 is composed of three SWMUs: the Homogeneous Reactor Experiment pond, which was used from 1958 to 1961 to hold contaminated condensate and shield water from the reactor; LLLW collection and storage tanks, which were used from 1957 to 1986; and a septic tank that has been used since 1950 for treatment of sewage from Building 7501.

Because of the small number of groundwater monitoring wells in WAG 8 and WAG 9, they are sampled together. The analytical results for the two WAGs are also reported together.

WAG 10

WAG 10 consists of the injection wells and grout sheets associated with two hydrofracture process experimental locations: the Old Hydrofracture Facility and the New Hydrofracture Facility. The facilities themselves are associated with WAGs 5, 7, and 8.

Hydrofracture Experiment Site 1 is located within the boundary of WAG 7 (south of Lagoon Road) and was the site of the first experimental injection of grout (October 1959) as a testing program for observing the fracture pattern created in the shale and for identifying potential operating problems. Injected waste was water tagged with ^{137}Cs and ^{141}Ce. Grout consisted of diatomaceous earth and cement.

Hydrofracture Experiment Site 2 is located about 0.8 km (0.5 mile) south of the 7500 (experimental reactor) area (WAG 8). The second hydrofracture experiment was designed to duplicate, in scale, an actual disposal operation; however, radioactive tracers were used instead of actual waste. Cement, bentonite, and water tagged with ^{137}Cs were used in formulating the grout.

The Old Hydrofracture Facility is located about 1.6 km (1.0 mile) southwest of the main ORNL complex near the southwest corner of WAG 5. The facility, commissioned in 1963, served as a pilot plant to demonstrate the feasibility of permanent disposal of liquid radioactive waste in impermeable shale formations by hydrofracture methods. Wastes used

in the experiments included concentrated LLLW, ^{90}Sr, ^{137}Cs, ^{244}Cm, transuranics, and other, unidentified radionuclides.

The New Hydrofracture Facility is located 900 ft southwest of the Old Hydrofracture Facility on the south side of Melton Branch. The facility was constructed to replace the Old Hydrofracture Facility and to serve as the operational LLLW waste disposal system for ORNL. Wastes used in the injections were concentrated LLLW and sludge removed from the Gunite tanks, ^{90}Sr, ^{137}Cs, ^{244}Cm, transuranics, and other nuclides.

White Wing Scrap Yard (WAG 11)

The White Wing Scrap Yard (WAG 11), a largely wooded area of about 30 acres, is located in the McNew Hollow area on the western edge of East Fork Ridge. It is 1.4 km (0.9 miles) east of the junction of White Wing Road and the Oak Ridge Turnpike. Geologically, the White Oak thrust fault bisects WAG 11. Lower-Cambrian-age strata of the Rome Formation occur southwest of the fault and overlie the younger Ordovician-age Chickamauga Limestone northeast of the fault. There is only one SWMU in WAG 11.

The White Wing Scrap Yard was used for aboveground storage of contaminated material from ORNL, the K-25 Site, and the Y-12 Plant. The material stored at the site by ORNL consisted largely of contaminated steel tanks; trucks; earth-moving equipment; assorted large pieces of steel, stainless steel, and aluminum; and reactor cell vessels removed during cleanup of Building 3019. An interim record of decision was agreed to by the TDEC, EPA, and DOE requiring surface debris to be removed from the site. This work was completed in 1994.

The area began receiving material (primarily metal, glass, concrete, and trash with alpha, beta, and gamma contamination) in the early 1950s. Information regarding possible hazardous waste contamination has not been found. The precise dates of material storage are uncertain, as is the time when the area was closed to further storage. In 1966, efforts were begun to clean up the area by disposing of contaminated materials in ORNL's SWSA 5 and by the sale of uncontaminated material to an outside contractor for scrap. Cleanup continued at least into 1970, and removal of contaminated soil began in the same year. Some scrap metal, concrete, and other trash are still located in the area. Numerous radioactive areas, steel drums, and PCB-contaminated soil were identified during surface radiological investigations conducted during 1989 and 1990 at WAG 11. The amount of material or contaminated soil remaining in the area is not known.

1994 Groundwater Quality Well Installation, Development, and Sampling Activities

Groundwater quality monitoring wells for the WAGs are designated as upgradient or downgradient (perimeter), depending on their location relative to the general direction of groundwater flow. Upgradient wells are located to provide groundwater samples that are not expected to be affected by possible leakage from the site. Downgradient wells are positioned along the perimeter of the site to detect possible groundwater contaminant migration from the site. There are no groundwater quality monitoring wells installed in WAG 10. The injection wells previously described are located in WAGs 5, 7, and 8.

A summary of the groundwater surveillance program is presented in Table 7.6. RCRA assessment data for WAG 6 were submitted to TDEC in March 1994. The report recommended continuing the sampling strategy for 1994 based on results of the analyses. At WAG 6, 8 wells were sampled quarterly for VOCs and radioactivity parameters; the other 16 wells were sampled semiannually for the same parameters. The remaining WAGs are currently monitored to comply with DOE orders 5400.1 and 5400.5, which do not

Table 7.6. Summary of the groundwater surveillance program at ORNL, 1994

WAG	Regulatory status	Upgradient/ downgradient wells		Parameters monitored[a]	Frequency and last date sampled
		Bethel Valley			
1	CERCLA and DOE Orders 5400.1 and 5400.5	3	24	Standard	Rotation June 1994
3	DOE Orders 5400.1 and 5400.5	3	12	Standard	Rotation September 1994
17	DOE Orders 5400.1 and 5400.5	4	4	Standard	Rotation July 1994
		Melton Valley			
2	CERCLA and DOE Orders 5400.1 and 5400.5	12	8	Standard	Rotation May 1994
4	CERCLA and DOE Orders 5400.1 and 5400.5	4	11	Standard	Rotation January 1994
5	CERCLA and DOE Orders 5400.1 and 5400.5	2	20	Standard	Rotation October 1994
6	RCRA/CERCLA and DOE Orders 5400.1 and 5400.5	7	17	Volatile organics, 8 wells quarterly; gross alpha, gross beta, ^{3}H, ^{137}Cs, ^{60}Co, semiannually total rad Sr + standard field measurements	16 wells
7	CERCLA and DOE Orders 5400.1 and 5400.5	2	14	Standard	Rotation November 1994
8 and 9	DOE Orders 5400.1 and 5400.5	2	9	Standard	Rotation December 1994
		White Wing Scrap Yard			
11	DOE Orders 5400.1 and 5400.5	6	5	Standard	Rotation March, July 1994

[a]Standard: volatile and semivolatile organics, total organic carbon, total organic halides, metals, anions, total phenolics, total suspended solids, alkalinity, gross alpha and beta, ^{3}H, ^{137}Cs, ^{60}Co, and total radioactive strontium. Standard field measurements: pH, conductivity, turbidity, oxidation/reduction potential, temperature, and dissolved oxygen.

specify sampling schedules. ORNL samples groundwater quality wells at the remaining WAGs on a rotational basis.

The plant perimeter surveillance program, as stipulated in the EMP, was initiated in 1993. A summary of the program is presented in Table 7.7.

ORNL Groundwater Quality

The following section describes the 1994 groundwater monitoring results for the ORNL WAG perimeter monitoring network and the ORNL plant perimeter surveillance (about

Table 7.7. Summary of the plant perimeter surveillance program at ORNL, 1994[a]

Exit pathway	WAG	Number of wells	Surface water locations
White Oak Creek/Melton Valley	6 & 2[b]	10	White Oak Creek at White Oak Dam
West Bethel Valley	3	3	Raccoon Creek
East Bethel Valley	17	4	Bearden Creek
White Wing Scrapyard	11	3	Bear Creek

[a]All locations are monitored for volatile organics, tritium, total radioactive strontium, gross alpha and beta, ^{60}Co, and ^{137}Cs.

[b]Four wells are part of the ORNL WAG 6 perimeter network, and four wells are part of the ORNL WAG 2 perimeter network. Two other wells were not sampled in 1994, pending a decision regarding installation of dedicated pumps in them.

200 sampling events). In a few cases, no samples could be collected because the wells were dry.

Eighteen of the 20 wells identified by the EMP to represent the ORNL plant perimeter are also part of the WAG perimeter monitoring program (WAGs 2, 3, 6, 11, and 17). As such, 1994 result data from sampling conducted under the WAG perimeter program are used for the monitoring plan program. The other two wells (of the 20) were not sampled in 1994 because a decision is pending regarding installation of dedicated pumps in them. The four surface water locations (Bear Creek, Racoon Creek, Bearden Creek, and White Oak Creek at White Oak Dam) were sampled in October 1994. The results of the plant perimeter monitoring program are discussed as part of the OU discussions.

Groundwater quality is regulated under RCRA by referring to the SDWA standards. The standards are applied when a site undergoes RCRA permitting. None of the ORNL WAGs are under RCRA permits at this time; therefore, no permit standards exist with which to compare sampling results. In an effort to provide a basis for evaluation of analytical results and for assessment of groundwater quality at ORNL WAGs, federal DWSs and Tennessee water quality criteria for domestic water supplies have been used as reference values in the following discussions. When no federal or state standard has been established for a radionuclide, then 4% of the DOE DCG has been used. Although DWSs are used, it is unrealistic to assume that members of the public are going to drink groundwater from ORNL WAGs.

Bethel Valley

WAG 1

In 1994, as in the past, radionuclides have been detected in a number of WAG 1 wells, with gross alpha and beta activity and total radioactive strontium above DWSs at a few wells. The highest levels of radioactivity continue to be observed in the same five wells: one in the northwest plant area and four in the southwest and western plant area. One well located in the northeast corner had total radioactive strontium measured at 9.2 pCi/L, which is greater than the DWS. This is the first type of occurrence at this well, or any of the wells in this part of WAG 1. (The upgradient wells are located in the northeast corner of the WAG.)

The well in the northwest plant area continues to show gross alpha that is attributable to ^{234}U and ^{238}U. Gross alpha activity was measured at this well at 380 pCi/L, which is considerably higher than the DWS of 15 pCi/L. The gross beta activity at the five wells of

concern is attributable mainly to total radioactive strontium and its daughters. Gross alpha activity at WAG 1 ranged from not being detected to 380 pCi/L; beta activity ranged from not being detected to 12,000 pCi/L (the DWS is 50 pCi/L); and total radioactive strontium ranged from not being detected to 5700 pCi/L (the DWS is 8 pCi/L).

VOCs were detected in a few wells; however, most of these were also detected in the laboratory blanks or were at levels within five times the analytical detection limit. One well had vinyl chloride detected above DWSs. This concentration was within five times the analytical detection limit; however, this well has had similar vinyl chloride concentrations in the past.

Fluoride was detected at one well slightly above DWSs. Nitrate was detected at one well above DWSs; this is the third year in a row nitrate has exceeded DWSs at this well. Chromium was detected above DWSs at one well, and lead was detected above DWSs at another well.

WAG 3

Analytical results for 1994 at WAG 3 are similar to those obtained in the previous 3 years. WAG 3 is located on a north-facing slope, with its upgradient wells to the south. The long axis of the site runs east to west; consequently, most of the downgradient wells are along the northern border.

Strontium is present along the entire northern perimeter of the site. Values exceeding the primary DWS for total radioactive strontium and gross beta activity have consistently been observed at four wells in every sampling event. Apparently, the gross beta signatures are mainly attributable to total radioactive strontium. The data for the eastern and northeastern boundaries show evidence of radioactive contamination, including ^{3}H and gross alpha activity. The data for the northwest boundary show the presence of ^{3}H.

Gross alpha activity at WAG 3 ranged from not being detected to 14 pCi/L (the DWS is 15 pCi/L); beta activity ranged from not being detected to 1500 pCi/L (the DWS is 50 pCi/L); and total radioactive strontium ranged from not being detected to 650 pCi/L (the DWS is 8 pCi/L). Tritium ranged from not being detected to 21,000 pCi/L (the DWS is 20,000 pCi/L).

In a few of the wells, VOCs were detected, but at levels within five times the analytical detection limit. Trichloroethene has consistently been detected above DWSs in every sampling event at one well located in the northeast part of the WAG. The values have always been less than five times the analytical detection limit for the analysis method used.

WAG 17

WAG 17 is located on a northwest-facing slope, with its upgradient wells on the eastern border and downgradient wells on the western border. Although none of the wells had radiological levels above any DWSs, the data for the eastern and western boundaries show evidence of radioactive contamination, including gross beta activity and ^{3}H. In the past, gross alpha activity has exceeded the DWS at two wells; however, this did not occur in 1994. The highest gross alpha activity was 9.7 pCi/L; gross beta was 32 pCi/L; total radioactive strontium was 6.2 pCi/L; and ^{3}H was 9200 pCi/L.

The data for the southeastern and southwestern boundaries show evidence of VOC contamination. The contamination has consistently been located primarily in one well. The pollutants include trichloroethene, vinyl chloride, benzene, 1,2-dichloroethene, 1,1-dichloroethene, and tetrachloroethene.

Plant Perimeter

No wells in the East and West Bethel Valley exit pathways have ever had either VOC or radiological constituents detected above any DWSs. At the East Bethel Valley surface-water location, neither VOCs nor radiological constituents were detected above any DWS. In the West Bethel Valley exit pathway, gross beta activity and total radioactive strontium were detected above DWSs at the Racoon Creek surface water location, 57 and 25 pCi/L, respectively. One of the three wells in the West Bethel Valley exit pathway has always been dry when sampled; a second well was also dry at the time of the 1994 sampling.

Melton Valley

WAG 2

At WAG 2, most of the downgradient wells are to the west and downstream. The upgradient wells are to the east and upstream. WAG 2 receives contamination from many other WAGs, and this seems to be reflected in the analytical results. Major contributors of ^{3}H and total radioactive strontium to WAG 2 (in order of contribution) are WAGs 5, 8, 9, 4, 1, 6, and 7.

For example, four of the WAG 2 wells that exhibited high levels of ^{3}H are located south of and downgradient of WAGs 5, 6, and 8. All of the WAG 2 wells show evidence of radioactive contamination, including gross alpha and gross beta activity and ^{3}H. Gross beta activity above primary DWSs was detected at one well on the west side of WAG 7 and at one well south of WAG 6. The elevated levels of ^{3}H and total radioactive strontium in the perimeter wells at White Oak Dam are believed to be the result of surface-water underflow at the dam, not groundwater contamination. Gross alpha activity at WAG 2 ranged from not being detected to 12 pCi/L (the DWS is 15 pCi/L); beta activity ranged from not being detected to 1000 pCi/L (the DWS is 50 pCi/L); and total radioactive strontium ranged from not being detected to 350 pCi/L (the DWS is 8 pCi/L). Tritium ranged from not being detected to 380,000 pCi/L (the DWS is 20,000 pCi/L).

Little VOC contamination was detected in the wells. Chromium was detected above Tennessee general water quality criteria at a well south of WAG 6. This well has had similar results during the past two sampling events.

WAG 4

In 1994, as in the past, radionuclides (including gross beta activity, total radioactive strontium, and ^{3}H) have been detected in a number of WAG 4 wells. The highest levels of radioactivity continue to be observed in the same six wells along the eastern boundary. Gross alpha activity at WAG 4 ranged from not being detected to 6.2 pCi/L (the DWS is 15 pCi/L); beta activity ranged from not being detected to 1500 pCi/L (the DWS is 50 pCi/L); and total radioactive strontium ranged from not being detected to 730 pCi/L (the DWS is 8 pCi/L). Tritium ranged from not being detected to 8.1×10^{6} pCi/L (the DWS is 20,000 pCi/L).

VOCs continue to be detected also on the eastern boundary. At all but one well concentrations are within five times the analytical detection limit for the respective compound. The one well has consistently had VOC concentrations above DWSs.

WAG 5

The results for 1994 sampling are similar to results from previous sampling events. WAG 5 contributes a significant percentage of the ^{3}H and total radioactive strontium that exits the ORNL site at White Oak Dam via Melton Branch. Tritium contamination is particularly prevalent on the southern and western boundaries, with values as high as 3.2×10^{8} pCi/L.

Total radioactive strontium appears to be the major beta emitter (other than ^{3}H) found in WAG 5 groundwater. It is found mainly on the southern perimeter. Alpha activity above DWSs has been consistently observed in one well on the northwestern boundary of the WAG; however this well was pumped dry in 1994. Two wells along the southern boundary that consistently have had gross beta activity above DWSs were not able to be sampled this year.

Gross alpha activity at WAG 5 ranged from not being detected to 13 pCi/L (the DWS is 15 pCi/L); beta activity ranged from not being detected to 1500 pCi/L (the DWS is 50 pCi/L); and total radioactive strontium ranged from not being detected to 540 pCi/L (the DWS is 8 pCi/L).

VOCs were detected on the southern and western boundaries, including 1,2-dichloroethene, vinyl chloride, trichloroethene, and benzene. Several wells have consistently exceeded DWSs for these contaminants.

No upgradient wells exceeded DWSs for radionuclides or volatile organics.

WAG 6

Results obtained during 1994 were comparable to past results. VOC contamination is apparently isolated in the area around a pair of wells in the northeastern corner of the perimeter. During 1994, 1,2-dichlorethane, carbon tetrachloride, and trichloroethene were detected above DWSs at one of these wells in every sampling event. This well is subject to the quarterly RCRA assessment monitoring.

Elevated levels of ^{3}H are found along the eastern perimeter, with the highest levels found in six of the eight RCRA quarterly assessment wells. Gross alpha activity at WAG 6 ranged from not being detected to 6.2 pCi/L (the DWS is 15 pCi/L); beta activity ranged from not being detected to 220 pCi/L (the DWS is 50 pCi/L); and total radioactive strontium ranged from not being detected to 19 pCi/L (the DWS is 8 pCi/L). Tritium ranged from not being detected to 2.7×10^{6} pCi/L (the DWS is 20,000 pCi/L).

WAG 7

Results obtained during 1994 were comparable to past results. Tritium was detected in more than half of the wells but was highest along the western perimeter next to SWSA 6. Compared with previous years, ^{3}H contamination appears to be decreasing at the wells on the western perimeter and increasing on the southern perimeter.

Gross alpha activity was detected at one well in excess of primary DWSs. Although isotopic identification was not performed in 1994, this activity can be attributed to ^{241}Am, ^{238}Pu, ^{239}Pu, ^{228}Th, ^{230}Th, ^{234}U, ^{235}U, and ^{238}U based on historic analyses. Gross alpha activity ranged from not being detected to 22 pCi/L.

Gross beta activity was detected at levels in excess of primary DWSs at five wells, and ^{3}H was detected at four of these wells, also above DWSs. Gross beta activity ranged from not being detected to 5700 pCi/L; total radioactive strontium ranged from not being detected to 5.9 pCi/L; and ^{3}H ranged from not being detected to 430,000 pCi/L.

Two wells have consistently had nitrate detected at levels that exceed primary DWSs. A third well also had nitrate detected above DWSs for the first time. This concentration was approximately three times historical values. Minimal VOC contamination has been detected in the WAG 7 wells.

WAGs 8 and 9

The two upgradient wells are located north of the WAGs, two of the downgradient wells are located northwest of the WAGs, two are located south of WAG 8, and the remaining five are in WAG 8 west of WAG 9 and in WAG 9. The analytical results for 1994 are comparable to results from the previous 3 years.

All of the perimeter wells show evidence of radioactive contamination. The data indicate that the gross beta activity is attributable to total radioactive strontium. The two wells on the northwestern perimeter exceeded DWSs: one well with respect to ^{3}H contamination and the other with respect to gross beta activity and total radioactive strontium contamination. Gross alpha activity ranged from not being detected to 4.6 pCi/L (the DWS is 15 pCi/L); beta activity ranged from not being detected to 4100 pCi/L (the DWS is 50 pCi/L); and total radioactive strontium ranged from not being detected to 2100 pCi/L (the DWS is 8 pCi/L). Tritium ranged from not being detected to 62,000 pCi/L (the DWS is 20,000 pCi/L). Total radioactive strontium and gross beta activity levels exceeded the DWSs at the two WAG 9 wells.

The values were within five times the analytical detection limit, although VOCs were detected at downgradient wells. One well has historically shown trichloroethene above DWSs; this year it did not. None of the data for the upgradient wells show evidence of VOC contamination.

Plant Perimeter

In the Melton Valley exit pathway, White Oak Creek at White Oak Dam had gross beta activity (17 pCi/L), total radioactive strontium (6.8 pCi/L), and ^{3}H concentrations (320 pCi/L) detected above the reference values for groundwater. One of the wells also had gross beta activity, total radioactive strontium, and ^{3}H concentrations detected above DWSs; a second well had ^{3}H concentrations detected above DWSs. This is consistent with historical data in both cases. No VOC contamination was detected above DWSs in either the wells or the surface-water location.

