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ANNUAL SITE ENVIRONMENTAL REPORT

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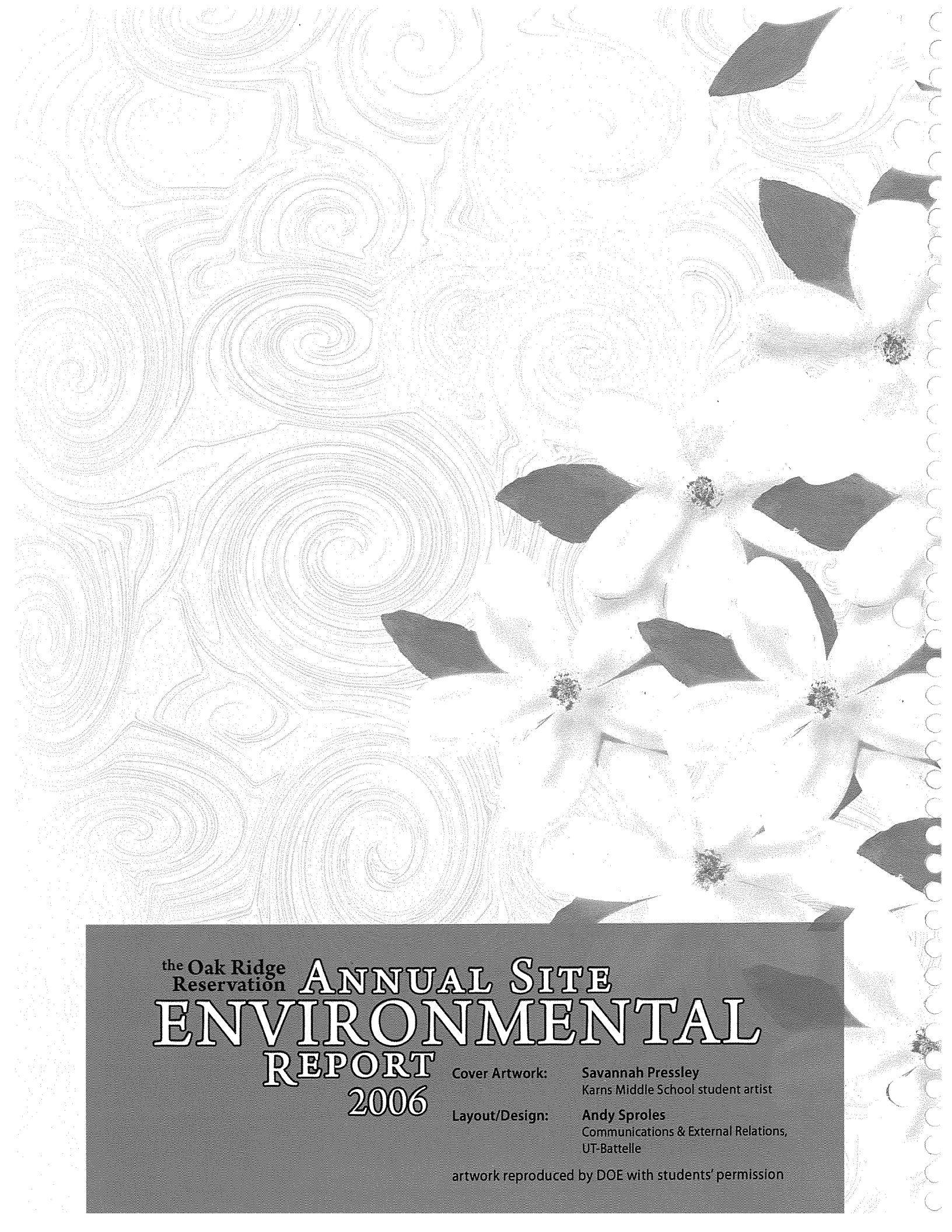
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"These stars of earth,
these golden flowers
– Henry Wadsworth Longfellow

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the Oak Ridge Reservation **ANNUAL SITE ENVIRONMENTAL REPORT 2006**

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**Oak Ridge Reservation Annual Site
Environmental Report for 2006**

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Acronyms and Abbreviations

AAS	ambient air station
AM	action memorandum
ANSI	American National Standards Institute, Inc.
AOC	area of concern
ARAP	aquatic resource alteration permit
ASER	annual site environmental report
ASTM	American Society for Testing and Materials
ATDD	Atmospheric Turbulence and Diffusion Division
BCG	biota concentration guide
BCK	Bear Creek kilometer
BERA	baseline ecological risk assessment
BFK	Brushy Fork kilometer
BJC	Bechtel Jacobs Company LLC
BMAP	Biological Monitoring and Abatement Program
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFC	chlorofluorocarbon, chlorinated fluorocarbon
CFR	<i>Code of Federal Regulations</i>
CMTS	Central Mercury Treatment System
CNF	Central Neutralization Facility
CRK	Clinch River kilometer
CROET	Community Reuse Organization of East Tennessee
CWA	Clean Water Act
CX	categorical exclusion
CY	calendar year
CYRTF	Coal Yard Runoff Treatment Facility
D&D	decontamination and decommissioning
DCG	derived concentration guide
DOE	Department of Energy
DOE-EM	DOE Office of Environmental Management
DOE-HQ	DOE Headquarters
DOE-ORO	DOE Oak Ridge Office
dps	disintegrations per second
DWI	David Witherspoon, Inc.
EDE	effective dose equivalent
EFK	East Fork Poplar Creek kilometer
EM	(DOE Office of) Environmental Management
EMC	event mean concentration
EMEF	Environmental Management and Enrichment Facilities
EMS	environmental management system
EMWMF	Environmental Management Waste Management Facility
EPA	Environmental Protection Agency

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EPCRA	Emergency Planning and Community Right-to-Know Act
EPT	Ephemeroptera, Plectoptera, and Trichoptera (taxa)
ETTP	East Tennessee Technology Park
EWQP	ETTP Water Quality Program
FCK	First Creek kilometer
FFK	Fifth Creek kilometer
FONSI	finding of no significant impact
FY	fiscal year
HCK	Hinds Creek kilometer
HFIR	High Flux Isotope Reactor
HQ	hazard quotient
HRE	Homogeneous Reactor Experiment
IC ₂₅	inhibition concentration
ICK	Ish Creek kilometer
ICP	inductively coupled plasma
ICP-MS	inductively coupled plasma mass spectrometry
ID	identification (number)
ISMS	Integrated Safety Management System
ISO	International Organization for Standardization
JTU	Jackson turbidity unit
LC ₅₀	concentration of an aqueous sample lethal to 50% of test organisms in a given time span
LEED	Leadership in Energy and Environmental Design
LLLW	liquid low-level radioactive waste
LLW	low-level radioactive waste
MACT	Maximum Achievable Control Technology
MDA	minimum detectable activity
MEK	Melton Branch kilometer
MIK	Mitchell Branch kilometer
MLLW	mixed low-level waste
MSDS	material safety data sheet
MSRE	Molten Salt Reactor Experiment
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NIST	National Institute of Standards and Technology
NNSA	National Nuclear Security Administration
NOAA	National Oceanic and Atmospheric Administration
NOEC	no-observed-effect concentration
NOV	notice of violation
NPDES	National Pollutant Discharge Elimination System
NTRC	National Transportation Research Center
NTU	nephelometric turbidity unit
NWTK	Northwest Tributary kilometer
OCF	Oxide Conversion Facility

ODS	ozone-depleting substance
ORAU	Oak Ridge Associated Universities
OREIS	Oak Ridge Environmental Information System
ORGDP	Oak Ridge Gaseous Diffusion Plant
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
ORSSAB	Oak Ridge Site Specific Advisory Board
ORSTP	Oak Ridge Science and Technology Park
OS	DOE Office of Science
OSTI	DOE Office of Scientific and Technical Information
PAM	perimeter air monitoring
PCB	polychlorinated biphenyls
PM ₁₀	particulate matter with an aerodynamic diameter less than or equal to 10 micrometers
PM _{2.5}	particulate matter with an aerodynamic diameter less than or equal to 2.5 micrometers
PWTC	Process Waste Treatment Complex
QA	quality assurance
QC	quality control
R&D	research and development
RCK	Racoon Creek kilometer
RCRA	Research Conservation and Recovery Act
REDC	Radiochemical Engineering Development Center
RfD	reference dose
RI	remedial investigation
ROD	record of decision
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SBMS	Standards-Based Management System
SC	DOE Office of Science
SDWA	Safe Drinking Water Act
SE	standard error
SF	slope factor
SNS	Spallation Neutron Source
SPCC	spill prevention, control, and countermeasure
SPWTF	Steam Plant Wastewater Treatment Facility
STP	sewage treatment plant
SWEIS	sitewide environmental impact statement
SWMU	solid waste management unit
SWP3	Storm Water Pollution Prevention Plan
SWSA	solid waste storage area

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TDEC	Tennessee Department of Environment and Conservation
TRC	total residual chlorine
TRU	transuranic
TSCA	Toxic Substances Control Act
TVA	Tennessee Valley Authority
TWPC	Transuranic Waste-Processing Center
TWRA	Tennessee Wildlife Resources Agency
UST	underground storage tank
UT	University of Tennessee
VOC	volatile organic compound
WAG	waste area grouping
WBK	Walker Branch kilometer
WCK	White Oak Creek kilometer
WIPP	Waste Isolation Pilot Plant
WOC	White Oak Creek
WQC	Water quality criteria
WRRP	Water Resources Restoration Program
Y-12 Complex	Y-12 National Security Complex

Units of Measure and Conversion Factors

Units of measure and their abbreviations

acre	acre	millimeter	mm
becquerel	Bq	million	M
centimeter	cm	millirad	mrad
curie	Ci	millirem	mrem
day	day	millisievert	mSv
degrees Celsius	°C	minute	min
degrees Fahrenheit	°F	nephelometric turbidity unit	NTU
foot	ft	parts per billion	ppb
gallon	gal	parts per million	ppm
gallons per minute	gal/min	parts per trillion	ppt
gram	g	picocurie	pCi
hectare	hectare	pound	lb
hour	h	pounds per square inch	psi
kilogram	kg	quart	qt
kilometer	km	rad	rad
kilowatt	kW	roentgen	R
liter	L	roentgen equivalent man	rem
megawatt	MW	second	s
meter	m	sievert	Sv
microcurie	μCi	standard unit (pH)	SU
microgram	μg	ton, short (2000 lb)	ton
millicurie	mCi	yard	yd
milligram	mg	year	year
milliliter	mL		

Quantitative prefixes

tera	$\times 10^{12}$	pico	$\times 10^{-12}$
giga	$\times 10^9$	nano	$\times 10^{-9}$
mega	$\times 10^6$	micro	$\times 10^{-6}$
kilo	$\times 10^3$	milli	$\times 10^{-3}$
hecto	$\times 10^2$	centi	$\times 10^{-2}$
deka	$\times 10^1$	deci	$\times 10^{-1}$

Unit conversions

Unit	Conversion	Equivalent	Unit	Conversion	Equivalent
Length					
in.	$\times 2.54$	cm	cm	$\times 0.394$	in.
ft	$\times 0.305$	m	m	$\times 3.28$	ft
mile	$\times 1.61$	km	km	$\times 0.621$	mile
Area					
acre	$\times 0.405$	ha	ha	$\times 2.47$	acre
ft ²	$\times 0.093$	m ²	m ²	$\times 10.764$	ft ²
mile ²	$\times 2.59$	km ²	km ²	$\times 0.386$	mile ²
Volume					
ft ³	$\times 0.028$	m ³	m ³	$\times 35.31$	ft ³
qt (U.S. liquid)	$\times 0.946$	L	L	$\times 1.057$	qt (U.S. liquid)
gal	$\times 3.7854118$	L	L	$\times 0.264172051$	gal
Concentration					
ppm	$\times 1$	mg/L	mg/L	$\times 1$	ppm
Weight					
lb	$\times 0.4536$	kg	kg	$\times 2.205$	lb
ton	$\times 907.1847$	kg	kg	$\times 0.00110231131$	ton
Temperature					
°C	$F = (9/5) C + 32$	°F	°F	$C = (5/9) (F - 32)$	°C
Activity					
Bq	$\times 2.7 \times 10^{-11}$	Ci	Ci	$\times 3.7 \times 10^{10}$	Bq
Bq	$\times 27$	pCi	pCi	$\times 0.037$	Bq
mSv	$\times 100$	mrem	mrem	$\times 0.01$	mSv
Sv	$\times 100$	rem	rem	$\times 0.01$	Sv
nCi	$\times 1000$	pCi	pCi	$\times 0.001$	nCi
mCi/km ²	$\times 1$	nCi/m ²	nCi/m ²	$\times 1$	mCi/km ²
dpm/L	$\times 0.45 \times 10^9$	µCi/cm ³	µCi/cm ³	$\times 2.22 \times 10^9$	dpm/L
pCi/L	$\times 10^{-9}$	µCi/mL	µCi/mL	$\times 10^9$	pCi/L
pCi/m ³	$\times 10^{-12}$	µCi/cm ³	µCi/cm ³	$\times 10^{12}$	pCi/m ³

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1. Site and Operations Overview

The Oak Ridge Reservation (ORR), a government-owned, contractor-operated facility, contains three major operating sites: the Y-12 National Security Complex, Oak Ridge National Laboratory, and East Tennessee Technology Park. The ORR was established in the early 1940s as part of the Manhattan Project, a secret undertaking that produced materials for the first atomic bombs. The reservation's role has evolved over the years, and it continues to adapt to meet the changing defense, energy, and research needs of the United States. Both the work carried out for the war effort and subsequent research, development, and production activities have involved, and continue to involve, the use of radiological and hazardous materials.

The *Oak Ridge Reservation Annual Site Environmental Report* and supporting data are available at http://www.ornl.gov/Env_Rpt or from the project director.

1.1 Background

This document is prepared annually to summarize environmental activities, primarily environmental-monitoring activities, on the Oak Ridge Reservation (ORR) and within the ORR surroundings. The document fulfills the requirement of Department of Energy (DOE) Order 231.1A, "Environment, Safety and Health Reporting," for an annual summary of environmental data to characterize environmental performance. The environmental-monitoring criteria are described in DOE Order 450.1, "Environmental Protection Program." The results summarized in this report are based on data collected prior to and through 2006. This report is not intended to provide the results of all sampling on the ORR. Additional data collected for other site and regulatory purposes, such as environmental restoration remedial investigation reports, waste management characterization sampling data, and environmental permit compliance data, are presented in other documents that have been prepared in accordance with applicable DOE guidance and/or laws and are referenced herein as appropriate. Corrections to the report for the previous year are found in Appendix A.

Environmental monitoring on the ORR consists primarily of two major activities: effluent monitoring and environmental surveillance. Effluent monitoring involves the collection and analysis of samples or measurements of liquid and gaseous effluents at the point of release to the environment; these measurements allow the quantification and official reporting of contaminants, assessment of radiation and chemical exposures to the public, and demonstration of

compliance with applicable standards and permit requirements. Environmental surveillance consists of the collection and analysis of environmental samples from the site and its environs; these activities provide direct measurement of contaminant concentrations in air, water, groundwater, soil, foods, biota, and other media. Environmental surveillance data provide information regarding conformity with applicable DOE orders and, combined with data from effluent monitoring, allow the determination of chemical and radiation dose/exposure assessments of ORR operations and effects, if any, on the local environment.

1.2 Description of Site Locale

The city of Oak Ridge lies within the Great Valley of Eastern Tennessee between the Cumberland and Great Smoky Mountains and is bordered on two sides by the Clinch River (Fig. 1.1). The Cumberland Mountains are 16 km to the northwest; the Great Smoky Mountains are 51 km to the southeast. The ORR encompasses about 13,651 hectares of mostly contiguous land owned by DOE in the Oak Ridge area. Most of it lies within the corporate limits of the city of Oak Ridge; 243 hectares west of the East Tennessee Technology Park (ETTP) are outside the city limits. 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

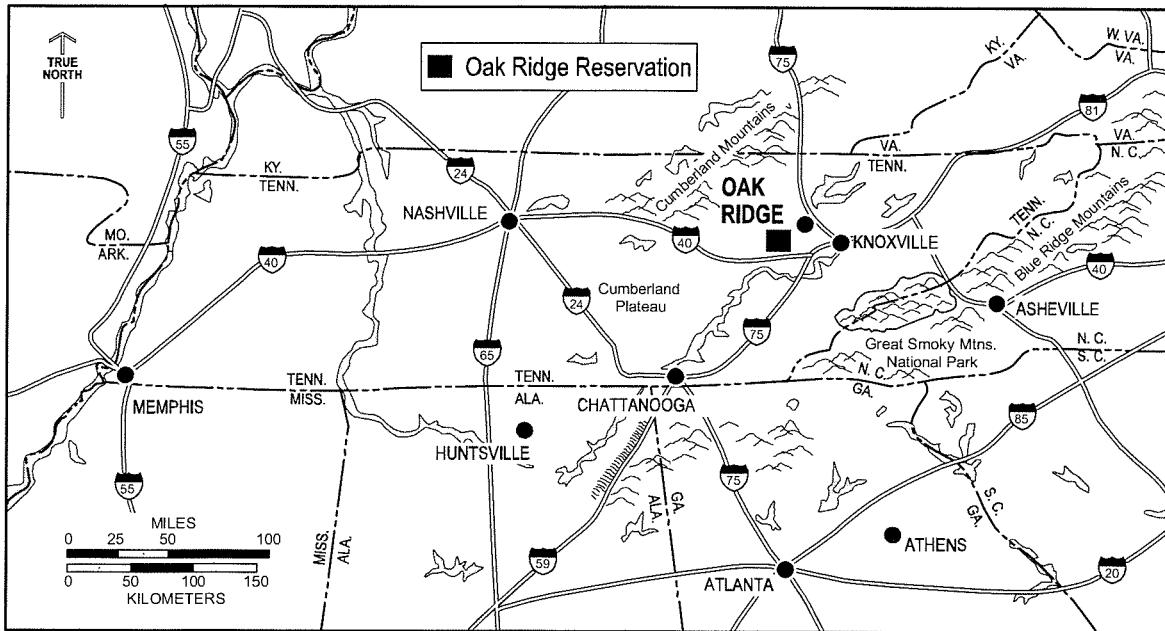


Fig. 1.1. Location of the city of Oak Ridge.

(Fig. 1.2). The population of the ten-county region surrounding the ORR is about 895,890 with about 4% of its labor force employed on the reservation (Fig. 1.3). Other towns close to the reservation include Oliver Springs, Clinton, Karns, Lenoir City, Farragut, Kingston, and Harriman (Fig. 1.4).

Knoxville, the major metropolitan area nearest Oak Ridge, is located about 40 km to the east and has a population of about 180,130. Except for the city of Oak Ridge, the land within 8 km of the ORR is semirural and is used primarily for residences, small farms, and cattle pasture. Fishing, boating, water skiing, and swimming are popular recreational activities in the area.

1.3 Climate

The climate of the Oak Ridge region may be broadly classified as humid subtropical and is characterized by significant temperature changes between summer and winter. The average temperature for the Oak Ridge area during 2006 was 15.3°C compared with a 30 year mean temperature (1976–2005) of 14.4°C. The coldest month is usually January, with temperatures averaging about 2.3°C. July tends to be the warmest month, with average temperatures of 25.3°C.

Average annual precipitation in the Oak Ridge area for the 30 year period from 1976 to 2005 was 1,374.3 mm, including about 27.4 cm of snowfall (NOAA 2006). Total rainfall during 2006, measured at the Oak Ridge meteorological tower, was 1,233.6 mm, and total 2006 snowfall was 8.9 cm. This marks the third consecutive year with below-normal precipitation. Monthly summaries of precipitation averages, extremes, and 2006 values are provided in Appendix B, Table B.1.

In 2006 wind speeds at Oak Ridge National Laboratory (ORNL) Tower C (MT2) measured at 10 m above ground level averaged 1.4 m/s. This value increased to about 3 m/s for winds at 100 m above the ground (about the height of local ridgetops). The local ridge-and-valley terrain reduces average wind speeds at valley bottoms, resulting in frequent periods of nearly calm conditions, particularly during clear, early morning hours. Wind direction and speed frequencies for Tower C at 10, 30, and 100 m above the ground can be found in Appendix B (Figs. B.1 thru B.3).

Detailed information on the climate of the Oak Ridge area is available in *Oak Ridge Reservation Physical Characteristics and Natural Resources* (Parr and Hughes 2006).

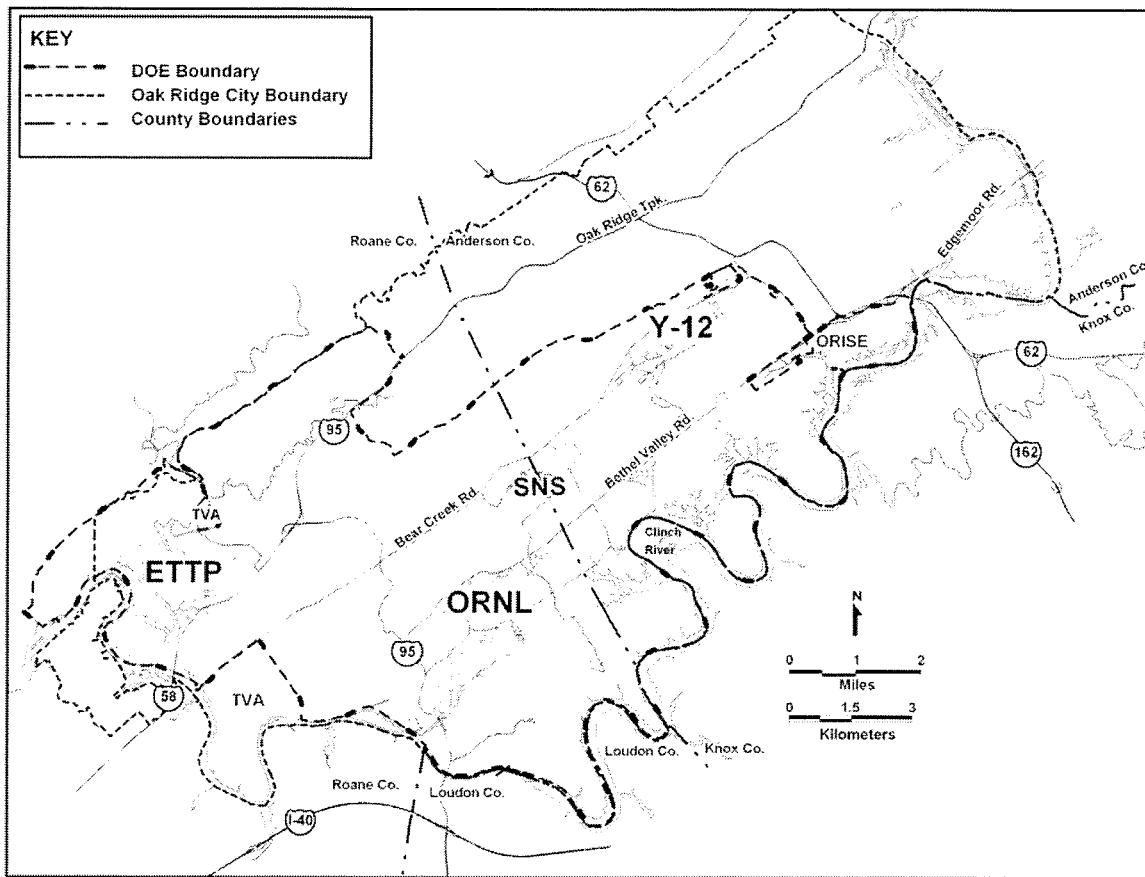


Fig. 1.2. The Oak Ridge Reservation.

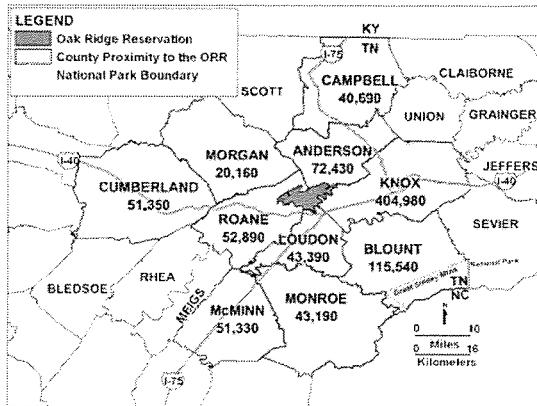


Fig. 1.3. Population by county in the 10-county region surrounding the Oak Ridge Reservation.

Appendix C contains a glossary of technical terms that may be useful for clarifying some of the language used in this document.

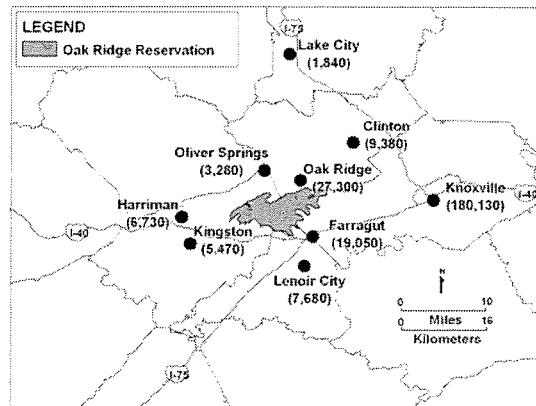


Fig. 1.4. Locations and populations of towns nearest to the Oak Ridge Reservation.

1.4 Regional Air Quality

The Environmental Protection Agency (EPA) Office of Air Quality Planning and Standards has set National Ambient Air Quality Standards (NAAQSs) for key principal pollut-

ants, which are called “criteria” pollutants. These pollutants are sulfur dioxide (SO_2), carbon monoxide (CO), carbon dioxide (CO_2), nitrogen dioxide (NO_2), lead (Pb), ozone (O_3), particulate matter with aerodynamic diameter less than or equal to 2.5 microns ($\text{PM}_{2.5}$), and particles with an aerodynamic diameter less than or equal to 10 microns in diameter (PM_{10}). EPA evaluates NAAQS based on ambient (outdoor) levels of the criteria pollutants. Areas that satisfy NAAQS are classified as attainment areas, and areas that exceed the NAAQS for a particular pollutant are classified as nonattainment areas for that pollutant.

The ORR is located in Anderson and Roane counties in Air Quality Control Region 207 (East Tennessee-Southeastern Virginia). The EPA has designated Anderson County as a basic nonattainment area for the 8-h O_3 standard as part of the larger Knoxville 8-h basic O_3 nonattainment area, which encompasses several counties. In addition, the EPA has designated Anderson, Knox, and Blount counties as nonattainment for the new, stricter federal fine particulate matter ($\text{PM}_{2.5}$) air quality standard. EPA designated the portion of Roane County surrounding the Kingston Steam Plant as nonattainment as well. For all other criteria pollutants, for which EPA has made attainment designations, existing air quality in the greater Knoxville and Oak Ridge area is in attainment with the NAAQS.

1.5 Surface Water Setting

Waters drained from the ORR eventually reach the Tennessee River via the Clinch River, which forms the southern and western boundaries of the ORR (Fig. 1.2). The ORR lies within the Valley and Ridge Physiographic Province, which is composed of a series of drainage basins or troughs containing many small streams feeding the Clinch River. Surface water at each of the major facilities on the ORR drains into a tributary or series of tributaries, streams, or creeks within different watersheds. Each of these watersheds drains into the Clinch River.

The largest of the drainage basins is that of Poplar Creek, which receives drainage from a 352-km² area, including the northwestern sector of the ORR. It flows from northeast to southwest, approximately through the center of the

ETTP, and discharges directly into the Clinch River.

East Fork Poplar Creek, which discharges into Poplar Creek east of the ETTP, originates within the Y-12 National Security Complex (Y-12 Complex) near the former S-3 Ponds and flows northeast along the south side of the Y-12 Complex. Various Y-12 Complex wastewater discharges to the upper reaches of East Fork Poplar Creek from the late 1940s to the early 1980s left a legacy of contamination (e.g., mercury, polychlorinated biphenyls [PCBs], uranium) that has been the subject of water quality improvement initiatives over the past two decades. Bear Creek also originates within the Y-12 Complex with headwaters near the former S-3 Ponds, where the creek flows southwest. Bear Creek is mostly affected by stormwater runoff, groundwater infiltration, and tributaries that drain former waste disposal sites in the Bear Creek Valley Burial Grounds Waste Management Area and the current Environmental Management Waste Management Facility (EMWMF).

Both the Bethel Valley and Melton Valley portions of ORNL are in the White Oak Creek drainage basin, which has an area of 16.5 km². White Oak Creek headwaters originate on Chestnut Ridge, north of ORNL, near the Spallation Neutron Source (SNS) site. At the ORNL site, the creek flows west along the southern boundary of the developed area and then flows southwesterly through a gap in Haw Ridge to the western portion of Melton Valley, where it forms a confluence with Melton Branch. The waters of White Oak Creek enter White Oak Lake, which is an impoundment formed by White Oak Dam. Water flowing over White Oak Dam enters the Clinch River after passing through the White Oak Creek embayment area.

1.6 Geological Setting

The ORR is located in the Tennessee portion of the Valley and Ridge Physiographic Province, which is part of the southern Appalachian fold-and-thrust belt. As a result of thrust faulting and differential erosion rates, a series of parallel valleys and ridges have formed that trend southwest-northeast.

Two geologic units on the ORR, designated as the Knox Group and the Maynardville Limestone of the Conasauga Group, both consisting

of dolostone and limestone, constitute the Knox Aquifer. A combination of fractures and solution conduits in the aquifer control flow over substantial areas, and large quantities of water may move long distances. Active groundwater flow can occur at substantial depths in the Knox Aquifer (91.5 to 122 m deep). The Knox Aquifer is the primary source of groundwater to many streams (base flow), and most large springs on the ORR receive discharge from the Knox Aquifer. Yields of some wells penetrating larger solution conduits are reported to exceed 3,784 L/min.

The remaining geologic units on the ORR (the Rome Formation, the Conasauga Group below the Maynardville Limestone, and the Chickamauga Group) constitute the ORR Aquitards, which consist mainly of siltstone, shale, sandstone, and thinly bedded limestone of low to very low permeability (Fig. 1.5). Nearly all groundwater flow in the ORR Aquitards occurs through fractures. The typical yield of a well in the ORR Aquitards is less than 3.8 L/min, and the base flows of streams draining areas underlain by the ORR Aquitards are poorly sustained because of such low flow rates. Detailed information on ORR groundwater hydrology and flow is available in *Oak Ridge Reservation Physical Characteristics and Natural Resources* (Parr and Hughes 2006).

1.7 Description of Site Facilities and Operations

1.7.1 History of the Oak Ridge Reservation

Beginning in early 1943, thousands of scientists, engineers, and workers came from all over the United States to small crossroads communities such as Scarboro, Wheat, Robertsville, and Elza to build and operate three huge facilities that would change the history of the region and the world forever. These people came to rural East Tennessee to do whatever was necessary to end World War II and, as part of the then secret Manhattan Project, helped produce the first nuclear weapons.

The site was selected for use by the Manhattan Project because the Clinch River provided ample supplies of water, nearby Knoxville was a good source of labor, and the TVA could supply

the huge amounts of electricity needed. About 3,000 residents received court orders to vacate within weeks the homes and farms that their families had occupied for generations. Very soon afterwards, the site was given its wartime name of “Clinton Engineering Works.”

The workers’ city, named Oak Ridge, was established on the reservation’s northern edge. The “Secret City” grew to a population of 75,000, used one-seventh of the electrical power generated in the country at the time, and was the fifth-largest city in Tennessee; however, it was not shown on any map. At the Y-12 Complex, south of the city, an electromagnetic method was used to separate fissionable isotopes of uranium (^{235}U) from natural uranium. At its peak operation, the Y-12 Complex employed 22,000 workers. A gaseous diffusion plant, later known as K-25, was built on the reservation’s western edge and included a multistory process building covering more area than any other structure ever built. Operated by 12,000 workers, the K-25 Plant separated ^{235}U from ^{238}U . Near the reservation’s southwest corner, about 16 km from Y-12, was a third facility, known as X-10 (or Clinton Laboratories), where the Graphite Reactor was built. Employing only about 1,500 people during the war, X-10 was a pilot plant for the larger plutonium production plant built at Hanford, Washington. The Graphite Reactor used neutrons emitted in the fission of ^{235}U to convert ^{238}U into a new element, plutonium-239 (^{239}Pu).

The primary missions of the three sites have evolved during the past 60+ years and continue to adapt to meet the changing defense, energy, and research needs of the United States. The reservation contains three major DOE installations: the Y-12 National Security Complex (formerly the Y-12 Plant), ORNL (formerly the X-10 site), and ETTP (formerly the K-25 site). DOE also operates a number of facilities in addition to the major installation sites.

1.7.2 The Y-12 National Security Complex

The Y-12 Complex (Fig. 1.6), operated by BWXT Y-12 for the National Nuclear Security Administration (NNSA) within DOE, is a one-of-a-kind manufacturing facility that plays an important role in U.S. national security and is dedicated to making the nation and the world a

ORNL 2007-G00482

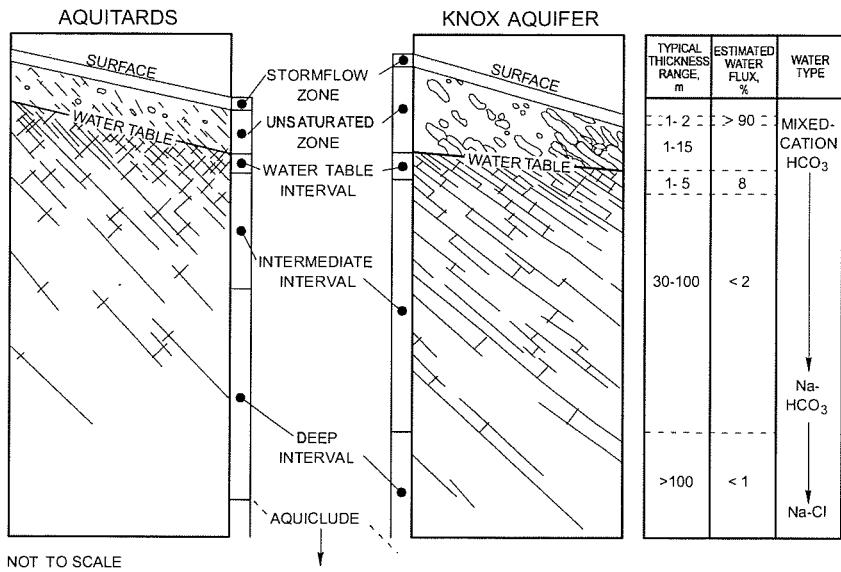


Fig. 1.5. Vertical relationships of flow zones of the ORR: estimated thicknesses, water flux, and water types.

Y-12 PHOTO 306208

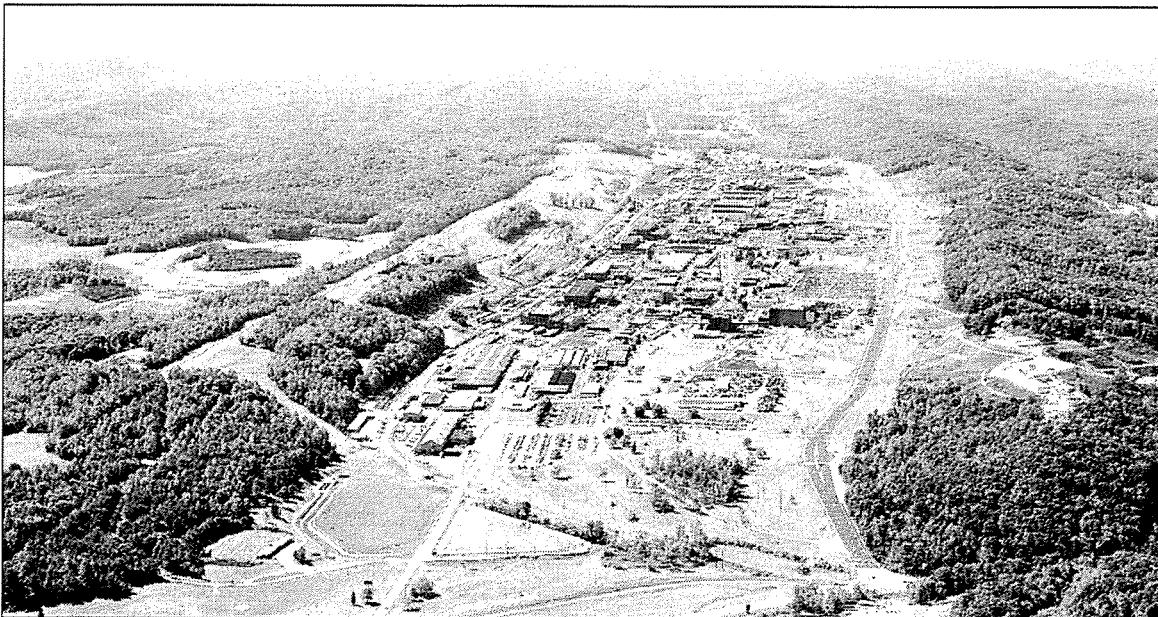


Fig. 1.6. The Y-12 National Security Complex.

safer place. With more than 60 years of experience to draw from, Y-12 is uniquely qualified to address the existing and emerging security challenges facing our nation and the world today. Today Y-12's roles include

- providing critical elements of NNSA's missions that ensure the safety, reliability,

and performance of the U.S. nuclear weapons deterrent;

- supplying the special nuclear material for use in naval reactors;
- promoting international nuclear safety and nonproliferation;

- reducing global dangers from weapons of mass destruction; and
- supporting U.S. leadership in science and technology.

Presently, the Y-12 Complex is pursuing an aggressive program of infrastructure reduction, modernization, and investment in technology to make the site as safe and efficient as possible and to improve production capabilities. The *Ten-Year Comprehensive Site Plan* is a rolling 10-year plan of missions, programs, workload, and investments outlining the new construction, recapitalization, maintenance requirements, and excess facility demolition required to modernize the Y-12 Complex. Overall implementation of the modernization program is consistent with NNSA's Complex 2030 vision for the nuclear weapons complex. The Y-12 Complex is making all these improvements while maintaining safety, security, and environmental stewardship as its highest priorities.

1.7.3 East Tennessee Technology Park

The ETTP was built as the home of the Oak Ridge Gaseous Diffusion Plant (ORGDP) (Fig. 1.7). The plant's original mission was production of highly enriched uranium for nuclear weapons.

Enrichment was initially carried out in two process buildings, K-25 and K-27. Later, the K-29, K-31, and K-33 buildings were built to increase the production capacity of the original facilities by raising the assay of the feed material entering K-27. After military production of highly enriched uranium was concluded in 1964, the two original process buildings were shut down. For the next 20 years, the plant's primary missions were production of only slightly enriched uranium to be fabricated into fuel elements for nuclear reactors and the recycling of fuel elements from nuclear reactors. Other missions during the latter part of this 20-year period included development and testing of the gas centrifuge method of uranium enrichment and the laser isotope separation research and development (R&D).

By 1985, demand for enriched uranium had declined, and the gaseous diffusion cascades at ORGDP were placed in standby mode. That

same year, the gas centrifuge program was canceled. The decision to permanently shut down the diffusion cascades was announced in late 1987, and actions necessary to implement that decision were initiated soon thereafter. Because of the termination of the original and primary missions, ORGDP was renamed the "Oak Ridge K-25 Site" in 1990. In 1997, the K-25 Site was named the "East Tennessee Technology Park" to reflect its new mission.

DOE's long-term goal for ETTP is to convert the site into a private industrial park. The site is undergoing environmental cleanup, which is now expected to be completed on an accelerated schedule. The new accelerated closure plan will achieve cleanup several years ahead of the original plan, and thereby will reduce environmental and safety risks more quickly and will reduce long-term maintenance costs. The reuse of key site facilities through title transfer is part of the closure plan for the site. The accelerated cleanup approach makes land and various types of buildings (e.g., office, manufacturing) suitable for private industrial use and suitable for title transfer to the Community Reuse Organization of East Tennessee (CROET) or other entities, such as the city of Oak Ridge. The facilities may then be subleased or sold, with the goal of stimulating private industry and recruiting business to the area.

The ETTP mission is to reindustrialize and reuse site assets through leasing of excess or underutilized land and facilities and incorporation of commercial industrial organizations as partners in the ongoing environmental restoration, decontamination and decommissioning, and waste treatment and disposal. During 2006, two additional office buildings, K-1400 and K-1036, were transferred from DOE ownership to CROET. There are now a total of six transferred facilities, and work continues on the transfer of additional facilities and land parcels. In a process similar to its leasing process for federally owned facilities, CROET also subleases transferred facilities.

George Jones Memorial Baptist Church, commonly called the Wheat Church (part of the early Wheat Community), located within the ETTP, predates World War II and is included in the *National Register of Historic Places* (National Park Service 2003).

**Fig. 1.7. The East Tennessee Technology Park.**

1.7.4 Oak Ridge National Laboratory

ORNL is DOE's largest science and energy laboratory (Fig. 1.8). Managed since April 2000 by UT-Battelle, a partnership between the University of Tennessee (UT) and Battelle, ORNL was established in 1943 as a part of the secret Manhattan Project to pioneer a method for producing and separating plutonium. ORNL's involvement with nuclear weapons ended after the war, and the Laboratory's scientific expertise shifted in the 1950s and 1960s to peacetime research in medicine, biology, materials, and physics. The Graphite Reactor evolved from a wartime role to produce the world's first medical radioisotopes for treating cancer. Following the creation of DOE in 1977, ORNL's mission broadened to include research in energy production, transmission, and consumption. The end of the Cold War and the growth of international terrorism led to a further expansion of research into a range of national security technologies. As the laboratory entered the twenty-first century, new cross-disciplinary programs in nanophase materials, computational sciences, and biology led to the term "nano-info-bio" to describe the emerging synthesis in ORNL's research agenda. As ORNL's missions have changed over the

years to meet the nation's priorities and needs, the Laboratory's underpinning standards in science and public service have remained.

ORNL supports the DOE Oak Ridge Office (DOE-ORO) in its responsibilities for land use planning, land management activities, and natural resource management for the ORR. ORNL also coordinates research and its associated operational and maintenance activities within the National Environmental Research Park.

The SNS site is located on approximately 35 hectares of Chestnut Ridge near ORNL. The SNS, an accelerator-based neutron source, is currently operating at low power, and will provide neutron beams with up to ten times more intensity than any other such source in the world. Construction began in 1999 and was completed in May 2006 at a total cost of \$1.4 billion. Design and construction was performed by a partnership of six DOE national laboratories (Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge). At present, limited operational experiments are being conducted at the SNS. Once the SNS reaches full power in 2009, it will attract scientists and

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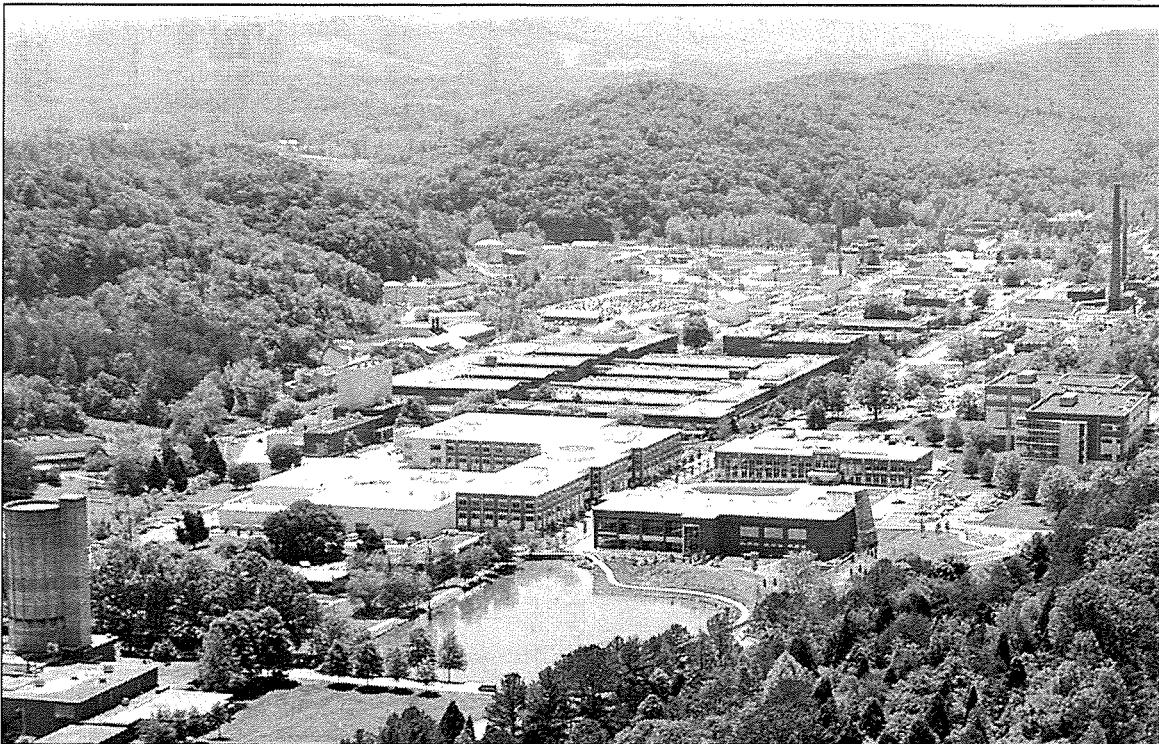


Fig. 1.8. The Oak Ridge National Laboratory.

engineers from universities, industries, and government laboratories in the United States and abroad.

In 2006 a small portion of ORNL property was leased to CROET for development into the Oak Ridge Science and Technology Park (ORSTP). The ORSTP will provide space where companies doing research at ORNL, partner universities, start-ups built around ORNL technologies, and ORNL contractors can do business within a short distance of ORNL researchers and DOE user facilities such as the SNS, the Center for Nanophase Materials Sciences and the High Flux Isotope Reactor (HFIR).

1.7.5 Oak Ridge National Environmental Research Park

In 1980, DOE established the Oak Ridge National Environmental Research Park (Fig. 1.9). Consisting of about 8,094 hectares, the Research Park serves as an outdoor laboratory to evaluate the environmental consequences of energy use and development as well as the strategies to mitigate those effects. The combination of protected, undeveloped areas with dis-

turbed, developed, or developing areas within the Research Park allows the demonstration and assessment of various environmental and land-use options.

Major DOE Office of Science research programs use the ORR land to meet mission objectives. In fiscal year (FY) 2006 almost \$10 million was spent on DOE-supported environmental field-based research directly dependent on the ORR land base. This expenditure is independent of construction of new facilities such as the SNS. The Office of Science considers the research and science value of the ORR to be critical and provides primary operations funding. The Oak Ridge National Environmental Research Park is one of the few sites in the nation where large-scale ecological research, environmental technology, and measurement science are integrated with 50 years of environmental monitoring and research.

The availability of the protected lands and field research sites on the ORR allows DOE to support major field experiments that could not be conducted if the lands and associated eco-

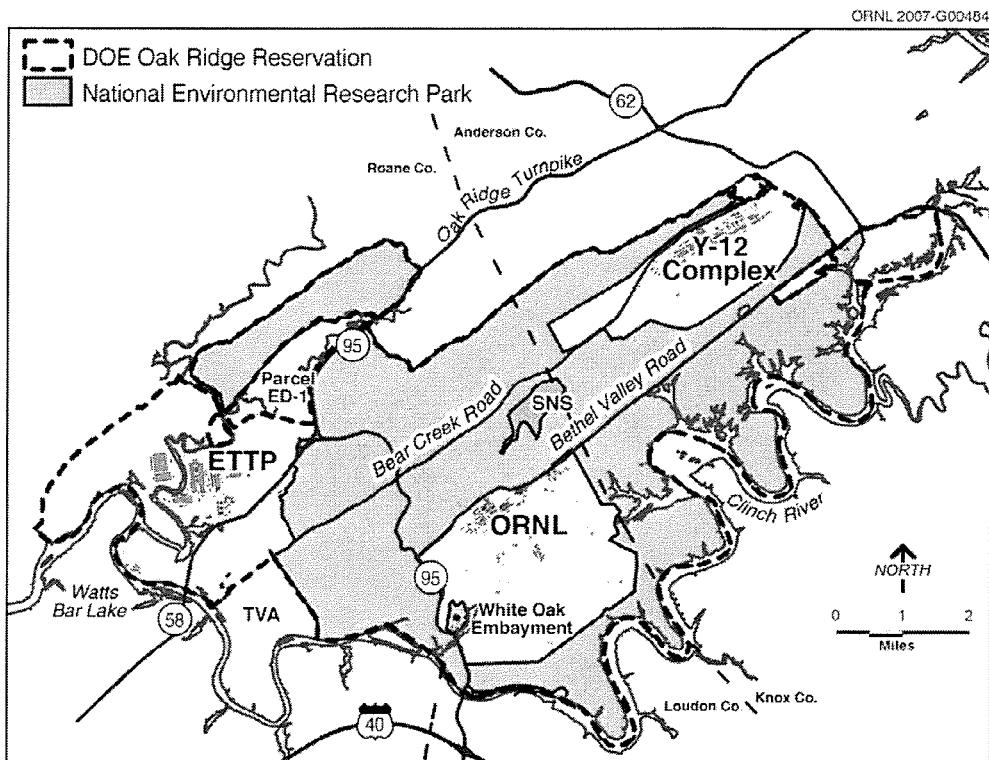


Fig. 1.9. The Oak Ridge National Environmental Research Park covers about 8,094 hectares (about 20,000 acres) on the reservation.

logical systems were not protected and secured for such long-term studies. This research addresses fundamental questions about the effects of energy-related activities on ecological systems and compares such effects with the natural variation of ecological systems.