White Wing Scrapyard (WAG 11)

WAG 11 has gently rolling terrain, and the upgradient wells are located north, east, and south of the WAG. Gross alpha activity and gross beta activity have been detected at low levels along the entire perimeter of the site, including the upgradient wells. Tritium has been detected in some of the wells. No radiological constituents were detected in 1994 above DWSs. Gross alpha activity ranged from not being detected to 5.7 pCi/L (the DWS is 15 pCi/L); beta activity ranged from not being detected to 23 pCi/L (the DWS is 50 pCi/L); and total radioactive strontium ranged from not being detected to 2.1 pCi/L (the DWS is 8 pCi/L). Tritium ranged from not being detected to 970 pCi/L (the DWS is 20,000 pCi/L).

Two wells had trichloroethene detected above DWSs, which is consistent with historical data for these two wells. No other VOCs were detected in those wells, and little VOC contamination was detected at the other wells.

Plant Perimeter

In the White Wing Scrapyard exit pathway, one well had trichloroethene detected above DWSs, and the Bear Creek surface water location had 1,1-dichloroethane detected above DWSs. Both of these values were less than five times the analytical detection limit for the analysis method used to perform the organic analysis. None of the wells or the surface water location considered in this exit pathway had radionuclide concentrations above DWSs.

Well Plugging and Abandonment at ORNL

The purpose of the ORNL well plugging and abandonment program is to remove unneeded wells and boreholes as a possible source of cross-contamination of groundwater from the surface or between geological formations. Because of the complex geology and groundwater pathways at ORNL, it has been necessary to drill many wells and boreholes to establish the information base needed to predict groundwater properties and behavior. However, many of the wells that were established before the 1980s were not constructed satisfactorily to serve current long-term monitoring requirements. Where existing wells do not meet monitoring requirements, they become candidates for plugging and abandonment.

Wells Plugged During 1994

During 1994, 98 monitoring wells were plugged and abandoned at ORNL, as part of the SWSA 6 activities of the ER Division. A total of 232 wells has been recommended for plugging and abandonment as soon as funds are available.

Methods Used

Plugging and abandonment is accomplished by splitting the existing well casing and filling the casing and annular voids with grout or bentonite to create a seal between the ground surface and water-bearing formations and between naturally isolated water-bearing formations.

Splitting and abandoning the well casing in place also minimize the generation of waste that would be created if other methods were used. Special tools were developed to split the casings of different sizes and material. A downhole camera was used during development of the splitting tools to evaluate their effectiveness.

Detailed procedures have been developed and documented regarding the use of specific grout materials in different well environments. These procedures were tested and evaluated during the 1993 plugging and abandonment activities.

GROUNDWATER MONITORING AT THE K-25 SITE

Background

Groundwater effluent monitoring at the K-25 Site is focused primarily on investigating and characterizing sites for remediation under CERCLA. As a result of the FFA, the principal driver at the K-25 Site is CERCLA. With the certification of closure of the K-1407-B and K-1407-C Ponds by the TDEC in 1994, RCRA groundwater monitoring is no longer conducted at the K-25 Site.

In accordance with the FFA, the potentially contaminated units at the K-25 Site were grouped into 14 source OUs and one groundwater OU. OUs were based on previously

defined WAGs and the groundwater OU that encompasses the source OUs and surrounding areas. WAG boundaries were originally defined to correspond, as much as possible, with perceived hydrogeological boundaries. Recently, in association with the decontamination and decommissioning (D&D) Program, WAG designations have again been adopted for administrative purposes at the K-25 Site. Because well installations in the past were focused on individual waste sites and many wells are not associated with a designated OU, the current WAG designations also have been adopted for reporting results of environmental monitoring for groundwater quality at the K-25 Site. The WAG designations and associated OUs are described in the following section.

The K-25 Site Groundwater Program is a component in the ORR Environmental Restoration strategy that was detailed in the *Oak Ridge Reservation Management Plan for the Environmental Restoration Program* (DOE 1993). The strategy for addressing groundwater at the K-25 Site is based on the ORR strategy that emphasizes groundwater monitoring during and after source OU remediation. The impact of source OU remediation will be documented in long-term trends of contaminant concentrations in groundwater. In addition, groundwater investigations and monitoring results may be used to identify and/or reprioritize source investigations. The success of the strategy requires a thorough understanding of the site hydrogeology and implementation of a long-term groundwater monitoring program.

Groundwater investigations are being implemented to provide physical data on the geology and hydrogeology of the site and chemical data on the groundwater quality. In addition, the results of these investigations will provide geochemical data for characterizing active flow zones and physical properties of the aquifer for modeling contaminant transport. The results of ongoing and proposed investigations will be used to further focus subsequent groundwater investigations and sampling and analysis efforts.

Groundwater investigations completed during 1994 include geophysical logging of bedrock wells, sitewide aquifer testing of existing wells, continuous water-level monitoring in selected wells, preparation of a cut-and-fill map of the site, and collection and analysis of groundwater samples from more than 200 monitoring wells located throughout the K-25 Site. Investigations that were started in 1994 and are continuing into 1995 include a sitewide spring and seep survey, a submerged spring and seep survey of Poplar Creek and the Clinch River, continuous water-level monitoring at several locations along Poplar Creek and the Clinch River, and a second sitewide groundwater sampling event.

A variety of rocks underlie the K-25 Site. Differences in their lithology, mode of deposition, and manner of weathering affect the movement of groundwater through them. Although the original permeability of the limestone, dolostone, and shale that make up the bulk of the bedrock at the K-25 Site was low, geologic events (fracturing, weathering, and dissolution) subsequent to their deposition have developed zones of enhanced secondary permeability. These enhanced zones control the flow of groundwater at the site. Dissolution of the carbonate bedrock, which underlies much of the K-25 Site, has led to the development of solution conduits as evidenced by the presence of sinkholes and the widespread occurrence of cavities in boreholes drilled throughout the site. Solution conduits generally represent significant drainage pathways for karst groundwater basins and potentially represent contaminant transport pathways as well.

Unlike the other ORR facilities where many source OUs are located in relatively undeveloped areas of the reservation, the major source areas at the K-25 Site are located within the highly industrialized areas of the site. The site has experienced extensive anthropogenic modifications with major cut-and-fill activities and underground utility installations overlain on the original karst features. As a result, preferential pathways for

shallow groundwater flow likely follow these anthropogenic features. In addition, the concept of integration points at surface water drainage intersections is less applicable at the K-25 Site. Field observations suggest that integration points are more likely to include springs discharging directly to the Clinch River and Poplar Creek and storm drain discharges.

Waste Area Groupings

The K-25 Site WAGs, within which the monitoring wells have been grouped for reporting groundwater monitoring results, are described in the following sections and are indicated on Fig. 7.22.

South Main Plant Area

The South Main Plant Area encompasses the southern area of the K-25 Site and includes the K-1004 OU and the K-1007 OU. The K-1004 OU contains the K-1004-J Vaults, the K-1004-L UST, the K-1004-L RCW lines, K-1004 cooling tower basin, and the K-1004 area laboratory drain and holding tank. The K-1007 OU contains the K-1007 UST. Potential contaminants include heavy metals, acids, organic solvents, other organic chemicals, and radioactivity.

North Main Plant Area

The North Main Plant Area encompasses the northeastern portion of the K-25 Site and includes the K-1407 OU, K-1401 OU, K-1413 OU, K-1420 OU, and the K-1070-C/D OU. The K-1407 OU includes the K-1407-A Neutralization Pit, the K-1407-B and C Ponds, the K-1407-C upgradient area, the K-1070-B Classified Burial Ground, and the K-1700 stream (Mitchell Branch). The K-1401 OU is composed of the K-1401 acid line and degreaser tanks. The K-1413 OU includes the K-1413-C neutralization pit, two sumps in the K-1413 building, and associated process lines. The K-1420 OU contains the oil storage area and the process lines that connected the K-1420 building to the K-1407-B Pond. The K-1070-C/D OU consists of the K-1070-C/D Classified Burial Ground, the K-1071 concrete pad, and the K-1414 Garage. Potential contaminants at these OUs include organic solvents, waste oils, heavy metals, PCBs, and radioactivity.

K-25 and K-1064 Area

The K-25 and K-1064 Area encompasses the K-25 Building and the area north and northwest of the building and includes the K-25 OU and K-1064 OU. The K-25 OU contains the west wing of the K-1024 building and a dilution pit located adjacent to the building. The K-1064 OU is composed of the K-802-B and K-802-H cooling tower basins and the K-1064-G burn area/peninsula storage area. Potential contaminants include waste oils, heavy metals, organic solvents, and radioactivity.

K-33 and K-31 Area

The K-33 and K-31 Area encompasses the area around these two buildings and includes the K-33 OU composed of the K-892-G, K-892-H, K-892-J, and K-862-E cooling tower basins and the K-31 and K-33 RCW lines. Potential contaminants in this WAG include heavy metals and radioactivity.

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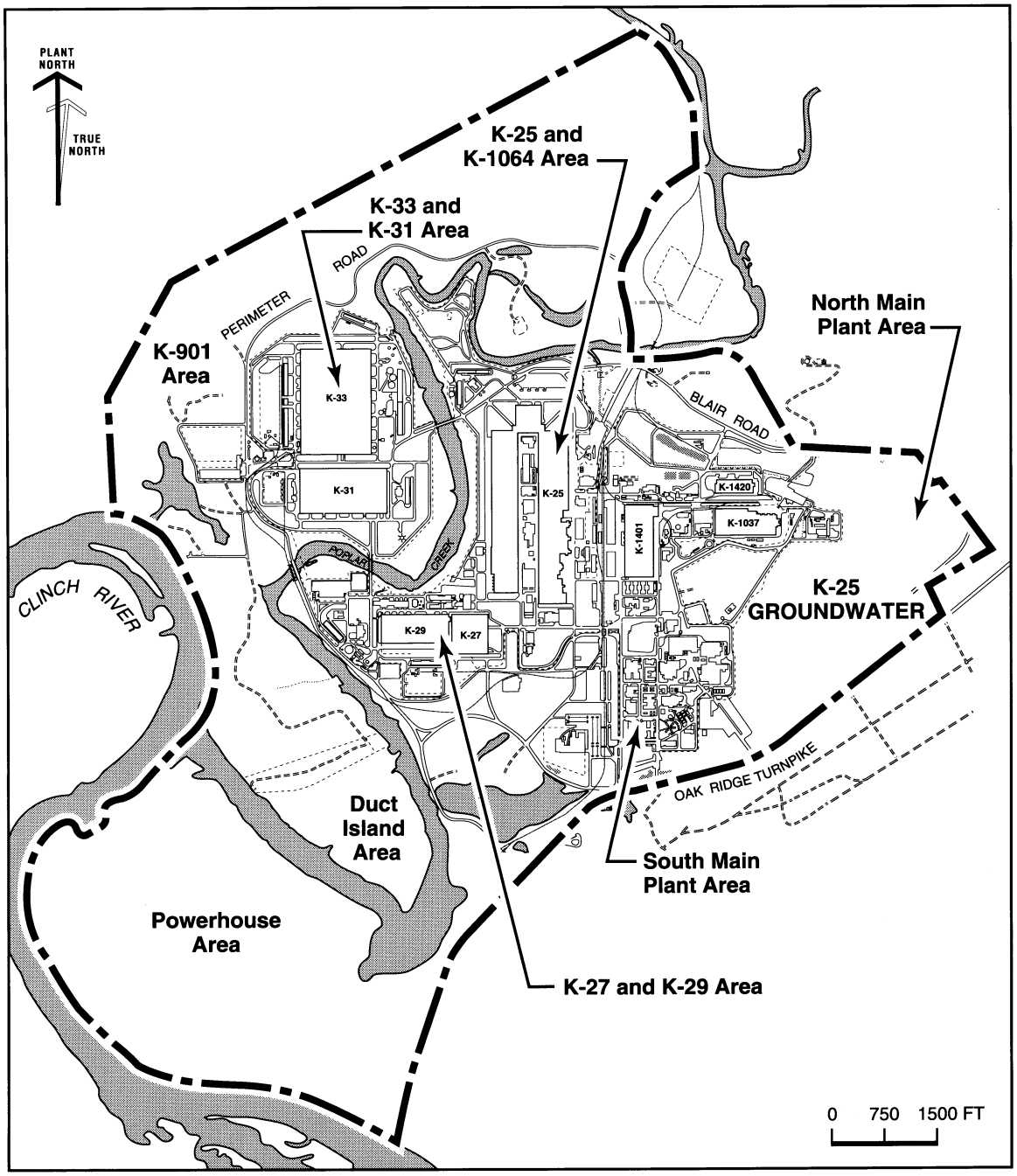

Fig. 7.22. K-25 Site waste area groupings.

K-27 and K-29 Area

The K-27 and K-29 Area encompasses the southwestern portion of the main plant area and includes the K-29 and the K-1410 OUs and the K-1232 chemical recovery facility. The K-29 OU consists of the K-27 and K-29 RCW lines, the K-832-H cooling tower basin, the K-732 switchyard, and the K-1203 sewage treatment plant. The K-1410 OU consists

of the K-1410 neutralization pit. The potential contaminants include organics, heavy metals, PCBs, and radioactivity.

K-901 Area

The K-901 Area encompasses the northwestern portion of the K-25 Site and includes the K-901 OU. The K-901 OU is composed of the K-1070-A Burial Ground, the K-1070-A Landfarm, the K-901 North and South Disposal Area, the K-901 Holding Pond, and the K-895 Cylinder Destruct Facility. The potential contaminants are organics and other chemicals, heavy metals, and radioactivity.

Duct Island Area

The Duct Island Area encompasses the K-1070-F peninsula on Poplar Creek, which contains the K-1070-F Old Contractor's Burial Ground. The potential contaminants in this WAG are heavy metals, solvents, and uranium.

Powerhouse Area

The Powerhouse Area encompasses the southwestern portion of the K-25 Site along the Clinch River. The Powerhouse Area includes the K-770 OU composed of the K-770 Scrap Yard and the K-1085 Firehouse Burn Area. The potential contaminants are waste oils, organics, heavy metals, PCBs, and radioactivity.

1994 Well Installation and Plugging and Abandonment Activities

In 1994 there were a total of 224 water quality monitoring wells at the K-25 Site. Ten new monitoring wells were completed during 1994. Four wells were installed to complete the eight-well exit-pathway monitoring network and six wells were installed as part of the K-1070-C/D OU RI. Additional well installations, under way for the K-901 OU focused remedial investigation at the K-1070-A Burial Ground, will be completed during the first half of 1995.

Well plugging and abandonment activities are conducted at the K-25 Site as part of the overall management program for the K-25 Site monitoring well network. Wells that may become damaged beyond repair, interfere with planned construction activities, or which no longer provide useful data are scheduled for plugging and abandonment. In 1994 four wells were plugged and abandoned at the site. These four wells had been installed as part of the environmental assessment of the K-1220-NE UST site. Following closure of the UST site, groundwater monitoring was no longer necessary at the site and no future benefit of the wells was identified.

1994 Groundwater Monitoring Program

Groundwater samples were collected from 191 wells during a 6-week period in the fall of 1994. Twenty-six wells of the 217 scheduled for sampling were either dry or could not sustain a steady flow rate for sampling. The immediate objectives of this sampling effort were to establish a baseline of constituent concentrations during the low base (dry weather) period; to evaluate the use of micropurging/low-flow sampling techniques; and provide consistent, high-quality, site-wide geochemical data. Groundwater samples were analyzed

for volatile and semivolatile organics, metals, radioactivity, pesticides, herbicides, PCBs, cyanide, and major ions.

RCRA Monitoring

Groundwater monitoring at the K-1407-B and K-1407-C Ponds was implemented as RCRA interim-status detection monitoring in 1986. The initiation of CERCLA remedial construction activities and RCRA clean closure status for the ponds resulted in a transition from RCRA interim-status monitoring requirements in 1994. Groundwater monitoring at the former ponds is currently designed to verify the effectiveness of remedial actions to support the postremediation review required under CERCLA.

DOE, EPA, and TDEC have requested that groundwater monitoring implemented at the site be conducted semiannually until the initial CERCLA review. This monitoring will be used to assess the impact to groundwater as a result of the remedial actions at the ponds. Potential groundwater contaminants of concern identified during the RI/FS, including additional analytes requested by the regulatory agencies, are included in the analyte list for the sitewide groundwater sampling conducted by the K-25 Site Groundwater Program. The data generated will be used for the development of a long-term monitoring program and for the CERCLA review process for the K-1407-B and C Ponds.

Exit-Pathway Monitoring

Currently exit-pathway groundwater surveillance monitoring is conducted at convergence points where shallow groundwater flows from relatively large areas of the K-25 Site and converges before discharging to surface water locations. The exit-pathway groundwater surveillance network is illustrated in Fig. 7.23. The eight-well monitoring network was completed in 1994 with the installation of four monitoring wells. Exit-pathway monitoring of groundwater quality in both the unconsolidated zone and the bedrock will be supported by surface water monitoring at these locations. Groundwater samples from these eight wells were collected during the 1994 sitewide groundwater sampling effort.

1994 Groundwater Monitoring Results

The following summary of the 1994 monitoring results focuses on those constituents that were detected at concentrations above DWSs. The results are presented for each WAG described previously. The 1994 groundwater sampling program at the K-25 Site marked the first attempt to collect groundwater samples from all existing wells in a short time-frame and using micropurging/low-flow sampling procedures. Based on the results of this groundwater sampling program, the primary groundwater contaminants at the K-25 Site are VOCs and radioactivity with rare occurrences of elevated levels of trace metals and semivolatile organics. Secondary DWSs for aluminum, iron, and manganese were consistently exceeded in wells throughout the K-25 Site and likely represent the natural geochemical nature of the groundwater. Several semivolatile organics also were consistently detected in monitoring wells; however, they are primarily phthalate esters, which are considered common laboratory contaminants and were detected in blank samples.

ORNL-DWG 94M-7065R

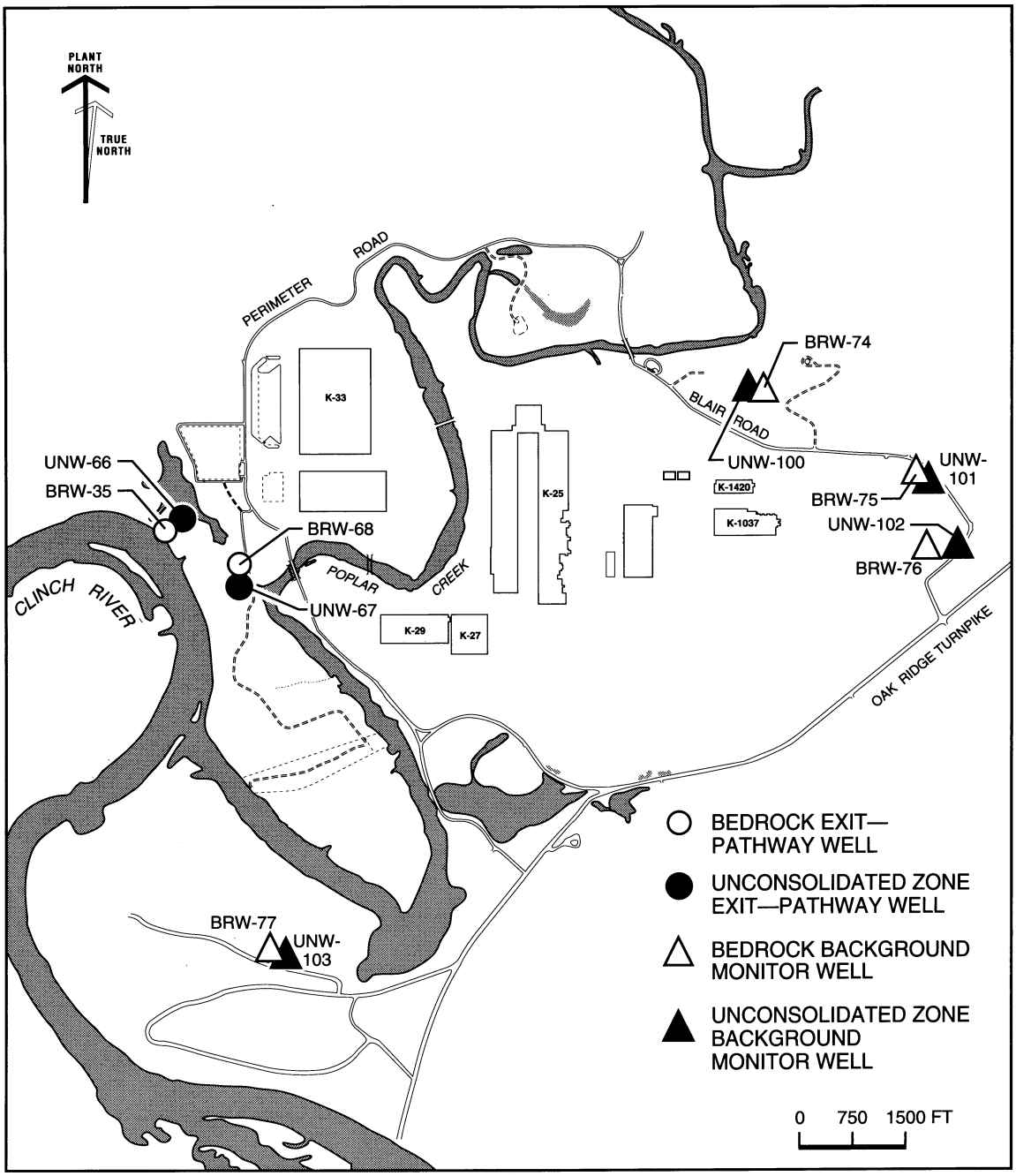

Fig. 7.23. Background and exit-pathway monitoring well locations at the K-25 Site.