The Oak Ridge National Environmental Research Park is a DOE national user facility that has attracted more than 1200 users from ORNL, 150 colleges, universities, industries, and other state and federal agencies over the past 5 years. The 270 users during 2006 represented 50 organizations, including educational institutions, state and federal agencies, and others.

1.7.6 Oak Ridge Institute for Science and Education

The Oak Ridge Institute for Science and Education (ORISE) is managed for DOE by Oak Ridge Associated Universities (ORAU), a non-profit consortium of 91 doctoral-granting members and 10 associate members. ORISE includes 94 hectares 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 UT.

The ORISE South Campus lies immediately southeast of the intersection of Bethel Valley Road and Pumphouse Road. The site houses offices, laboratories, and storage areas for the ORISE program offices and support departments, and it is being developed for other productive uses.

For more information, visit the ORAU home page at <http://www.orau.org> and the ORISE home page at <http://www.orau.gov/orise.htm>.

1.7.7 Other Sites

DOE operates a number of facilities in addition to the major installation sites. The other facilities are described in the following sections.

1.7.7.1 American Museum of Science and Energy

The American Museum of Science and Energy occupies a 7-hectare site contiguous to the ORAU campus, on South Tulane Avenue in Oak Ridge. In 1975, the American Museum of Science and Energy was moved from its previous

facility (55–59 Jefferson Circle) to a masonry structure with about 53,000 ft². In addition to the main museum facility, the site contains the Energy House, which is licensed to the city of Oak Ridge for use by the Convention and Visitors' Bureau. The museum also has warehouse space in the Office of Scientific and Technical Information (OSTI) Building 1916T-2 complex. The museum is managed by UT-Battelle.

1.7.7.2 Atmospheric Turbulence and Diffusion Division—National Oceanic and Atmospheric Administration Facility

The Atmospheric Turbulence and Diffusion Division—National Oceanic and Atmospheric Administration (ATDD-NOAA) Facility is composed of a wood-frame building built in the 1940s and several smaller buildings at 456 South Illinois Avenue in Oak Ridge. ATDD conducts meteorological and atmospheric diffusion research that is jointly supported by DOE and NOAA. It also provides services to other DOE contractors and operates the Weather Instrument Telemetering Monitoring System for DOE.

1.7.7.3 Buildings 2714 and 2715

Building 2714 (the “Laboratory Road Facility”) and Building 2715 are DOE-owned facilities that DOE shares with ORISE. The facilities are used for general offices. In February 2007, ORISE relocated its laboratory-based training program to the ORISE South Campus and turned the G wing over to DOE-ORO. The ORISE-occupied facilities now comprise only Building 2715 (about 3,413 ft²). Both buildings are located in Oak Ridge immediately south of the Federal Office Building.

1.7.7.4 Central Training Facility

The Central Training Facility, used primarily by security forces, consists of a small office building, an indoor firing range, two classroom/storage trailers, on-site parking, fitness facilities (an outdoor track), and numerous outdoor firing ranges. The site, including a buffer area, is south of Bear Creek Road, less than

1.6 km southeast of ETTP, and currently occupies about 61 hectares.

1.7.7.5 Checking Stations

Three checking stations (gathouses), which are DOE-ORO properties, are included in the *National Register of Historic Places* (National Park Service 2003): (1) the Oak Ridge Turnpike Checking Station (Turnpike Checking Station), (2) the Scarboro Road Checking Station (Midway Checking Station), and (3) the Bethel Valley Road Checking Station. Although these structures are listed as checking stations in the *National Register*, they were originally called “gatehouses.” The main building of the Bethel Valley Road Checking Station is located on a parcel of land that was transferred to the city of Oak Ridge. However, the small associated block building just opposite the main structure is still owned by DOE-ORO.

1.7.7.6 Clark Center Recreation Park

Clark Center Recreation Park, an area containing about 32 hectares, is currently being used for recreational park purposes and is available to DOE and its contractor personnel and to the public on a limited basis. The area lies within landholding under the jurisdictional control of DOE and is managed by DOE.

1.7.7.7 DOE Information Center

The DOE Information Center, located at 475 Oak Ridge Turnpike, provides centralized public access to DOE documents and information. The Information Center consolidates Freedom of Information Act documents that were previously available at the DOE Public Reading Room and information about the DOE Office of Environmental Management (DOE-EM) Program that was previously located at the Information Resource Center. The building, which is leased to DOE by R&R Rental Properties, has about 8,000 ft² of space and provides public meeting rooms and office space for the Oak Ridge Site Specific Advisory Board.

1.7.7.8 Federal Office Building

The Federal Office Building, located in Oak Ridge and owned by the General Services Administration, is maintained by DOE. DOE-ORO offices occupy the vast majority of the 113,000 ft² of space in the building.

1.7.7.9 National Transportation Research Center

The National Transportation Research Center (NTRC), an alliance among ORNL, UT, DOE, NTRC, Inc., and the Development Corporation of Knox County, is the site of activities that span the whole range of transportation research. The center is an 85,000-ft² building, located on a 2.4-hectare site in the Pellissippi Corporate Center and is leased to ORNL and UT separately by Pellissippi Investors LLC.

1.7.7.10 Office of Scientific and Technical Information

OSTI is located in Buildings 1916T-1 and 1916T-2, two masonry buildings constructed as warehouses in the 1940s. Building 1916T-1 houses the main OSTI functions as well as other occupants. Portions of it were converted to office space in the 1950s, and additional bays were added in the 1950s and 1960s. Currently, the building has one office bay and seven other bays, for a total space of 135,000 ft². Building 1916T-2 houses DOE-ORO operations, including warehousing and maintenance staff. The two DOE buildings are located on a tract (about 3 hectares) that parallels the Oak Ridge Turnpike about 3.2 km east of the Federal Office Building. Because of their age and configuration, they are classified as Class B buildings (i.e., semipermanent buildings, constructed primarily of wood, which may need to be renewed, renovated, or rehabilitated in the near future) but are deemed adequate for current functions.

1.7.7.11 The Horizon Center

The Horizon Center (previously known as ED-1), was leased to CROET, effective April 28, 1998, and 198 hectares were transferred (by quit claim deed) to CROET in April 2003. The developable portions of the parcel were transferred. The other portions (the natural area that surrounds the East Fork Poplar Creek

floodplain and other locations), remain part of the CROET leasehold. CROET may sublease the land transferred to it or may sell it to others for purposes of economic development. CROET is responsible for the protection and maintenance of all portions of the property.

1.7.7.12 Parcel ED-2

Parcel ED-2, which includes the K-1252 barge facility and an adjacent laydown/access area, is about 4 hectares in size. ED-2 is located in the K-700 area west of the main ETTP site, and it has been leased to CROET. CROET has changed its long-range plan for the barge facility and adjoining property. The current plan recognizes the advent of Rarity Ridge, a residential community across the river from the barge facility. CROET wishes to ensure that future use and further development of the peninsula would be achieved in a manner compatible with this evolving residential community and will be in contact with Rarity Ridge as plans for the barge area are identified.

1.7.7.13 Office of Secure Transportation Firing Range

The Office of Secure Transportation Firing Range, located to the east of the Central Training Facility, is operated by the NNSA Albuquerque Service Center. The surface danger zones for the Central Training Facility and the Office of Secure Transportation Firing Range overlap and together comprise about 1,012 hectares.

1.7.7.14 Office of Secure Transportation Vehicle Maintenance Facility

The Office of Secure Transportation Vehicle Maintenance Facility is located on an 8-hectare site about 1.6 km east of ETTP, on the south side of State Route 58 (Oak Ridge Turnpike), near the intersection with Blair Road. The building has undergone major modifications, including the addition of security fencing, paved parking, and paved access around the building. The total site area constitutes about 40 hectares. The facility is maintained by the Y-12 Complex's Facilities, Infrastructure, and Services

Organization and is funded by the NNSA Albuquerque Service Center.

1.7.7.15 Union Valley Facility

The Union Valley Facility, located on Union Valley Road, is a leased facility operated by the Y-12 Analytical Chemistry Organization. Analytical Chemistry provides a wide range of routine and nonroutine analytical services for environmental and hazardous waste programs of NNSA, DOE, and other customers.

1.7.7.16 Vance Road Facility

On June 20, 2006, the DOE-owned Vance Road Facility, formerly operated by ORISE, was deeded to the Oak Ridge Methodist Medical Center. ORISE and DOE worked together to complete all the necessary paperwork and to obtain all the required approvals to allow DOE to make it available for community reuse.

1.7.7.17 Transuranic Waste Processing Center

The Transuranic (TRU) Waste Processing Center (TWPC), managed by Foster-Wheeler Environmental Company, LLC, is located at 100 Wipp Road, in Lenoir City, Tennessee. The site is located on about 2 hectares of leased land

adjacent to the Melton Valley Storage Tanks, along State Route 95 on the western boundary of ORNL. On November 3, 2006, DOE took over ownership of the TWPC from Foster Wheeler. EnergX is the managing subcontractor.

The TWPC's mission is to receive current inventories of retrievably-stored and legacy TRU wastes and future wastes to be generated from decontamination and decommissioning, remediation, and ongoing mission operations at the ORNL complex. TWPC processes, treats, repackages, and ships the waste for final disposal at the Waste Isolation Pilot Plant (WIPP), Nevada Test Site, or any other designated disposal facility. The TWPC is the only facility of its type in the region specifically designed to accomplish this mission. Low-level radioactive waste, and low-level mixed wastes generated as by-products of TRU process operations are also processed for shipment to the Nevada Test Site or other appropriate disposal facility.

The TWPC consists of the Waste Processing Facility, the Contact-Handled Staging Area, the Personnel Building, and numerous support buildings and storage areas. The TWPC began processing supernatant liquid from the Melton Valley Storage Tanks in 2002, and contact-handled solids in December 2005.

2. Environmental Compliance

It is DOE-ORO and NNSA policy to conduct operations in compliance with federal, state, and local environmental protection laws, regulations, compliance agreements and decrees, settlement agreements, executive orders, DOE orders (as incorporated into the operating contracts), 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.

Except for the few instances of noncompliance discussed in this chapter, all ORR sites were in compliance with applicable environmental regulations in 2006. Each site achieved a National Pollutant Discharge Elimination System permit compliance rate greater than 99.9% in 2006.

In 2006, all three ORR facilities operated in compliance with the regulatory dose limits of Tennessee Rule 1200-3-11-08 (Emission Standards for Hazardous Air Pollutants for Radionuclides) and met its emission and test procedures.

No releases of reportable quantities of hazardous chemicals or asbestos were reported under the Comprehensive Environmental Response, Compensation, and Liability Act by any of the sites.

Several private businesses operate under leasing arrangements at the ETTP under the DOE Reindustrialization Program. Lessees are accountable for complying with all applicable standards and regulations and for obtaining permits and licenses with local, state, and federal agencies as appropriate. Unless specified, lessee operations are not discussed in this report.

2.1 Introduction

DOE's operations on the reservation are required to be in conformance with environmental standards established by a number of federal and state statutes and regulations, executive orders, DOE orders, contract-based standards, and compliance and settlement agreements. However, numerous facilities at the ETTP site have been leased to private entities over the past several years through the DOE Reindustrialization Program. Their level of compliance is not addressed in this report.

Principal among the regulating agencies are the Environmental Protection Agency (EPA) and the Tennessee Department of Environment and Conservation (TDEC). These agencies issue permits, review compliance reports, participate in joint monitoring programs, inspect facilities and operations, and oversee compliance with applicable regulations.

When environmental issues are identified during routine operations or during ongoing self-assessments of compliance status, the issues are typically discussed with the regulatory agencies. In the following sections, major environmental statutes are summarized for the ORR sites. More detailed information can be found in the appendices. See Appendix D for reference standards data for water, Appendix E for National Pollut-

ant Discharge Elimination (NPDES) noncompliances, and Appendix F for a listing of permits.

2.2 Compliance Activities

2.2.1 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, waste chemicals, and many other substances deemed potentially harmful to human health and to the environment. RCRA also regulates underground storage tanks (USTs) used to store petroleum and hazardous substances; recyclable used oil; and universal waste such as batteries, mercury-containing equipment, pesticides, and fluorescent lamps.

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

Oak Ridge Reservation

are required to obtain a permit that includes a plan for long-term, postclosure care of the facility.

The Y-12 Complex, ORNL, and ETTP are considered RCRA large-quantity generators of hazardous waste because each facility individually generates more than 1,000 kg of hazardous waste per month. This number includes the amount of hazardous waste that is managed under permitted activities. Each site is also regulated as a handler of universal waste (e.g., fluorescent lamps, batteries, and other items regulated under *Code of Federal Regulations* (CFR) Title 40, Sect. 273; however, the types of universal wastes managed as such at each site may vary. Some of the hazardous waste contains or is contaminated with radionuclides (this is referred to as "mixed waste"). The hazardous and/or mixed wastes are accumulated at various locations within each site or project location and are eventually transported to a permitted treatment, storage, or disposal facility. A significant quantity is shipped directly off site for treatment, storage, disposal or recycle. At the end of 2006, the Y-12 Complex had 102 generator accumulation areas for hazardous or mixed waste, ORNL had 339 generator accumulation areas, and ETTP maintained 11.

The Union Valley Facility is considered a small-quantity generator of hazardous waste (< 1,000 kg/month). At the end of 2006, it was managing a total of eight accumulation areas.

ORISE, the Central Training Facility on Bear Creek Road, the Office of Secure Transportation Vehicle Maintenance Facility, the ORNL 0800 Area, the National Transportation Research Center (NTRC), and the Freel's Bend area are all classified as conditionally exempt small-quantity generators for calendar year (CY) 2006, meaning that they generate less than 100 kg of hazardous waste per month.

The Y-12 Complex is registered as a large-quantity generator under EPA identification (ID) Number TN3890090001 and is permitted to perform hazardous waste treatment and storage. During 2006, nine units operated as permitted units. The RCRA units at the Y-12 Complex operate under two permits: TNHW-122 and TNHW-127. The permits are modified whenever necessary.

ORNL is registered as a large-quantity generator under EPA ID Number TN1890090003 and is permitted to perform hazardous waste treatment and storage. During 2006, 26 units operated as interim-status or permitted units; another 4 units were proposed (new construction). Five of the interim status units completed the steps for RCRA closure by the end of the calendar year (Table 2.1).

ORNL's RCRA units operate under three permits: TNHW-097, TNHW-010A, and TNHW-121 (formerly TNHW-010). TNHW-121 is the existing RCRA Hazardous and Solid Waste Amendments permit for the ORR (see Table 2.2). The permits are modified when necessary. The process for adding the Foster-Wheeler TRU facility to the TNHW-097 permit that was started at the end of CY 2005 continued in CY 2006. This included both a Part A permit modification and a Part B Permit (TNHW-097) modification. Those Foster-Wheeler units operated under an interim approval during 2006. The renewal application for the TNHW-010A permit submitted in late 2004 is still pending.

In late 2005, ORNL requested permit-by-rule status for extended storage of recyclable lead. In late 2006, TDEC determined that the ORNL lead waste operations are not subject to permitting under TN Rule 1200-1-7-02.

At ETTP, the RCRA closure of K-1025C was completed in CY 2004, while K-1036A and K-711 were closed in CY 2005. The remaining

Table 2.1 Closed RCRA^a units for ORR, CY 2006

Site	Unit	Permit No.	Certified Closed Date
ORNL	SWSA-6 (includes Hillcut Test Facility and Former Chemical Detonation Facility)	NA	November 6, 2006
ORNL	Chemical Detonation Facility	NA	November 15, 2006
ORNL	Trench 27	NA	November 6, 2006
Y-12	East Chestnut Ridge Waste Pile	NA	January 5, 2006

^aResource Conservation and Recovery Act.

Table 2.2. RCRA^a operating permits, 2006

Permit number	Building/description
Y-12 Complex	
TNHW-122	Building 9720-9 Container Storage Unit
	Building 9720-25 Container Storage Unit
	Building 9720-31 Container Storage Unit
TNHW-127	Building 9206
	Building 9212
	Building 9720-12
	Organic Handling Unit
	Building 9812 Container Storage Area
	Building 9811-9 Container Storage Area
ORNL	
TNHW-10A	Building 7507W Container Storage Unit
	Building 7651 Container Storage Unit
	Building 7652 Container Storage Unit
	Building 7653 Container Storage Unit
	Building 7654 Container Storage Unit
	Building 7669 Container Storage Unit
	Portable Buildings 1 & 2 Container Storage Unit
TNHW-097	Building 7572 Container Storage Unit
	Building 7574 Container Storage Unit
	Building 7576 Container Storage Unit
	Building 7577 Container Storage Unit
	Building 7580 Container Storage Unit
	Building 7823 Container Storage Unit
	Building 7824 Container Storage Unit
	Building 7842 Container Storage Unit
	Building 7855 Container Storage Unit
	Building 7878 Container Storage Unit
	Building 7879 Container Storage Unit
	Building 7883 Container Storage Unit
	Building 7884 Container Storage Unit
	Building 7880 Waste Processing Facility 2
	Building 7880 Waste Processing Facility 4
	Building CHSA Waste Processing Facility 1
	Building DAC Waste Processing Facility 3
	Building CSA Waste Processing Facility 5
ORR	
TNHW-121	Hazardous Waste Corrective Action Permit

Table 2.2 (continued)

Permit number	Building/description
ETTP	
TNHW-015	K-1435 Toxic Substances Control Act Incinerator
TNHW-015A	K-1425 and K-1435 Container and Tank Storage Units
TNHW-117	Building K-25 Vault K-309-2A Building K-1065-A Container Storage Unit Building K-1065-B Container Storage Unit Building K-1065-C Container Storage Unit Building K-1065-D Container Storage Unit Building K-1065-E Container Storage Unit Building K-1065-F Container Storage Unit Building K-1065-G Container Storage Unit Building K-1065-H Container Storage Unit Building K-1423 Container Storage Unit Building K-1423 Repackaging Area Portable Buildings 1 & 2 Container Storage Units

^aResource Conservation and Recovery Act

RCRA-permitted units at the ETTP Site include K-1065 A through H, K-1423, vault K-309-2A (located in the K-25 Building), and K-1425/K-1435 TSCA Incinerator units. All other cleanup actions at ETTP are being conducted under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

ETTP is registered as a large-quantity generator under EPA ID Number TN0890090004 and is permitted to perform hazardous waste treatment and storage. ETTP has received three RCRA permits (see Table 2.2). The K-1435 TSCA Incinerator is a hazardous waste treatment unit operating under a RCRA permit (TNHW-015) issued by TDEC on September 28, 1987. A revised RCRA permit based on trial-burn results was received in December 1995. A reapplication of the permit was submitted to TDEC in March 1997. A trial burn was conducted in 2001, and the results were submitted to TDEC. A second permit (TNHW-015A) is for storage of waste at the incinerator. Permit TNHW-117 (formerly TNHW-056) covers container storage at various locations throughout the plant. Permit TNHW-117 was issued September 30, 2004. The historical USTs will be addressed through the CERCLA process.

2.2.1.1 RCRA Assessments, Closures, and Corrective Measures

The Hazardous and Solid Waste Amendments 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 Hazardous and Solid Waste Amendments permit requires DOE to address past, present, and future releases of hazardous constituents to the environment. The Hazardous and Solid Waste Amendments permit requirement for corrective action has been integrated into the ORR Federal Facility Agreement (see Sect. 2.2.2 for details). The current Hazardous Waste Corrective Action permit (TNHW-121) was issued in September 2004.

The renewed permit addresses contaminant releases from SWMUs and from RCRA areas of concern, but also integrates RCRA requirements with cleanups conducted under the Federal Facility Agreement and CERCLA programs (see Sect. 2.2.3).

“Areas of concern” are areas contaminated by a release of hazardous constituents that originated from something other than an SWMU. Under the new Hazardous and Solid Waste Amendments permit, DOE must notify TDEC within 30 days of identification of a new SWMU or new potential areas of concern. DOE has provided to EPA the *2006 Annual Update of the*

Solid Waste Management Units and Area of Concern for the Oak Ridge Reservation (DOE 2005a) (see Table 2.3).

Since the mid-1980s, 45 RCRA units at ETTP have been closed. The RCRA closure of

Table 2.3. Summary of 2006 annual update of ORR solid waste management units

Revision ^a	Number of sites/revisions
Addition of solid waste management units (SWMUs) or area of concern (AOC) to A-2 list	2
Revision made to SWMU/AOC Names, Notes, and Operation end dates on A-1 list	5
Revision made to SWMU/AOC Names, Notes, and Operation end dates on A-2 list	8
Additions to Table A-1	2
Deleted from Table A-2	2
Moved from Table A-1 to A-2	46

^aDepartment of Energy. 2005a. *Annual Update of the Solid Waste Management Units and Areas of Concern for the Oak Ridge Reservation*. Submitted to the Environmental Protection Agency.

At the Y-12 Complex, 37 RCRA units have been closed since the mid-1980s. TDEC accepted the certification of final closure to the East Chestnut Ridge Waste Pile on January 5, 2006. See Table 2.1 for RCRA units closed in 2006.

Since the mid-1980s, ORNL has closed a total of 21 hazardous waste management units. ORNL's solid waste storage area (SWSA) 6 was an interim-status disposal site (landfill) that underwent partial closure beginning in late 1988; the final steps for RCRA closure were completed in 2006. Although a revised closure plan for SWSA 6 (which included the eight interim-measure caps, the Hillcut Test Facility, and the Former Explosives Detonation Trench) was submitted in July 1995, actual final remediation of SWSA 6 was deferred to CERCLA. The Melton Valley Record of Decision, which includes the selected remedy under CERCLA for SWSA 6, was signed in September 2000. The Interim Record of Decision for ORNL's Bethel Valley was issued in May 2002; its goal is to maintain the ORNL main plant as a controlled industrial-use facility. A postclosure permit application for SWSA 6 was submitted to TDEC in September 2002; issuance of the postclosure permit is pending. Phased construction completion reports were submitted to TDEC in 2006 for both SWSA 6 and Trench 27 (in SWSA 5). The RCRA closure of the Chemical Detonation Facility was also completed in 2006.

K-1025C was completed in CY 2004, while K-1036A and K-711 were closed in CY 2005. The remaining RCRA-permitted units at the ETTP Site include K-1065 A through H, K-1423, vault K-309-2A (located in the K-25 Building), and K-1425/K-1435 TSCA Incinerator units. All other cleanup actions at ETTP are being conducted under CERCLA.

RCRA inspections conducted by TDEC at the facilities resulted in four notices of violations (NOVs) issued in 2006, one each at the Y-12 Complex, ORNL, NTRC, and ETTP. Details of the violations are presented in Sect. 2.5.

2.2.1.2 RCRA Subtitle D Solid Waste

Located within the boundary of the Y-12 Complex are two Class II operating industrial solid waste disposal landfills and one operating Class IV construction demolition landfill. These facilities are permitted by TDEC and accept solid waste from DOE operations on the ORR. A second Class IV construction demolition landfill (Landfill VI) has been certified closed, and the permit terminated March 15, 2007. In addition, one Class IV facility (Spoil Area 1) is overfilled by 11,700 yd³ and has been the subject of a CERCLA remedial investigation/feasibility study. A CERCLA record of decision for Spoil Area 1 was signed in 1997. One Class II facility (Landfill II) has been closed and is subject to postclosure care and maintenance. Associated

TDEC permit numbers are noted in Appendix F, Table F.1.

2.2.1.3 RCRA Underground Storage Tanks

The USTs containing petroleum and hazardous substances are regulated under Subtitle I of RCRA (40 CFR 280). TDEC has been granted authority by EPA to regulate USTs containing petroleum under TDEC Rule 1200-I-15; however, hazardous-substance USTs are still regulated by EPA. Table 2.4 summarizes the status of USTs on the ORR.

ORNL has responsibility for 54 USTs registered with TDEC under Facility ID Number 0-730089. These 54 USTs can be classified as follows:

- 49 USTs closed to meet the RCRA Subtitle I requirements;
- 3 USTs in service that meet the 1998 standards for new UST installations; and
- 2 USTs still in service that are deferred or exempt from Subtitle I because they are regulated by other statutes (one UST under the RCRA Subtitle C and one UST under the Clean Water Act [CWA]).

Of the 49 closed USTs, 24 were replaced by double-walled, concrete-encased aboveground storage tanks; 3 were replaced by the new, state-of-the-art USTs; and 22 were not replaced because they were no longer needed. Closure approval letters have been received for all USTs closed between 1988 and 1998.

The Y-12 UST Program includes four active petroleum USTs that meet all current regulatory compliance requirements. Two of these are located at the Office of Secure Transportation Vehicle Maintenance Facility. The UST registration certificates for these tanks are current, and certificates are posted at the UST locations, enabling fuel delivery until March 31, 2007.

All legacy petroleum UST sites at the Y-12 Complex have either been granted final closure by TDEC or have been deferred to the CERCLA process for further investigation and remediation.

The ETTP UST Program includes two active petroleum USTs that meet all current regulatory compliance requirements. The UST registration certificates are updated annually and are conspicuously posted in accordance with TDEC

Table 2.4. ORR underground storage tank (UST) status, 2006

	Y-12 Complex	ORNL	ETTP
Active/in-service	4 ^a	3	2
Closed, deferred or excluded	43 ^b	51 ^c	14
Hazardous substance	0	0 ^d	6 ^e
Known or suspected sites	0	0	16
Total	47	54	38

^aTwo are located off the Y-12 Complex at the Office of Secure Transportation Vehicle Maintenance Facility.

^bIncludes two USTs that are deferred because they are regulated by the Atomic Energy Act of 1954, and one that is a permanently closed methanol UST.

^cThe 51 “closed” USTs include deferred or excluded tanks of various categories, as detailed in the text.

^dClosed tanks include two hazardous substance tanks, both of which were excavated, removed, and dismantled.

^eFour USTs were permanently closed that had been used to store natural gas odorant and that are regulated under the Pipeline Safety Act. A fifth UST, designed as a spill-overflow tank, has never permanently been placed into service. A sixth UST, which stored a methanol-gasoline mixture, was permanently closed.

rules. Fourteen other petroleum USTs have been removed or closed in place with TDEC regulators' recommendation of "case closed" status. During the construction of the haul road, a previously undocumented UST was discovered near Portal 5. The tank was removed and closed out.

Five hazardous substance USTs at ETTP have been removed since 1996. One other hazardous substance UST, designed as a spill overflow tank, is present at ETTP but has never been activated.

Sixteen known and/or suspected historical USTs that were out of service before January 1, 1974, are also included in the ETTP UST Program as a best management practice. These historical UST sites could be subject to closure requirements if directed by UST regulators. Magnetic and electromagnetic geophysical techniques are being used for detection and characterization of these historical UST sites and other underground structures to provide property database information for reindustrialization of ETTP.

2.2.2 CERCLA

CERCLA, also known as Superfund, was passed in 1980 and was amended in 1986 by the Superfund Amendments and Reauthorization Act (SARA). Under CERCLA, a site is investigated and remediated if it poses significant risk to health or the environment. The EPA National Priorities List is a comprehensive list of sites and facilities that have been found to pose a sufficient threat to human health and/or the environment to warrant cleanup under CERCLA. The ORR was placed on the National Priorities List on November 21, 1989, ensuring that the environmental impacts associated with past activities at the ORR are thoroughly investigated and that appropriate remedial actions or interim measures are taken as necessary to protect human health and the environment. An interagency agreement under Sect. 120(c) of CERCLA, known as the ORR Federal Facility Agreement, was effective in 1992 among EPA, TDEC, and DOE. The agreement establishes the procedural framework and schedule for developing, implementing, and monitoring remedial actions on the ORR in accordance with CERCLA. Appendix C of the Federal Facility Agreement lists all of the sites/areas that will be investigated, and possibly remediated, under CERCLA. Milestones for

submittal of CERCLA documents are available in Appendix E of the agreement.

The progress toward achieving these goals is described in the *2006 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE 2007a). This report describes the individual remedial actions and provides an overview of some of the monitoring conducted to evaluate the efficacy of those actions.

Staff from NNSA and BWXT Y-12 have provided periodic updates of proposed construction and demolition activities at the Y-12 Complex (including alternative financing projects) to managers and project personnel from the TDEC DOE Oversight Division, EPA Region 4, and DOE-ORO. A CERCLA screening process is used to identify proposed construction and demolition projects that warrant CERCLA oversight. The goal is to ensure that modernization efforts do not impact the effectiveness of previously completed CERCLA environmental remedial actions and that they do not adversely impact future CERCLA environmental remedial actions. A similar CERCLA screening process is being utilized by ORNL (UT-Battelle, LLC) for its revitalization/modernization efforts.

2.2.3 RCRA-CERCLA Coordination

The CERCLA response action and RCRA corrective action processes are similar and include four steps with similar purposes (Table 2.5). The ORR Federal Facility Agreement is intended to coordinate the corrective action processes of RCRA required under the Hazardous and Solid Waste Amendments permit with CERCLA response actions.

As a further example, three RCRA postclosure permits, one for each of the three hydrogeologic regimes at Y-12, have been issued to address the eight major closed waste disposal areas at Y-12. Because it falls under the jurisdiction of two postclosure permits, the S-3 Pond Site is described as having two parts (eastern and former S-3) (see Table 2.6). Postclosure care and monitoring of East Chestnut Ridge Waste Pile was incorporated into permit TNHW-088 in 2006. Groundwater corrective actions required under the postclosure permits have been deferred to CERCLA. RCRA groundwater

Table 2.5. RCRA corrective action processes and CERCLA response actions^a

RCRA	CERCLA	Purpose
RCRA facility assessment	Preliminary assessment/site investigation	Identify releases needing further investigation
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

^aAbbreviations

RCRA

Resource Conservation and Recovery Act

CERCLA

Comprehensive Environmental Response, Compensation, and Liability Act

monitoring data will be reported yearly to TDEC and EPA in the Annual CERCLA *Remediation Effectiveness Report* for the ORR.

2.2.4 Federal Facility Compliance Act

The Federal Facility Compliance Act was passed by Congress to bring federal facilities (including those under DOE) into full compliance with RCRA. The Federal Facility Compliance Act waives the government's sovereign immunity and allows fines and penalties to be imposed for RCRA violations at DOE facilities. In addition, the act requires that DOE facilities provide comprehensive data to EPA and state regulatory agencies on mixed waste inventories, treatment capacities, and development of site treatment plans. It 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.

The ORR Site Treatment Plan calls for mixed 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 Transuranic Waste Processing Facility as necessary to meet the waste acceptance criteria for disposal at the WIPP.

The ORR Site Treatment Plan provides overall schedules, milestones, and target dates

for achieving compliance with land disposal restrictions, a general framework for the establishment and review of milestones, and other provisions for implementing the plan that are enforceable under an order from the TDEC commissioner. Semiannual progress reports document the quantity of land-disposal-restricted mixed waste in storage at the end of the previous 6-month period and the estimated quantity to be placed in storage for the next 5 fiscal years. The annual update of the ORR Site Treatment Plan has been issued for CY 2006.

The Site Treatment Plan will terminate in accordance with Sect. 2.7.2 of the Federal Facility Compliance Act, when there is no longer any land-disposal-restriction mixed waste, regardless of when generated, being stored on the ORR; to do so in the absence of a site treatment plan would be in violation of RCRA Section 3004(j).

2.2.5 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. The NEPA review process results in the preparation of NEPA documents in which federal, state, and local environmental regulations and DOE orders applicable to the environmental resource areas must be considered. These environmental resource areas include air, surface water, groundwater, terrestrial, and aquatic ecology; threatened and/or endangered species; land use; and environmentally sensitive areas.

Table 2.6. RCRA postclosure status for former treatment, storage, and disposal units on the ORR^{a, b}

Unit	Major components of closure	Major postclosure requirements
Upper East Fork Poplar Creek Hydrogeologic Regime (RCRA Postclosure Permit No. TNHW-113)		
New Hope Pond	Engineered cap, Upper East Fork Poplar Creek distribution channel	Cap inspection and maintenance. No current groundwater monitoring requirements in lieu of ongoing CERCLA actions in the eastern portion of Y-12
Chestnut Ridge Hydrogeologic Regime (RCRA Postclosure Permit No. TNHW-088)		
Chestnut Ridge Security Pits	Engineered cap	Cap inspection and maintenance. Postclosure corrective action monitoring. Inspection and maintenance of monitoring network and survey benchmarks
Kerr Hollow Quarry	Waste removal, access controls	Access controls inspection and maintenance. Postclosure detection monitoring. Inspection and maintenance of monitoring network and survey benchmarks
Chestnut Ridge Sediment Disposal Basin	Engineered cap	Cap inspection and maintenance. Postclosure detection monitoring. Inspection and maintenance of monitoring network and survey benchmarks
Bear Creek Hydrogeologic Regime (RCRA Postclosure Permit No. TNHW-116)		
Former S-3 Ponds (S-3 Site)	Neutralization and stabilization of wastes, engineered cap, asphalt cover	Cap inspection and maintenance. Postclosure corrective action monitoring. Inspection and maintenance of monitoring network and survey benchmarks
Oil Landfarm	Engineered cap	Cap inspection and maintenance. Postclosure corrective action monitoring. Inspection and maintenance of monitoring network and survey benchmarks
Bear Creek Burial Grounds A, B, and Walk-In Pits	Engineered cap, leachate collection system specific to the burial grounds	Cap inspection and maintenance. Post-closure corrective action monitoring. Inspection and maintenance of monitoring network and survey benchmarks

^aThere were no closures of treatment, storage, and disposal units at East Tennessee Technology Park during CY 2006.

^bAbbreviations

RCRA	Resource Conservation and Recovery Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act

Environmentally sensitive areas include floodplains, wetlands, prime farmland, habitats for threatened and/or endangered species, historic properties, and archaeological sites. Each ORR site NEPA program maintains compliance with NEPA through the use of its site-level procedures and program descriptions. These procedures and program descriptions assist in establishing effective and responsive communications with program managers and project engineers to establish NEPA as a key consideration in the formative stages of project planning. Table 2.7 notes the types of NEPA activities conducted at the ORR during 2006.

of project-specific CXs that were approved by DOE-ORO during 2006.

UT-Battelle utilizes the Standards-Based Management System (SBMS) as the delivery system to manage and control work at ORNL. This system uses three work-control categories: (1) R&D programs and projects; (2) operations, maintenance and services; and (3) office environment (e.g., management, office support, and clerical activities). NEPA is an integral part of SBMS and often utilizes principal investigators, environmental compliance representatives, and environmental protection officers within each

Table 2.7. National Environmental Policy Act (NEPA) activities during 2006

Types of NEPA documentation	Y-12 Complex	ORNL	ETTP
Categorical exclusions (CX) approved	15	5	1
Approved under general actions or generic CX documents	35 ^a	32 ^a	8
Environmental assessment	1 ^b	1	
Initiated Site-Wide Environmental Impact Statement (SWEIS)	1		
Supplement Analysis ^c	1		

^aProjects that were reviewed and documented through the site NEPA compliance coordinator.

^bPotable water system upgrade.

^cSupplement to current Y-12 sitewide environmental impact statement for enriched uranium global transportation.

During 2006, ORNL operated under a procedure that provided requirements for project reviews and compliance with NEPA. This procedure called for review of each proposed project, activity, or facility to determine its potential to result in significant impacts to the environment. To streamline the NEPA review and documentation process, DOE-ORO approved “generic” categorical exclusions (CXs) that would cover proposed bench- and pilot-scale research activities and generic CXs that would cover proposed nonresearch activities (i.e., maintenance activities, facilities upgrades, personnel safety enhancements). A CX is one of a category of actions defined in 40 CFR 1508.4 that do not individually or cumulatively have a significant effect on the human environment and for which neither an environmental assessment nor an environmental impact statement is normally required. Table 2.7 provides the number

ORNL division to determine the appropriate NEPA decision. The NEPA decision is based on the approved generic CXs for a particular division, a person’s NEPA training, and, when necessary, guidance from the ORNL NEPA compliance coordinator. UT Battelle projects involving the assignment of a project engineer from the ORNL Facilities Development Division, projects that are outside the scope of generic CXs, and projects that will adversely impact cultural resources are reviewed and documented by the ORNL NEPA compliance coordinator.

DOE implemented the Facilities Revitalization Project at ORNL, and groundbreaking activities for the various infrastructures (e.g., parking lots, utilities) started in March 2002. The Facilities Revitalization Project is being accomplished through a cooperative effort between DOE, the state of Tennessee, and private

entities. The environmental assessment and finding of no significant impact (FONSI) (DOE 2001b) that were prepared by DOE addressed the Facilities Revitalization Project phased program approach to cover construction and upgrading of facilities according to ORNL's Strategic Facilities Plan into FY 2011.

DOE has completed an environmental assessment (DOE 2006b) that evaluates the impacts of facility modifications and the processing of uranium-233 (^{233}U) stored at ORNL and other small quantities of similar material currently stored at other DOE sites. The project objectives are to modify the facility to accommodate the process equipment and operations; process the inventory in order to render it suitable for safe, economical storage; and place the Building 3019 Complex in safe and stable shutdown for decontamination and decommissioning (D&D). Based on the results of the analyses reported in the environmental assessment, DOE has determined that the proposed action is not a major federal action that would significantly affect the quality of the human environment within the meaning of NEPA. Therefore, the preparation of an environmental impact statement is not necessary, and DOE is issuing a FONSI.

In 2006, NEPA reviews at ETTP supported a number of tenant modifications and improvements to leased facilities. There was one site-specific CX prepared in 2006 for ETTP for the installation of a wastewater treatment system at the TSCA Incinerator.

At the Y-12 Complex, 14 job-specific CX documents were prepared and were approved in CY 2006 in support of the Infrastructure Reduction Program. The Infrastructure Reduction effort is focused on preparing the Y-12 Complex for modernization. During FY 2006 it reduced the Y-12 Complex "footprint" by more than 109,000 ft² through building demolition (19 buildings or structures were demolished). In addition, three general CXs prepared for the NNSA small business program were approved. Other general NEPA CX reviews covered routine actions, such as office renovations, improvements to security systems, equipment replacements, and infrastructure improvements. In CY 2006, 52 NEPA reviews were performed and approved.

The Y-12 NNSA Site Office prepared the final environmental assessment for the potable water system upgrade project to evaluate the repairs and upgrades to the existing system. The FONSI was signed March 29, 2006.

In addition, NNSA is preparing a Site-Wide Environmental Impact Statement (SWEIS) for the Y-12 Complex. The new SWEIS will evaluate new proposals as well as update the analyses presented in the original SWEIS (DOE 2000), issued in November 2001. Three action alternatives are proposed for consideration in the new SWEIS in addition to a "no action alternative." The three alternatives differ in that one includes a new, fully modernized manufacturing facility optimized for safety, security, and efficiency; another consists of upgrading the existing facilities to attain the highest level of safety, security, and efficiency possible without construction of new facilities; and the third consists of operating the current facilities until they are no longer viable and then deactivating those facilities and ceasing the associated operations. The public scoping period began December 15, 2005, and was extended through January 31, 2006, to provide the public with an opportunity to present comments and ask questions.

A supplement analysis to the Y-12 SWEIS was prepared and was approved on August 30, 2006. It presents an assessment of the impacts of transportation of foreign enriched uranium (highly-enriched uranium and low enriched uranium) to the United States. The impact analyses presented in the supplement analysis for air transport are based on hypothetical shipments that provide an upper bound for impacts of any actual shipment.

On October 19, 2006, NNSA announced its plans to prepare an environmental impact statement for the transformation and modernization of the Cold War-era nuclear weapons complex. NNSA issued in the *Federal Register* a notice of intent to prepare an environmental impact statement, which will be entitled *Complex 2030 Supplement to the Stockpile Stewardship and Management Programmatic Environmental Impact Statement*. The notice of intent outlines the alternatives that the NNSA will consider in transforming the nuclear weapons complex to better meet future national security requirements. Earlier in the year, NNSA outlined its comprehensive plan, called Complex 2030, for a

smaller, more efficient nuclear weapons complex that would be better able and more suited to respond to future national security challenges.

2.2.6 National Historic Preservation Act

In March 2003, President Bush signed Executive Order 13287, "Preserve America," directing federal agencies to improve their management of historic properties and to foster heritage tourism in partnership with local communities. Section 106 of the National Historic Preservation Act (NHPA) requires that federal agencies take into account the effects of their undertakings on properties included in or eligible for inclusion in the *National Register of Historic Places* (National Park Service 2003). To comply with Section 106 of the NHPA and its implementing regulations at 36 CFR 800, DOE-ORO was instrumental in the ratification of a programmatic agreement among DOE-ORO, the Tennessee state historic preservation officer, and the Advisory Council on Historic Preservation concerning management of historical and cultural properties on the ORR. The programmatic agreement was ratified on May 6, 1994, and has been incorporated into the approved *Cultural Resource Management Plan, DOE Oak Ridge Reservation* (DOE 2001a). The plan was completed in accordance with stipulations in the programmatic agreement, including historical surveys to identify significant historical properties on the ORR. Measures were implemented in 2005 to update the plan by giving the principal participants (ORNL, Y-12 Complex, and ETTP) key sections that pertain to their sites for revision. Because of plans to demolish a significant number of buildings on the ORNL and Y-12 Complex sites, a second programmatic agreement was drafted for each site. Both agreements have been approved by DOE-ORO, the state historic preservation officer, and the council. In concurrence with the programmatic agreement, a historic preservation plan was drafted and was issued (Thomason 2004) for the management and disposition of properties managed by DOE-ORO that included the DOE offices of Science, Nuclear Energy, and Environmental Management. Requirements of the programmatic agreement (also stated in the historic preservation plan) include

1. developing and implementing an interpretive plan for ORNL by 2007,
2. developing an oral history program of current and former ORNL employees by 2005, and
3. conducting a survey to identify significant historical machinery and equipment by 2007.

The oral history program was completed in 2005, and a draft of the ORNL interpretative plan was completed and submitted to upper management for review and approval. Compliance with NHPA at ORNL, the Y-12 Complex, and ETTP is achieved and maintained in conjunction with NEPA compliance. The scope of proposed actions is reviewed in accordance with the *Cultural Resource Management Plan* (DOE 2001a). If warranted, consultation is initiated with the state historic preservation officer and the advisory council, and the appropriate level of documentation is prepared and submitted.

The Y-12 Complex, in accordance with the programmatic agreement, submitted to the state historic preservation officer Section 106 recordation, interpretation, and documentation information for the demolition of Building 9720-6. The state historic preservation officer reviewed the information and agreed that the Section 106 documentation adequately mitigated project effects upon properties eligible for listing in the National Register of Historic Places.

A machinery and equipment survey was completed December 31, 2006. This survey documented the remaining machinery and equipment associated with the historic missions of the Y-12 Complex during World War II and the Cold War. The Y-12 Complex continues ongoing efforts to demonstrate its commitment to interpret the history of Y-12 by conducting oral histories of former and current employees, maintaining several interpretive centers located at Y-12, maintaining the Y-12 History Library, collecting artifacts throughout the plant, continuing to use and maintain its historic properties, and partnering with local businesses and organizations. Planning is also under way for the two new facilities being constructed at Y-12, the New Hope Center and the Jack Case Center, to house historic exhibits that convey the history of the Y-12 Complex to the public and its employees.

ETTP was surveyed in 1994 to identify properties eligible for inclusion in the *National Register*. An archaeological survey was also completed at ETTP. Eligible properties include the ETTP Main Plant Historic District, which includes facilities within the main plant and contains 120 contributing structures; 37 noncontributing structures; and 11 structures that are not contiguous with the historic district. More detailed information on the properties eligible for inclusion in the National Register is provided in the *Cultural Resource Management Plan* (DOE 2001a).

In August 2002, DOE submitted a notification of adverse effect for a proposed undertaking that involved D&D of properties located at the ETTP. The proposed project is to decontaminate and demolish or transfer all remaining properties located within the K-25 site main plant and powerhouse historic districts located on the ORR in Roane County, Tennessee, as outlined in the Oak Ridge Comprehensive Closure Plan. The Tennessee state historic preservation officer, the advisory council, and other interested parties were invited to participate in the planning stages of the proposed undertaking and to enter into the consultation process. Consultation began to develop a path forward, and a memorandum of agreement was negotiated among the consulting parties in 2003 on the D&D of the K-25 and K-27 buildings to determine actions to avoid, minimize, or mitigate the adverse effects to those two historical properties. Other ETTP projects were reviewed in accordance with the programmatic agreement or the *Cultural Resource Management Plan*, and a memorandum of agreement was signed in 2004 for the demolition of 108 buildings and structures. Meetings were held in 2004 with the consulting parties to finalize a memorandum of agreement for the historical interpretation of the K-25 Site. The agreement was signed in 2005.

A survey of all ORISE structures was conducted to comply with the NHPA. Only one structure currently under ORISE stewardship, the Atmospheric Turbulence and Diffusion Division Laboratory main building, was identified as being included in the *National Register*. All actions performed at that site conform to the programmatic agreement with the state historic preservation officer.

2.2.7 Protection of Wetlands

The ORR implements protection of wetlands through each site's NEPA program in accordance with Executive Order 11990 and 10 CFR 1022, "Compliance with Floodplain/Wetlands Environmental Review Requirements," and each of the three major sites conducts surveys for the presence of wetlands on a project- or program-as-needed basis. In the 1990s, an effort was initiated to conduct a wetlands survey of the entire reservation (LMES 1995). That effort was not completed, but wetland surveys and delineations were conducted on about 5,666 hectares of the 13,931 hectares that made up the reservation at that time (LMER 1996).

About 243 hectares of wetlands have been identified, most being classified as forested palustrine, scrub/shrub, and emergent wetlands. Wetlands occur across the ORR at low elevation, primarily in riparian zones of headwater streams and their receiving streams, as well as in the Clinch River embayments. Wetlands identified to date range in size from several square meters at small seeps and springs to approximately 10 hectares at White Oak Lake. Surveys of wetlands resources presented in Identification and Characterization of Wetlands in the Bear Creek Watershed (MMES 1993), Wetland Survey of Selected Areas in the Oak Ridge Y-12 Plant Area of Responsibility, Oak Ridge, Tennessee (LMES 1997), and Wetland Survey of the X-10 Bethel Valley and Melton Valley Groundwater Operable Units at Oak Ridge National Laboratory (Rosensteel 1996), serve as reference documents to support wetlands assessments for upcoming projects and activities.

Construction of an access road to the SNS Facility at ORNL in 2000 resulted in the loss of a small amount of wetland area. To mitigate the loss, a wetlands restoration project was designed and implemented in accordance with the aquatic resources alteration permit (ARAP) issued by TDEC. The ARAP required 5 years of annual monitoring to evaluate the success of the mitigation project and required an annual report detailing vegetation, soils, hydrology, and any remedial actions necessary to address deficiencies. The fifth and final annual report, which detailed the results of the monitoring done in 2005, was completed in August 2006. The five years of monitoring indicate that the restored

wetland acreage is functioning as a viable wetland community (Peterson and Trotter 2006).

In 2005, the construction of the haul road from ETTP to the Environmental Management Waste Management Facility (EMWMF) raised concerns about the impact on several small wetland areas along the proposed route. The route was surveyed by personnel from ORNL's Environmental Sciences Division. Jurisdictional wetland areas were delineated and marked. Wherever feasible, the route of the road was modified to bypass the wetlands areas. Wetlands compensatory mitigation measures included wetlands creation and restoration and stream restoration efforts, including the construction of the Bear Creek weir bypass. The weir bypass project was completed in March 2006.

2.2.8 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 statements of findings are prepared in accordance with 10 CFR 1022, usually as part of the NEPA review and documentation process.

A floodplain, according to 10 CFR 1022, means the lowlands adjoining inland and coastal waters and relatively flat areas and flood-prone areas of offshore islands including, at a minimum, that area inundated by a 1% or greater chance of flood in any given year. The base floodplain is defined as the 100-year (1.0%) floodplain. The critical action floodplain is defined as the 500-year (0.2%) floodplain. Floodplain assessments and the associated notices of involvement and statements of findings are prepared in accordance with 10 CFR 1022, usually

as part of the NEPA review and documentation process. The TVA has conducted floodplain studies along the Clinch River, Bear Creek, and East Fork Poplar Creek. Portions of the Y-12 Complex lie within the 100- and 500-year floodplains of East Fork Poplar Creek; portions of ORNL lie within the floodplain of White Oak Creek.