South Main Plant Area

Groundwater samples from 16 wells located in the South Main Plant Area were collected and analyzed in 1994. The primary groundwater contaminants are VOCs in this portion of the K-25 Site. Of the VOCs detected in groundwater, the predominant compound was trichloroethene, which was detected in 10 of the 16 wells. The reported concentration

of trichloroethene exceeded the DWS in six of the wells located in this WAG and ranged in concentration from 7 µg/L to 170 µg/L.

Metals in groundwater that exceeded either a primary or secondary DWS include iron, manganese, and nickel. The primary DWS for nickel was exceeded in three wells with a maximum reported concentration of 0.566 mg/L. The secondary DWS for iron was exceeded in one well and for manganese in seven wells.

Gross alpha activity was not detected in any of the 16 groundwater samples analyzed from wells in the South Main Plant Area. Gross beta activity was detected in five of the 16 filtered groundwater samples analyzed. Gross beta activity ranged from 4.1 to 17.3 pCi/L, well below the reference level of 50 pCi/L.

North Main Plant Area

Groundwater samples were collected from 86 wells in the North Main Plant Area. The primary groundwater contaminants detected in this WAG are VOCs and radioactivity. A total of ten different VOCs exceeded their DWSs in wells throughout this WAG. The most widespread constituent was trichloroethene, with reported concentrations at 41 wells exceeding the DWS. The highest single VOC concentration was an estimated value of 100,000 µg/L of 1,1,1-trichloroethane in one well downgradient of the K-1070-C/D Classified Burial Ground. Other VOCs reported at concentrations greater than 1000 µg/L include 1,1-dichloroethane, 1,1-dichloroethene, 1,2-dichloroethene, 1,1,2-trichloro-trifluoroethane, acetone, trichloroethene, and toluene.

The DWS for gross alpha was exceeded in five wells within this WAG. Reported gross alpha activity ranged from 17.7 pCi/L to 40 pCi/L at these five wells. Uranium and thorium appear to be the primary alpha-emitting isotopes present in groundwater at the five wells. Two of the wells that exhibit elevated gross alpha activity are located near the K-1420 Building and two are located near the K-1070-C/D Classified Burial Ground. The fifth well is located at the Blair Road Quarry. Accounting for the limit of error for the analysis, the gross alpha activity in the Blair Road Quarry well may or may not exceed the DWS.

Gross beta activity exceeded the reference value at four wells within the North Main Plant Area and ranged from 198 to 484 pCi/L in these wells. Three of the four wells are located near the K-1070-C/D Classified Burial Ground and the fourth well is located near the K-1407-B Pond. It appears that ^{99}Tc is the primary beta emitting isotope present in groundwater at these well locations.

Metals that were detected at concentrations above a primary DWS based on dissolved concentrations include antimony, lead, nickel, and thallium. Lead and nickel were exceeded in only one well each while antimony and thallium were each exceeded in nine wells. Dissolved metal concentrations that exceeded a secondary DWS in this WAG included aluminum, iron, and manganese.

Semivolatile organics are present in several wells in the vicinity of the K-1414 Garage. This area is generally the only location within the K-25 Site where semivolatile organics that are not common laboratory contaminants have been consistently detected in groundwater samples.

K-25 and K-1064 Area

Eleven monitoring wells were sampled during 1994 in the K-25 and K-1064 Area. The primary contaminants detected were VOCs and radioactivity.

The predominant VOC detected was trichloroethene which exceeded the DWS in three of the eleven wells sampled. Trichloroethene concentrations in these wells ranged from 6 to

17 µg/L. The DWSs for 1,1,2-trichloroethane and benzene also were exceeded at one well each.

Gross alpha activity at levels exceeding the DWS was reported for four bedrock monitoring wells in this WAG. The gross alpha activities ranged from 17.5 pCi/L to 33 pCi/L in these four wells. Based on the limit of error of the analysis, two of these wells may or may not exceed the DWS. Uranium appears to account for most of the gross alpha activity detected in the four wells.

Dissolved metals concentrations that exceed a primary DWS include arsenic and thallium. Arsenic concentrations above the DWS were reported for two wells and thallium exceeded the DWS in one well. The secondary DWS was exceeded for manganese at one bedrock well. Fluoride also exceeded the primary DWS in one bedrock monitoring well.

K-33 and K-31 Area

Groundwater samples were collected from 19 monitoring wells in the K-33 and K-31 Area. The primary contaminants detected were VOCs and metals. Trichloroethene, the only VOC detected at a concentration exceeding the DWS, was detected at a concentration of 35 µg/L at one bedrock well west of Building K-33. Additional VOCs detected in monitoring wells in this area, but not exceeding DWSs, include 1,1,1-trichloroethane, 1,1-dichloroethene, 1,2-dichloroethene, methylene chloride, and toluene.

The dissolved metals concentrations exceeding a primary or secondary DWS include chromium, iron, manganese, and nickel. The primary DWS was exceeded for chromium at two bedrock monitoring wells and for nickel at three unconsolidated zone monitoring wells. Iron and manganese exceeded secondary DWSs at one and four wells, respectively.

Gross alpha activity exceeded the DWS at one unconsolidated zone monitoring well at the southwest corner of Building K-33. The reported gross alpha activity for this well was 58.2 pCi/L with a limit of error of 9.4 pCi/L; however, the results from the unfiltered analysis for this well did not exceed the DWS.

One herbicide was detected in this area at a concentration above its respective DWS of 4.0 µg/L. An estimated concentration of 4.6 mg/L of simazine was reported for one bedrock well near the K-33 Building. Simazine was not detected in any other wells in this area, including the unconsolidated zone well paired with the bedrock well at this location.

K-27 and K-29 Area

Groundwater samples were collected from 18 monitoring wells in the K-27 and K-29 Area. The primary contaminants detected during the 1994 sampling program are VOCs.

Trichloroethene was detected in 14 of the 18 monitoring wells sampled and exceeded the DWS in nine of the wells in this WAG. Trichloroethene concentrations ranged from 9 µg/L to 390 µg/L in these nine wells. Concentrations of 1,2-dichloroethene, carbon tetrachloride, and vinyl chloride above the DWS also were reported for one well each in the K-27 and K-29 Area.

Chromium concentrations in excess of the primary DWS were reported for two unconsolidated-zone wells in this WAG. These two wells had chromium concentrations of 0.131 mg/L and 0.334 mg/L. Nickel exceeded the primary DWS in one unconsolidated-zone monitoring well at a concentration of 0.185 mg/L. The secondary DWSs for aluminum, iron, and manganese also were exceeded in several wells in this area. Fluoride, at a reported concentration of 4.6 mg/L in one bedrock well, is the only other DWS exceeded at any wells in this area.

Gross alpha activity was detected in one of the 18 filtered groundwater samples analyzed from the K-27 and K-29 Area. The result of 5.0 pCi/L is well below the DWS of 15 pCi/L. Gross beta activity was detected in 16 of 18 filtered groundwater samples analyzed. The beta activity ranged from 2.5 to 43.4 pCi/L and averaged 9.7 pCi/L with a mean limit of error of 0.5 pCi/L. The reference level of 50 pCi/L was not exceeded at any of the wells in this WAG.

K-901 Area

Groundwater samples were collected from 10 monitoring wells in the K-901 Area during 1994. The primary contaminants detected were VOCs and radioactivity.

Six VOCs were detected at concentrations exceeding their respective DWSs. These include 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,1-dichloroethene, carbon tetrachloride, tetrachloroethene, and trichloroethene. Trichloroethene is the predominant VOC detected in this area. The DWS for trichloroethene was exceeded in six wells, with concentrations ranging from 18 μg/L to 3200 μg/L in both unconsolidated-zone and bedrock wells. All of the wells in which VOCs exceeded the DWS are located in the vicinity of the K-1070-A Burial Ground.

Gross beta activity exceeded the reference value of 50 pCi/L in three monitoring wells in the K-901 Area. The reported gross beta activity in these three wells ranged from 169.7 pCi/L to 646 pCi/L; the highest activity was detected in an unconsolidated-zone monitoring well. Based on analysis for beta-emitting isotopes, it appears that the primary contributor to gross beta activity is ^{99}Tc in this WAG.

Thallium is the only metal detected at concentrations exceeding a primary DWS. A thallium concentration of 0.0039 mg/L was reported for one bedrock well in the K-901 Area. Metals for which secondary DWSs were exceeded include aluminum, iron, and manganese.

Duct Island Area

Groundwater samples from five monitoring wells were collected during 1994 in the Duct Island Area. Analytical results of these samples indicate little or no contamination in this area of the K-25 Site. The only metal detected at concentrations exceeding a DWS was manganese, which exceeded the secondary DWS of 0.05 mg/L in two bedrock wells.

Three semivolatile organics were detected at concentrations above their respective DWSs in one well. 1,2,4-trichlorobenzene, 1,4-dichlorobenzene, and pentachlorophenol were detected at estimated concentrations of 280 μg/L, 250 μg/L, and 660 μg/L, respectively in one bedrock well south of the K-1070-F Contractor's Burial Ground.

There are no indications of significant groundwater contamination from VOCs or radioactivity in the Duct Island Area.

Powerhouse Area

Groundwater samples were collected from 18 monitoring wells in the Powerhouse Area. The primary contaminants detected in groundwater were metals and radioactivity.

The DWS for cadmium was exceeded in three wells and the DWS for nickel was exceeded in two wells in groundwater samples analyzed for dissolved constituents. Dissolved cadmium concentrations ranged from 0.0067 mg/L to 0.0176 mg/L in three unconsolidated-zone wells. Dissolved nickel concentrations ranged from 0.108 mg/L to 0.227 mg/L in the two unconsolidated-zone wells that exceeded the DWS. Selenium

concentrations exceeded the DWS in two wells; thallium concentrations exceeded the DWS in one well. Secondary DWSs were exceeded for aluminum, iron, and manganese in several wells.

Gross alpha activity exceeded the DWS in one unconsolidated-zone monitoring well. The reported gross alpha activity was 27.3 pCi/L in the well located west of the K-770 Scrap Yard. Gross beta activities exceeded the reference value in two unconsolidated-zone monitoring wells: gross beta activities of 64.6 pCi/L and 201.3 pCi/L were reported for the two wells located northwest of the K-770 Scrap Yard. From the analytical results for beta-emitting isotopes, it appears that the gross beta activities can be attributed primarily to the presence of ^{99}Tc in these wells.

Tetrachloroethene was detected at a concentration of 7 μg/L in one unconsolidated-zone well north of the K-770 Scrap Yard. No other VOCs were detected at concentrations exceeding a DWS in the Powerhouse Area.

Three wells exhibited sulfate concentrations exceeding the secondary DWS. Sulfate concentrations in these three unconsolidated-zone monitoring wells ranged from 448 mg/L to 1380 mg/L.

K-25 Site Exit-Pathway Monitoring Results

The K-25 Site exit-pathway monitoring network consists of eight monitoring wells. All eight wells were sampled during 1994. Primary DWSs were exceeded for only two constituents in groundwater samples collected from the exit-pathway wells (Fig. 7.23).

The primary DWS for thallium was exceeded in one exit-pathway bedrock well located on the north side of the K-25 Site near the confluence of Mitchell Branch and Poplar Creek. The secondary DWSs for aluminum, iron, and manganese were exceeded in several exit-pathway wells, as is the case with many of the wells at the K-25 Site, including background monitoring wells.

The DWS for trichloroethene was exceeded in one exit-pathway bedrock well. A concentration of 8 μg/L of trichloroethene was reported for the well located south of the K-901 Pond. Trichloroethene is present in several monitoring wells in the K-901 Area. DWSs for other VOCs were not exceeded in any exit-pathway well.

The DWS of 15 pCi/L for gross alpha activity was not exceeded in any of the groundwater samples collected from the exit-pathway wells. Gross alpha activity detected in filtered groundwater samples ranged from 2.8 to 8.5 pCi/L and averaged 4.4 pCi/L with a mean limit of error of 1.2 pCi/L. Gross beta activity detected in filtered groundwater samples from the exit-pathway wells ranged from 4.2 to 13.1 pCi/L and averaged 8.8 with a mean limit of error of 1.1 pCi/L. None of the gross beta results reported for the exit-pathway wells exceeded the reference level of 50 pCi/L.

8. Quality Assurance

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Abstract

The overall goal of a well-designed and well-implemented sampling and analysis program is to measure accurately what is really there. Environmental decisions are made on the assumption that analytical results are, within known limits of accuracy and precision, representative of site conditions. Many sources of error exist that could affect the analytical results. Factors to consider as sources of error include improper sample collection, handling, preservation, and transport; inadequate personnel training; and poor analytical methods, data reporting, and record keeping. A quality assurance program is designed to minimize these sources of error and to control all phases of the monitoring process.

INTRODUCTION

The application of a quality assurance/quality control (QA/QC) program for environmental monitoring activities at the ORR is essential to generating data of known and defensible quality. Each aspect of the environmental monitoring program, from sample collection to data management, must address and meet applicable quality standards.

The 1994 QA/QC results for the three sites have been compiled into a summary that represents the performance of the reservation as a whole. In past years, the results were reported separately for each of the three site analytical laboratories. The three laboratories were recently combined into a single entity, the Analytical Services Organization. The 1994 results are based on data from the Analytical Services Organization, the ORNL Environmental Sciences Division, and the K-25 Site Technical Division.

FIELD SAMPLING QUALITY ASSURANCE

Field sampling QA encompasses many practices that minimize error and evaluate sampling performance. Some key quality practices include the following:

- use of standard operating procedures (SOPs) for sample collection and analysis;
- use of chain-of-custody and sample-identification procedures;
- instrument standardization, calibration, and verification;
- technician and analyst training;
- sample preservation, handling, and decontamination; and
- use of QC samples such as field and trip blanks, duplicates, and equipment rinses.

Preparation of SOPs is a continually evolving process. In 1988, the Environmental Surveillance Procedures Quality Control Program was issued for use by Energy Systems, with oversight by DOE-ORO and the EPA. This document contained sampling and QC procedures that addressed each of the issues in the preceding list.

A process is in place for continuous improvement in the field sampling QA program and for incorporation of new procedures to reflect changing technologies and regulatory protocols. An Environmental Surveillance Procedures Quality Control Committee is tasked

with updating the field sampling and QC procedures. Membership in the committee includes representatives from each of the five Energy Systems facilities, DOE, Environmental Restoration, Central Waste Management, and the Analytical Services Organization. The committee ensures that requirements from relevant federal and state regulations are incorporated into the procedures and that new procedures are incorporated only after appropriate review and approval.

Because of changing technologies and regulatory protocols, training of field personnel is a continuing process. To ensure that qualified personnel are available for the array of sampling tasks within Energy Systems, training programs by EPA as well as private contractors have been used to supplement internal training. Examples of topics addressed include the following:

- planning, preparation, and record keeping for field sampling;
- well construction and groundwater sampling;
- surface water, leachate, and sediment sampling;
- soil sampling;
- stack sampling;
- decontamination procedures; and
- health and safety considerations.

ANALYTICAL QUALITY ASSURANCE

The Energy Systems analytical laboratories have well-established QA/QC programs, well-trained and highly qualified staff, and excellent equipment and facilities. Current, approved analytical methodologies employing good laboratory and measurement control practices are used routinely to ensure analytical reliability. The analytical laboratories conduct extensive internal QC programs with a high degree of accuracy, participate in several external QC programs, and use statistics to evaluate and to continuously improve performance. Thus, QA and QC are daily responsibilities of all employees.

Internal Quality Control

Analytical activities are supported by the use of standard materials or reference materials (e.g., materials of known composition that are used in the calibration of instruments, methods standardization, spike additions for recovery tests, and other practices). Certified standards from the National Institute of Standards and Technology (NIST), EPA, or other DOE laboratories are used for such work. The laboratories operate under specific QA/QC criteria at each installation. Additionally, separate QA/QC documents relating to analysis of environmental samples associated with regulatory requirements are developed.

QA/QC measurement control programs external to the sample analysis groups have single, blind control samples submitted to the analytical laboratories to monitor performance. The results of such periodic measurement programs are statistically evaluated and reported to the laboratories and their customers. Most reports are issued quarterly, and some laboratories compile annual summary reports. These reports assist in evaluating the adequacy of analytical support programs and procedures. If serious deviations are noted by the QC groups, the operating laboratories are promptly notified so that corrective actions can be initiated and problems can be resolved. QC data are stored in an easily retrievable manner so that they can be related to the analytical results they support.

External Quality Control

In addition to the internal programs, all Energy Systems analytical laboratories are directed by DOE and are expected by EPA to participate in external QA programs. The QA programs generate data that are readily recognizable as objective packets of results. The external QA programs typically consist of the Energy Systems Laboratories analyzing a sample of unknown composition provided by various QA organizations. The organizations know the true composition of the sample and provide the Energy Systems laboratories with a data report on their analytical performance. The sources of these programs are laboratories in EPA, DOE, and the commercial sector. Energy Systems participates in ten such programs (Table 8.1). The following sections describe the external QA programs in which Energy Systems participates.

Table 8.1. QA/QC results for the Oak Ridge Reservation, 1994

Program	Total number of analytes	Acceptable	
		Total	Percentage
EPA Contract Laboratory Program (CLP)[a]			90.0
EPA Discharge Monitoring Report Quality Assurance Study (DMR)[b]	94	88	93.6
AIHA Environmental Lead Proficiency Analytical Testing Program (ELPAT)	124	120	96.8
DOE Environmental Measurements Laboratory (EML)	170	159	93.5
EPA Environmental Monitoring Systems Laboratory at Las Vegas (EMSL-LV) Intercomparison Radionuclide Control Program	212	183	86.3
DOE Mixed Analyte Performance Evaluation Program (MAPEP)[c]			
AIHA Proficiency Analytical Testing Program (PAT)[d]	288	269	93.4
Proficiency Environmental Testing Program (PET)	4371	4327	99.0
Water Pollution Performance Evaluation QC Program (WP)[c]	233	227	97.4
Water Supply Laboratory Performance QC Program (WS)[c]	341	329	96.5

[a]The CLP Program scores its results on other factors besides quantitation. An average score was determined by averaging each site's average score from the CLP Program.

[b]Includes toxicology data from the ORNL Environmental Sciences Division.

[c]All data not available at press time.

[d]Includes asbestos data from the K-25 Site Technical Division.

Environmental Protection Agency Contract Laboratory Program (CLP)

The Contract Laboratory Program (CLP) is an EPA-administered qualification program for laboratories to do CERCLA (Superfund) program analyses. The program operates from the CLP Sample Management Office at Alexandria, Virginia, in cooperation with the EPA Environmental Monitoring Systems Laboratory at Las Vegas (EMSL-LV) and EPA regional offices. The program qualifies laboratories for the determination of organic and inorganic contaminants in aqueous and solid hazardous waste materials and enforces stringent QA/QC requirements to ensure comparable data. This program scores on additional criteria other than an acceptable-unacceptable evaluation of the measurement result. All three ORR sites participate.

Water Supply Laboratory Performance Quality Control Program

This program is administered by EPA and is used by the state of Tennessee to certify laboratories for drinking-water analysis. To maintain a certification, a laboratory must meet a specified set of criteria relating to technical personnel, equipment, work areas, QA/QC operating procedures, and successful analysis of QA samples. In addition, inclusion on the state of Tennessee's UST approved listing may be granted as a result of successful participation in this program.

Water Pollution Performance Evaluation Quality Control Program

This program is used by DOE to evaluate laboratories engaged in analysis of polluted-water samples at existing and former DOE sites. It is administered by EPA in Cincinnati, Ohio (Region V). It is also used by some states as part of their laboratory certification process. All three ORR sites participate.

American Industrial Hygiene Association Proficiency Analytical Testing Program

The American Industrial Hygiene Association (AIHA) administers the Proficiency Analytical Testing (PAT) Program as part of its AIHA accreditation process for laboratories performing analyses of industrial hygiene air samples.

EPA Discharge Monitoring Report Quality Assurance Study

EPA conducts a national QA program in support of the NPDES permits, and it is mandatory for major permit holders. The EPA supplies the QA samples and furnishes the evaluated results to the permittee, who is required to report the results and any necessary corrective actions to the state or regional coordinator. All three ORR sites participate.

EPA Intercomparison Radionuclide Control Program

The EPA Intercomparison Radionuclide Control Program is administered by EMSL-LV. Samples include water, air filters, and milk. The state of Tennessee requires participation for drinking-water certification of radionuclide analysis, and all sites are involved. The EMSL-LV program calculates a normalized standard deviation for each laboratory based on all reported results. By their criteria, any reported value above three standard deviations is considered unacceptable.