2.2.9 Endangered Species Protection

Good stewardship, state laws ("The Rare Plant Protection and Conservation Act of 1985," Tennessee Code Annotated Section 70-8-301 to 314, and "Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act of 1974," Tennessee Code Annotated Section 70-8-101 to 110), and federal laws ("Endangered Species Act of 1973," 16 U.S.C. 1531 et seq.) dictate that animal and plant species of concern be considered when a proposed project has the potential to alter their habitat or otherwise harm them. At the federal level, such species are classified as endangered, threatened, or species of concern. At the state level, these species are considered endangered, threatened, of special concern (plants), or in need of management (animals). All such species are termed "special concern" species in this report. Additionally, a memorandum of understanding has been established between DOE and the U.S. Fish and Wildlife Service regarding implementation of Executive Order 13186 for protection of migratory birds (Federal Register, Vol. 71, No 218, Nov. 13, 2006). The memorandum of understanding identifies specific areas in which cooperation will contribute to the conservation and management of migratory birds and their habitats.

2.2.9.1 Special Concern Animals

Listed animal species known to be present on the reservation (excluding the Clinch River bordering the reservation) are given along with their status in Table 2.8. The list illustrates the diversity of birds on the ORR, which is also habitat for many unlisted species, some of which are in decline nationally or regionally. Other

Table 2.8. Animal species of concern reported from the Oak Ridge Reservation^a

Sensitive wildlife species recently found on the Oak Ridge Reservation

Scientific name	Common name	Status ^b		
		Federal	State	PIF ^c
Fish				
<i>Phoxinus tennesseensis</i>	Tennessee dace		NM	
Amphibians and reptiles				
<i>Hemidactylum scutatum</i>	Four-toed salamander		NM	
Birds				
<i>Accipiter striatus</i>	Sharp-shinned hawk		NM	
<i>Anhinga anhinga</i>	Anhinga		NM	
<i>Caprimulgus carolinensis</i>	Chuck-will's-widow			C
<i>Ardea alba</i>	Great egret		NM	
<i>Circus cyaneus</i>	Northern harrier		NM	
<i>Contopus cooperi</i>	Olive-sided flycatcher		NM	
<i>Dendroica caerulescens</i>	Black-throated blue warbler			C
<i>Dendroica cerulean</i>	Cerulean warbler		NM	C
<i>Dendroica discolor</i>	Prairie warbler			C
<i>Egretta caerulea</i>	Little blue heron		NM	
<i>Egretta thula</i>	Snowy egret		NM	
<i>Falco peregrinus</i>	Peregrine falcon	^d	E	
<i>Haliaeetus leucocephalus</i>	Bald eagle	^e	NM	
<i>Helminthorus vermicivorus</i>	Worm-eating warbler			C
<i>Hylocichla mustelina</i>	Wood thrush			C
<i>Lanius ludovicianus</i>	Loggerhead shrike		NM	
<i>Oporornis formosus</i>	Kentucky warbler			C
<i>Pooecetes gramineus</i>	Vesper sparrow		NM	
<i>Prothonotaria citrea</i>	Prothonotary warbler			C
<i>Seiurus motacilla</i>	Louisiana waterthrush			C
<i>Sitta pusilla</i>	Brown-headed nuthatch			C
<i>Sphyrapicus varius</i>	Yellow-bellied sapsucker		NM	
<i>Spizella pusilla</i>	Field sparrow			C
<i>Tyto alba</i>	Barn owl		NM	
<i>Vermivora chrysoptera</i>	Golden-winged warbler		NM	C
<i>Vermivora pinus</i>	Blue-winged warbler			C
Mammals				
<i>Myotis grisescens</i>	Gray bat	E	E	
<i>Sorex longirostris</i>	Southeastern shrew		NM	

^aLand and surface waters of the ORR exclusive of the Clinch River, which borders the ORR. Some (e.g., anhinga) have been seen only once or a few times; others (e.g., sharp-shinned hawk, southeastern shrew) are comparatively common and widespread on the reservation.

^bE endangered

T threatened

NM in need of management

C birds of concern

^cPartners in Flight.

^dThe peregrine falcon was federally delisted on August 25, 1999.

^eThe bald eagle was proposed for federal delisting on July 6, 1999.

listed species may also be present, although they have not been observed recently. These include several species of mollusks (such as the spiny river snail), amphibians (such as the hellbender), birds (such as Bachman's sparrow), and mammals (such as the smoky shrew). Birds, fish, and aquatic invertebrates are the most thoroughly surveyed animal groups on the ORR. The only federally listed animal species that has recently been observed on the ORR is the gray bat, which was observed over water bordering the ORR (the Clinch River) in 2003 and over a pond on the ORR in 2004. A gray bat was mist-netted outside a cave on the ORR in 2006. The federally threatened bald eagle is increasingly seen in winter and may well begin nesting here within a few years. Similarly, several state-listed bird species, such as the anhinga, olive-sided flycatcher, and little blue heron, are currently uncommon migrants or visitors to the reservation; however, the little blue heron is probably increasing in numbers. The cerulean warbler, listed by the state as in need of management, has been recorded during the breeding season; however, this species is not actually known to breed on the reservation. Others, such as the cerulean warbler, northern harrier, great egret, and yellow-bellied sapsucker, are migrants or winter residents that do not nest on the reservation. The golden-winged warbler (*Vermivora chrysoptera*), listed by the state as in need of management, has been sighted once on the reservation. One federal and state threatened species, the spotfin chub (*Cyprinella monnacha*), has been sighted and collected in the city of Oak Ridge and is possibly present on the ORR. The Tennessee Dace has been found in some sections of Grassy Creek.

The Grassy Creek population of the Tennessee Dace is one of the most important populations of this species in Tennessee. The construction of the haul road from ETTP to EMWMF had the potential to impact that population. As a result, several mitigation measures were incorporated into the construction. Measures included construction of bridges at Bear Creek and other tributaries where the dace are suspected to live (to minimize disturbance of the streams) and the use of extra large culverts and "skylights" at the crossover points where bridges were not feasible (these features reduce sedi-

mentation and allow more light into the culvert, which facilitates migration of the fish through these points.)

2.2.9.2 Threatened and Endangered Plants

There are currently 21 listed plant species that have been observed in the last 10 years on the ORR; among them are the pink lady's-slipper and Canada lily (Table 2.9). Two species occurring on the ORR, Carey's saxifrage and the purple fringeless orchid, have been removed from the state list as of November 17, 1999. Big-tooth aspen, recently found on the ORR was down-listed by the state at the January 2007 scientific advisory committee meeting. Four species (spreading false-foxglove, Appalachian bugbane, tall larkspur, and butternut) have been under review for listing at the federal level and were listed under the formerly used "C2" candidate designation. These species are now informally referred to as "special concern" species by the U.S. Fish and Wildlife Service.

Two additional species listed by the state, the Michigan lily and the hairy sharp-scaled sedge, were identified in the past on the ORR; however, they have not been found in recent years. Several state-listed plant species currently found on adjacent lands may be present on the ORR as well, although they have not been located (Table 2.9).

2.2.10 Environmental Justice

On February 11, 1994, Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," was promulgated. 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 and that federal agencies must ensure that there are no disproportionate impacts from their actions on low-income and minority communities surrounding their facilities.

An environmental justice strategy is in place at DOE under the direction of the Office of Legacy Management. It addresses the refocusing of policies and programs by departmental elements, more meaningful dialogue with stakeholders to

Table 2.9. Vascular plant species listed by state or federal agencies, 2006

Species	Common name	Habitat on ORR	Status code ^a
Currently known or previously reported from the ORR			
<i>Aureolaria patula</i>	Spreading false-foxfoglove	River bluff	FSC, S
<i>Carex gravida</i>	Heavy sedge	Varied	S
<i>Carex oxylepis</i> var. <i>pubescens</i> ^b	Hairy sharp-scaled sedge	Shaded wetlands	S
<i>Cimicifuga rubifolia</i>	Appalachian bugbane	River slope	FSC, T
<i>Cypripedium acaule</i>	Pink lady's-slipper	Dry to rich woods	E, CE
<i>Delphinium exaltatum</i>	Tall larkspur	Barrens and woods	FSC, E
<i>Diervilla lonicera</i>	Northern bush-honeysuckle	River bluff	T
<i>Draba ramosissima</i>	Branching whitlow-grass	Limestone cliff	S
<i>Elodea nuttallii</i>	Nuttall waterweed	Pond, embayment	S
<i>Fothergilla major</i>	Mountain witch-alder	Woods	T
<i>Hydrastis canadensis</i>	Golden seal	Rich woods	S, CE
<i>Juglans cinerea</i>	Butternut	Slope near stream	FSC, T
<i>Juncus brachyccephalus</i>	Small-head rush	Open wetland	S
<i>Lilium canadense</i>	Canada lily	Moist woods	T
<i>Lilium michiganense</i> ^c	Michigan lily	Moist woods	T
<i>Liparis loeselii</i>	Fen orchid	Forested wetland	E
<i>Panax quinquefolius</i>	Ginseng	Rich woods	S, CE
<i>Platanthera flava</i> var. <i>herbiola</i>	Tubercled rein-orchid	Forested wetland	T
<i>Ruellia purshiana</i>	Pursh's wild-petunia	Dry, open woods	S
<i>Scirpus fluviatilis</i>	River bulrush	Wetland	S
<i>Spiranthes lucida</i>	Shining ladies-tresses	Boggy wetland	T
<i>Thuja occidentalis</i>	Northern white cedar	Rocky river bluffs	S
<i>Viola tripartita</i> var. <i>tripartita</i>	Three-parted violet	Rocky woods	S
Rare plants that occur near and could be present on the ORR			
<i>Agalinis auriculata</i>	Earleaf false foxglove	Calcareous barren	FSC, E
<i>Allium burdickii</i> or <i>A. tricoccum</i> ^d	Ramps	Moist woods	S, CE
<i>Berberis canadensis</i>	American barberry	Rocky bluff, creek bank	S
<i>Gnaphalium helleri</i>	Catfoot	Dry woodland edge	S
<i>Lathyrus palustris</i>	A vetch	Moist meadows	S
<i>Liatris cylindracea</i>	Slender blazing star	Calcareous barren	E
<i>Lonicera dioica</i>	Mountain honeysuckle	Rocky river bluff	S
<i>Meehania cordata</i>	Heartleaf meehania	Moist calcareous woods	T
<i>Pedicularis lanceolata</i>	Swamp lousewort	Calcareous wet meadow	T
<i>Pycnanthemum torrei</i>	Torrey's mountain-mint	Calcareous barren edge	S
<i>Solidago ptarmicoides</i>	Prairie goldenrod	Calcareous barren	E

^aStatus codes:

FSC Federal Special Concern; formerly designated as C2. See Federal Register, February 28, 1996.

E Endangered in Tennessee.

T Threatened in Tennessee.

S Special concern in Tennessee.

CE Status due to commercial exploitation.

^b*Carex oxylepis* var. *pubescens* has not been observed during recent surveys.^c*Lilium michiganense* is believed to have been extirpated from the ORR by the impoundment at Melton Hill.^dRamps have been reported near the ORR, but there is not sufficient information to determine which of the two species is present or if the occurrence may have been introduced by planting. Both species of ramps have the same state status.

address the impact of DOE operations on communities, and the continuation of ongoing programmatic activities with the infusion of a heightened sensitivity to the principles of environmental justice.

In addition to the strategy, federal actions that may significantly affect the quality of the human environment require NEPA documents that address minority and low-income communities. The “affected environment” and “environmental consequences” sections include a “socioeconomic impacts” subsection of the document to identify any disproportionately high and adverse impacts on low-income and minority populations.

2.2.11 Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) of 1974 is an environmental statute for the protection of drinking water. This act requires the 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.

The city of Oak Ridge supplies potable water to the Y-12 Complex and ORNL. The water treatment plant, located north of the Y-12 Complex, is owned by the city of Oak Ridge. The K-1515 sanitary water plant provides drinking water for ETTP and for an industrial park located on Bear Creek Road south of the site. The DOE-owned facility is classified as a nontransient, noncommunity water supply system by TDEC and is subject to state regulations. On April 1, 1998, operation of this leased facility became the responsibility of Operations Management International, Inc., under contract with CROET.

The Y-12 Complex, ORNL, and ETTP perform certain monitoring activities, including analyses for free residual chlorine, bacteriological agents, disinfectant by-products, and copper and lead. The Y-12 Complex and ORNL potable water systems are classified as a nontransient, noncommunity water supply system by TDEC.

The Y-12 Complex and ORNL distribution systems have qualified for triennial lead and

copper sampling. The Y-12 Complex distribution system was last sampled in 2005 and is scheduled to be sampled again in 2008; the ORNL system was sampled in 2006. The Y-12 Complex and ORNL were compliant with the lead and copper requirements. In addition, the ORNL drinking water distribution system’s bacteriological sample analyses were satisfactory in 2006. There was one exception at Y-12. On March 6, 2006, a letter of a violation of the National Primary Drinking Water Regulations for the compliance period ending January 31, 2006, was received from TDEC. Regulation 1200-5-1-07 requires water systems to collect and submit eight bacteriological sample results during each month. While eight samples were sent for analysis, only seven were documented as being received. Y-12’s response included changes in site notification, procedures, and sampling handling. At no time was there any indication of contamination of the water supply. Analytical results were satisfactory for disinfection by-products (total trihalomethanes and haloacetic acids) for the Y-12 and ORNL water systems.

ORNL and ETTP have cross-connection prevention programs to prevent the contamination of potable water through the use of backflow preventers, engineering design, and physical separation. Backflow preventers that fail performance checks are repaired, or the water supply to the equipment is taken out of service. Y-12 continues to revise its cross-connection control program in response to TDEC comments. Y-12 is also developing a sampling program to validate the adequacy of check valves on approximately 120 antifreeze loop fire systems containing propylene glycol that are connected to the potable water supply. A potable water upgrade project, scheduled for completion in 2010, is planned to install backflow preventers on those systems.

2.2.12 Clean Water Act

The objective of the CWA is to restore, maintain, and protect the chemical, physical, and biological integrity of the nation’s waters. With continued amendments, the CWA serves as the basis for comprehensive federal and state programs to protect the nation’s waters from pollutants. Congress continues to work on amendments to and reauthorization of the CWA.

(See Appendix D for reference standards for water.)

2.2.12.1 National Pollutant Discharge Elimination System

One of the strategies developed to achieve the goals of the CWA was EPA's establishment of limits on specific pollutants that are allowed to be discharged to waters of the United States by municipal sewage treatment plants and industrial facilities. 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. Authority for implementation and enforcement of the NPDES program has been delegated by EPA to the state of Tennessee.

Y-12 Complex

The Y-12 Complex continued to operate under Permit TN0002968, issued in 1995, through April 2006. The TDEC Division of Water Pollution Control issued a new permit on March 13, 2006, and monitoring under the new permit began on the permit-effective date of May 1, 2006. The new permit expires on December 31, 2008. An appeal to certain terms, including limitations on legacy constituents such as mercury and polychlorinated biphenyls (PCBs), and new chlorine limits at several outfalls, was filed with the Division of Water Pollution Control on April 18, 2006.

Presently about 60 active point-source discharges or in-stream monitoring locations are monitored for compliance with the permit. In 2006 the Y-12 Complex achieved an NPDES permit compliance rate of >99.9%. In 2006 there was one NPDES noncompliance (chlorine at outfall 201 on February 7, 2006). Information on the exceedance is provided in Appendix E, Sect. E.1. The new permit requires routine monitoring at two East Fork Poplar Creek in-stream locations, storm water sampling at a number of individual outfalls plus four in-stream locations and Clinch River raw water discharge. The permit continues radiological monitoring of surface water under a revised Radiological Monitoring Plan, a revised Biological Monitoring and

Abatement Program, and biotoxicity testing on three major outfalls. It sets forth a compliance schedule for more stringent total residual chlorine sampling.

ORNL

ORNL is currently operating under NPDES Permit TN0002941, which was renewed by TDEC on December 6, 1996, and which went into effect on February 3, 1997. A four-volume permit renewal application was submitted to TDEC and EPA in June 2001. In 2006 ORNL and TDEC staffs held discussions about renewal of the ORNL permit. The ORNL NPDES permit lists 164 point-source discharges and monitoring points that require compliance monitoring. Approximately 100 are storm drains, roof drains, and parking lot drains. Compliance was determined by approximately 7000 laboratory analyses and measurements in 2006, in addition to numerous field observations by ORNL field technicians. The NPDES permit limit compliance rate for all discharge points for 2006 was nearly 100%, with only five out of about 7000 individual measurements exceeding their respective permit limit (Fig. 2.1). Information on the exceedances is provided in Appendix E, Sect. E.3. None of the five exceedances resulted in any discernable ecological impact.

The current permit requires ORNL to conduct detailed characterization of numerous storm water outfalls, develop and implement a radiological monitoring plan, develop and implement a storm water pollution prevention plan, implement a revised Biological Monitoring and Abatement Program (BMAP) plan, and develop and implement a chlorine-control strategy. In 1997 DOE appealed certain limits and conditions of the 1996 ORNL permit, including numeric limits on effluent mercury, arsenic, and selenium.

ETTP

An application for renewal of ETTP NPDES Permit TN0002950 was submitted to TDEC in March 1997. To facilitate the transfer of ownership and operation of ETTP facilities to other parties, it was determined that separate NPDES permits would be required for each of the ETTP treatment facilities. In addition, it was determined that a separate NPDES permit for the

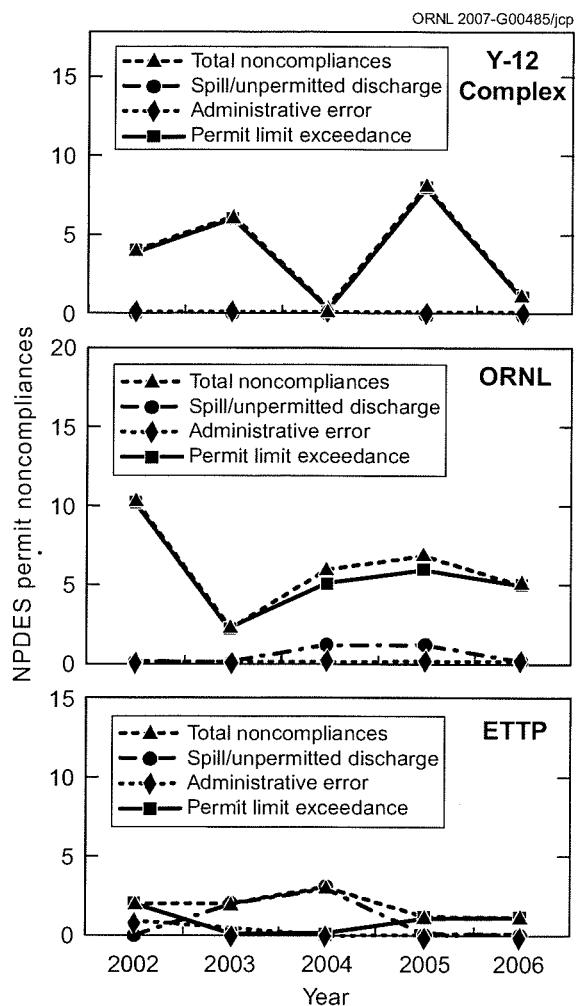


Fig. 2.1. Five-year summary of NPDES noncompliances.

storm water drainage system would be necessary. A general NPDES permit for former outfalls 009 (K-1515 Sanitary Water Plant) and 013 (K-1513 Sanitary Water Intake Backwash Filter) was issued on January 14, 2000, and became effective on March 1, 2000. Issuance of the permit (Permit Number TN0074233) allowed outfalls 009 and 013 to be removed from ETTP NPDES Permit Number TN0002950. A permit for the K-1203 sewage treatment plant (permit number TN0074241) was issued by TDEC and became effective on August 1, 2003. This allowed outfall 005 to be removed from ETTP NPDES Permit Number TN0002950. A permit for the K-1407-J Central Neutralization Facility (permit number TN0074225) was issued on October 7, 2003, and became effective on November 1, 2003. The permit allowed outfall 014 to

be removed from ETTP NPDES Permit Number TN0002950.

ETTP storm water outfalls continue to discharge under NPDES Permit Number TN0002950; the permit was reissued on March 1, 2004, with an effective date of April 1, 2004. The reissued NPDES Permit Number TN0002950 includes 121 storm water outfalls. Of these 121 outfalls, 39 are monitored on a routine basis as part of the requirements of the NPDES permit. In accordance with this NPDES permit, the ETTP is authorized to discharge storm water, steam condensate, and groundwater to the Clinch River, Poplar Creek, and Mitchell Branch.

In 2006, 48 spills were reported at ETTP. Only one of them resulted in an NPDES permit noncompliance. With approximately 580 laboratory analyses in 2006, this represents a compliance rate of almost 100% (Fig. 2.1). ETTP had one NPDES permit noncompliance in 2006. Details of the noncompliance are given in Sect. 4.4.1 and in Appendix E, Sect. E.2.

2.2.12.2 Sanitary Wastewater

Y-12 Complex

The CWA includes pretreatment regulations for publicly owned treatment works. Sanitary wastewater from the Y-12 Complex is discharged to the city of Oak Ridge treatment works under an industrial and commercial wastewater discharge permit. The Y-12 Complex was issued a new industrial user discharge permit by the city of Oak Ridge effective April 1, 2005. The permit establishes discharge limits for total suspended solids, biochemical oxygen demand, total nitrogen, and various metals and requires monitoring and reporting of uranium, gross alpha and beta radiation, and several organic compounds. Compliance with the permit is determined from samples taken at the East End Sanitary Sewer Monitoring Station, located on the east end of the complex where the Y-12 system ties into the city's sanitary sewer collection system.

City personnel performed semiannual compliance inspections on March 16 and August 1, 2006. During 2006, there was no noncompliance to the Y-12 Complex industrial user discharge permit. During the year Y-12 conducted sanitary

sewer system flow studies to determine the location of excessive inflow or infiltration. One subarea of the sanitary sewer system, the abandoned biology area, was identified as a contributor to excessive flows. The sewer line draining that area into the main system has been plugged. Status reports regarding flow-reduction efforts were submitted to the city of Oak Ridge in a letter dated July 17, 2006, and as part of the third-quarter (October 18, 2006) compliance report.

Compliance to a state-issued operating permit for a holding tank/pump-and-haul at office trailer 9983-AZ was also maintained.

Sanitary sewer radiological sample results at the Y-12 Complex are routinely reviewed to determine compliance with DOE Order 5400.5, "Radiation Protection of the Public and Environment." Sample results are compared to the derived concentration guides (DCGs) listed in the order. No radiological parameter that is monitored (including uranium) has exceeded a DCG.

ORNL

At ORNL, sanitary wastewater is collected, treated, and discharged separately from other liquid wastewater streams through an on-site sewage treatment plant. Wastewater discharged into the 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 specifically approved small volumes of nonhazardous biodegradable wastes, such as 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 have, at times, caused the sludge generated during the treatment process to become slightly radioactive. ORNL has completed a line-item project for comprehensive upgrades of its sanitary sewage system to reduce infiltration of contaminated groundwater and surface water and to redirect discharges from the laundry to appropriate alternative treatment facilities. The radioactivity level of ORNL sewage treatment plant sludge continues to decline. In 1998, ORNL's

sewage sludge was accepted into the city of Oak Ridge's Biosolids Land Application Program. ORNL transported no sewage sludge to the Oak Ridge sewage treatment plant in 2006 because the plant was undergoing an expansion project. During 2006, ORNL's sewage sludge was dried and handled as solid low-level waste (LLW). Shipments of sludge to the city of Oak Ridge may resume in 2007. In 2006, an application was submitted for a state-issued operating permit for a small holding tank/pump-and-haul at Bldg 3544.

ETTP

ETTP domestic wastewater is treated at the on-site K-1203 sewage treatment plant and is discharged pursuant to the NPDES Permit TN0074241; this permit became effective on August 1, 2003. Beginning on April 1, 1998, operation of that leased facility became the responsibility of publicly owned treatment works under a contract with CROET. Bechtel Jacobs Company LLC (BJC) operates a holding tank/pump-and-haul system to dispose of sanitary wastewater from the K-1310-DF facility at ETTP. The permit to operate this system (State Operation Permit No. SOP-99033) was issued April 28, 2000, and was renewed April 29, 2005. It expires April 20, 2010. An application to renew the permit was submitted October 20, 2004. Operations reports are submitted each month to the TDEC Environmental Assistance Center; there were no noncompliances or operational problems in 2006. Weskem LLC, a BJC subcontractor, operates a pump-and-haul system (State Operation Permit No. SOP-01042) for sanitary waste at ETTP. The permit for that facility was issued November 30, 2006, and expires May 31, 2010. A pump-and-haul system is also operated at the Washington Safety Management Solutions Waste Transportation Project Site, which is located off Blair Road near Portal 6. The permit for operation of that facility (State Operation Permit SOP-05068) was issued on February 28, 2006, and became effective on April 1, 2006. The permit expires on February 28, 2009.

2.2.12.3 Storm Water Protection Permits

Storm water discharges associated with construction activities that disturb 1 acre or more of

land must be NPDES-permitted. Coverage under a general permit is typically approved for a construction project if the proper notice of intent is filed. In February 2004 a general permit for storm water associated with construction activity for the Highly Enriched Uranium Materials Facility and Hollow-Fill Project at Y-12 was approved. The permit remained in effect during 2006, and construction proceeded in compliance.

In 2006, ORNL had three construction projects covered by the Tennessee General Permit for Storm Water Runoff Associated with Construction Activity. These included the SNS project, the ORNL Research Support Center, and the ORNL 24 inch Water Line Replacement Project.

2.2.12.4 Aquatic Resources Protection

The Army Corps of Engineers, TVA, and TDEC conduct permitting programs for projects and activities that could affect aquatic resources, including navigable waters, surface waters (including tributaries), and wetlands. These are the Corps of Engineers Section 404 dredge-and-fill permits, TDEC ARAPs, and TVA 26A approvals.

In February 2004, TDEC issued a general NPDES permit for discharges associated with the Y-12 Highly Enriched Uranium Materials Facility and Hollow-Fill Project. The permit remains active, and the work is being conducted in compliance. In October 2006, TDEC issued a General ARAP for Construction of Intake and Outfall Structures associated with construction of the new dechlorination facilities which are designed to remove chlorine at five Y-12 NPDES outfalls.

No TVA or Corps of Engineers permits were issued to the Y-12 Complex in 2006.

In 2006, ORNL had six projects that were conducted under ARAPs. These included two ARAPs for the East Campus Landscaping Addition project, three ARAPs for the East Campus Parking Expansion Project and one for the Freels Bend Boathouse Removal Project. Army Corps of Engineers permit coverage was also established for the Freels Bend project.

2.2.12.5 Oil Pollution Prevention

Section 311 of the CWA regulates the discharge of oils or petroleum products to waters of the United States and requires the development and implementation of a spill prevention, control, and countermeasure plan to minimize the potential for oil discharges. Currently, each facility implements a site-specific plan. This section of the CWA was significantly amended by the Oil Pollution Act of 1990, which has as its primary objective the improvement of responses to oil spills. On July 17, 2002, EPA issued the new final rule for 40 CFR Part 112, "Oil Pollution Prevention and Response; Non-Transportation-Related Onshore and Offshore Facilities," in the *Federal Register*. The rule contains significant changes in the requirements for spill prevention, control, and countermeasure plans, including how the plans are prepared, reviewed, and certified and the information that must be included in the plans. Existing plans must be amended as necessary to bring them into compliance with rule revisions, and the amended plans must be fully implemented by October 31, 2007. The ORNL Spill Prevention, Control, and Countermeasure Plan was revised in August 2006, including incorporation of the new EPA requirements.

2.2.12.6 Clean Water Action Plan

The Clean Water Action Plan, which essentially reflects a commitment by federal agencies to work cooperatively to improve water quality in the United States, is structured around watershed-based approaches in four key areas of need:

- prioritizing and undertaking water quality assessments,
- preparing restoration action strategies,
- developing and refining water quality standards, and
- enhancing stewardship of water resources on federal lands.

On a national level, the Department of Agriculture and the Department of the Interior are developing the Unified Federal Policy for Ensuring a Watershed Approach to Federal Land and Resource Management, to which other agencies (including DOE) are contributing. The goals and principles of this multiagency policy are to

- use a consistent and scientific approach to managing lands and resources and for as-

- assessing, protecting, and restoring watersheds;
- identify specific watersheds in which to focus budgetary and other resources and to accelerate improvements in water quality and watershed condition;
- use the results of watershed assessments to guide planning and management activities;
- work closely with states, tribes, local governments, and stakeholders to implement this policy;
- meet CWA responsibilities to adhere to federal, state, tribal, interstate, and local water quality requirements to the same extent as nongovernmental entities; and
- take steps to ensure that federal land and resource management actions are consistent with federal, state, tribal, and, where appropriate, local government water quality management programs.

2.2.13 Clean Air Act

Authority for implementation and enforcement of the Clean Air Act (CAA) has been delegated to the state of Tennessee by EPA as described in the State Implementation Plan. Air pollution control rules are developed and administered by TDEC.

2.2.13.1 General CAA Compliance

The TDEC air pollution control rules ensure compliance with the CAA. The TDEC Air Permit Program is the primary method by which emission sources are reported to and regulated by the state.

CAA compliance program staff participate in regulatory inspections and internal audits to verify compliance with applicable regulations or permit conditions. Air emission sources subject to the permitting requirements are permitted, and relevant compliance documentation for these sources is maintained at each site. In addition, a number of sources that are exempt from permitting requirements under state rules but subject to listing on Title V major source operation permits are documented, and information about them is available upon request from the state. Programs for permitting, compliance inspection, and documentation are in place and ensure that all ORR operations remain in compliance with all

federal and state air pollution control regulations.

2.2.13.2 Title V Operating Permits

All three sites are subject to the CAA Title V Operating Permit Program. The Y-12 site was issued two permits, one for BWXT operations and one for BJC operations. The ORNL site was also issued two permits, one for UT-Battelle operations and one for BJC operations. TDEC has not issued a Title V permit for BJC operations at the ETTP site. Operations at the ETTP site operate under permits issued prior to implementation of the Title V program. An update for each site follows.

The DOE/NNSA and BWXT Y-12 Title V permit includes 35 air emission sources and more than 100 air emission points. All remaining emission sources are categorized as insignificant and exempt from permitting. During 2006, a significant permit modification to the Y-12 Complex Title V permit was issued to identify new requirements and compliance methodologies for the Y-12 steam plant maintenance project. The new requirements will be effective upon completion of the project. Also, the permit modification identified new requirements to implement a future applicable Maximum Achievable Control Technology (MACT) standard for hazardous air pollutants at the Y-12 Steam Plant. One minor permit amendment was made to the Y-12 Title V permit in 2006. Permit change requests submitted in 2006, which were still pending at the end of 2006, include a minor modification request to convert one construction permit to an operating permit, a request to revise the Steam Plant MACT conditions, and a request to add Fuel Station Stage 1 emission control requirements to the permit.

DOE and UT-Battelle were issued a Title V permit covering ten emission sources for ORNL Office of Science Operations. One construction permit was also active for the Central Exhaust Facility, located at the SNS facility. All remaining emission sources are categorized as insignificant and are exempt from permitting. Semiannual reports were submitted on time and with no compliance issues.

DOE and BJC were issued two Title V permits in October and November 2004 for two air emission sources located at ORNL and one source at Y-12. At the end of 2005, there were

82 active air emission sources under DOE control at ETTP. The total includes 25 sources covered by 3 TDEC operating permits and 2 new construction permits. A new construction permit was issued for the TSCA Incinerator that supersedes the previous permit to operate until such time that a Title V permit is issued for ETTP that included recently promulgated regulations not covered by the previous permit. The second construction permit was issued for the K-1423 TSCA Solid Waste Repacking facility that reflects changed compliance requirements due to a new member of the public location. All remaining active air emission sources are exempt from permitting requirements. Permitted sources under DOE's Reindustrialization Program are not reported in this report except for the portion of the year that the source was under DOE control.

Air permit data are summarized in Appendix F.

2.2.13.3 National Emission Standards for Hazardous Air Pollutants for Radionuclides

Under Section 112 of the CAA, on December 15, 1989, the EPA promulgated "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities" at 40 CFR 61, Subpart H. This emission standard limits emissions of radionuclides to the ambient air from DOE facilities not to exceed amounts that would cause any member of the public to receive in any year an effective dose equivalent (EDE) of 10 mrem/year. As noted in the preamble to the rule, the entire DOE facility at Oak Ridge, Tennessee, must meet this emission standard.

On June 10, 1996, EPA delegated authority for regulation of airborne radionuclide emissions from DOE facilities in Tennessee to the TDEC Division of Air Pollution Control. TDEC adopted the federal rule verbatim as Tennessee Rule 1200-3-11-08, "Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities." In addition, TDEC codified that all past formal agreements between DOE and EPA, including the March 1994 *Compliance Plan* (MMES 1994), would be recognized provided that they are current, valid, and supported by appropriate documentation. The TDEC Division of Air Pollution Control has given primary administrative author-

ity of the radionuclide emission standard to the TDEC Division of Radiological Health, which also licenses non-DOE nuclear facilities in the state. However, authority to approve alternative methods and procedures still resides with EPA Region 4.

In October 2001, EPA Region 4 approved two addendums to the compliance plan, Addendum C.1, "Monitoring for Fugitive and Diffuse Sources," and Addendum C.2, "Monitoring Plan for On-Site Receptors." Addendum C.1 formalizes the use of environmental measurements from ambient air monitoring to confirm compliance for fugitive and diffuse sources for the ORR. This compliance approach has been in place since January 1993. Addendum C.2 formalizes EPA guidance in a February 1, 2001, guidance letter, that allows the use of environmental measurements from ambient air monitors in lieu of continuous stack monitoring as an alternative method to demonstrate compliance with 40 CFR Part 61, Subpart H, for sources that are major when modeled to "on-site" receptors, but minor when modeled to off-site receptors. In March 2005, EPA Region 4 approved a third addendum to the plan, Addendum C.3, "ANSI/HPS N13.1-1999 Upgrade Policy," which clarifies when an existing source on the ORR undergoing a modification must be upgraded to meet the new design criteria of the ANSI/HPS N13.1-1999 Standard in accordance with the September 9, 2002, amendment to 40 CFR Part 61, Subpart H. During the March 2005 approval cycle, the title page to the compliance plan was updated with a DOE document number (DOE 2005b), and a revision to Sect. 2.1 of the plan was approved that incorporated updated criteria under 10 CFR Part 835.

Beginning in 2000, the TDEC Division of Radiological Health required DOE to assess the dose from airborne radionuclide emissions to members of the public located on the ORR. Specifically, dose was determined for lessees located in areas of the ORR where access to the public is not restricted. Beginning in 2001, dose was also determined for construction workers supporting activities at construction sites that were deeded to a non-DOE entity.

During 2006, the ORR facilities operated in compliance with the Radionuclide National Emission Standards for Hazardous Air Pollutants (NESHAP) dose limit of 10 mrem/year to

the most exposed member of the public. Based on modeling of radionuclide emissions from all major and minor point sources, the EDE in 2006 to the most exposed member of the public was 0.8 mrem/year.

Continuous sampling for radionuclide emissions is conducted at the ETTP TSCA Incinerator, major sources at ORNL, and exhaust stacks serving uranium-processing areas at the Y-12 Complex. Compliance with the off-site dose limit is demonstrated by using grab samples and other EPA-approved estimation techniques on the remaining minor emission points and on grouped area sources to estimate confirmatory measurements of emissions. Fugitive emissions continue to be monitored by the ORR Perimeter Air Monitoring System. In addition, ETTP continued to operate a site-specific ambient air monitoring system for surveillance of TSCA Incinerator uranium emissions and fugitive emissions from remedial actions and D&D projects. In addition to the ORR regulatory compliance program, the EPA and DOE Oversight Division also conduct independent ambient air monitoring programs.

2.2.13.4 NESHPA for Asbestos

The ORR facilities have numerous buildings and equipment that contain asbestos-containing materials. The compliance program for management of removal and disposal of asbestos-containing materials includes demolition and renovation notifications to TDEC and inspections, monitoring, and prescribed work practices for abatement and disposal of asbestos materials. No releases of reportable quantities of asbestos were reported at ETTP, ORNL, or the Y-12 Complex in 2006.

2.2.13.5 NESHPA for Source Categories

The EPA has missed congressionally established promulgation dates for a number of NESHPA MACT standards (see 40 CFR Part 63, Subpart B, starting at § 63.50). Sources that may be subject to a delayed standard must comply with the “MACT hammer” permitting provisions in Section 112(j) of the CAA. Impacted sources must submit applications for case-by-case MACT determinations in two parts. Part 1 notifies agencies of the applicability of the de-

layed MACT standard to the facility. Part 2 is a detailed application based on a number of requirements and is due on a specific date, depending upon the applicable MACT standard.

In 2003, ORR facilities submitted Part 1 applications regarding applicability of several MACT standards (e.g., industrial heaters/process boilers, site remediation). There are currently only three sources on the ORR subject to MACT standards. One source is the TSCA Incinerator; another source, registered with the EPA, is a waste drum storage area at ETTP designated for storage of waste received from off site, making this area subject to the Off-Site Waste and Recovery Operations standard. The Y-12 Steam Plant is subject to the Industrial Commercial, and Institutional Boilers and Process Heaters MACT Standard. The effective date for compliance with this standard is September 2007.

2.2.13.6 Stratospheric Ozone Protection

DOE remains committed to continued reductions in the use of regulated ozone-depleting substances (ODSs) and, where possible, replacing them with materials that have less ozone-depleting potential. For example, DOE has committed to replacing refrigeration appliances at all DOE installations if the appliances were installed before 1984, contain Class I ozone-depleting substances, and have cooling capacities of 150 tons or greater, except in certain cases where replacement is not economical and will not benefit the environment. All units meeting this criterion at ETTP, ORNL, and the Y-12 Complex have been evaluated and replaced.

2.2.13.7 Chemical Accident Release Prevention

All DOE sites on the ORR have determined that there are no processes or facilities containing inventories of chemicals in quantities exceeding thresholds specified in rules pursuant to Title III, Section 112(r), “Prevention of Accidental Releases.” Therefore, no DOE sites are subject to this rule.

2.2.14 Toxic Substances Control Act

TSCA was passed in 1976 to address the manufacture, processing, distribution in commerce, use, and disposal of chemical substances

and mixtures that present an unreasonable risk of injury to human health or the environment. TSCA mandated that EPA identify and control chemical substances manufactured, processed, distributed in commerce, and used within the United States. EPA imposes strict information-gathering requirements on both new and existing chemical substances, including PCBs.

EPA's TSCA regulations present specific requirements for disposal of PCB wastes. TSCA requires disposal of certain PCB wastes in chemical waste landfills or incinerators and allows disposal of other PCB wastes (i.e., drained equipment with PCB concentrations below specific levels, PCB remediation wastes below specific levels, and PCB bulk product wastes) in certain permitted solid waste landfills. In the state of Tennessee, under TSCA regulations, TDEC requires a special waste review and approval for the disposal of PCB waste in solid waste landfills. Several special waste approvals for disposal of drained PCB equipment, and PCB bulk product waste (demolition debris and/or equipment coated with dried paint containing PCBs) at the Y-12 landfill have been approved by TDEC.

2.2.14.1 Polychlorinated Biphenyls

TSCA specifically bans the manufacture, processing, and distribution in commerce of PCBs but authorizes the continued use of some existing PCBs and PCB equipment. TSCA also imposes marking, storage, and disposal requirements for PCBs. The regulations governing PCBs mandated by TSCA are administered by EPA. Most of the regulatory requirements are matrix- and concentration-dependent. TDEC restricts PCBs from being disposed of in landfills and classifies PCBs as special wastes under Tennessee solid waste regulations. A special waste approval is required from the state of Tennessee to dispose of solid PCB-contaminated waste in certain permitted solid waste landfills. In the state of Tennessee, TDEC requires a special waste review and approval for the disposal of PCB waste in solid waste landfills. Several special waste approvals for receipt of drained PCB equipment, PCB remediation waste, and PCB bulk product waste (painted construction debris and/or equipment) at the Y-12 landfill have been approved by TDEC.

2.2.14.2 PCB Compliance Agreements

The Oak Ridge Reservation Polychlorinated Biphenyl Federal Facilities Compliance Agreement (ORR/PCB/FFCA) between EPA Region 4 and DOE-ORO became effective on December 16, 1996. The agreement addresses PCB compliance issues at ETTP, ORNL, the Y-12 Complex, and ORISE. It specifically addresses the unauthorized use of PCBs, storage and disposal of PCB wastes, PCB spill cleanup and/or decontamination, PCBs mixed with radioactive materials, PCB R&D, and records and reporting requirements for the ORR.

In 2006, UT-Battelle received and implemented a risk-based disposal approval from EPA for the management of PCB bulk product and PCB remediation waste for UT-Battelle operations at ORNL and at ORNL/Y-12.

2.2.14.3 Authorized and Unauthorized Uses of PCBs

Specific applications of PCBs are authorized by EPA for continued use under restricted conditions. A variety of PCB systems and equipment have been in service at the ORR during its 60-year history. Many of the systems and equipment were used in accordance with industry standards at the time, and their continued use was authorized under the 1979 PCB regulations. Systems that were authorized included transformers, capacitors, and other electrical distribution equipment; heat-transfer systems; and hydraulic systems. The vast majority of these PCB uses have been phased out on the ORR. Small amounts of PCBs remain in service in PCB light ballasts; however, ballasts containing PCBs are being replaced by non-PCB ballasts during normal maintenance. Most transformers that contained PCBs either have been retrofitted (replacement of PCB fluid with non-PCB dielectric fluid) to reduce the PCB concentration to below regulated limits or have been removed from service altogether.

The 1979 regulations did not anticipate the use of PCBs in many applications for which they were used. The proposals to the 1998 "Mega Rule" that would have addressed uses still prevalent on the ORR were omitted from the final rule. As a result, past uses not specifically

authorized continue to present compliance issues for DOE under TSCA.

At the ORR, unauthorized uses of PCBs have been found in building materials, lubricants, paint coatings, paint sealants, adhesives, and nonelectrical systems (including a rolling mill and a reactor-positioning device). More such unauthorized uses are likely to be found during the course of D&D activities. The most widespread of these unauthorized uses of PCBs are PCBs in paint and PCB-impregnated gaskets in the gaseous diffusion process motor ventilation systems at ETTP. The discoveries of such uses include rubber gasket components used to seal glove-box units, paint coatings used on hydraulic equipment at the Y-12 Complex, and interior and exterior wall paints. In 1998, ORNL reported finding PCBs at regulated levels in roofing paint used on Buildings 2000 and 2001. An annual sampling and monitoring plan was prepared and was submitted for the site. EPA approval of the sampling and monitoring plan was verbally issued on February 11, 1999. Annual monitoring has been conducted since 1999. Summaries of the 1999, 2002, 2003, 2004, and 2005 results of that sampling were submitted to EPA as required. Submittals of the 2000, 2001, and 2006 monitoring results were not required. In 2006, ORNL decontaminated the Building 2519 No. 5 Stack of its PCB-contaminated paint. In 2005, DOE notified EPA of issues regarding historical uses of PCBs associated with the calutron operations in Building 9204-3 (ORNL/Y-12) and proposed that those issues be addressed under the ORR/PCB/FFCA.

In 2006, BWXT Y-12 reported finding PCBs at regulated levels in interior and exterior paint for several facilities and/or their structural components. The Y-12 Complex issued notification letters to EPA, in accordance with the terms of the ORR/PCB/FFCA, declaring that a pre-TSCA PCB use had been discovered. Administrative controls and postings are in place to ensure that painted surfaces are not disturbed until proper evaluations are conducted. Additionally, administrative and engineering controls are used to ensure the protection of workers and the environment. Additionally in 2006, the Y-12 Complex reported finding regulated concentrations of PCBs in a hydraulic system in a building ventilation duct gasket and notified EPA Region 4 in accordance with the terms of the

ORR/PCB/FFCA. Both the hydraulic system and the ventilation duct gasket are historical uses of PCBs and are being addressed under the ORR-PCB-FFCA.

In 1998, depleted uranium hexafluoride (UF_6) steel cylinders were found to contain high concentrations of PCBs in the paint. The ETTP notified EPA of the UF_6 cylinder population under terms of the compliance agreement. DOE obtained approval from Regions 4 and 5 to ship contaminated cylinders to the Portsmouth Gaseous Diffusion Plant in Portsmouth, Ohio, in 2005. Once the cylinders arrive at the Portsmouth plant, the product remaining in the cylinders is processed, and the cylinders are disposed of as PCB bulk product waste. The K-1066-B, and K-1066-E, K-1066-F, K-1066-J, K-1066-K and K-1066-LK cylinder storage yards are currently empty, and the K-1066-B yard demolition has been completed. The concrete rubble from the demolition of the K-1066-B concrete storage pad is planned for use as fill material for the on-site K-25 D&D Project.

In the fall of 2005, a notification was made to EPA Region 4 of the discovery of PCB contamination in Building K-1035, located at the ETTP. Due to the PCB contamination and several other unrelated issues, the property could not be cost-effectively transferred to CROET for long-term ownership as planned. Demolition of the building, which is scheduled to begin in 2007, depends upon DOE-EM funding levels. The building is identified in the CERCLA Federal Facilities Agreement and will be demolished in accordance with the CERCLA Remaining Facilities Demolition Action Memorandum decision document.

Building K-726, located at ETTP, previously contained materials contaminated with low-level uranium and was used as a PCB waste storage facility. In 1992, a container of PCB waste was discovered leaking onto the floor of the storage unit. The floor of the building underwent several decontamination attempts, but the contamination remained above regulatory limits. In 1996, in agreement with EPA Region 4, Building K-726 was added to the list of Environmental Restoration units in the Federal Facilities Agreement for future decontamination and demolition. In October of 2006, the K-726 Building was demolished, and approximately 516 yd^3 of PCB remediation waste debris was

generated from the demolition. The PCB waste generated from the demolition of the building was transported to the EMWMF for disposal.

In 1994, PCBs were discovered in the K-1206-E Firewater tower, located at ETTP. On September 29, 1995, EPA Region 4 concurred by letter with the DOE's proposed plan for the removal and management of the PCB-contaminated water within the tank and the firewater system. The proposed ORR/PCB/FFCA identified this tank for future action under the CERCLA Federal Facilities Agreement. The K-1206-E Firewater Tower was demolished in June 2006 and the waste was disposed of in the Y-12 Landfill as PCB bulk product waste.

2.2.14.4 ETTP TSCA Incinerator PCB Disposal Approval

The ETTP TSCA Incinerator is currently operating under an extension of EPA Region 4 approval granted on March 20, 1989. This extension is based on submittal of a reapplication for PCB disposal approval filed with EPA Region 4 on December 20, 1991, which was within the time frame allowed for reapplication. Minor amendments, updates, and corrections to this reapplication identified by DOE have been made in the interim and have been submitted to EPA. Since the submittal of the December 20, 1991, reapplication, a joint RCRA/PCB permit reapplication has been under development. This joint reapplication was submitted in March 1997 to TDEC under RCRA for treatment of hazardous wastes and to EPA Region 4 for disposal of PCB wastes. The new reapplication will replace the December 20, 1991, PCB disposal reapplication. In anticipation of this joint application, EPA Region 4 has delayed action on renewal of the PCB incineration approval.

2.2.15 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 to federal, state, and local authorities of emergency planning information, hazardous chemical inventories, and releases of certain toxic chemicals to the environment. The ongoing requirements are contained in Sects. 302, 303, 304, 311, 312, and 313 of EPCRA and in 40 CFR Parts 355, 370,

and 372. Table 2.10 describes the main parts of EPCRA. All DOE-ORO sites in Oak Ridge are in compliance with all aspects of EPCRA. Executive Order 13148, "Greening the Government Through Leadership in Environmental Management," requires all federal agencies to comply with provisions of EPCRA and the Pollution Prevention Act.

2.2.15.1 Planning Notification and Extremely Hazardous Substance Release Notifications (Sections 302–304)

The ORR did not have any releases of extremely hazardous substances, as defined by EPCRA, in 2006.

2.2.15.2 Material Safety Data Sheet/Chemical Inventory (Sections 311–312)

The required Sect. 311 notifications were made as hazardous materials were determined to be over threshold for the first time. Inventories, locations, and associated hazards of hazardous and extremely hazardous chemicals were submitted in an annual report to state and local emergency responders as required by the Sect. 312 requirements. Of the chemicals identified for CY 2006 on the ORR, 66 were located at the Y-12 Complex, 31 at ORNL, and 12 at ETTP.

Private-sector lessees associated with the re-industrialization effort were not included in the CY 2006 submittals. Under the terms of their lease, lessees must evaluate their own inventories of hazardous and extremely hazardous chemicals and must submit information as required by the regulations.