Environmental Lead Proficiency Analytical Testing (ELPAT) Program

This program was established by AIHA in 1992 to evaluate analysis of environmental lead samples in different matrices. The matrices evaluated are paint, soil, and dust wipes. The participating laboratory analyzes each matrix at four levels. In addition, a laboratory may request to become accredited for lead analysis in this program. ELPAT is administered by AIHA.

Mixed Analyte Performance Evaluation Program (MAPEP)

MAPEP is a pilot program set up by the DOE Radiological and Environmental Sciences Laboratory in conjunction with the Laboratory Management Division of the Office of Technology Development. It was set up to evaluate analysis of mixed-waste samples. The program is evaluated by Argonne National Laboratory.

DOE Environmental Measurements Laboratory (EML) Quality Assessment Program

Participation in the radionuclide Quality Assessment Program, administered by DOE EML in New York, is required by DOE Order 5400.1. Various matrices, such as soil, water, air filters, and vegetation, are submitted semiannually for analysis of a variety of radioactive isotopes. All matrices, except air filters, are actual materials obtained from the environment at a DOE facility. A statistical report is submitted to the sites by EML for each period. All three ORR sites participate.

Proficiency Environmental Testing (PET) Program

The PET program is a service purchased from an outside vendor and is used by all five Energy Systems analytical laboratories and the DOE laboratory at the Fernald, Ohio, facility, to meet the need for a QA program for all environmental analyses. The samples are supplied by the commercial company at two concentration levels (high and low). All data from each of the six laboratories are reported to the supplier. The commercial supplier provides a report on the evaluated data to the site QA/QC managers. The report includes a percentage recovery of the referenced value, deviation from the mean of all reported data, specific problems in a site lab, and other statistical information. A corporate report is also provided that compares the data from the Energy Systems laboratories with those of other corporate laboratories.

Quality Assessment Program for Subcontracted Laboratories

Requirements for Quality Control of Analytical Data for the Environmental Restoration Program (Energy Systems 1992b) defines the basic requirements that laboratories must satisfy in providing support to ORR environmental restoration projects. Oversight of subcontracted commercial laboratories is performed by Analytical Project Office personnel, who conduct on-site laboratory reviews and monitor the performance of all subcontracted laboratories.

The components of the review process are as follows.

- *Laboratory Quality Assurance Plan* (LQAP)—A review of the LQAP is performed by the Analytical Project Office prior to an initial audit of the laboratory. Each laboratory is required

to have an LQAP in place and to correct any deficiencies noted by the Analytical Project Office review.

- Performance evaluation samples—Each laboratory is required to successfully participate in an external performance evaluation program for analytes representative of those anticipated in the environmental samples. Participation is reviewed before samples are submitted to the laboratory and as part of the initial audit and periodic audits.
- Initial audit—After the laboratory has satisfactorily responded to LQAP comments and submitted the required performance evaluation data, an audit is conducted to verify that conditions of *Requirements for Quality Control of Analytical Data for the Environmental Restoration Program* (Energy Systems 1992) are being implemented.
- Periodic audits—Audits of laboratories participating in the Analytical Project Office pricing agreement are conducted every 6 to 12 months to verify continuing compliance with requirements.
- Monthly progress reports—Reports are submitted to the Analytical Project Office by each laboratory to maintain communication so that changes in certification status, personnel, or facilities may be monitored.
- Project-specific surveillances—Surveillances are conducted as required to monitor specific project data quality.

DATA MANAGEMENT, VERIFICATION, AND VALIDATION

Verification and validation of environmental data are performed as components of the data collection process, which includes planning, sampling, analysis, and data review. Verification and validation of field and analytical data collected for environmental monitoring and restoration programs are necessary to ensure that data conform with applicable regulatory and contractual requirements. Validation of field and analytical data is a technical review performed to compare data with established quality criteria to ensure that data are adequate for intended use. The extent of project data verification and validation activities is based upon project-specific requirements.

Over the years, the environmental data verification and data validation processes used by ORR environmental programs have evolved to meet continuing regulatory changes and monitoring objectives. Procedures have been written to document the processes. For routine environmental effluent monitoring and surveillance monitoring, data verification activities may include processes of checking whether (1) data have been accurately transcribed and recorded, (2) appropriate procedures have been followed, (3) electronic and hard-copy data show one-to-one correspondence, and (4) data are consistent with expected trends. For example, the requirements for self-monitoring of surface-water and wastewater effluents under the terms of an NPDES permit require the permittee to conduct the analyses as defined in 40 CFR 136 and to certify that the data reported in the monthly discharge monitoring report are true and accurate.

Typically, routine data verification actions alone are sufficient to document the truthfulness and accuracy of the discharge monitoring report. For environmental restoration projects, routine verification activities are more contractually oriented and include checks for data completeness, consistency, and compliance against a predetermined standard or contract.

Certain projects may perform a more thorough technical validation of the data as mandated by the project's data quality objectives. For example, sampling and analyses conducted as part of a remedial investigation to support the CERCLA process may generate data that are needed to evaluate risk to human health and the environment, to document that

no further remediation is necessary, or to support a multimillion-dollar construction activity and treatment alternative. In that case, the data quality objectives of the project may mandate a more thorough technical evaluation of the data against predetermined criteria. For example, EPA has established functional guidelines for validation of organic and inorganic data collected under the protocol of the EPA's CLP. These guidelines are used to offer assistance to the data user in evaluating and interpreting the data generated from monitoring activities that require CLP performance.

The validation process may result in identifying data that do not meet predetermined QC criteria (in flagging quantitative data that must be considered qualitative only) or in the ultimate rejection of data from its intended use. Typical criteria evaluated in the validation of CLP data include the percentage of surrogate recoveries, spike recoveries, method blanks, instrument tuning, instrument calibration, continuing calibration verifications, internal standard response, comparison of duplicate samples, and sample holding times.

Electronic data transfers from portable computers in the field and from laboratory information management systems used by on-site and commercial analytical laboratories to environmental data management systems have greatly enhanced the efficiency of the review process. In addition, the ongoing development of data-review software applications continues to provide necessary tools for data review. For example, as groundwater monitoring data are compiled, computer capabilities accomplish the following tasks:

- calculate charge balance;
- calculate conductivity and compare the data with field and laboratory measurements of conductivity;
- compare alkalinities and pH, field-duplicate measurements, results of filtered and unfiltered samples for elemental analyses, and current data with historical data to note results that are statistical outliers from established patterns;
- generate a summary of holding times for volatile organics; and
- screen volatile-organic results from samples against volatile-organic results from laboratory blanks.

Irregularities in the laboratory results that are discovered through this program are flagged and reviewed with the laboratory. If corrections need to be made, the laboratory provides a revised laboratory report. If a data point is found to be an outlier, it remains flagged in the data base as information for the data user.

Continuing improvements are being made to computerized environmental data management systems maintained by the Y-12 Plant, ORNL, and the K-25 Site to improve the functionality of the systems, to allow access by a wide range of data users, and to integrate the mapping capabilities of a geographic information system (GIS) with the data bases containing results of environmental monitoring activities.

Integration of compliance-monitoring data for the ORR with sampling and analysis results from remedial investigations by the Environmental Restoration Division is a function of the Oak Ridge Environmental Information System (OREIS). OREIS is necessary to fulfill requirements prescribed in both the FFA and Tennessee Oversight Agreement and to support data management activities for all five facilities managed by Energy Systems. The FFA, a tripartite agreement between DOE, EPA Region IV, and the state of Tennessee, requires DOE to maintain one consolidated data base for environmental data generated at DOE facilities on the ORR. According to the FFA, the consolidated data base is to include data generated pursuant to the FFA as well as data generated under federal and state environmental permits. The Tennessee Oversight Agreement further

defines DOE staff obligations to develop a quality assured, consolidated data base of monitoring information that will be shared electronically on a near-real-time basis with the state staff.

OREIS is the primary component of the data management program for the Environmental Restoration Program, providing consolidated, consistent, and well documented environmental data and data products to support planning, decision making, and reporting activities. OREIS provides a direct electronic link of ORR monitoring and remedial investigation results to EPA Region IV and the state of Tennessee DOE Oversight Division.

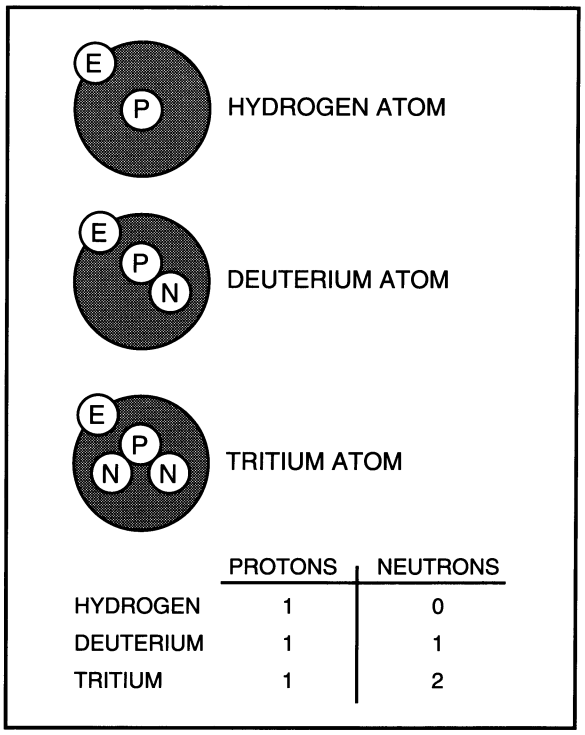
Appendix A: Radiation

This appendix presents basic facts about radiation. The information is intended to be a basis for understanding the potential doses associated with releases of radionuclides from the Oak Ridge Reservation (ORR), not as a comprehensive discussion of radiation and its effects on the environment and biological systems.

Radiation comes from natural and human-made sources. People are exposed to naturally occurring radiation constantly. For example, cosmic radiation; radon in air; potassium in food and water; and uranium, thorium, and radium in the earth's crust are all sources of radiation. The following discussion describes important aspects of radiation, including atoms and isotopes; types, sources, and pathways of radiation; radiation measurement; and dose information.

ATOMS AND ISOTOPES

ORNL-DWG 94M-5236



	PROTONS	NEUTRONS
HYDROGEN	1	0
DEUTERIUM	1	1
TRITIUM	1	2

Fig. A.1. The hydrogen atom and its isotopes.

All matter is made up of atoms. An atom is "a unit of matter consisting of a single nucleus surrounded by a number of electrons equal to the number of protons in the nucleus" (ANS 1986). The number of protons in the nucleus determines an element's atomic number or chemical identity. With the exception of hydrogen, the nucleus of each type of atom also contains at least one neutron. Unlike protons, the neutrons may vary in number among atoms of the same element. The number of neutrons and protons determines the atomic weight. Atoms of the same element that have different numbers of neutrons are called isotopes. In other words, isotopes have the same chemical properties but different atomic weights (Fig. A.1).

For example, the element uranium has 92 protons. All isotopes of uranium, therefore, have 92 protons. However, each uranium isotope has a different number of neutrons. Uranium-238 has 92 protons and 146 neutrons; uranium-235 has 92 protons and 143 neutrons; and uranium-234 has 92 protons and 142 neutrons.

Some isotopes are stable, or nonradioactive; some are radioactive. Radioactive isotopes are called radionuclides, or radioisotopes. In an attempt to become stable, radionuclides "throw away," or emit, rays or particles. This emission of rays and particles is known as radioactive decay. Each radioisotope has a "radioactive half-life," which is the average time that it takes for half of a specified number of atoms to decay. Half-lives can be very short (fractions of a second) or very long (thousands of years), depending on the isotope (Table A.1).

Table A.1. Radionuclide nomenclature

Radionuclide	Symbol	Half-life	Radionuclide	Symbol	Half-life
Americium-241	^{241}Am	432.2 years	Plutonium-238	^{238}Pu	87.75 years
Americium-243	^{243}Am	7.38E+3 years	Plutonium-239	^{239}Pu	2.41E+4 years
Antimony-125	^{125}Sb	2.77 years	Plutonium-240	^{240}Pu	6.569E+3 years
Argon-41	^{41}Ar	1.827 hours	Potassium-40	^{40}K	1.2777E+9 years
Beryllium-7	^{7}Be	53.44 days	Promethium-147	^{147}Pm	2.6234 years
Californium-252	^{252}Cf	2.639 years	Protactinium-234*m*	^{234m}Pa	1.17 minutes
Carbon-14	^{14}C	5.730E+3 years	Radium-226	^{226}Ra	1.6E+3 years
Cerium-141	^{141}Ce	32.50 days	Radium-228	^{228}Ra	5.75 years
Cerium-143	^{143}Ce	1.38 days	Ruthenium-103	^{103}Ru	39.35 days
Cerium-144	^{144}Ce	284.3 days	Ruthenium-106	^{106}Ru	368.2 days
Cesium-134	^{134}Cs	2.062 years	Strontium-89	^{89}Sr	50.55 days
Cesium-137	^{137}Cs	30.17 years	Strontium-90	^{90}Sr	28.6 years
Cobalt-58	^{58}Co	70.80 days	Technetium-99	^{99}Tc	2.13E+5 years
Cobalt-60	^{60}Co	5.271 years	Thorium-228	^{228}Th	1.9132 years
Curium-242	^{242}Cm	163.2 days	Thorium-230	^{230}Th	7.54E+4 years
Curium-244	^{244}Cm	18.11 years	Thorium-232	^{232}Th	1.405E+10 years
Iodine-129	^{129}I	157E+7 years	Thorium-234	^{234}Th	2.41E+1 days
Iodine-131	^{131}I	8.04 days	Tritium	^{3}H	12.28 years
Krypton-85	^{85}Kr	10.72 years	Uranium-234	^{234}U	2.445E+5 years
Krypton-88	^{88}Kr	2.84 hours	Uranium-235	^{235}U	7.038E+8 years
Manganese-54	^{54}Mn	312.7 days	Uranium-236	^{236}U	2.3415E+7 years
Neptunium-237	^{237}Np	2.14E+6 years	Uranium-238	^{238}U	4.468E+9 years
Niobium-95	^{95}Nb	35.06 days	Xenon-133	^{133}Xe	5.245E+9 years
Osmium-185	^{185}Os	93.6 days	Xenon-135	^{135}Xe	9.11 hours
Phosphorus-32	^{32}P	14.29 days	Yttrium-90	^{90}Y	64.1 hours
Polonium-210	^{210}Po	138.378 days	Zirconium-95	^{95}Zr	64.02 days

Source: Radioactive Decay Tables: A Handbook of Decay Data for Application to Radioactive Dosimetry and Radiological Assessments (DOE 1989).

RADIATION

Radiation, or radiant energy, is energy in the form of waves or particles moving through space. Visible light, heat, radio waves, and alpha particles are examples of radiation. When people feel warmth from the sunlight, they are actually absorbing the radiant energy emitted by the sun.

Electromagnetic radiation is radiation in the form of electromagnetic waves. Examples include gamma rays, ultraviolet light, and radio waves. Particulate radiation is radiation in the form of particles. Examples include alpha and beta particles. Radiation also is characterized as ionizing or nonionizing because of the way in which it interacts with matter.

Ionizing Radiation

Normally, an atom has an equal number of protons and electrons; however, atoms can lose or gain electrons in a process known as ionization. Some forms of radiation (called ionizing radiation) can ionize atoms by "knocking" electrons off atoms. Examples of ionizing radiation include alpha, beta, and gamma radiation.

Ionizing radiation is capable of changing the chemical state of matter and subsequently causing biological damage. By this mechanism, it is potentially harmful to human health.

Nonionizing Radiation

Nonionizing radiation bounces off or passes through matter without displacing electrons. Examples include visible light and radio waves. At this time it is unclear whether or not nonionizing radiation is harmful to human health. In the discussion that follows, the term radiation is used to describe ionizing radiation.

SOURCES OF RADIATION

Radiation is everywhere. Most occurs naturally; a small percentage is human-made. Naturally occurring radiation is known as background radiation.

Background Radiation

Many materials are naturally radioactive. In fact, this naturally occurring radiation is the major source of radiation in the environment. Although people have little control over the amount of background radiation to which they are exposed, this exposure must be put into perspective. Background radiation remains relatively constant over time and is present in the environment today much as it was hundreds of years ago.

Sources of background radiation include uranium in the earth, radon in the air, and potassium in food. Background radiation is categorized as cosmic, terrestrial, or internal, depending on its origin.

Cosmic Radiation

Energetically charged particles from outer space continuously hit the earth's atmosphere. These particles and the secondary particles and photons they create are called cosmic radiation. Because the atmosphere provides some shielding against cosmic radiation, the intensity of this radiation increases with altitude above sea level. In other words, a person in Denver, Colorado, is exposed to more cosmic radiation than a person in New Orleans, Louisiana.

Principal Radiation Types Emitted by Radionuclides

Alpha

A particle consisting of two protons and two neutrons emitted from the nucleus.

Low penetration: the mean range of a 5-MeV alpha particle in air is about 3.5 cm; in tissue its range is about 44 μm (Shapiro).

For environmental dosimetry, particularly important as an internal emitter, especially in the respiratory passages, on bone surfaces, and in red marrow. Its energy is concentrated along short paths and can deliver high localized doses to sensitive surface regions.

Beta

An electron emitted from the nucleus.

The average range of a 1-MeV beta particle is about 3 m in air but only about 3 mm in tissue.

For environmental dosimetry, of primary concern as an internal emitter. Because of their relatively short range in tissue, beta particles principally irradiate the organs in which they originate.

Gamma and X rays

Electromagnetic radiation, emitted as energy packets called photons, similar to light and radio waves but from a different energy region of the electromagnetic spectrum. X rays originate in the orbital electron field surrounding the nucleus; gamma rays are emitted from the nucleus.

Gamma radiation: to absorb 95% of the gamma energy from a ^{60}Co source, 6 cm of lead, 10 cm of iron, or 33 cm of concrete would be needed.

For environmental dosimetry, important both for internal and external exposure. Gamma emitters deposited in one organ of the body can significantly irradiate other organs.

Terrestrial Radiation

Terrestrial radiation refers to radiation emitted from radioactive materials in the earth's rocks, soils, and minerals. Radon (Rn); radon progeny (the relatively short-lived decay products from the decay of ^{222}Rn); potassium (^{40}K); isotopes of thorium (Th); and isotopes of uranium (U) are the elements responsible for most terrestrial radiation.

Internal Radiation

Radionuclides in the environment enter the body with the air people breathe and the foods they eat. They also can enter through an open wound. Natural radionuclides that can be inhaled and ingested include isotopes of uranium and its progeny, especially radon (^{222}Rn) and its progeny, thoron (^{220}Rn) and its progeny, potassium (^{40}K), rubidium (^{87}Rb), and carbon (^{14}C). Radionuclides contained in the body are dominated by ^{40}K and ^{210}Po; others include rubidium (^{87}Rb) and carbon (^{14}C) (NCRP 1987).

Human-Made Radiation

In addition to background radiation, there are human-made sources of radiation to which most people are exposed. Examples include consumer products, medical sources, fallout from atmospheric atomic bomb tests, and industrial by-products. No atmospheric testing of atomic weapons has occurred since 1980 (NCRP 1987).

Consumer Products

Some consumer products are sources of radiation. The radiation in some of these products, such as smoke detectors and airport X-ray baggage inspection systems, is essential to the performance of the device. In other products, such as televisions and tobacco products, the radiation occurs incidentally to the product function.

Medical Sources

Radiation is an important tool of diagnostic medicine and treatment and is the main source of exposure to the public from human-made radiation. Exposure is deliberate and directly beneficial to the patients exposed. In general, medical exposures from diagnostic or therapeutic X rays result from beams directed to specific areas of the body. Thus, all body organs generally are not irradiated uniformly. Nuclear medicine examinations and treatments involve the internal administration of radioactive compounds, or radiopharmaceuticals, by injection, inhalation, consumption, or insertion. Even then, radionuclides are not distributed uniformly throughout the body. Radiation and radioactive materials also are used in the preparation of medical instruments, including the sterilization of heat-sensitive products such as plastic heart valves.

Other Sources

Radioactive fallout, the by-product of nuclear-weapon testing in the atmosphere, is a source of radiation. Other sources of radiation include emissions of radioactive materials from nuclear facilities such as uranium mines, fuel-processing plants, and nuclear power plants; transportation of radioactive materials; and emissions from mineral-extraction facilities.

PATHWAYS OF RADIONUCLIDES

People can be exposed to radionuclides in the environment through a number of routes (Fig. A.2). Potential routes for internal and/or external exposure are referred to as pathways. For example, radionuclides in the air could fall on a pasture. The grass then could be eaten by cows, and the radionuclides deposited on the grass would show up in milk. People drinking the milk would be exposed to this radiation. People also could simply inhale airborne radionuclides. Similarly, radionuclides in water could be ingested by fish, and people eating the fish would also ingest the radionuclides in the fish tissue. People swimming in the water would be exposed also.

ORNL-DWG 94M-5235R2

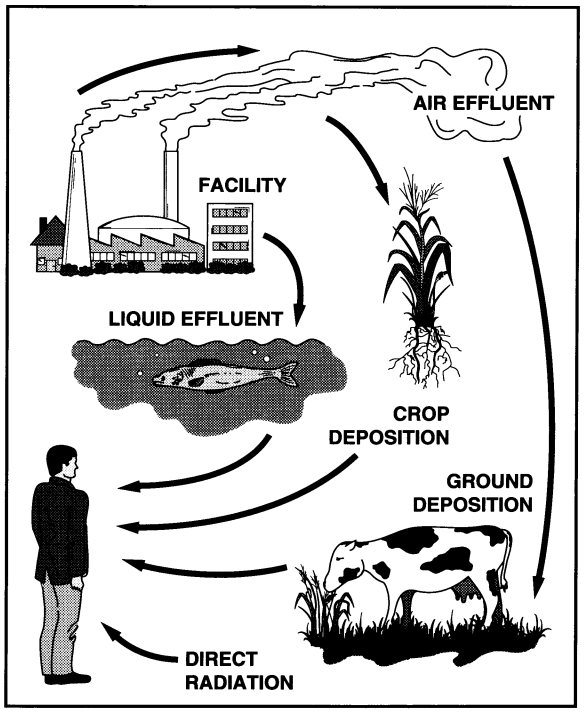


Fig. A.2. Examples of radiation pathways.

MEASURING RADIATION

To determine the possible effects of radiation on the health of the environment and people, the radiation must be measured. More precisely, its potential to cause damage must be ascertained.

Activity

When we measure the amount of radiation in the environment, what is actually being measured is the rate of radioactive decay, or activity. The rate of decay varies widely among the various radioisotopes. For that reason, one gram of a radioactive substance may contain the same amount of activity as several tons of another material. This activity is expressed in a unit of measure known as a curie (Ci). More specifically, one curie equals 3.7×10^{10} (37,000,000,000) atomic disintegrations per second (dps). In the international system of units, 1 dps equals 1 becquerel (Bq).

Absorbed Dose

The total amount of energy absorbed per unit mass of the exposed material as a result of exposure to radiation is expressed in a unit of measure known as a rad. In this case, it is the effect of the absorbed energy (the biological damage that it causes) that is important, not the actual amount. In the international system of units, 100 rad equals 1 gray (Gy).

Dose Equivalent

The measure of potential biological damage to specific body organs or tissues caused by exposure to and subsequent absorption of radiation is expressed in a unit of measure known as a rem. One rem of any type of radiation has the same total damaging effect. Because a rem represents a fairly large dose equivalent, dose equivalents are expressed as fractions of a rem—millirem (mrem), which is 1/1000 of a rem. In the international system of units, 1 sievert (Sv) equals 100 rem; 1 millisievert (mSv) equals 100 mrem. Specific types of dose equivalents are defined as follows.

- committed dose equivalent—the total dose equivalent to an organ during the 50-year period following intake.
- effective dose equivalent (EDE)—the weighted sum of dose equivalents to a specified list of organs. The organs and weighting factors are selected on the basis of risk to the entire body. "EDE" is the unit used in the *Annual Site Environmental Report.*
  - committed effective dose equivalent—the total effective dose to specified organs in the human body during the 50-year period following intake.
  - collective effective dose equivalent—the sum of effective dose equivalents of all members of a given population.

Dose Determination

Determining dose is an involved process in which complex mathematical equations based on several factors, including the type of radiation, the rate of exposure, weather conditions, and typical diet, are used. Basically, radioactive decay, or activity, generates radiant energy. People absorb some of the energy to which they are exposed. The effect of this absorbed energy is responsible for an individual's dose. Whether radiation is natural or human-made, it has the same effect on people.

Many terms are used to report dose. The terms take several factors into account, including the amount of radiation absorbed, the organ absorbing the radiation, and the effect of the radiation over a 50-year period. The term "dose," in this report, means the committed EDE, which is the

Units of Radiation Measure

To comply with DOE orders, this report will present results using the current system followed by Système International (SI) units in parentheses. For example, the dose from a typical chest X ray is 10 mrem (0.10 mSv).

Current System	SI System	Conversion
Activity		
curie (Ci)	becquerel (Bq)	1 Ci = 3.7×10^{10} Bq
Absorbed dose		
rad (radiation absorbed dose)	gray (Gy)	1 rad = 0.01 Gy
Dose equivalent		
rem (roentgen equivalent man	sievert (Sv)	1 rem = 0.01 Sv

Converting Dose Equivalent

Because a rem represents a fairly large dose of radiation, dose is best expressed as a millirem, or 1/1000 of a rem. The same is true of sieverts. Dose is expressed in millisieverts (mSv). Because 1 mrem equals 0.01 mSv, converting from millirem to millisieverts is simply a matter of moving the decimal point two places to the left. For example, 267 mrem equals 2.67 mSv.

total effective dose equivalent that will be received during a specified time (50 years) from radionuclides taken into the body in the current year, and the EDE attributable to penetrating radiation from sources external to the body.

Dose Conversion Factor

A dose conversion factor (DCF) is defined as the dose equivalent received from exposure to a unit quantity of a radionuclide by way of a specific exposure pathway. Two types of DCFs exist. One type gives the committed dose equivalent (rem) resulting from intake (by inhalation and ingestion) of a unit activity (1.0 μCi) of a radionuclide. The second gives the dose equivalent rate (millirem per year) per unit activity (1.0 μCi) of a radionuclide in a unit (cubic or square centimeters) of an environmental compartment (air volume or ground surface). All DCFs used in this report were approved by DOE or by EPA (DOE 1988a; DOE 1988b; Beres 1990; EPA 1988; EPA 1993b).

Comparison of Dose Levels

Table A.2 presents a scale of dose levels, with an example of the type of exposure that may cause such a dose, or the special significance of such a dose. This information is intended to help the reader become familiar with a range of doses that various individuals may receive.

The maximally exposed person living near the ORR area could receive an annual EDE of about 3 mrem (0.03 mSv) from radionuclides released from the ORR during 1993.

Dose from Cosmic Radiation

The average annual dose equivalent to people in the United States from cosmic radiation is about 27 mrem (0.27 mSv) (NCRP 1987). The average dose equivalent caused by cosmic radiation in Tennessee is about 45 mrem per year (0.45 mSv per year) (Tsakeres 1980). When shielding and the time spent indoors are considered, the dose for the surrounding population is reduced to 80%, or about 36 mrem (0.36 mSv) per year.

Dose from Terrestrial Radiation

The average annual dose from terrestrial gamma radiation is about 28 mrem (0.28 mSv) in the United States but varies geographically across the country (NCRP 1987). Typical reported values are about 16 mrem (0.16 mSv) on the Atlantic and Gulf coastal plains and about 63 mrem (0.63 mSv) on the eastern slopes of the Rocky Mountains. The average external gamma exposure rate in the vicinity of the ORR is about 8.7 μR/h, which results in an equivalent dose of about 53 mrem per year (0.53 mSv per year) (Myrick 1981).

Dose from Internal Radiation

The major contributors to the annual dose equivalent for internal radionuclides are the short-lived decay products of radon, which contribute an average dose of about 200 mrem (2.00 mSv) per year. This dose estimate is based on an average radon concentration of about 1 pCi/L (0.037 Bq/L) (NCRP 1987).

The average dose from other internal radionuclides is about 39 mrem (0.39 mSv) per year, which is predominantly attributed to the naturally occurring radioactive isotope of potassium, ^{40}K. The concentration of radioactive potassium in human tissues is similar in all parts of the world (NCRP 1987).

Table A.2. Comparison and description of various dose levels

Dose level	Description
1 mrem	Approximate daily dose from natural background radiation, including radon
2.5 mrem	Cosmic dose to a person on a one-way airplane flight from New York to Los Angeles
10 mrem	Annual exposure limit set by EPA for exposures from airborne emissions from operations of nuclear fuel cycle facilities, including power plants, uranium mines, and mills
45 mrem	Average yearly dose from cosmic radiation received by people in the Paducah area
46 mrem	Estimate of the largest dose any off-site person could have received from the March 28, 1979, Three Mile Island nuclear accident
66 mrem	Average yearly dose to people in the United States from human-made sources
100 mrem	Annual limit of dose from all DOE facilities to a member of the public who is not a radiation worker
110 mrem	Average occupational dose received by U.S. commercial radiation workers in 1980
244 mrem	Average dose from an upper gastrointestinal diagnostic X-ray series
300 mrem	Average yearly dose to people in the United States from all sources of natural background radiation
1 to 5 rem	Level at which EPA Protective Action Guidelines state that public officials should take emergency action when this is a probable dose to a member of the public from a nuclear accident
5 rem	Annual limit for occupational exposure of radiation workers set by the U.S. Nuclear Regulatory Commission and DOE
10 rem	Estimated level at which an acute dose would result in a lifetime excess risk of death from cancer 0.8%
25 rem	EPA guideline for voluntary maximum dose to emergency workers for non-lifesaving work during an emergency
75 rem	EPA guideline for maximum dose to emergency workers volunteering for lifesaving work
50 to 600 rem	Level at which doses received over a short period of time produce radiation sickness in varying degrees. At the lower end of this range, people are expected to recover completely, given proper medical attention. At the top of this range, most people will die within 60 days

Adapted from *Savannah River Site Environmental Report for 1993, Summary Pamphlet*, WSRC-TR-94-076, Westinghouse Savannah River Company, 1994.

Dose from Consumer Products

The U.S. average annual dose to an individual from consumer products is about 10 mrem (0.10 mSv) (NCRP 1987); however, not all members of the U.S. population are exposed to all of these sources.

Dose from Medical Sources

Nuclear medicine examinations, which involve internal administration of radiopharmaceuticals, generally account for the largest portion of dose from human-made sources. However, the radionuclides used for specific tests are not distributed uniformly throughout the body. In these cases, the concept of EDE, which relates the significance of exposures of organs or body parts to the effect on the entire body, is useful in making comparisons. The average annual EDE from medical examinations is 53 mrem (0.53 mSv), including 39 mrem (0.39 mSv) for diagnostic X rays and 14 mrem (0.14 mSv) for nuclear medicine procedures (NCRP 1989). The actual doses to individuals who receive such medical exams are much higher than these values, but not everyone receives such exams each year (NCRP 1989).

Dose from Other Sources

A few additional sources of radiation contribute minor doses to individuals in the United States. The dose to the general public from nuclear fuel cycle facilities, such as uranium mines, mills, fuel-processing plants, nuclear power plants, and transportation routes, has been estimated at less than 1 mrem (0.01 mSv) per year (NCRP 1987).

A comprehensive U.S. Environmental Protection Agency report projected an average occupational dose to monitored radiation workers in medicine, industry, the nuclear fuel cycle, government, and miscellaneous industries to be 105 mrem (1.05 mSv) per year for 1985, down slightly from 110 mrem (1.10 mSv) per year in 1980 (Kumazawa et al. 1984).

Small doses to individuals occur as a result of radioactive fallout from atmospheric atomic bomb tests, emissions of radioactive materials from nuclear facilities, emissions from certain mineral-extraction facilities, and transportation of radioactive materials. The combination of these sources contributes less than 1 mrem (0.01 mSv) per year to the average dose to an individual (NCRP 1987).

Appendix B: Chemicals

This appendix presents basic facts about chemicals. The information is intended to be a basis for understanding the dose or relative toxicity assessment associated with releases from the Oak Ridge Reservation (ORR), not a comprehensive discussion of chemicals and their effects on the environment and biological systems.

PERSPECTIVE ON CHEMICALS

The lives of modern humans have been greatly improved by the development of chemicals such as pharmaceuticals, building materials, housewares, pesticides, and industrial chemicals. Through the use of chemicals we can increase food production, cure diseases, build more efficient houses, and send people to the moon. At the same time we must be cautious to ensure that our own existence is not endangered by uncontrolled and overexpanded use of chemicals (Chan et al. 1992).

Just as all humans are exposed to radiation in the normal daily routine, humans are also exposed to chemicals. Some potentially hazardous chemicals do exist in the natural environment. In many areas of the country, soils contain naturally elevated concentrations of metals such as selenium, arsenic, or molybdenum, which may be hazardous to humans or animals. However, exposures to many more hazardous chemicals result from the direct or indirect actions of humans. Building materials used for the construction of homes may contain chemicals such as formaldehyde (in some insulation materials), asbestos (formerly used in insulations and ceiling tiles), and lead (formerly used in paints). Some chemicals are present as a result of application of pesticides and fertilizers to soil. Other chemicals may have been transported long distances through the atmosphere from industrial sources before being deposited on soil or water.

PATHWAYS OF CHEMICALS FROM THE ORR TO THE PUBLIC

Pathways refer to the route or way in which a person can come in contact with a chemical substance. Chemicals released to the air may remain suspended for long periods of time, or they may be deposited on plants, soil, and water. Chemicals may also be released as liquid wastes called effluents, which can enter streams and rivers.

People are exposed to chemicals by inhalation (breathing air), ingestion (eating exposed plants and animals or drinking water), or by direct contact (touching the soil or swimming in water). For example, fish in a river that receives effluents may take in some of the chemicals present. People eating the fish would then be exposed to the chemical. Less likely would be exposure by directly drinking from the stream or river.

The public is not normally exposed to chemicals on the ORR because access to the reservation is limited. However, chemicals released as a result of ORR operations can move through the environment to off-site locations, resulting in potential exposure to the public.

DEFINITIONS

Toxicity

Chemicals have varying types of effects. Generally, when considering human health, chemicals are divided into two broad categories: chemicals that cause health effects but do not cause cancer (noncarcinogens) and chemicals that cause cancer (carcinogens). The potential health effects of noncarcinogens range from irritation to life-shortening. Carcinogens cause or increase the incidence of malignant neoplasms or cancers.

Toxicity refers to an adverse effect of a chemical on human health. Not all chemicals are toxic: every day we ingest chemicals in the form of food, water, and sometimes medications. Even those chemicals that are usually considered toxic are usually nontoxic or harmless below a certain concentration.

Concentration limits or advisories are set by government agencies for some chemicals that are known or thought to have an adverse effect on human health. These concentration limits can be used to calculate a chemical dose that would not harm even individuals who are particularly sensitive to the chemical.

Dose Terms for Noncarcinogens

Reference Dose (RfD)

An estimate (with uncertainty spanning an order of magnitude or greater) of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. Units are expressed as milligrams per kilogram per day (mg kg^{-1} day^{-1}).

Values for RfDs are derived from doses of chemicals that result in no adverse effect or the lowest dose that showed an adverse effect on humans or laboratory animals. Because these doses are in most cases derived from animal studies, safety factors are added for application to humans. Safety factors range from 10 to 1000 (i.e., safe doses for humans are set at 10 to 1000 times lower than doses showing no effect or a non-life-threatening effect in animals). This is thought to protect the most sensitive individuals. The U.S. Environmental Protection Agency (EPA) maintains the Integrated Risk Information System (IRIS) data base (EPA 1991), which contains verified RfDs and slope factors and up-to-date health risk and EPA regulatory information for numerous chemicals.

Primary and secondary maximum contaminant level

For chemicals for which RfDs are not available, national primary [maximum contaminant levels (MCLs)] and secondary drinking water regulation [secondary MCLs (SMCLs)] concentrations, expressed in milligrams per liter, are converted to RfD values by multiplying by 2 L (the average daily adult water intake) and dividing by 70 kg (the reference adult body weight). The result is a "derived" reference dose expressed in milligrams per kilogram per day (mg kg^{-1} day^{-1}).

Dose Term for Carcinogens

Slope factor (SF)

A plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor is used to estimate an upper-bound probability of

an individual developing cancer as a result of a lifetime exposure to a particular level of a potential carcinogen. Units are expressed as risk per dose (mg kg^{-1} day^{-1}).

The SF converts the estimated daily intake averaged over a lifetime exposure to the incremental risk of an individual developing cancer. Because it is unknown whether a threshold (a dose below which no adverse effect occurs) exists for carcinogens, units for carcinogens are set in terms of risk factors. For potential carcinogens at the ORR, a specific risk of developing cancer over a human lifetime of 1 in 100,000 (10^{-5}) was used to establish acceptable levels of exposure. That is, EPA estimates that a certain concentration in food or water could cause a risk of one additional cancer case for every 100,000 exposed persons.

MEASURING CHEMICALS

Environmental samples are collected in areas surrounding the ORR and are analyzed for chemical constituents that are most likely to be released from the ORR. Typically, chemical concentrations in liquids are expressed in terms of milligrams or micrograms of chemical per liter of water; concentrations in solids (soil and fish tissue) are expressed in terms of milligrams or micrograms of chemical per gram or kilogram of sample material.

The instruments used to measure chemical concentrations are very sensitive; however, they have limits, beyond which they cannot detect the chemicals of interest. Concentrations that are below the detection limits of the instruments are recorded as "less-than" (<) values or with tildes (~). Exposure calculations are given "less-than" values unless at least one sample exceeds the detection limit. The tilde indicates that estimated values and/or detection limits were used in estimating the average concentration of a chemical.

RISK ASSESSMENT METHODOLOGY

Exposure Assessment

To evaluate an individual's exposure by way of a specific exposure pathway, the intake amount of the chemical must be determined. For example, chemical exposure by drinking water and eating fish from the Clinch River is assessed in the following way. It is assumed that individuals outside the ORR boundary are exposed to statistically significant concentrations of contaminants. It is also assumed that they drink 2 L (0.53 gal) of water per day directly from the river, which amounts to 730 L (193 gal) per year, and that they eat 58 g (0.13 lb) of fish per day [21.2 kg (46.7 lb) per year]. Estimated daily intakes or estimated doses to the public can be calculated by multiplying measured concentrations in water by 2 L or those in fish by 58 g. These are conservative assumptions that in many cases result in higher estimated intakes and doses than an actual individual would receive.

Dose Estimate

Once the contaminant oral daily intake via exposure pathways is estimated, the dose can be determined. For chemicals, dose to humans is measured in terms of milligrams per kilogram per day (mg kg^{-1} day^{-1}). In this case, the "kilogram" refers to the body weight of an adult individual. When we calculate a chemical dose, the length of time an individual is exposed to a certain concentration is important. To assess off-site doses, it is assumed that the exposure duration occurs over a lifetime, which is defined as 70 years. Such exposures are called chronic in contrast to short-term exposures, which are called acute.

Calculation Methodology

In previous annual environmental reports, the "calculated daily intakes," based on chemical concentrations in water or fish, were divided by the "acceptable daily intake," which was based on the RfD. Both intakes were expressed in milligrams per day by multiplying by 70 kg for body weight. Current risk assessment methodologies use the term hazard quotient (HQ) to evaluate noncarcinogenic health effects. Therefore, in this environmental report the HQ methodology is used. Because intakes are calculated in milligrams per kilogram per day in the HQ methodology, they are expressed in terms of dose. The HQ compares the estimated exposure dose (I) to the RfD as follows:

$$HQ = \frac{I}{RfD} ,$$

where

HQ = hazard quotient (unitless),
I = estimated dose (mg kg^{-1} day^{-1}),
RfD = reference dose (mg kg^{-1} day^{-1}).

HQ values of less than 1 indicate an unlikely potential for adverse health effects, whereas HQ values greater than 1 indicate a concern for adverse health effects or the need for further study.

To evaluate carcinogenic risk, SFs are used instead of RfDs. In this report, we compare the estimated dose attributed from ingesting water or fish from rivers and streams surrounding ORR to the chronic daily intake (CDI) derived from assuming a human lifetime risk of developing cancer of 10^{-5} (1 in 100,000). The SF is converted to a CDI as follows:

$$CDI = \frac{1 \times 10^{-5}}{SF} ,$$

where

CDI = chronic daily intake (mg kg^{-1} day^{-1}),
SF = slope factor, oral (risk per mg kg^{-1} day^{-1}).

In typical risk assessments risks are generally derived; however, in this report we assume 10^{-5} as the level of acceptable risk. To estimate the risk of inducing cancers, from ingestion of water and fish, relative to the risk of 10^{-5}, the estimated dose (I) is divided by the CDI. A ratio greater than 1 indicates a risk greater than 10^{-5}.