2.2.15.3 Toxic Chemical Release Reporting (Section 313)

DOE submits annual toxic release inventory reports to EPA and TDEC on or before July 1 of each year. The reports cover the previous calendar year and address releases of certain toxic chemicals to air, water, and land as well as waste management, recycling, and pollution prevention activities. Threshold determinations and reports for each of the ORR facilities are made separately. Operations involving toxic release

Table 2.10. Descriptions of the main parts of The Emergency Planning and Community Right-to-Know Act (EPCRA)

Title	Description
Sections 302–303, Planning notification	Requires that local planning committee and state emergency response commission be notified of EPCRA-related planning
Section 304, Extremely hazardous substance release notification	Addresses reporting to state and local authorities of off-site releases
Section 311–312, Material safety data sheet (MSDS)/chemical inventory	Requires that either MSDSs or lists of hazardous chemicals for which MSDSs are required be provided to state and local authorities for emergency planning. Requires that an inventory of hazardous chemicals maintained in quantities over thresholds be reported annually to the Environmental Protection Agency.
Section 313, Toxic chemical release reporting	Requires that releases of toxic chemicals be reported annually to the Environmental Protection Agency

inventory chemicals were compared with regulatory thresholds to determine which chemicals exceeded the reporting thresholds based on amounts manufactured, processed, or otherwise used at each facility. After threshold determinations were made, releases and off-site transfers were calculated for each chemical that exceeded one or more of the thresholds.

The following text explains how the reporting thresholds were exceeded. Table 2.11 summarizes releases and off-site transfers for those chemicals exceeding reporting thresholds.

Y-12 Complex

Total 2006 reportable toxic releases to air, water, and land and waste transferred off site for treatment, disposal, and recycling were more than the amounts reported for the Y-12 Complex in 2005. This was the result of increased methanol usage in the methanol brine system. The following list describes the reported chemicals for the Y-12 Complex.

- **Chromium, copper, and nickel.** The processing threshold for each of these metals was exceeded as a result of off-site metal recycling and metal machining and welding operations.
- **Sulfuric acid (aerosol form).** Sulfuric acid aerosols were coincidentally manufactured in excess of the reporting threshold as a combustion by-product from burning coal at the steam plant.

- **Lead and lead compounds.** The “otherwise-use” threshold for lead was exceeded at the steam plant and at the Central Training Facility firing range. The processing threshold for lead was exceeded as a result of off-site metal for recycling.
- **Mercury and mercury compounds.** Mercury compounds were otherwise used and coincidentally manufactured as a combustion by-product from burning coal in excess of the 10-lb reporting threshold at the steam plant.
- **Methanol.** Most of the methanol at the Y-12 Complex is otherwise used in the chiller buildings for the brine-methanol system.
- **Nitrate compounds.** Nitrate compounds were coincidentally manufactured in excess of the reporting threshold as by-products of neutralizing nitric acid wastes and in the sanitary sewer. The compounds are also contained in various mixtures used throughout the complex.
- **Nitric acid.** Nitric acid was used in excess of the otherwise-use threshold as a chemical-processing aid.

ETTP

The otherwise-use activity threshold for PCBs was exceeded at ETTP by the incineration of PCBs in waste received from off site in the TSCA Incinerator.

Oak Ridge Reservation

Table 2.11. EPCRA Section 313 toxic chemical release and off-site transfer summary for the ORR, 2006

	Year	Quantity (lb) ^a			
		Y-12 Complex	ORNL	ETTP	Total
Chlorine	2005	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
	2006	<i>b</i>	<i>b</i>	34,698	34,698
Chromium	2005	1,274	<i>b</i>	<i>b</i>	1,274
	2006	<i>c</i>	<i>b</i>	<i>b</i>	<i>b,c</i>
Cobalt	2005	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
	2006	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
Copper	2005	932	<i>b</i>	<i>b</i>	932
	2006	<i>c</i>	<i>b</i>	<i>b</i>	<i>b,c</i>
Copper/copper compounds	2005	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
	2006	<i>c</i>	<i>b</i>	<i>b</i>	<i>b,c</i>
Freon 11	2005	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
	2006	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
Freon 113	2005	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
	2006	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
Hexachlorobenzene	2005	<i>b</i>	<i>b</i>	160	160
	2006	<i>b</i>	<i>b</i>	19	19
Hydrochloric acid (aerosol)	2005	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
	2006	<i>b</i>	<i>b</i>	35,685	35,685
Lead/lead compounds	2005	9,626	<i>b</i>	<i>b</i>	9,626
	2006	10,049	<i>b</i>	<i>b</i>	10,049
Manganese	2005	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
	2006	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
Mercury/mercury compounds	2005	109	<i>b</i>	<i>b</i>	109
	2006	39	<i>b</i>	<i>b</i>	39
Methanol	2005	34,307	<i>b</i>	<i>b</i>	34,307
	2006	140,840	<i>b</i>	<i>b</i>	140,840
Nickel	2005	3,393	<i>b</i>	<i>b</i>	3,393
	2006	<i>c</i>	<i>b</i>	<i>b</i>	<i>b,c</i>
Nitrate compounds	2005	7,922	51,000	<i>b</i>	58,922
	2006	0	51,000	<i>b</i>	51,000
Nitric acid	2005	18,701	53,990	<i>b</i>	72,691
	2006	<i>c</i>	54,013	<i>b</i>	54,013
Ozone	2005	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
	2006	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
PCBs	2005	<i>b</i>	<i>b</i>	2,951	2,951
	2006	<i>b</i>	<i>b</i>	77,261	77,261
Sulfuric acid (aerosol)	2005	52,000	<i>b</i>	<i>b</i>	52,000
	2006	52,000	<i>b</i>	<i>b</i>	52,000
Total	2005	128,264	104,990	3,111	236,365
	2006	202,928	105,013	147,663	455,604

^aRepresents total releases to air, land, and water and includes off-site waste transfers. Also includes quantities released to the environment as a result of remedial actions, catastrophic events, or one-time events not associated with production processes. 1 lb = 0.45359237 kg.

^bNo reportable releases because the site did not exceed the applicable Toxic Release Inventory reporting thresholds.

^cNot applicable because releases were less than 5000 lb, and hence a Form A was submitted.

ORNL

ORNL reported nitric acid and nitrate compounds. Lead metal was not reported again for 2006 because the lead shop has been shut down since October 2004. Nitric acid is used to regenerate ion-exchange columns at the Process Waste Treatment Complex and at the HFIR, in the separation process for californium by the Nuclear Science and Technology Division, and for pH adjustment at the Process Waste Treatment Complex. Nitrate compounds are coincidentally manufactured as by-products of neutralizing nitric acid waste and as by-products of sewage treatment.

2.2.16 Environmental Occurrences

CERCLA requires that the National Response Center be notified if a nonpermitted release of a reportable quantity or more of a hazardous substance (including radionuclides) is released to the environment within a 24-h period. The CWA requires that the National Response Center be notified if an oil spill causes a harmful-quantity release on navigable waters, such as rivers, lakes, or streams. When notified, the National Response Center alerts federal, state, and local regulatory emergency organizations for determination of appropriate government response.

There were no releases of hazardous substances exceeding reportable quantities, no reportable oil sheens, and no fish kills at Y-12 during 2006. There were two events that triggered occurrence reports under DOE's Occurrence Reporting System, but neither resulted in an environmental impact. On January 12, 2006, demolition and modification of small chiller building resulted in overflow of a small amount of brine (21% methanol and water) into the storm sewer system. On March 30, 2006, a random survey of a two-wheeled hand truck/dolly by the TDEC Division of Radiological Health found radiological contamination on a tire at the excess Property Sales building. The dolly never entered the public domain and was returned to the Y-12 Complex.

At ETTP, on November 27, 2006, during a routine weekly NPDES storm water sampling event, a noncompliance with the NPDES Permit limit for total residual chlorine (TRC) concentration was identified at storm water outfall 100. The sample result was 0.20 mg/L. This result

exceeded the NPDES Permit limit for TRC for that outfall, which is a daily maximum concentration of 0.140 mg/L.

On November 28, 2006, field investigations were initiated by environmental subcontractor personnel to identify the source of the TRC in the discharge from outfall 100. Based on that investigation, the source of the TRC was thought to be an underground sanitary water line break in the vicinity of the northwest corner of the K-1006 building. The exact location of the water line break could not be determined at the time of the investigation. Also on November 28, 2006, the ETTP utilities contractor began deploying dechlorination tablets into the outfall 100 drainage network. Field monitoring of the TRC levels upstream and downstream of the dechlorination tablets was performed on a daily basis to evaluate the effectiveness of the dechlorination tablets in the removal of TRC from the outfall 100 discharge. The dechlorination tablets remained in the outfall 100 drainage network until the broken sanitary water line was repaired. On December 15, 2006, excavation of the broken sanitary water line was completed, and repairs to the pipe were made.

On December 11, 2006, during routine NPDES permit compliance sampling activities, sampling subcontractor personnel observed several dead fish in the riprap-lined channel that transports discharges from the outfall 100 storm drain network to the K-1007-P1 Pond. Initial examination of the dead fish did not identify any obvious causes for their deaths. However, levels of TRC upstream of the outfall 100 discharge channel continued to be elevated because the location of the water line break had still not been found.

On December 12, 2006, storm water outfall 100 was revisited to determine whether additional dead fish were present. A large number of dead and dying fish were noted during this visit. ORNL Environmental Sciences Division personnel were contacted to collect the dead and dying fish in an effort to determine the cause of the fish kill. They collected or visually counted 811 dead fish. Because some of the fish could not be recovered, it was estimated that the total mortality was in excess of 1000 fish.

Outfall 100 and the K-1007-P1 pond were visited several times daily between December 12, 2006, the day after the fish kill was noted,

and December 15, 2006, when the sanitary water line break was repaired. Observations of those areas revealed that there were no additional dead or distressed fish.

One reportable oil sheen occurred at ORNL in 2006. On November 16, 2006, a utility contractor's street sweeper leaked hydraulic fluid on Bethel Valley Road, and runoff from the area of the incident caused a visible sheen on White Oak Creek. Spill response staff immediately placed absorbents, including spill booms, to contain the release and to minimize the extent of the sheen. The incident did not cause any discernable impact on fish or other aquatic species. The release was reported to the National Response Center on November 16.

2.2.17 DOE Order 450.1, Environmental Protection Program

DOE Order 450.1, "Environmental Protection Program," encompasses environmental management systems (EMSs), pollution prevention, affirmative procurement, ozone-depleting substances, energy management and fleet management, and beneficial landscaping requirements. The order affirms DOE's approach to improving environmental performance through the use of management systems and aggressive pollution prevention initiatives.

The ORR sites are addressing the requirements of the order as well as all other requirements related to those areas. The 2006 efforts and associated results across the ORR are summarized in the remainder of this section.

2.2.17.1 Implementation of Environmental Management Systems

The EMSs and Integrated Safety Management Systems (ISMSs) at DOE facilities are integrated to provide a unified strategy for the management of resources; the control and attenuation of risks; and the establishment and achievement of the organization's environment, safety, and health goals. ISMS and EMS both strive for continual improvement through a "plan-do-check-act" cycle. Under ISMS, the term "safety" also encompasses environmental safety and health, including pollution prevention, waste minimization, and resource conserva-

tion. Therefore, the guiding principles and core functions in ISMS are as applicable to the protection of the environment as they are to safety. Figure 2.2 depicts the relationship between EMS and ISMS.

ORNL 2007-G00486/jcp

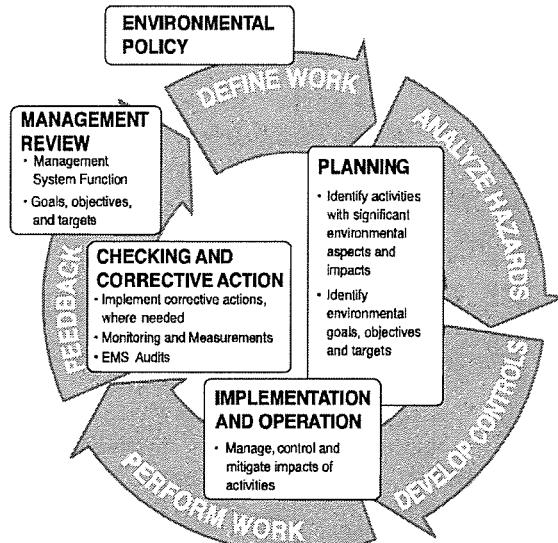


Fig. 2.2. The relationship between environmental management systems and the Integrated Safety Management System.

UT-Battelle, as the management and operating contractor for ORNL, and BWXT Y-12 have both chosen to implement EMSs that are modeled after the international standard established by the International Organization for Standardization (ISO) 14001. The purpose of the EMSs is to achieve, maintain, and demonstrate continuing environmental improvement by assessing and controlling the impact of activities and facilities on the environment. The system is designed to ensure that activities are in compliance with environmental laws and regulations, and it provides a framework for integrating compliance, pollution prevention, and other environmental considerations into the planning and implementation phases of site activities. The ISO 14001 EMS is consistent with ISMS core functions and guiding principles and includes the following features:

- policy,
- identified significant environmental aspects and controls,
- applicable legal requirements,

- objectives and targets,
- training requirements,
- communication with stakeholders,
- records and document control requirements,
- monitoring and measurement requirements,
- an emergency preparedness and response program, and
- provisions for handling nonconformances and corrective/preventive actions.

Environmental aspects are elements of an organization's activities, products, or services that can interact with the environment. In the ISMS, these may be thought of as environmental hazards associated with a facility operation or work activity.

UT-Battelle EMS Implementation Status

The UT-Battelle EMS is integrated into ISMS through the work control process. All significant environmental aspects are incorporated into work control to ensure that appropriate controls are in place.

In 2004, UT-Battelle's EMS was registered to the ISO 14001 Standard by a third-party registrar. In July 2006, NSF International Strategic Registrations, Ltd., conducted a surveillance audit of the ORNL EMS to ensure continued conformance to the ISO 14001:2004 requirements. No major nonconformances were noted by the audit team. One minor nonconformance, related to document control, was promptly resolved. A number of noteworthy practices were also identified. ORNL was recognized for its outstanding environmental management system and compliance record in 2007 by being accepted into the EPA's National Performance Track Program.

ISO 14001 encourages organizations to provide information on environmental policy and significant environmental aspects of their activities.

The UT-Battelle Policy for ORNL is a high-level document that contains scientific; technical; and environment, safety, and health commitments. As required by ISO 14001, the policy contains commitments to (1) comply with applicable requirements, (2) prevent pollution, and (3) continually improve. The environmental policy statements in the UT-Battelle Policy for

ORNL are available on the external web site (<http://train.ornl.gov/wbt/EnvPolicy.cfm>).

UT-Battelle has identified the following aspects as potentially having significant environmental impacts:

- hazardous waste,
- radioactive waste,
- mixed waste,
- PCB waste,
- permitted air emissions,
- regulated liquid discharges,
- storage or use of chemicals or radioactive materials.

Activities containing these aspects are carefully controlled to minimize or eliminate impacts to the environment. Monitoring activities associated with these aspects are described in Chaps. 3, 5, and 7.

BWXT Y-12 EMS Implementation Status

BWXT Y-12 has self-declared implementation of an EMS based on the principles of the ISO 14001 standard and has integrated the EMS with the BWXT Y-12 ISMS policies and procedures. Y-12 made the self-declaration after verifying and validating implementation based on a second-party independent assessment.

There is a synergistic relationship between the Y-12 EMS and the Pollution Prevention Program with the pollution prevention implementation playing an integral part. In concert, the EMS provides a forward-thinking framework for environmental management that supports the recognition and implementation of pollution prevention.

Our environment, safety and health policy contains environmental commitments required by ISO 14001 to

- protect the environment,
- prevent pollution,
- comply with applicable legal and other requirements, and
- continually improve.

Y-12's policy has been communicated to all its employees, and they know and understand how the commitments relate to their work activities.

Y-12 has evaluated its activities and services to identify those activities with a potential to impact the environment. Activities involving these aspects are evaluated and are controlled to minimize potential impacts to the environment. Monitoring activities associated with these aspects are described in Chaps. 6 and 7. The following aspects have been identified as potentially having significant environmental impact:

- waste generation—excess materials and chemicals and low-level radiological, hazardous, mixed, PCB universal, special industrial, medical, and sanitary wastes;
- air emissions—criteria pollutants, hazardous air pollutants and other nonradiological air contaminants, ozone, and radiological emissions;
- liquid discharges—process wastewater, cooling water, sanitary wastewater, flow management discharges, and chlorinated water discharges;
- potential releases from spills, leaks, and runoff—storage of radiological and nonradiological materials, oil and gas, waste, storm water runoff;
- spread of legacy contamination—historical waste management units, legacy mercury and PCB spills, demolition of excess and surplus facilities, and groundwater contamination;
- interactions with historical and cultural resources and wildlife habitat;
- natural resource consumption—power and energy use; and
- natural resource conservation—purchasing materials with recycled content, recycling, and preventing pollution.

Each year environmental objectives and targets (goals) that are consistent with the environmental policy and reflect our commitment to pollution prevention and continual improvement are established at the Y-12 Complex. During 2006 Y-12 accomplished the following goals that had been established at the beginning of the year:

- reduced inventory of ozone-depleting substances by more than 5000 lb,
- implemented a plan to survey sanitary sewer in-flow/infiltration,

- implemented 100% use of E-85 (85% ethanol) in flex fuel vehicles in fleet (76 vehicles),
- eliminated 5% of the outdoor LLW storage areas,
- completed FY 2006 milestone for mixed waste disposition,
- recycled 34,020 metric tons of material in FY 2006,
- reduced visible mercury from a storm drain,
- achieved 11.4% reduction in energy use (relative to 2004 baseline),
- achieved 44% reduction in number of storm water outfalls requiring monitoring, and
- achieved progress in implementing sustainability principles in design and construction of new facilities.

BJC EMS Implementation Status

BJC uses ISMS core functions and guiding principles to integrate EMS considerations into work activities. By integrating EMS considerations within the elements of ISMS, the BJC Environment, Safety, and Health Organization provides procedures and processes for identifying environmental protection controls and compliance impacts and concerns prior to performing a scope of work, during work activities, and after the work is completed. Issued in September 2000, the BJC environmental management policy is a key attribute of the EMS. The policy reflects the mission, goals, and responsibilities of the company with respect to environmental aspects and impacts, including pollution prevention. At the beginning of each project, subject-matter experts, called “environmental compliance and protection leads,” are assigned to each subcontractor’s work activity to support the formation of project and subproject teams in identifying and analyzing environmental hazards and in implementing controls that comply with DOE Work Smart Standards and applicable laws and regulations. The EMS is supported by communication between BJC and its subcontractors through the project’s environmental compliance and protection lead. The EMS ensures that periodic assessments against the EMS attributes are conducted to evaluate the ISMS performance of each project and the subcontractor in charge of managing the project.

During 2005 BJC updated the company’s ISMS description document to incorporate EMS,

completed implementation of an Awareness Training Program on the EMS, and updated the self-performed EMS implementation gap analysis initiated in 2003. During 2005 BJC formally identified six significant environmental aspects and 48 accompanying activities that could result in environmental impacts, six targets, and five objectives for the EMS and integrated these into the ISMS description. BJC performed an independent assessment of the EMS in September 2005 to confirm that the system met all requirements under DOE Order 450.1, "Environmental Protection Program." In December 2005, BJC formally self-declared to DOE-ORO that the EMS was fully implemented to meet both the DOE order and Executive Order 13148.

2.2.17.2 Pollution Prevention

During 2006, the ORR continued to implement a substantial number of pollution prevention projects. Results are summarized by program secretarial office in Table 2.12. The EM Program at the ETTP site is also using Six Sigma projects as a means of capturing additional pollution prevention project-related data. The project-specific waste volume reduction and cost avoidance data are not as yet being reported as it is confidential information proprietary to Bechtel Jacobs Company, LLC, and undergoes a review prior to public release. Pollution-prevention-specific information is also available on the DOE pollution prevention homepage (<http://www.ch.doe.gov/p2/>).

The ORR sites' pollution prevention programs are driven by federal and state laws and regulations; executive orders; and DOE policies, notices, and orders. During 2006, in addition to supporting the implementation of pollution prevention projects, the ORR facilities performed activities to ensure that both the requirements established by DOE Order 450.1 and all other existing requirements were addressed.

In December 2005, DOE issued DOE Order 450.1, Change 2, "Environmental Protection Program." An integral part of the order was the establishment of new, more qualitative EMS-related pollution prevention performance goals and strategies. The new goals and strategies replace the prior quantitative goals, which have been declared achieved by DOE Headquarters. The ORR facilities must complete pollution-prevention-related requirements such as planning and reporting to comply with many regulatory requirements, including RCRA, the Tennessee Hazardous Waste Reduction Act, and the EPCRA/Pollution Prevention Act. The ORR facilities must also comply with DOE requirements, including the reporting of pollution prevention project and program activities. The *Annual Report on Waste Generation and Pollution Prevention Progress*, the annual *Environmentally Preferable Purchasing Report*, and reports on pollution prevention projects completed by each site are designed to provide data used to measure progress. Reported reduction results for

Table 2.12. ORR pollution prevention project implementation results summary, 2006^a

Program secretarial office	Total projects reported in FY 2006	Total quantity of waste reduced in FY 2006 (MT)	Total cost avoidance in FY 2006 (\$M)
NNSA	84	138,609.52	5.7
EM	12	13,715.1	<i>b</i>
SC/Other R&D	26	1,708.51	3.7

^aAbbreviations:

EM	Environmental Management
NNSA	National Nuclear Security Administration
R&D	research and development
SC	Office of Science

^bBechtel Jacobs Company, LLC, proprietary information.

Oak Ridge Reservation

FY 2006 (percentages based on a 1993 baseline) are summarized by program secretarial office or by the site as appropriate in Table 2.13.

provides national-level DOE waste management and cleanup data to the public.

Table 2.13. ORR affirmative procurement and waste reduction progress summary, 2006^a

Program secretarial office	Waste reduction by office (%) ^b				Site	Sanitary waste reduction by site (%) ^b	
	Transuranic	Mixed low-level and RCRA	Low-level waste	Affirmative procurement		Landfill	Recycling
NNSA	N/A	97	78	94	Y-12	88	71
EM	N/A	c	c	84	ETTP	d	d
SC/Other R&D	67	72	76	19	ORNL	47	52

^aAbbreviations:

EM Environmental Management.
 NNSA National Nuclear Security Administration
 RCRA Resource Conservation and Recovery Act
 SC Office of Science
 R&D research and development

^bPercentages based on a 1993 baseline.

^cThe facilities at ETTP are undergoing decontamination and decommissioning (D&D) to support privatization and reindustrialization of ETTP or for demolition as part of site closure activities. The accelerated closure contract has and is resulting in increased waste generation volumes. As a result, waste generation from on-site DOE activities is expected to fluctuate significantly from year to year. Also, the DOE Office of Environmental, Safety, and Health did not require EM sites to report waste generation data beginning in FY 2006.

^dAs a result of ongoing D&D activities at the ETTP site as well as those activities associated with the accelerated closure contract on-site recycling activities can be expected to fluctuate significantly from year to year.

The ORR also supports DOE's efforts of reducing off-site releases and transfers of toxic chemicals by assessing operations associated with releases and transfers. However, because of substantial changes since 1993 in the operations included in the EPCRA-related reporting from which these values are obtained, the ORR does not anticipate an overall reduction when compared with the 1993 baseline. Information on program secretarial office-specific and site-specific waste generation, recycling, and environmentally preferable purchasing is available on the DOE pollution prevention homepage (<http://www.eh.doe.gov/p2/>).

Additionally, each site's data are included in DOE's complex-wide reports. Elements of DOE's annual reports are extracted and are included in DOE's central internet database, which

In FY 2006, ORR-related activities received the following pollution-prevention awards in recognition of specific 2005 pollution-prevention accomplishments.

- 2006 DOE Office of Science Pollution Prevention—Best in Class Award. ORNL received the award for Overall Laboratory Operations. Specifically, ORNL was recognized for leadership in the development and implementation of Conceptual Landscape Plan Design Guidelines, implementation of a Green Transportation Initiative, continued evaluation and implementation of source-reduction technologies, and implementation of new recycling initiatives.
- BWXT Y-12 was awarded the 2006 White House Closing the Circle Award—Partnering at Y-12 through Y-12's Multiorganizational Reduce/Reuse/Recycle Team.
- BWXT Y-12 was awarded the FY 2006 NNSA Pollution Prevention Award for FY 2005 Environmental Stewardship Best in

Class Award—Recycling Category—Partnering at Y-12 through Y-12's Multiorganizational Reduce/Reuse/Recycle Team.