Appendix C: Air Permits

Table C.1. Air permits at the Y-12 Plant

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
		Part I—operating permits at Y-12 Plant		
Y-9201-1-A	01-0020-15	730303P	582	Weld booths sanders and grinders
			583	Metal sanders and grinders
			584	Plasma torch
			585	Grinding room area exhaust
Y-9201-1-B	01-0020-59	730310P	586	Tool grinding machine shop
			587	Sand blaster exhaust
Y-9201-1-C	01-0020-17	036057P	278	Graphite carbon machine shop
			279	Graphite carbon machine shop
Y-9201-1-E	01-1020-92	035050P	00	Lead machining operations
			6	Welding shop sanding
Y-9201-1W-A	01-0020-99	036129P	00	Machine shop equipment
			272	Grit blasting
Y-9201-4-A	01-1020-96	032956P	264	Mercury flasking hood
Y-9201-5-H	01-0020-16	026019P	762	Mixing process material
			763	Setup and sample area
			764	Vapor blaster
			765	Nickel plating tank exhaust
			766	Material handling
			767	Material handling
			768	Glovebox and blending station
			769	Inspection house vacuum
Y-9201-5-J	01-0020-21	730305P	276	Tool grinding machine shop
Y-9201-5E-B	01-0020-21	730305P	273	Electrochemical machine shop
			71	Machining operations L5N
			72	Vacuum inlets L5E machining
			73	Palarite shop—Machine
Y-9201-5N-A	01-1020-18	730314P	67	Machine shop exhaust
Y-9201-5N-B	01-0020-30	030484P	239	Plating tanks and hoods
			240	Plating tanks and hoods
			241	Plating tanks and hoods
			242	Incinerator
			243	Grit blaster
			244	Grit blaster and area exhaust
			245	Process hoods
			454	Plating hoods
			8	Degreaser (removed)
Y-9201-5W-I	01-0020-24	730305P	00	Machine shop equipment
			455	Rubber-gel potting hood exhaust
Y-9202-A	01-0020-06	031696P	160	Laboratory beryllium
			161	Laboratory beryllium
			3	Laboratory beryllium
			4	Laboratory beryllium

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
Y-9204-2-A	01-0020-46	026107P	301	Storage tank
			302	Storage tank
			303	Storage tank
			304	Storage tank
			305	Storage tank
			306	Storage tank
			307	Storage tank
			308	Storage tank
			309	Storage tank
			310	Storage tank
			311	Storage tank/head tank
			312	Storage tank
Y-9204-2-D	01-1020-57	730327P	342	Salvage vats
			343	Storage tank
			344	Lithium chloride crystallizer
			345	Lithium chloride crystallizer
			346	Neutralizer
			347	Processor tank
			348	Lithium chloride crystallizer
			349	Processor tanks
			350	Processor tank
Y-9204-2-E	01-1020-55	730325P	351	Oven
			352	Oven
			356	Tungsten screener
			357	Dry box vent
			358	Material handling
			359	Gloveboxes
			360	Outgassing/annealing oven
			361	Material handling
			362	Gloveboxes
			363	Reactor unloading station
			364	Reactor unloading station
			365	Metal ingot storage glovebox
			366	New metal ingot storage glovebox
Y-9204-2-F	01-0020-51	730309P	368	Classified
			369	Classified
			370	Classified
Y-9204-2E-A	01-1020-91	730312P	202	Positive ion accelerator
			436	Oven
			439	Hood exhaust
			441	Hood
			442	Hood
			443	Perc degreaser
			444	Chromic acid eletcropolish
			445	Surface coating

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
Y-9204-3-A	01-0020-89	018208P	106	Furnaces
Y-9204-4-B	01-0020-72	730313P	481	Exhaust from machining operations
			482	Exhuast from hood—reclamation
			484	Rolling mill—1st floor
			485	Exhaust from paint hood
			486	Filtering exhaust from paint booths
			488	Laboratory hoods—1st floor
			489	Laboratory hoods—reclamation area
			490	Assembly process—1st floor
			491	Assembly process—1st floor
Y-9204-4-E	01-0020-33	032932P	258	Plating equipment
			259	Plating equipment
			260	Plating equipment
			261	Plating equipment
Y-9206-A	01-0020-48	012892P	421	Storage tank
Y-9206-B	01-0020-03	731689P	013	South stack incinerator
			015	West stack
			016	Dissolving hood
			017	Steam cleaning hoods
			115	Reduction fluid bed
			135	AEC scrubber stack
			136	AEC consolidated stack
			208	Conversion fluid bed
			209	HF purge vent
			210	Chemical makeup area
			211	Hood 29 and 30
			212	DRY vacuum system
Y-9206-C	01-1020-24	730316P	12	Classified
			14	Uranium alloy production
Y-9212-A	01-1020-72	036942P	111	Reduction fluid bed
			112	Conversion fluid beds
			132	Decontamination facility
			134	B-Wing and C-1 Wing exhaust
			19	FILT Exhaust
			21	Centrifuges
			22	Reduction salvage crusher
			24	Calciner and dry vacuum system enclosure
			25	Denitrator area and fluid bed room enclosure
			27	D-Wing room 1010 hoods
			28	Reduction shear and room
			33	Headhouse equipment incinerator
			36	East scrubber (C-1 wing)
			40	B-1 sampling lab hood

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
			42	Chloride removal system (C-1)
			429	Fluorine cylinder rack enclosure
			430	HF dock cylinder/vaporizer
			431	N_2O_4 cylinder purge vent
			432	Muffle furnaces (2) vent Room 229
			50	C-1 chip burner enclosure
			500	Primary extraction vent
			501	Secondary extraction vent
Y-9212-B	01-0020-02	730301P	110	U metal and U metal alloy
			38	U metal drying and briquetting process
			43	Exhaust from chip washing
			48	E-Wing machine shop
Y-9212-C	01-0020-05	025984P	113	Dissolver trays/scrubber
			114	Shear and hacksaw hood
			128	Precipitation process
			26	Drum receiving/sampling hood and glovebox
			290	Tube furnace/gas purge vent
			44	Leaching and dissolving hoods
			45	Muffle furnance dry hoods
			46	Tray dissolver hoods
			47	Dissolver tray hoods/room 1
Y-9215-A	01-0020-37	731839P	3	Machine shop hood exhaust
Y-9215-B	01-1020-51	732125P	1	O-wing metal working operations
			2	Turco pretreat spray hood
			4	O-wing metal working operations
			6	O-wing metal working operations
Y-9215-D	01-1020-53	025966P	10	Roll mill exhaust
			11	Furnance/quench tank/conveyor exhaust
			12	Hydraulic shear exhaust
			9	Rolling mill/ salt bath
Y-9401-3-A	01-1020-31	034809F	170	Coal-fired boiler
Y-9401-3-B	01-1020-32	034809F	170	Coal-fired boiler
Y-9401-3-C	01-1020-33	034809F	171	Coal-fired boiler
Y-9401-3-D	01-1020-34	034809F	171	Coal-fired boiler
Y-9404-11-A	01-1020-81	28426P	373	Purification plant reator
			374	Purification plant glovebox
			375	Purification plant glovebox
			376	Purification plant glovebox
Y-9404-5-A	01-0020-25	012866P	676	Paint spray booth
			677	Paint spray booth
Y-9404-7-A	01-1020-89	034295P	00	Maintenance shop
Y-9404-9-C	01-1020-19	730315P	323	Halar oven
			324	Urethane warming oven

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
			325	Urethane oven #3
			326	PVC oven #4
			327	PVC oven #5
			328	Steam autoclave
			329	General use oven
			330	Halar spray booth
			331	Blue M oven
			332	Drape forming equipment
			333	Vacuum system
			336	Despatch oven
			337	Rubber preparation equipment
			338	Lab hood
			339	Despatch oven
			340	Vacuum pumps
			341	Plastics fume hood
Y-9616-10-A	01-1020-62	029280P	428	Sulfuric acid storage tank
Y-9616-7-A	01-1020-80	031254P	271	Vent from air stripper
Y-9616-7-B	01-1020-74	737019P	459	West end treatment storage
			460	West end treatment storage
			461	West end treatment storage
			462	West end treatment storage
			463	West end treatment vent reactor vessel
			464	West end treatment storage
			465	West end treatment vent degasifier unit
			466	West end treatment storage
			467	West end treatment storage
			468	West end treatment storage
			469	West end treatment vent lime silo
			470	West end treatment storage
			471	WETF laboratory hood
			472	WETF sodium hydroxide tank
			473	WETF clarifier (6-315)
			650	Biological treatment tank
			651	Biological treatment tank
			652	Biological treatment tank
			653	Biological treatment tank
			654	Biological treatment tank
			655	Biological treatment tank
			656	Solids storage tank
			657	Solids storage tank
			658	Solids storage tank
			659	Solids storage tank
			660	Solids storage tank
			661	Solids storage tank
			662	Solids storage tank

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
			665	WETF-F-380A sludge settling
			666	WETF-F-380B sludge settling
			667	WETF-F-381A sludge concentrator
			668	WETF-F-381B sludge denitrator
			669	WETF-F-384 decant hold tank
			670	WETF-F-382 decant tank/30
			671	WETF-F-385 decant tank/30
			672	WETF-F-390A calcium carbonate
			673	WETF-F-390B calcium carbonate
			674	WETF-F-390C calcium carbonate
			675	WETF-F-400 F-401 slurry tank
Y-9720-12-A	01-1020-89	034295P	00	Non-special nuclear material
Y-9720-25-A	01-1020-89	034295P	00	Drum storage warehouse
Y-9720-28-A	01-1020-89	034295P	00	Drum storage warehouse
Y-9720-31-A	01-1020-89	034295P	00	RCRA and mixed waste storage
Y-9720-32-A	01-0020-42	032547P	201	Classified waste shredder
			435	Classified paper incinerator
Y-9720-44-A	01-1020-89	034295P	00	Low-level waste storage pad
Y-9720-58-A	01-1020-89	034295P	00	PCB and RCRA staging and storage
Y-9720-6-A	01-0020-26	012867P	678	Paint spray booth
			679	Oven
Y-9720-60-A	01-1020-89	034295P	00	DARA solids storage unit
Y-9720-9-A	01-1020-89	034295P	00	PCB and RCRA hazardous waste
Y-9738-A	01-0020-14	036776P	576	Sand blaster
			577	Hood with fan
			578	Sand blaster
			579	Hood with fan
			580	Hood with fan (removed)
Y-9767-4-B	01-0020-35	012877P	00	Chilled water circulating system
Y-9811-1-A	01-1020-95	731997P	400	Waste oil/storage bulk storage
			401	Waste oil/storage bulk storage
			402	Waste oil/storage bulk storage
			403	Waste oil/storage bulk storage
			404	Waste oil/storage bulk storage
			405	Waste oil/storage bulk storage
Y-9811-1-B	01-1020-89	034295P	00	Waste oil/solvent drum storage
Y-9811-6-A	01-1020-82	029415P	377	Dry ash handling system
			378	Dry ash handling system
Y-9811-8-A	01-1020-63	032988P	407	Waste oil/solvent storage
			408	Waste oil/solvent storage
			409	Waste oil/solvent storage
			410	Waste oil/solvent storage
			411	Waste oil/solvent storage
Y-9811-8-B	01-1020-89	034295P	00	Waste oil/solvent drum storage

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
Y-9815-A	01-0020-11	025895P	780	Vent from dissolvers
			781	Nitric acid storage tank
			782	Nitric acid storage tank
			783	Storage tank/4400 gal
			784	Storage tank/1800 gal
			785	2 storage tankS/2200 gal
Y-9818-A	01-0020-12	025965P	790	Hot well seal tank
			791	10 storage tanks—nitric acid
			792	Bioreactor tanks/ozonation
			793	Basement exhaust
			794	Nitric acid supply line vent
			795	Calcium acetate storage tank
			796	Nitric waste storage tank
			797	Nitric waste storage tank
			798	Nitric acid storage tank
			799	Nitric acid storage tank
			800	Ozone generator/area exhaust
			801	Nitric acid waste tank
			802	Caustic waste tank
			803	Still condensers
Y-9828-6-A	01-1020-89	034295P	00	Trash monitoring station
Y-9983-74-A	01-1020-89	034295P	00	Old salvage yard
Part II—construction permits at Y-12 Plant				
Y-9201-1-A	01-0020-15	730303P	582	Weld booths sanders and grinders
			583	Metal sanders and grinders
			584	Plasma torch
			585	Grinding room area exhaust
Y-9201-1-B	01-0020-59	730310P	586	Tool grinding machines
			587	Sand blaster exhaust
Y-9201-5-J	01-0020-21	730305P	276	Tool grinding machines
Y-9201-5E-B	01-0020-21	730305P	273	Electrochemical machine
			71	Machining operations L5N
			72	Vacuum inlets L5E machining
			73	Palarite shop—machine
Y-9201-5N-A	01-1020-18	730314P	67	Machine shop exhaust
Y-9201-5W-I	01-0020-24	730305P	00	Machine shop equipment
			455	Rubber-gel potting hood exhaust
Y-9204-2-D	01-1020-57	730327P	342	Salvage vats
			343	Storage tank
			344	Lithium chloride crystallizer
			345	Lithium chloride crystallizer
			346	Neutralizer
			347	Processor tank
			348	Lithium chloride crystallizer

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
			349	Processor tanks
			350	Processor tank
Y-9204-2-E	01-1020-55	730325P	351	Oven
			352	Oven
			356	Tungsten screener
			357	Dry box vent
			358	Material handling
			359	Gloveboxes
			360	Outgassing/annealing oven
			361	Material handling
			362	Gloveboxes
			363	Reactor unloading station
			364	Reactor unloading station
			365	Metal ingot storage glovebox
			366	New metal ingot storage glovebox
Y-9204-2-F	01-0020-51	730309P	368	Classified
			369	Classified
			370	Classified
Y-9204-2E-A	01-1020-91	730312P	202	Positive ion accelerator
			436	Oven
			439	Hood exhaust
			441	Hood
			442	Hood
			443	Perc degreaser
			444	Chromic acid electropolish
			445	Surface coating
Y-9204-4-B	01-0020-72	730313P	481	Exhaust from machining operations
			482	Exhaust from hood
			484	Rolling mill
			485	Exhaust from paint hood
			486	Filtering exhaust from paint booths
			488	Laboratory hoods
			489	Laboratory hoods
			490	Assembly process
			491	Assembly process
Y-9206-B	01-0020-03	731689P	013	South stack incinerator
			015	West stack
			016	Dissolving hood
			017	Steam cleaning hoods
			115	Reduction fluid bed
			135	AEC scrubber stack
			136	AEC consolidated stack
			208	Conversion fluid bed
			209	HF purge vent
			210	Chemical makeup area

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
			211	Hood 29 and 30
			212	Dry vacuum system
Y-9206-C	01-1020-24	730316P	12	Classified
			14	Uranium alloy production
Y-9212-B	01-0020-02	730301P	110	U metal and U metal alloy
			38	U metal drying and briquetting process
			43	Exhaust from chip washing
			48	E-wing machine shop
Y-9215-A	01-0020-37	731839P	3	Machine shop hood exhaust
Y-9215-B	01-1020-51	732125P	1	O-wing metal working operations
			2	Turco pretreat spray hood
			4	O-wing metal working operations
			6	O-wing metal working operations
Y-9404-9-C	01-1020-19	730315P	323	Halar oven
			324	Urethane warming oven
			325	Urethane oven #3
			326	PVC oven #4
			327	PVC oven #5
			328	Steam autoclave
			329	General use oven
			330	Halar spray booth
			331	Blue M oven
			332	Drape forming equipment
			333	Vacuum system
			336	Despatch oven
			337	Rubber preparation equipment
			338	Lab hood
			339	Despatch oven
			340	Vacuum pumps
			341	Plastics fume hood
Y-9616-7-B	01-1020-74	737019P	459	West end treatment storage
			460	West end treatment storage
			461	West end treatment storage
			462	West end treatment storage
			463	West end treatment vent reactor vessel
			464	West end treatment storage
			465	West end treatment vent degasifier unit
			466	West end treatment storage
			467	West end treatment storage
			468	West end treatment storage
			469	West end treatment vent lime silo
			470	West end treatment storage
			471	WETF laboratory hood
			472	WETF sodium hydroxide tank
			473	WETF clarifier (6-315)

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
			650	Biological treatment tank
			651	Biological treatment tank
			652	Biological treatment tank
			653	Biological treatment tank
			654	Biological treatment tank
			655	Biological treatment tank
			656	Solids storage tank
			657	Solids storage tank
			658	Solids storage tank
			659	Solids storage tank
			660	Solids storage tank
			661	Solids storage tank
			662	Solids storage tank
			665	WETF-F-380A sludge settling
			666	WETF-F-380B sludge settling
			667	WETF-F-381A sludge concentrator
			668	WETF-F-381B sludge denitrator
			669	WETF-F-384 decant hold tank
			670	WETF-F-382 decant tank/30
			671	WETF-F-385 decant tank/30
			672	WETF-F-390A calcium carbonate
			673	WETF-F-390B calcium carbonate
			674	WETF-F-390C calcium carbonate
			675	WETF-F-400 F-401 slurry tank
Y-9811-1-A	01-1020-95	31997P	400	Waste oil/storage bulk storage tank
			401	Waste oil/storage bulk storage tank
			402	Waste oil/storage bulk storage tank
			403	Waste oil/storage bulk storage tank
			404	Waste oil/storage bulk storage tank
			405	Waste oil/storage bulk storage tank

Table C.2. ORNL air pollution emission sources permitted with the Tennessee Department of Environment and Conservation

Source number	Emission source reference number	TDEC permit number	Source description
X-2519-1/5	73-0112-03	030284P	Steam plant
X-2522-T1A	73-0112-10	024114P	No. 2 fuel oil storage tank
X-2525-SV-11	73-0112-49	035026P	Electroplating
X-2547-01	73-0112-27	740817P	Surface coating spray booth
X-3039	73-0112-93	035494P	Off gas and hot cell ventilation
X-3500-SV12	73-0112-73	036689P	Electric belt furnace
X-3502-01	73-0112-05	030881P	Spray booths (3)
X-3502-09	73-0112-94	027194P	Hood gluing
X-3502-SV1	73-0112-39	023808P	Oven curing
X-3502-SV2	73-0112-40	023807P	Oven tempering
X-3502-SV4	73-0112-30	036053P	Carpenter shop
X-3544-SV1	73-0112-70	730468P	PWTP
X-3587-SV1	73-0112-56	029830P	Printed circuit board facility
X-3608-01	73-0112-37	730489P	NRWTP air stripper column
X-4508-SV8	73-0112-61	040077P	Acid etching process
X-4508-SV9	73-0112-55	024306P	Sandblaster
X-7002-04	73-0112-08	037231P	Vehicle spray booth
X-7005-00	73-0112-45	037516P	Lead shop machining operation
X-7005-3/7	73-0112-26	739585P	Five lead melting furnaces
X-7007-1/2	73-0112-09	030824P	Spray booth and cleaning booth
X-7021-00	73-0112-58	038357P	Grinding shop and sandblaster
X-7057-SV1	73-0112-76	030101P	Sandblaster
X-7069-T1	73-0112-60 NSPS	730836P	Gasoline storage tank
X-7600-01	73-0112-20	017930P	Nuclear fuel reprocessing
X-7602-01	73-0112-24	027090P	Boiler
X-7603-01	73-0112-25	740219F	Steam-generating process
X-7667-0	73-0112-0067-6	73-0112-0067-6	Chemical detonation facility
X-7830-SV1	73-0112-71	731010P	Liquid Waste Solidification Project
X-7911-00	73-0112-82	034381P	HFIR
X-7934-SV2	73-0112-53	024912P	Silver recovery system
X-7935-SV1	73-0112-78	027393P	Equipment cleaning facility
X-FE	73-0112-97	029660P	Fugitive emission source
X-FLC	73-0112-99	034960P	Fluorescent lamp disposers

Table C.3. K-25 Site air permits

K-25 source number	Emission source reference number	Permit number	Source description	Permit type
K1004L	73-0106-35	012503P	Main vent of development facility	Operating
K1004THOOD	73-1106-04	024498P	Hood evacuates fumes from mixing epoxy resin and hardener	Operating
K1004TWIND3	73-1106-28	029901P	Fiber-winding spools with epoxy dip	Operating
K1004TWIND2	73-1106-28	029901P	Fiber-winding spools with epoxy dip	Operating
K1004TWIND4	73-1106-28	029901P	Fiber-winding spools with epoxy dip	Operating
K1004TWIND1	73-1106-28	029901P	Fiber-winding spools with epoxy dip	Operating
K1024FT1	73-0106-18	025655P	Filter test facility	Operating
K1037AVLISLCDEV	73-0106-69	029897P	Expansion Lab C spray coating W exhaust filters	Operating
K1037AVLISOOVEN	73-0106-73	029900P	Electric oxidation oven	Operating
K1037AVLISEXLAB	73-0106-68	031404P	Materials Test Unit (MTU)	Operating
K1037AVLISEXLAB	73-0106-68	031404P	Vacuum system vents	Operating
K1037AVLISEXLAB	73-0106-68	031404P	Materials-Handling Development Module (MHDM)	Operating
K1037AVLISEXLAB	73-0106-68	031404P	Electron Beam One (EB-1)	Operating
K1037AVLISLGB	73-0106-77	032345P	Grit blast facility with baghouse	Operating
K1037AVLISQOVEN	73-0106-79	034645P	Quincy oven	Operating
K1037AVLISGOVEN	73-0106-80	034646P	Grieve oven TB-500 electric	Operating
K1037AVLISFURN	73-0106-81	034647P	Huppert furnace	Operating
K1037MLBH	73-0106-84	035867P	Mechanical lab—shaping graphite and metal parts	Operating
K1037AVLISSSB	73-0106-85	035868P	Small sandblaster	Operating
K1037AVLISLAB	73-1106-35	932953P	AVLIS Lab—metallothermic reduction unit, chlorinator, construct and oxide cell	Permit to
K1037AVLISPRODCON	73-1106-36	933170P	Products conversion demonstration	Permit to construct
K1095PS1234	73-0106-14	734461P	Paint spray operation, one oven, two spray booths, and one silk screen degreaser	Operating
K1098FSB1	73-0106-13	034231P	Sandblast facility with baghouse and grit recycle	Operating
K1200CENTERBAY	73-0106-87	732346P	Two hoods vent mixing epoxy resins, coating fibers, winding fibers	Operating

Table C.3 (continued)

K-25 source number	Emission source reference number	Permit number	Source description	Permit type
K1202ST1	73-1106-20	033203P	Tank stores waste oils and solvents for incinerator	Operating
K1202ST2	73-1106-41	034392P	Tank stores waste oils and solvents for incinerator	Operating
K1401275029PL	73-0106-38	012506P	Plastic shop curing oen	Operating
K1401MSMC1	73-0106-32	017337P	Motor curing oven	Operating
K1401JIGANDFIXT	73-0106-71	029898P	Vacuum exhaust for parts fabrication in the jig and fixture shop	Operating
K1401PLS1,4,6	73-0106-72	029899P	Ovens 1, 4, and 6 used for curing plastic parts in the plastic shop	Operating
K1401CARPENTERSHOP	73-1106-40	032930P	Miscellaneous wood and acrylic plastic working operations with cyclone control	Operating
K25BULBCRUSHER	73-1106-43	934193P	Flourescent lamp disposers with fabric/carbon filters	Operating
K1414UNLGAS	73-1106-39	035063P	20,000-gal unleaded gasoline underground storage tank	Operating
K1414UG	73-0106-28	037113P	Methanol, unleaded gasoline storage tank	Operating
K1420PHILLIPSVA	73-0106-70	023798P	Phillips vapor degreaser, perchloroethylene	Operating
K1420DISASSEMBL	73-0106-74	032344P	Disassembly stand for dismantling parts	Operating
K1420A1	73-0106-82	034619P	Flammable materials storage tank	Operating
K1425WOSC	73-0106-11	029895P	Waste oil and solvent storage tanks	Operating
K1425WOSA	73-0106-11	029895P	Waste oil and solvent storage tanks	Operating
K1425WOSD	73-0106-11	029895P	Waste oil and solvent storage tanks	Operating
K1425WOSB	73-0106-11	029895P	Waste oil and solvent storage tanks	Operating
K1435TSCAINCIN	73-0106-78	032449I	TSCA Incinerator	Operating
K1435CTANKFARM	73-0106-75	024105P	Tank farm for hazardous liquid wastes	Operating
K15012720FO	73-0106-28	016312P	K-1501 613,000-gal fuel oil tank	Operating
K15012810FO	73-0106-28	016312P	K-1501 15,228-gal fuel oil tank	Operating
K1501BOILER4	73-0106-04	029902F	Natural gas boiler	Operating
K1501BOILER7	73-0106-07	029902F	Gas/oil boiler	Operating
K1501BOILER8	73-0106-12	937114F	Gas/oil boiler	Permit to construct

Table C.3 (continued)

K-25 source number	Emission source reference number	Permit number	Source description	Permit type
K1501BOILER9	73-0106-12	937114F	Gas/oil boiler	Permit to construct
K1600TTFL	73-0106-59	017053P	Development lab with two hoods and one small oven	Operating
K1652FECS	73-1106-42	733774P	Fire extinquisher charging station	Operating
K-25-B-1	73-0106-19	016309P	Heat exchange medium freon for plant	Operating

Appendix D: Drinking Water Standards

Table D.1. Reference standards for water

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish and aquatic life[c]	Tennessee water quality criteria—recreation "organisms-only" values[c]	4% of DOE DCG[d]	DOE DCG
Anions (mg/L)							
Chloride		250					
Fluoride	4	2					
Nitrate	10						
Nitrite	1						
Sulfate, as SO_4		250					
Base/neutral/acid extractable organics (μg/L)							
1,2-Dichlorobenzene	600				17,000		
1,2,4-Trichlorobenzene	70						
1,3-Dichlorobenzene					2,600		
1,4-Dichlorobenzene (para)	75	5	75		2,600		
2,4-Dinitrophenol					14,000		
2,4-Dinitrotoluene					91		
2,4,6-Trichlorophenol					65		
2-Methyl-4,6-Dinitrophenol					765		
3,4-Benzofluoranthene					0.49		
Benzo(k)fluoranthene					0.49		
Acenaphthylene					0.3		
Anthracene					110,000		
Benzo(a)anthracene					0.3		
Benzo(a)pyrene	0.2				0.3		
bis-(2-chloroethyl)ether					14		
bis-(2-ethylhexyl)phthalate					59		

Table D.1 (continued)

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish and aquatic life[c]	Tennessee water quality criteria—recreation "organisms-only" values[c]	4% of DOE DCG[d]	DOE DCG
Di-n-butyl phthalate					12,000		
Diethyl phthalate					120,000		
Dimethyl phthalate					2,900,000		
Fluoranthene					32		
Fluorene					14,000		
Hexachlorobenzene	1				0.007		
Hexachlorocyclopentadiene	50				17,000		
Hexachloroethane					89		
Nitrobenzene					1,900		
Pentachlorophenol	1			20			
Phenathrene					0.03		
Pyrene					11,000		
			Field measurements				
Dissolved oxygen, mg/L				5			
Temperature, °C			30.5		30.5		
Turbidity, JTU[e]	1						
pH, standard units		(6.5, 8.5)	(6.0, 9.0)	(6.5, 8,5)	(6.0, 9.0)		
			Metals (mg/L)				
Aluminum		0.2					
Antimony	0.006				4.31		

Table D.1 (continued)

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish and aquatic life[c]	Tennessee water quality criteria—recreation "organisms-only" values[c]	4% of DOE DCG[d]	DOE DCG
Arsenic	0.05		0.05	0.36			
Barium	2						
Beryllium	0.004				0.0013		
Cadmium	0.005		0.005	0.0039			
Chromium (hexavalent)	0.1		0.100	0.016	670		
Copper	1.3[f]	1		0.018			
Cyanide	0.2			0.022			
Iron		0.3					
Lead	0.015[f]		0.05	0.082			
Manganese		0.05					
Mercury	0.002		0.002	0.0024	0.00015		
Nickel	0.1			1.418	4.6		
Selenium	0.05		0.050	0.02			
Silver		0.1	NA	0.004			
Thallium	0.002						
Zinc		5		0.117			
			Others				
Asbestos (fibers/L)	7,000,000						
Coliform Bacteria (mL)	0.01						
Color (color units)		15					
Cyanide (mg/L)				0.022			
Odor (T.O.N.)		3					
Total dissolved solids, mg/L		500	500				

Table D.1 (continued)

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish and aquatic life[c]	Tennessee water quality criteria—recreation "organisms-only" values[c]	4% of DOE DCG[d]	DOE DCG
Pesticides/herbicides/PCBs (μg/L)							
2,3,7,8-TCDD (Dioxin)	0.00003				0.000001		
2,4-D	70						
2,4,5-TP (Silvex)	50						
4,4′-DDT				1.1	0.006		
4,4′-DDE					0.006		
4,4′-DDD					0.008		
Alachlor	2						
Aldicarb sulfoxide	4						
Aldrin				3	0.014		
Atrazine	3						
Carbofuran	40						
Chlordane	2			2.4	0.006		
Dalapon	200						
Dibromochloropropane	0.2						
Di(ethylhexyl)adipate	400						
Di(ethylhexyl)phthalate	7						
Dinoseb	7						
Diquat	20						
a-Endosulfan				0.22	159		
b-Endosulfan				0.22	159		

Table D.1 (continued)

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish and aquatic life[c]	Tennessee water quality criteria—recreation "organisms-only" values[c]	4% of DOE DCG[d]	DOE DCG
Endothall	100						
Endrin	2			0.18			
Ethylene dibromide	0.05						
Glyphosate	700						
Heptachlor	0.4			0.52	0.002		
Heptachlor epoxide	0.2			0.52	0.001		
g-BHC (Lindane)	0.2			2	0.63		
Methoxychlor	40						
Oxamyl (Vydate)	200						
PCB-1242					0.0005		
PCB-1254					0.0005		
PCB-1221					0.0005		
PCB-1232					0.0005		
PCB-1248					0.0005		
PCB-1260					0.0005		
PCB-1016					0.0005		
PCB, total	0.5				0.00045		
Picloram	500						

Table D.1 (continued)

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish and aquatic life[c]	Tennessee water quality criteria—recreation "organisms-only" values[c]	4% of DOE DCG[d]	DOE DCG
Simazine	4						
Toxaphene	3			0.73	0.008		
Radionuclides (pCi/L)[g]							
^{241}Am						1.2	30
^{214}Bi						24,000	600,000
^{109}Cd						400	10,000
^{143}Ce						1,200	30,000
^{60}Co						200	5,000
^{51}Cr						4,000	100,000
^{137}Cs						120	3,000
^{155}Eu						4,000	100,000
Gross alpha	15						
Gross beta	50[h]						
^{3}H	20,000					80,000	2,000,000
^{131}I						120	3,000
^{40}K						280	7,000
^{237}Np						1.2	30
^{234m}Pa						2,800	70,000
^{238}Pu						1.6	40
$^{239/240}$Pu						1.2	30
^{226}Ra	5					4	100

Table D.1 (continued)

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish and aquatic life[c]	Tennessee water quality criteria—recreation "organisms-only" values[c]	4% of DOE DCG[d]	DOE DCG
^{228}Ra	5					4	100
^{106}Ru						240	6000
Sr, total rad	8					40	1,000
^{99}Tc						4,000	100,000
^{228}Th						16	400
^{230}Th						12	300
^{232}Th						2	50
^{234}Th						400	10,000
Thorium, natural						2	50
^{234}U						20	500
^{235}U						24	600
^{238}U						24	600
Uranium, natural						24	600
Uranium, total[i]						20	500
			Volatile organics (μg/L)				
1,1,1-Trichloroethane	200		200		170,000		
1,1-Dichloroethene	7		7		32		
1,1,2-Trichloroethane	5				420		
1,1,2,2-Tetrachloroethane					110		
1,2-Dichloroethane	5		5		990		
1,2-Dichloroethene	70						

Table D.1 (continued)

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish and aquatic life[c]	Tennessee water quality criteria—recreation "organisms-only" values[c]	4% of DOE DCG[d]	DOE DCG
cis-1,2-Dichloroethene	70						
trans-1,2-Dichloroethene	100						
1,2-Dichloropropane	5						
cis-1,3-Dichloropropane					1,700		
trans-1,2-Dichloropropane					1,700		
Acrolein					780		
Acrylonitrile					6.7		
Benzene	5		5		710		
Bromodichloromethane	100[j]						
Bromoform	100[j]				4,700		
Carbon tetrachloride	5		5		44		
Chlorobenzene	100						
Chloroethane	200						
Chloroform	100[j]				4,700		
Dibromochloromethane	100[j]				4,700		
Ethylbenzene	700				29,000		
Methylene chloride					16,000		
Styrene	100						
Tetrachloroethene	5				88		
Toluene	1,000				300,000		
Trichloroethene	5		5		807		

Table D.1 (continued)

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish and aquatic life[c]	Tennessee water quality criteria—recreation "organisms-only" values[c]	4% of DOE DCG[d]	DOE DCG
Trihalomethanes, total	100				100		
Vinyl chloride	2		2		5,250		
Xylene, total	10,000						

[a]40 CFR Part 141—National Primary Drinking Water Regulations, Subparts B and G, as amended.

[b]40 CFR Part 143—National Secondary Drinking Water Regulations, as amended.

[c]Rules of Tennessee Department of Environment and Conservation, Division of Water Pollution Control, Chapter 1200-4-3, General Water Quality Criteria, as amended.

[d]DOE Order 5400.5, Chapter III, Derived Concentration Guides for Air and Water. Four percent of the DOE DCG to represent the DOE criterion of 4 mrem effective dose equivalent from ingestion of drinking water.

[e]JTU an NTU are roughly equivalent in the range of 25 to 1000 JTU.

[f]Action level, which is applicable to community water systems and non-transient, non-community water systems.

[g]Only the radiounuclides that were sought at the Oak Ridge Reservation are listed.

[h]Regulatory guide for assessing compliance without further analysis.

[i]Minimum of uranium isotopes.

[j]Limit for total trihalomethanes (bromodichloromethane + bromoform + chloroform + dibromochloromethane).

Appendix E: Underground Storage Tank Data

Table E.1. Underground storage tanks (USTs) at the Y-12 Plant

Location	Tank identification number	Installation date	Out-of-service date	Capacity (gallons)	Contents	Status	Preliminary investigation(s)	Environmental assessment ( ) date to regulatory agency	Corrective action
						Petroleum USTs			
9722-6	2312-U	1987	1994	550	Diesel	Inert filled 2/95	CR (4/95)	NA	NA
9722-5	2313-U	1987	1994	550	Diesel	Inert filled 2/95	CR (4/95)	NA	NA
9999-7	2316-U	1986	1994	550	Diesel	Inert filled 2/95	CR (4/95)	NA	NA
9999-5	2320-U	1986	1994	550	Diesel	Removed 2/95	CR (4/95)	NA	NA
9722-4	2333-U	1988	1994	550	Diesel	Inert filled 3/95	CR (4/95)	NA	NA
9714	2334-U	1987	In use	6,000	Gasoline	Full compliance	Site check	NA	NA
9714	2335-U	1987	In use	10,000	Diesel	Full compliance	Site check	NA	NA
9754-3	2396-U	1993	In use	10,000	Diesel	Full compliance	NA	NA	NA
9754-3	2397-U	1993	In use	20,000	Gasoline	Full compliance	NA	NA	NA
9712	0084-U	1958	1988	500	Used oil	Removed 6/88	CERCLA	TBD	TBD
9204-2	0134-U	1966	1982	117	Gasoline	Removed 8/88	ISCR, FPRR	SIR (3/92)	EAR/CAP (8/92), CAP approval (5/93), CR (4/94), SRF (1/95)
9754-2	0439-U	1978	1989	20,000	Gasoline	Removed 9/89	IAR, ISCR, FPRR	SIR/CAP (3/91)	CAP (7/92), CAP approval (5/93), BMR (3/94), SSSR (4/94)
9754-2	0440-U	1978	1989	10,000	Diesel	Removed 9/89	IAR, ISCR, FPRR	SIR/CAP (3/91)	CAP (7/92), CAP approval (5/93), BMR (3/94), SSSR (4/94)
9754	2073-U	1944	1979	1,000	Gasoline	Removed 10/93	SI	SIR/CAP (3/91)	CAP (7/92), CAP approval (5/93), BMR (3/94), SSSR (4/94)
9754	2074-U	1944	1979	1,000	Gasoline	Removed 10/93	SI	SIR/CAP (3/91)	CAP (7/92), CAP approval (5/93), BMR (3/94), SSSR (4/94)
9754	2075-U	1944	1979	1,000	Diesel	Removed 10/93	SI	SIR/CAP (3/91)	CAP (7/92), CAP approval (5/93), BMR (3/94), SSSR (4/94)
9754-1	1219-U	1964	1988	12,000	Diesel	Removed 12/89	EA	SIR (3/91)	CAP (5/92), SRF (2/94), SRF approval (3/94), SSSR (9/94), SSSR revised (1/95)
9754-1	1222-U	1968	1988	12,000	Gasoline	Removed 12/89	EA	SIR (3/91)	CAP (5/92), SRF (2/94), SRF approval (3/94), SSSR (9/94),

Table E.1 (continued)

Location	Tank identification number	Installation date	Out-of-service date	Capacity (gallons)	Contents	Status	Preliminary investigation(s)	Environmental assessment ( ) date to regulatory agency	Corrective action
9720-15	2068-U	1968	1980	1,000	Gasoline	Removed 2/90	EA/FPRR	SIR (3/91)	CAP (5/92), SRF (2/94), SRF approval (3/94), SSSR (9/94), SSSR revised (1/95)
9754-1	2082-U	1981	1988	8,000	Gasoline	Removed 12/89	EA	SIR (3/91)	CAP (5/92), SRF (2/94), SRF approval (3/94), SSSR (9/94), SSSR revised (1/95)
PRW	2310-U	1975	1989	200	Gasoline	Removed 11/89	ISCR	SIR/CAP (7/91)	EAR/CAP (3/93), CAP approval (12/93), OE (4/94, 5/94), CR (7/94)
9201-1	2331-U	1973	1988	560	Gasoline	Removed 12/88	ISCR, FPRR	SIR (3/92)	EAR/CAP (7/92), CAP approval (12/93), BMR (3/94), SRF (4/94), SRF approval (5/94)
9401-3	0713-U	1955	1988	10,500	No. 2 fuel oil	Removed 11/88	NI	NA	NA
9754	0836-U	1944	1989	10,000	Used oil	Removed 10/89	RCRA	RCRA	RCRA
9204-3	0928-U	1966	1989	200	Gasoline	Removed 5/89	RIR, closure approved 8/92	NA	NA
9995	2078-U	1965	1979	110	Gasoline	Inert filled 1979	CERCLA	TBD	TBD
9995	2079-U	1965	1979	55	Gasoline	Inert filled 1979	CERCLA	TBD	TBD
9996	2080-U	1971	1987	560	Gasoline	Removed 12/88	RIR	NA	NA
9212	2081-U	1958	1970	280	Gasoline	Removed 4/91	ISCR	NA	OE/CR (12/91)
9201-5	2099-U	1971	1989	560	Gasoline	Removed 7/89	IAR, RIR, closure approved 3/90	NA	NA
9929-1	2117-U	1971	1983	550	No. 2 fuel oil	Removed 10/88	NI	NA	NA
9204-4	2130-U	1960	1992	550	Gasoline	Removed 12/92	RIR	NA	NA
9999	2293-U	1954	1974	58	Gasoline	Removed 1974	NI	NA	NA
9999	2294-U	1954	1974	58	Gasoline	Removed 1974	NI	NA	NA
9998	2305-U	1956	1990	55	Diesel	Removed 10/90	RIR, closure approved 1/95	NA	NA

Table E.1 (continued)

Location	Tank identification number	Installation date	Out-of-service date	Capacity (gallons)	Contents	Status	Preliminary investigation(s)	Environmental assessment ( ) date to regulatory agency	Corrective action
PRE	2315-U	1960	1988	64	Gasoline	Removed 11/89	ISCR	EAR/CAP (2/91)	OE/CAR (12/92), closure approval 1/95
9769	2330-U	1949	1988	5,000	No. 2 fuel oil	Inert filled 4/88	NI	NA	NA
Chestnut Ridge	2336-U	1981	1991	550	Gasoline	Removed 5/91	RIR, closure approved 1/95	NA	NA
Buff. Mtn.	2337-U	1972	1990	250	Gasoline	Removed 3/90	IAR, ISCR	SIR (5/91), SIR Phase II (1/92)	Closure approval 2/95
9720-13	2338-U	1970	1984	200	Used oil	Removed 7/90	RIR	TBD	TBD
9219	2395-U	1964	1977	2,000	No. 2 fuel oil	Removed 6/93	NI	NA	NA
SYDD	2063-U	1959	1989	130	Oil/solvent	Removed 7/89	IAR, ISCR/FPRR	CERCLA	CERCLA
SYDD	2328-U	1959	1989	475	Oil/solvent	Removed 7/89	IAR, ISCR/FPRR	CERCLA	CERCLA
SYDD	2329-U	1959	1989	475	Oil/solvent	Removed 7/89	IAR, ISCR/FPRR	CERCLA	CERCLA
					Hazardous Substance USTs				
9767-13	2102-U	1987	1992	7,500	Methanol	Removed 1/93	CR	NA	NA
9418-3	2072-U	1943	1960	45,000	Solid uranium oxide	Exempt	CERCLA	CERCLA	CERCLA
9825-1	2129-U	1984	In use	240,000	Solid uranium oxide	Exempt	NA	NA	NA

Notes

BMR baseline monitoring report
CAP corrective action plan
CAR corrective action report
CERCLA conducted under the Comprehensive Environmental Response, Compensation and Liability Act
CR closure report
EA environmental assessment
EAR environmental assessment report
FPRR free product removal report
IAR initial abatement report
ISCR initial site characterization report
NA not applicable
NI not investigated
OE overexcavation
RCRA conducted under Resource Conservation and Recovery Act, Subtitle C
RIR release investigation report
TBD to be determined
SIR site investigation report
SRF site ranking form
SSSR site-specific standard request
SYDD salvage yard drum deheader

Appendix F: Errata

Appendix F: Errata

The following corrections pertain to the *Oak Ridge Reservation Annual Site Environmental Report for 1993* (Energy Systems 1994b).

Page	For	Read
4-6, Table 4.3, ^{239}Pu at Stack 3018	3.10E–01	3.1E–11
4-24, Table 4.13, K-1203 Sewage Treatment Plant, ^{228}Th		
Average	2.91E+02	2.50E+03
Percentage of DCG	7.27E+01[c]	5.21E+01[c]
All listed isotopes	8.61E–01[c]	6.55E–01[c]
5-8, Fig. 5.6, caption	Weekly averages for fluorides in ambient air at the Y-12 Plant, 1987–93.	Maximum annual average 7-day concentration for fluorides in ambient air at the Y-12 Plant.
5-21, "ORNL Reference Surface Water Monitoring," line 6	Fig. 4.15	Fig. 4.14

Glossary

AA — See atomic absorption spectrometry.

absorption — The process by which the number and energy of particles or photons entering a body of matter is reduced by interaction with the matter.

accuracy — The closeness of the result of a measurement to the true value of the quantity.

aliquot — The quantity of sample being used for analysis.

alkalinity — Alkalinity is a measure of the buffering capacity of water, and because pH has a direct effect on organisms as well as an indirect effect on the toxicity of certain other pollutants in the water, the buffering capacity is important to water quality.

alpha particle — A positively charged particle emitted from the nucleus of an atom having the same charge and mass as that of a helium nucleus (two protons and two neutrons).

ambient air — The surrounding atmosphere as it exists around people, plants, and structures.

analytical detection limit — The lowest reasonably accurate concentration of an analyte that can be detected; this value varies depending on the method, instrument, and dilution used.

analyte — A constituent or parameter that is being analyzed.

anion — A negatively charged ion.

aquifer — A saturated, permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients.

aquitard — A geologic unit that inhibits the flow of water.

ash — Inorganic residue remaining after ignition of combustible substances.

assimilate — To take up or absorb into the body.

atom — Smallest particle of an element capable of entering into a chemical reaction.

atomic absorption spectrometry (AA) — Chemical analysis performed by vaporizing a sample and measuring the absorbance of light by the vapor.

Atomic Energy Commission (AEC) — A federal agency created in 1946 to manage the development, use, and control of nuclear energy for military and civilian application. It was abolished by the Energy Reorganization Act of 1974 and succeeded by the Energy Research and Development Administration (now part of the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission).

base/neutral and acid extractables (BNA) — A group of organic compounds analyzed as part of Appendix IX of 40 CFR 264 and the EPA list of priority pollutants.

beta particle — A negatively charged particle emitted from the nucleus of an atom. It has a mass and charge equal to those of an electron.

biomass — The weight of any specific or general kind of organic matter, usually expressed per area or volume.

biota — The animal and plant life of a particular region considered as a total ecological entity.

blank — A control sample that is identical, in principle, to the sample of interest, except that the substance being analyzed is absent. In such cases, the measured value or signal for the substance being analyzed is believed to be a result of artifacts. Under certain circumstances, that value may be subtracted from the measured value to give a net result reflecting the amount of the substance in the sample. EPA does not permit the subtraction of blank results in EPA-regulated analyses.

calibration — Determination of variance from a standard of accuracy of a measuring instrument to ascertain necessary correction factors.

carcinogen — A cancer-causing substance.

cation — Positively charged ion.

CERCLA-reportable release — A release to the environment that exceeds reportable quantities as defined by CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act).

chain-of-custody — A form that documents sample collection, transport, analysis, and disposal.

chemical oxygen demand — Indicates the quantity of oxidizable materials present in a water and varies with water composition, concentrations of reagent, temperature, period of contact, and other factors.

chlorocarbons — Compounds of carbon and chlorine, or carbon, hydrogen, and chlorine, such as carbon tetrachloride, chloroform, tetrachloroethylene, etc. They are among the most significant and widespread environmental contaminants. Classified as hazardous wastes, chlorocarbons may have a tendency to cause detrimental effects, such as birth defects.

closure — Control of a hazardous waste management facility under RCRA requirements.

compliance — Fulfillment of applicable requirements of a plan or schedule ordered or approved by government authority.

concentration — The amount of a substance contained in a unit volume or mass of a sample.

conductivity — A measure of water's capacity to convey an electric current. This property is related to the total concentration of the ionized substances in water and the temperature at which the measurement is made.

confluence — The point at which two or more streams meet; the point where a tributary joins the main stream.

contamination — Deposition of unwanted material on the surfaces of structures, areas, objects, or personnel.

cosmic radiation — Ionizing radiation with very high energies, originating outside the earth's atmosphere. Cosmic radiation is one source contributing to natural background radiation.

count — The signal that announces an ionization event within a counter; a measure of the radiation from an object or device.

curie (Ci) — A unit of radioactivity. One curie is defined as 3.7×10^{10} (37 billion) disintegrations per second. Several fractions and multiples of the curie are commonly used:

kilocurie (kCi) — 10^3 Ci, one thousand curies; 3.7×10^{13} disintegrations per second.

millicurie (mCi) — 10^{-3} Ci, one-thousandth of a curie; 3.7×10^7 disintegrations per second.

microcurie (μCi) — 10^{-6} Ci, one-millionth of a curie; 3.7×10^4 disintegrations per second.

picocurie (pCi) — 10^{-12} Ci, one-trillionth of a curie; 0.037 disintegrations per second.

daughter — A nuclide formed by the radioactive decay of a parent nuclide.

decay, radioactive — The spontaneous transformation of one radionuclide into a different radioactive or nonradioactive nuclide, or into a different energy state of the same radionuclide.

dense nonaqueous phase liquid (DNAPL) — The liquid phase of chlorinated organic solvents. These liquids are denser than water and include commonly used industrial compounds such as tetrachloroethylene and trichloroethylene.

derived concentration guide (DCG) — The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air or inhalation), would result in either an effective dose equivalent of 0.1 rem (1 mSv) or a dose equivalent of 5 rem (50 mSv) to any tissue, including skin and lens of the eye. The guides for radionuclides in air and water are given in DOE Order 5400.5.

desorption — The process of removing a sorbed substance by the reverse of adsorption or absorption.

dilution factor — The mathematical factor by which a sample is diluted to bring the concentration of an analyte in a sample within the analytical range of a detector (e.g., 1 mL sample + 9 mL solvent = 1:10 dilution, or a dilution factor of 10).

disintegration, nuclear — A spontaneous nuclear transformation (radioactivity) characterized by the emission of energy and/or mass from the nucleus of an atom.

dissolved oxygen — A desirable indicator of satisfactory water quality in terms of low residuals of biologically available organic materials. Dissolved oxygen prevents the chemical reduction and subsequent leaching of iron and manganese from sediments.

dose — The energy imparted to matter by ionizing radiation. The unit of absorbed dose is the rad, equal to 0.01 joules per kilogram in any medium.

> **absorbed dose** — The quantity of radiation energy absorbed by an organ, divided by the organ's mass. Absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 Gy).
>
> **dose equivalent** — The product of the absorbed dose (rad) in tissue and a quality factor. Dose equivalent is expressed in units of rem (or sievert) (1 rem = 0.01 sievert).
>
> **committed dose equivalent** — The calculated total dose equivalent to a tissue or organ over a 50-year period after known intake of a radionuclide into the body. Contributions from external dose are not included. Committed dose equivalent is expressed in units of rem (or sievert).
>
> **committed effective dose equivalent** — The sum of the committed dose equivalents to various tissues in the body, each multiplied by the appropriate weighting factor. Committed effective dose equivalent is expressed in units of rem (or sievert).
>
> **effective dose equivalent** — The sum of the dose equivalents received by all organs or tissues of the body after each one has been multiplied by an appropriate weighting factor. The effective dose equivalent includes the committed effective dose equivalent from internal deposition of radionuclides and the effective dose equivalent attributable to sources external to the body.
>
> **collective dose equivalent/collective effective dose equivalent** — The sums of the dose equivalents or effective dose equivalents of all individuals in an exposed population within a 50-mile (80-km) radius, and expressed in units of person-rem (or person-sievert). When the collective dose equivalent of interest is for a specific organ, the units would be organ-rem (or organ-sievert). The 50-mile distance is measured from a point located centrally with respect to major facilities or DOE program activities.

dosimeter — A portable detection device for measuring the total accumulated exposure to ionizing radiation.

dosimetry — The theory and application of principles and techniques involved in the measurement and recording of radiation doses. Its practical aspect is concerned with using various types of radiation instruments to make measurements.

downgradient — In the direction of decreasing hydrostatic head.

downgradient well — A well that is installed hydraulically downgradient of a site and may be capable of detecting migration of contaminants from a site.

drinking water standards (DWS) — Federal primary drinking water standards, both proposed and final, as set forth by EPA.

duplicate samples — Two or more samples collected simultaneously into separate containers.

duplicate result — A result derived by taking a portion of a primary sample and performing the identical analysis on that portion as is performed on the primary sample.

effluent — A liquid or gaseous waste discharge to the environment.

effluent monitoring — The collection and analysis of samples or measurements of liquid and gaseous effluents for purposes of characterizing and quantifying the release of contaminants, assessing radiation exposures of members of the public, and demonstrating compliance with applicable standards.

Environmental Restoration — A DOE program that directs the assessment and cleanup of its sites (remediation) and facilities contaminated with waste as a result of nuclear-related activities.

exposure (radiation) — The incidence of radiation on living or inanimate material by accident or intent. Background exposure is the exposure to natural background ionizing radiation. Occupational exposure is that exposure to ionizing radiation that takes place during a person's working hours. Population exposure is the exposure to the total number of persons who inhabit an area.

external radiation — Exposure to ionizing radiation when the radiation source is located outside the body.

fecal coliform — The coliform group comprises all of the aerobic, non-spore-forming, rod-shaped bacteria. The test determines the presence or absence of coliform organisms.

formation — A mappable unit of consolidated or unconsolidated geologic material of a characteristic lithology or assemblage of lithologies.

friable asbestos — Asbestos that is brittle or readily crumbled.

gamma ray — High-energy, short-wavelength electromagnetic radiation emitted from the nucleus of an excited atom. Gamma rays are identical to X rays except for the source of the emission.

gamma spectrometry — A system consisting of a detector, associated electronics, and a multichannel analyzer that is used to analyze samples for gamma-emitting radionuclides.

genotoxicology — The study of the effects of chemicals or radioactive contaminants on the genetics of individual animals or plants.

grab sample — A sample collected instantaneously with a glass or plastic bottle placed below the water surface to collect surface water samples (also called dip samples).

groundwater, unconfined — Groundwater exposed to the unsaturated zone.

half-life, biological — The time required for a biological system, such as that of a human, to eliminate by natural processes half the amount of a substance (such as a radioactive material) that has entered it.

half-life, radiological — The time required for half of a given number of atoms of a specific radionuclide to decay. Each nuclide has a unique half-life.

halogenated compound — An organic compound bonded with one of the five halogen elements (astatine, bromine, chlorine, fluorine, and iodine).

halomethane — Any compound that includes a methane group (CH_3) bonded to a halogen element (astatine, bromine, chlorine, fluorine, or iodine).

hardness — Water hardness is caused by polyvalent metallic ions dissolved in water. In fresh water, these are mainly calcium and magnesium, although other metals such as iron, strontium, and manganese may contribute to hardness.

heavy water — Water in which the molecules contain oxygen and deuterium, an isotope of hydrogen that is heavier than ordinary hydrogen.

herbaceous — Having little or no woody tissue.

hydrology — The science dealing with the properties, distribution, and circulation of natural water systems.

hydrogeology — Hydrolic aspects of site geology.

in situ — In its original place; field measurements taken without removing the sample from its origin; remediation performed while groundwater remains below the surface.

internal dose factor — A factor used to convert intakes of radionuclides to dose equivalents.

internal radiation — Internal radiation occurs when natural radionuclides enter the body by ingestion of foods, milk, and water, and by inhalation. Radon is the major contributor to the annual dose equivalent for internal radionuclides.

ion — An atom or compound that carries an electrical charge.

ion exchange — Process in which a solution containing soluble ions is passed over a solid ion exchange column that removes the soluble ions by exchanging them with labile ions

from the surface of the column. The process is reversible so that the trapped ions are removed (eluted) from the column and the column is regenerated.

irradiation — Exposure to radiation.

isotopes — Forms of an element having the same number of protons in their nuclei but differing in the number of neutrons.

> **long-lived isotope** — A radionuclide that decays at such a slow rate that a quantity of it will exist for an extended period (half-life is greater than 3 years).
>
> **short-lived isotope** — A radionuclide that decays so rapidly that a given quantity is transformed almost completely into decay products within a short period (half-life is 2 days or less).

lower limit of detection (LLD) — The smallest concentration/amount of analyte that can be reliably detected in a sample at a 95% confidence level.

maximally exposed individual — A hypothetical individual who remains in an uncontrolled area and would, when all potential routes of exposure from a facility's operations are considered, receive the greatest possible dose equivalent.

mercury — A silver-white, liquid metal solidifying at –38.9°C to form a tin-white, ductile, malleable mass. It is widely distributed in the environment and biologically is a nonessential or nonbeneficial element. Human poisoning from this highly toxic element has been clinically recognized.

microbes — Microscopic organisms.

migration — The transfer or movement of a material through the air, soil, or groundwater.

millirem (rem) — The dose equivalent that is one one-thousandth of a rem.

milliroentgen (mR) — A measure of X-ray or gamma radiation. The unit is one-thousandth of a roentgen.

minimum detectable activity — The smallest activity of a radionuclide that can be distinguished in a sample by a given measurement system at a preselected counting time and at a given confidence level.

monitoring — Process whereby the quantity and quality of factors that can affect the environment and/or human health are measured periodically in order to regulate and control potential impacts.

natural radiation — Radiation arising from cosmic and other naturally occurring radionuclide sources (such as radon) present in the environment.

nuclide — An atom specified by its atomic weight, atomic number, and energy state. A radionuclide is a radioactive nuclide.

outfall — The point of conveyance (e.g., drain or pipe) of wastewater or other effluents into a ditch, pond, or river.

parts per million (ppm) — A unit measure of concentration equivalent to the weight/volume ratio expressed as milligrams per liter.

parts per billion (ppb) — A unit measure of concentration equivalent to the weight/volume ratio expressed as grams per liter or nanograms per milliter.

person-rem — Collective dose to a population group. For example, a dose of 1 rem to 10 individuals results in a collective dose of 10 person-rem.

pH — A measure of the hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH from 0 through 6, basic solutions have a pH > 7, and neutral solutions have a pH = 7.

piezometer — An instrument used to measure the potentiometric surface of the groundwater. Also, a well designed for this purpose.

precision — The closeness of approach of a value of similar or replicate results to a common value in a series of measurements.

priority pollutants — A group of approximately 130 chemicals (about 110 are organics) that appear on a U.S. Environmental Protection Agency list because they are toxic and relatively common in industrial discharges.

process water — Water used within a system process.

process sewer — Pipe or drain, generally located underground, used to carry off process water and/or waste matter.

purge — To remove water prior to sampling, generally by pumping or bailing.

quality assurance (QA) — Any action in environmental monitoring to ensure the reliability of monitoring and measurement data.

quality control (QC) — The routine application of procedures within environmental monitoring to obtain the required standards of performance in monitoring and measurement processes.

quality factor — The factor by which the absorbed dose (rad) is multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiation, the biological damage to exposed persons. It is used because some types of radiation, such as alpha particles, are more biologically damaging than others.

rad — The unit of absorbed dose deposited in a volume of material.

radioactivity — The spontaneous emission of radiation, generally alpha or beta particles or gamma rays, from the nucleus of an unstable isotope.

radioisotopes — Radioactive isotopes.

radionuclide — An unstable nuclide capable of spontaneous transformation into other nuclides by changing its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.

reclamation — Recovery of wasteland, desert, etc., by ditching, filling, draining, or planting.

reference material — A material or substance with one or more properties that is sufficiently well established and used to calibrate an apparatus, to assess a measurement method, or to assign values to materials.

regression analysis — A collection of statistical techniques that serve as a basis for drawing inferences about relationships among quantities in a scientific system.

release — Any discharge to the environment. Environment is broadly defined as any water, land, or ambient air.

rem — The unit of dose equivalent (absorbed dose in rads × the radiation quality factor). Dose equivalent is frequently reported in units of millirem (mrem) which is one-thousandth of a rem.

remediation — The correction of a problem. See Environmental Restoration.

RFI Program — RCRA Facility Investigation Program; EPA-regulated investigation of a solid waste management unit with regard to its potential impact on the environment.

RFI/RI Program — RCRA Facility Investigation/Remedial Investigation Program; On the ORR, the expansion of the RFI Program to include CERCLA and hazardous substance regulations.

roentgen — A unit of exposure from X or gamma rays. One roentgen equals 2.58×10^{-4} coulombs per kilogram of air.

screened interval — In well construction, the section of a formation that contains the screen, or perforated pipe, that allows water to enter the well.

seepage basin — An excavation that receives wastewater. Insoluble materials settle out on the floor of the basin, and soluble materials seep with the water through the soil column where they are removed partially by ion exchange with the soil. Construction may include dikes to prevent overflow or surface runoff.

self-absorption — Absorption of radiation by the sample itself, preventing detection by the counting instrument.

sensitivity — The capability of methodology or instruments to discriminate between samples with differing concentrations or containing varying amounts of analyte.

settleable solids — Material settling out of suspension within a defined period.

settling basin — A temporary holding basin (excavation) that receives wastewater, which is subsequently discharged.

sievert (Sv) — The SI (International System of Units) unit of dose equivalent, 1 Sv = 100 rem.

slurry — A suspension of solid particles (sludge) in water.

specific conductance — The ability of water to conduct electricity; this ability varies in proportion to the amount of ionized minerals in the water.

spike — The addition of a known amount of reference material containing the analyte of interest to a blank sample.

spiked sample — A sample to which a known amount of some substance has been added.

split sample — A sample that has been portioned into two or more containers from a single sample container or sample-mixing container.

stable — Not radioactive or not easily decomposed or otherwise modified chemically.

stack — A vertical pipe or flue designed to exhaust airborne gases and suspended particulate matter.

standard deviation — An indication of the dispersion of a set of results around their average.

standard reference material (SRM) — A reference material distributed and certified by the National Institute of Standards and Technology.

storm water runoff — Surface streams that appear after precipitation.

strata — Beds, layers, or zones of rocks.

substrate — The substance, base, surface, or medium in which an organism lives and grows.

surface water — All water on the surface of the earth, as distinguished from groundwater.

temperature — The thermal state of a body considered with its ability to communicate heat to other bodies.

terrestrial radiation — Ionizing radiation emitted from radioactive materials, primarily potassium-40, thorium, and uranium, in the earth's soils. Terrestrial radiation contributes to natural background radiation.

total activity — The total quantity of radioactive decay particles that are emitted from a sample.

total dissolved solids — Dissolved solids and total dissolved solids are terms generally associated with freshwater systems and consist of inorganic salts, small amounts of organic matter and dissolved materials.

total organic halogens — A measure of the total concentration of organic compounds that have one or more halogen atoms.

total solids — The sum of total dissolved solids and suspended solids.

total suspended particulates — Refers to the concentration of particulates in suspension in the air irrespective of the nature, source, or size of the particulates.

transect — A line across an area being studied. The line is composed of points where specific measurements or samples are taken.

transmissive zone — A zone of sediments sufficiently porous and permeable to allow the flow of groundwater through the zone.

transuranic waste — Solid radioactive waste containing primarily alpha-emitting elements heavier than uranium.

transuranium elements — Elements with higher atomic weights than uranium; all 13 known transuranic elements are radioactive and are produced artificially.

trip blank — A sample container of deionized water that is transported to the well sample location, treated as a well sample, and sent to the laboratory for analysis; trip blanks are used to check for contamination resulting from transport, shipping, and site conditions.

tritium (^3H) — The hydrogen isotope with one proton and two neutrons in the nucleus. It emits a low-energy beta particle (0.0186 MeV maximum) and has a half-life of 12.5 years.

t-test — Statistical method used to determine if the means of groups of observations are equal.

turbidity — A measure of the concentration of sediment or suspended particles in solution.

unconsolidated zone — Soil zone located above the water table.

uncontrolled area — Any area to which access is not controlled for the purpose of protecting individuals from exposure to radiation and radioactive materials.

upgradient — In the direction of increasing hydrostatic head.

volatile organic compounds — Used in many industrial processes, the levels of these carcinogenic compounds must be kept to a minimum. They are measured by volatile

organic analyses content. Common examples include trichloroethane, tetrachloroethylene, and trichloroethylene.

watershed — The region draining into a river, river system, or body of water.

wetlands — Lowland areas, such as a marshes or swamps, inundated or saturated by surface water or groundwater sufficiently to support hydrophytic vegetation typically adapted for life in saturated soils.

wind rose — A diagram in which statistical information concerning direction and speed of the wind at a location is summarized.

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