- BWXT Y-12 was awarded the FY 2006 NNSA Pollution Prevention Award for FY 2005 Environmental Stewardship Award—Waste/Pollution Prevention Category—Y-12 Oil-Free Vacuum Pump Implementation.
- BWXT Y-12 was awarded the 2005 Defense Programs Award of Excellence for 2004 Activities—Y-12 Pollution Prevention Awareness and Outreach Team.
- BWXT Y-12 was awarded the Tennessee Chamber of Commerce and Industry 2006 Comprehensive Environmental Excellence Award.
- BWXT Y-12 was awarded the Tennessee Chamber of Commerce and Industry 2006 Hazardous Waste Management Achievement Certificate.
- BWXT Y-12 was awarded the Tennessee Chamber of Commerce and Industry 2006 Solid Waste Management Achievement Certificate.
- BWXT Y-12 was awarded the Tennessee Chamber of Commerce and Industry 2006 Air Quality Achievement Certificate.

To support future pollution prevention implementation, compliance, and goal achievement, the ORR sites' pollution prevention programs continue to pursue site projects, perform required activities, and complete required reporting.

2.2.17.3 Ozone-Depleting Substances Phase-Out Efforts

Significant progress has been made in eliminating use of Class I and Class II ozone-depleting substances at the Y-12 Complex, and a number of projects have been identified to further reduce ozone-depleting substance uses. The Y-12 Complex Ozone Depleting Substances (ODS) Phase-Out and Management Plan (Y-12 2003), was revised and updated in June 2005 and provides a complete discussion of requirements and compliance activities at the Y-12 Complex.

Y-12 has implemented an ongoing program to identify and retrofit or replace chillers that use

Class I ODSs to satisfy DOE goals and requirements. As of March 2004, the Y-12 Complex had replaced all of their large-capacity chillers (> 150 tons) containing Class I ODSs. In 2006, Y-12 shipped more than 6000 lb of R-11 to the Defense Logistics Agency as a result of retrofit and demolition of chillers.

ORNL has implemented a plan to eliminate the use of Class I ODSs. The plan includes the replacement, retrofit, or decommissioning of all chillers that require Class I substances, the gradual phaseout of smaller refrigeration systems that require Class I substances, the elimination of all fire-protection systems that use Class I substances, and the elimination of all other systems or processes that require Class I substances. Currently, as the small refrigeration systems such as refrigerators and window air conditioners fail, they are replaced with new units that use Class II or unregulated refrigerants.

ETTP completed the phaseout of Class I ODS equipment in the mid-90s. At that time, ETTP surplused and moved all Class I ODSs to other DOE sites so they are no longer part of the ETTP ODS inventory.

2.2.17.4 Energy Management (Including Fleet Management)

BWXT Y-12 prepared a multiyear Energy Management Plan that defines the general energy requirements of the Y-12 Complex and provides a brief history of energy-reduction efforts and a timetable for further energy-saving measures. The primary focus for energy conservation is on electricity, with secondary concentrations on reducing the use of natural gas, fuel (gasoline and diesel), coal, and water.

Over the past 15 years, the energy consumption at the Y-12 Complex has been reduced by more than 40%. Much of the reduction came as a result of reduced production activities and energy-savings measures, such as replacing chillers, eliminating cooling towers, and regularly overhauling steam plant boilers.

ORNL's Energy Management and Implementation Plan outlines the strategy for managing and implementing short- and long-range energy-related activities. As a result of ORNL's emphasis on energy and utilities management and projects, standard building energy intensity

has been reduced by approximately 7% compared with FY 2005 usage (based on British thermal units per gross square foot). FY 2005 is the Energy Policy Act 2005 baseline year for building energy intensity reductions. Specific activities include the following.

- **Energy Star.** ORNL currently has two EPA Energy Star buildings, and FY 2007 energy-efficiency modifications are expected to result in additional Energy Star awards in FY 2008.
- **Leadership in Energy and Environmental Design (LEED®) and Sustainability.** The recent East Campus Modernization project at ORNL used third-party financing to add three buildings and more than 300,000 ft² of energy-efficient office, laboratory, and computer space and achieve a savings of \$0.5 million in annual energy costs (30% savings compared with the baseline conventional design). All three facilities have been approved by the U.S. Green Building Council as LEED-certified. Additionally, a fourth building has been LEED-certified, and a fifth building in the grouping has been certified LEED-Silver. A sixth building has recently been certified LEED-Gold. Modernization efforts at Y-12 have incorporated many LEED-guided sustainable building practices and techniques into the design and construction of the Jack Case and New Hope centers with New Hope pursuing LEED certification (see Sect. 6.11.3).
- **Chlorinated fluorocarbon (CFC) reductions.** As part of an aggressive chiller replacement program, ORNL has replaced 18 chillers, totaling 9,060 tons in cooling capacity, well ahead of legislated requirements. As a result, chiller energy use has dropped an average of 21% for an annual savings of \$300 thousand, and CFC emissions have been cut by more than 5000 lb/year. The chiller replacement program has effected an electrical demand reduction of approximately 1 MW.
- **Water savings.** Water-related projects and management efforts have resulted in water usage being reduced by 276.4 million gal (24.5%) since FY 2000.
- **Green power.** ORNL participates in TVA's "Green Power Switch" program. ORNL was TVA's first industrial green power partici-

pant and purchases 675 MWh in green power annually.

- **Distributed energy resource.** In FY 2001 a natural-gas-fired microturbine was installed by the ORNL Engineering, Science, and Technology Division, and it continues in service. The turbine is tied into the TVA electrical power grid and can generate 30 kW of power. The turbine can be remotely monitored, started, and stopped. Although it is tied into the electrical power grid, the turbine is primarily being used for research in the area of enhancing the energy efficiency of components and systems.
- **Greenhouse gas emission reductions.** Even though the gross square footage of nonprocess facilities at ORNL has increased almost 34% since FY 1995, improvements at the central steam plant has reduced CO₂-equivalent greenhouse gas emissions by 26.82% over the same time period.
- **Vehicle fleet management.** ORNL and Y-12 are working to minimize the use of petroleum-based fuels in the vehicle fleet. To minimize gasoline consumption, ORNL has put 91 ethanol-burning vehicles in service, and Y-12 has put 76 into service. Additional alternative-fuel vehicles are being added to the fleet as funding allows. E-85, a mixture of 85% ethanol and 15% petroleum, is available at the ORNL Garage and at Y-12 for use in flex fuel vehicles in the fleet. Approximately 13% of the vehicles in the ORNL fleet are flex fuel vehicles, and the number of petroleum vehicles continues to be downsized.

2.2.17.5 Beneficial Landscaping Practices

DOE Order 450.1 incorporates Executive Order 13148, "Guidance for Presidential Memorandum on Environmentally and Economically Beneficial Landscape Practices on Federal Landscaped Grounds." The guidance applicable to DOE-site landscaping includes

- use of regionally native plants for landscaping;
- design, use, or promotion of construction practices that minimize adverse effects on the natural habitat;
- seeking to prevent pollution;

- implementing water- and energy-efficient practices;
- creating outdoor demonstration projects; and
- other initiatives.

Y-12/NNSA partners with ORNL regarding stewardship responsibilities for lands on the ORR. Y-12 requires extensive use of erosion controls in construction projects (e.g., use of settling ponds and storm water detention areas), minimal use of water for irrigation, and use of trees where possible to provide shade for energy conservation. Active environmental compliance and preservation programs, such as an ongoing sitewide Pollution Prevention Program, Storm Water Pollution Prevention Plan activities, and policies requiring minimal use of pesticides and fertilizers also minimize environmental impacts. Additionally, Y-12 has limited its modernization construction to brownfield sites, thereby preserving ORR greenfield space.

ORNL has various ongoing programs and initiatives that involve or facilitate environmentally and economically beneficial landscaping practices:

- incorporation of native plants into planning for restoration or landscaping in areas across ORNL;
- development of the ORNL Conceptual Landscape Plan and Design Guidelines, which calls for use of native plant species;
- use of an internal stream corridor protection effort to encourage the growth of native plants in the riparian zone surrounding ORNL creeks;
- the formation of an informal interagency Native Grass Working Group;
- integration of native-plant requirements into facilities-development projects;
- evaluation of upcoming projects by the ORNL Land and Facilities Use Committee on potential impacts, including impact on natural habitat;
- creation of an ongoing sitewide Pollution Prevention Program and a Storm Water Pollution Prevention Plan and Program;
- minimal use of pesticides and fertilizers, and use of organic fertilizers;
- extensive use of erosion controls in construction projects (e.g., settling ponds and bioretention areas);
- minimal use of water for irrigation;

- incorporation of plants into project designs for energy conservation by providing shade and cooling to paved surfaces;
- provision of public-awareness interaction on invasive plants, nuisance wildlife, and restoration of native grasses;
- use of brownfield areas for siting new ORNL developments, when practicable; and
- implementation of an interagency cooperative agreement on conversion of TVA power-line rights-of-way from fescue grass to native grasses and shrubs.

2.2.18 Release of Property

DOE Order 5400.5 establishes standards and requirements for operations of DOE and its contractors with respect to protection of members of the public and the environment against undue risk from radiation. In addition to discharges to the environment, the release of property containing residual radioactive material is a potential contributor to the dose received by the public, and DOE Order 5400.5 specifies limits for unrestricted release of property to the public.

BWXT Y-12, UT Battelle, and BJC each utilize a graded approach for release of material and equipment for unrestricted use by the public. Material has been categorized so that in some cases an administrative release can be accomplished without a radiological survey. Such material originates from nonradiological areas and includes the following:

- documents, mail, diskettes, compact disks, and other office media;
- nonradioactive items or materials received that are immediately (within the same shift) determined to have been misdelivered or damaged;
- personal items or materials;
- paper, plastic products, aluminum beverage cans, toner cartridges, and other items released for recycling;
- office trash;
- nonradiological area housekeeping materials and associated waste;
- break-room, cafeteria, and medical wastes;
- medical and bioassay samples; and
- other items with an approved release plan.

Items originating from nonradiological areas within the sites' controlled areas not in the listed categories are surveyed prior to release to the

public, or a process knowledge evaluation is conducted to ensure that material has not been exposed to radioactive material or beams of radiation capable of creating radioactive material. In some cases both a radiological survey and a process knowledge evaluation are performed (e.g., a radiological survey is conducted on the outside of the item, and a process knowledge form is signed by the custodian for inaccessible surfaces.) When the process knowledge approach is employed, the item's custodian is required to sign a statement that specifies the history of the material and that confirms that no radioactive material has passed through or contacted the item. Items advertised for public sale via an auction are also surveyed on a random basis by state of Tennessee personnel, giving further assurance that material and equipment are not being released with inadvertent contamination.

A similar approach is used for material released to state-permitted landfills on the ORR. The only exception is for items that could be contaminated in depth; items contaminated in depth are also sampled by laboratory analysis to ensure that landfill permit criteria are met.

ORR contractors continue to follow the requirements of the scrap metal moratorium. No scrap metal originating from radiological areas is being released for recycle.

2.3 Appraisals and Surveillances of Environmental Programs

Numerous appraisals, surveillances, and audits of ORR environmental activities were conducted during 2006 (see Table 2.14). The table does not include internal DOE prime contractor assessments for 2006.

2.4 Environmental Permits

Table 2.15 contains a summary of environmental permits for the three ORR sites. Continuing permits, required at each of the ORR facilities, are RCRA operating permits, NPDES permits, and air operating permits. Additional permit information is provided in Appendix F.

2.5 Notices of Violations and Penalties

ORNL received one NOV from TDEC in 2006 for RCRA nonconformances. The RCRA issues were based on observations found during the May 2006 RCRA inspection. The NOV included violations for failure to label two used oil containers, failure to properly label a satellite area container, and failure to comply with the Low-Level Waste Management Agreement. A fourth violation was later rescinded by TDEC. Corrective actions were undertaken where necessary.

One NOV was issued by TDEC on April 26, 2006, for ETTP RCRA operations as a result of a February 2006 inspection. The NOV included violations for failure to provide accumulation start dates and labeling of some containers, failure to close a hazardous waste container when bulking operations ceased, containers stored greater than one year with Burden of Proof considered unacceptable, failure to comply with the Low-Level Waste Management Agreement, container label for pesticide did not state "universal waste," and decanted waste labeled as newly generated. The alleged violation for failure to close a container after bulking operations had ceased was rescinded. Based on the out-brief information provided by TDEC, the violations were fully corrected except for those related to interpretation of the LLW Agreement between DOE and the state of Tennessee and the adequacy of the Burden-of-Proof documentation for waste destined for disposal at the TSCA Incinerator. Discussions have been initiated by DOE, BJC and TDEC to further review and reach an understanding and to decide upon a path forward for the resolution of these two interpretational issues.

Y-12 received one NOV in late 2006 for RCRA violations found during the November 2006 inspection. The issue involved the storage of universal waste (used lamps) greater than one year. Following the inspection, the used lamps were shipped to an off-site recycle facility, and the issue has been resolved. An NOV dated January 11, 2006, was received from the TDEC for the Dry Ash Handling System Baghouse pressure drop readings which were reported as being below the permitted range in July 2005.

Table 2.14. Summary of environmental audits and assessments, 2006^a

Date	Reviewer	Subject	Issues
Y-12 Complex, BWXT Y-12			
3/16	City of Oak Ridge	Sanitary Sewer pretreatment inspection	0
3/23–24	TDEC—City of Knoxville	TDEC Annual Clean Air Compliance inspection	0
8/1	City of Oak Ridge	Sanitary Sewer pretreatment inspection	0
9/9	EPA	Spill Prevention Control and Countermeasures Plan	0
11/14–16	TDEC	TDEC Annual RCRA inspection	0
Y-12 Complex, UT-Battelle			
11/14–16	TDEC	TDEC Annual RCRA Inspection	0
Y-12 Complex, Bechtel Jacobs			
11/14	TDEC	TDEC Annual RCRA inspection	1
ORNL, UT-Battelle			
3/29 & 12/7	TDEC	NPDES permit renewal	0
5/15–5/18	TDEC, RCRA	TDEC Annual RCRA Inspection	2
6/20–21	TDEC	NPDES Program	0
09/12	EPA	SPCC Plan and Program	0
10/14	TDEC, CAA	Title V Air Permit	0
12/07	TDEC, CAA	Relative Accuracy Test Audit	0
ORNL, Bechtel Jacobs Company			
5/15–5/18	TDEC	TDEC Annual RCRA Inspection	1
11/14	TDEC, CAA	Title V Air Permit	0
ORNL, 0800 Area			
8/1	TDEC	RCRA Inspection	0
ETTP			
2/13	TDEC	Annual RCRA Inspection	1
2/23	TDEC	Air Source Inspection	0
NTRC			
3/22	EPA/TDEC	RCRA Inspection	1

^aAbbreviations:

CAA	Clean Air Act
EPA	Environmental Protection Agency
ETTP	East Tennessee Technology Park
NPDES	National Pollutant Discharge Elimination System
NTRC	National Transportation Research Center
ORNL	Oak Ridge National Laboratory
RCRA	Resource Conservation and Recovery Act
SPCC	spill prevention, control, and countermeasure
TDEC	Tennessee Department of Environment and Conservation

There was no insult to the environment, and subsequently the permit was revised to accommodate the readings experienced in July 2005. A response to the NOV was submitted on January 30, 2006.

NTRC received one NOV in 2006 for a RCRA violation found during a March 2006 inspection. That violation was for failure to label used oil containers and was corrected during the inspection.

2.6 Tennessee Oversight Agreement

The Tennessee Oversight Agreement is a voluntary agreement entered into between DOE and the state of Tennessee. The agreement reflects an extension through June 30, 2011, of the agreement between the DOE and the state executed on May 13, 1991, and continues to reflect

Oak Ridge Reservation

Table 2.15. Summary of permits as of December 2006

	Y-12 Complex	ORNL	ETTP
Resource Conservation and Recovery Act (RCRA)			
RCRA operating (Parts A and B)	2	2 ^a	3
Part B applications in process	0	0 ^b	0
Postclosure	3 ^c	0	0
Solid waste landfills	6 ^d	0	0
Annual petroleum underground storage tank facility certificate	2	1	1
Transporter permit	1	1	1
Hazardous Waste Corrective Action Permit	1 ^e	1 ^e	1 ^e
Clean Water Act			
National Pollutant Discharge Elimination System (NPDES)	1 ^f	2	4 ^g
Storm water	1 ^h	1 ^h	1 ^h
Aquatic resource alteration	1	6	1
Army Corps of Engineers 404 permits	0	1	1
General storm water construction	1 ⁱ	3	0
Clean Air Act			
Operating Title V Major Source Permit	2	2	8 ^j
Construction	2	1	2
Prevention of significant deterioration	0	0	0
Sanitary Sewer			
Sanitary sewer	1	0	0
Pump-and-haul permit	2	2 ^k	3
Toxic Substances Control Act (TSCA)			
TSCA Incinerator	0	0	1
Research and development for alternative disposal methods	0	0	0
Safe Drinking Water Act			
Class V underground injection control permits	0	0	0

^aTwo permits have been issued, representing 16 active units and 5 proposed units. One additional permit covers corrective action (Hazardous and Solid Waste Amendments) only.

^bTwo Part B Permit renewals are in process.

^cThree permits have been issued, representing units closed under RCRA in Bear Creek Hydrogeologic Regime, Chestnut Ridge Hydrogeologic Regime, and Upper East Fork Poplar Creek Regime.

^dThree landfills are operational; one is inactive and has a record of decision under the Comprehensive Environmental Response, Compensation, and Liability Act; one is closed pending certification; and one is in postclosure care and maintenance.

^eOak Ridge Reservation (ORR) permit (TNHW-121). Requirements for corrective action have been integrated into the ORR Federal Facility Agreement.

^fIssued 4/28/95 and effective 7/1/95. TDEC has incorporated requirements for storm water into individual NPDES permits.

^gOnly two NPDES permits are directly administered by DOE contractor. Two permits are administered through the Community Reuse Organization of East Tennessee.

^hTDEC has incorporated into individual NPDES permits.

ⁱNotice of intent that accesses a general NPDES permit. A notice of intent remains on file for construction of the Highly Enriched Uranium Materials Facility and hollow-fill.

^jETTP has not been issued a Title V major source permit. The listed number represents the total of all applicable source-specific operating and construction permits previously issued by the state.

^kThis includes one pump-and-haul permit for Y-12 and two for office trailers at ORNL, as well as one at Clark Center Park, which is operated by East Tennessee Mechanical Contractors.

the obligations and agreements regarding DOE's technical and financial support.

The agreement is designed to assure the citizens of Tennessee that their health, safety, and environment are being protected through existing programs and through substantial new commitments by DOE. Through a program of independent monitoring and oversight, the state will advise and assist in verifying that DOE's activities do not adversely impact the public health, public safety, or the environment. DOE and the state, in a spirit of partnership and cooperation, agree to find ways to achieve clean air, water, and land in concert with sustainable economic growth.

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 pertaining to

the environmental management, restoration, and emergency management programs are provided or are made available to the state for its review. The TDEC/DOE Oversight Division routinely visits the three DOE sites to attend formal meetings and briefings and conducts walk-throughs of buildings to assess compliance with environmental regulations. The TDEC/DOE Oversight Division also collects air samples, water samples, and soil samples and occasionally performs radiological surveys. Also, prior to surplus sales, the TDEC/DOE Oversight Division performs a radiological survey of all equipment and material to be auctioned off.

The TDEC/DOE Oversight Division also prepares an annual environmental monitoring report of its activities (TDEC 2005), which is available on the web (<http://www.state.tn.us/environment/doeo/>).

3. Environmental Management and Reservation Activities

Much of the work accomplished by the DOE Oak Ridge Office of Environmental Management (DOE-EM) on the ORR is performed as a result of the requirements of the Federal Facility Compliance Act and CERCLA. The 1992 Federal Facility Compliance Agreement requires that all DOE facilities manage and dispose of mixed waste in accordance with their respective site treatment plans. Bechtel Jacobs Company LLC has established programs to address the storage, transportation, treatment, disposal, and recycling of legacy and newly generated waste from the ORR. Bechtel Jacobs LLC manages the TSCA Incinerator, wastewater treatment facilities, landfill operations, and certain other treatment and recycle facilities that also contribute to meeting the requirements of the Federal Facility Compliance Agreement and other EM milestones.

Another large portion of the DOE-EM work conducted at ORR is performed according to the requirements of CERCLA, which is implemented by the 1991 Federal Facility Agreement. The Federal Facility Agreement, signed by DOE, TDEC, and EPA, addresses contamination resulting from past activities of DOE operations that remain in structures, buildings, facilities, soil, groundwater, surface water, or other environmental media.

Much of the information in this chapter has been previously published in *Cleanup Progress Report FY 2006 Annual Report to the Oak Ridge Community* (DOE 2006a). Where noted, some quantitative data is based upon a fiscal, rather than a calendar, year.

3.1 Introduction

For more than half a century, one of the primary missions of DOE and its predecessor agencies was the production of nuclear weapons for the nation's defense. Production of materials for nuclear weapons, which began in 1943, produced hazardous and radioactive waste and resulted in contamination of facilities, structures, and environmental media. Two laws passed by Congress included requirements to address these problems. These two laws are the Federal Facility Compliance Act and CERCLA. The Federal Facility Compliance Agreement, made in accordance with the Federal Facility Compliance Act, requires that all DOE facilities manage and dispose of waste in accordance with their respective site treatment plans. The Waste Disposition and Waste Operations projects address waste stored, treated, disposed of, or recycled on the ORR in accordance with the Site Treatment Plan. The DOE Environmental Management (EM) program also operates and maintains waste treatment, storage, disposal, and recycling facilities at each of the three Oak Ridge sites (ETTP, ORNL, and the Y-12 Complex). These activities are included in the Waste Operations Project.

CERCLA addresses any environmental contamination resulting from past industrial operations, not just those performed at federal facilities. CERCLA requires that sites requiring cleanup actions be placed on the National Priorities List. Once on the list, the responsible entities are required to investigate and remedy abandoned or uncontrolled hazardous waste sites where a release has occurred or may occur. The ORR was placed on the National Priorities List in 1989. In 1990, DOE Headquarters (DOE-HQ) established DOE-EM, making DOE-ORO responsible for cleanup of the reservation. CERCLA also requires public involvement to ensure that citizens will be informed of cleanup decisions that may affect them or the area in which they live.

The following sections highlight some of the EM activities for 2006 and some related activities carried out to ensure good stewardship of the reservation.

3.2 East Tennessee Technology Park

3.2.1 Decontamination and Decommissioning

ETTP was built as part of the World War II-era Manhattan Project. The primary mission of the ETTP for most of its history was the enrichment of uranium for weapons and fuel. The site consists of hundreds of buildings and other facilities, ranging from small monitoring stations to the K-25 Building, which has more than 1.6 million ft² of floor space. Twenty-six of these buildings are scheduled to be transferred to private-sector ownership for reuse. All of the other facilities are scheduled to be demolished. As of 2006, six buildings have been transferred and seven others are at various stages in the process. The demolition process is being performed through several projects: (1) K-25/K-27 Buildings, (2) K-25 Auxiliary Facilities (Main Plant), (3) Group II, Phase II Buildings (K-1064 Peninsula), and (4) Remaining Facilities.

Because these are interim removal actions, the CERCLA Zone 1 and Zone 2 decisions will determine the final remedy for the contaminated slabs, soils, and below-grade structures.

3.2.1.1 K-25/K-27 Facilities Decontamination and Decommissioning

The three-story, U-shaped K-25 Building was built during the Manhattan Project and contained 3018 stages of gaseous diffusion process equipment and associated auxiliary systems. Each stage consists of a converter, compressors, motors, and associated piping. The K-27 Building covers 383,000 ft² and contains 540 stages of gaseous diffusion equipment and associated auxiliary equipment.

An action memorandum (AM) for the demolition of the K-25 and K-27 Buildings was signed in February 2002. The AM stipulates that the buildings be demolished to the slab and that the associated waste be disposed of. The first phase of the demolition, hazardous materials removal, started in December 2001 and was completed in June 2005. Hazardous materials removal primarily included the removal of asbestos-containing building material, such as

transite panels and insulation, from inside the K-25 and K-27 buildings. During the 3.5-year period, 944 waste shipments, comprising approximately 621,000 ft³ of waste, were transported to the EMWMF, a CERCLA disposal facility located near the Y-12 National Security Complex.

Process equipment removal is under way with the shipment of 115 loose converters to the Nevada Test Site and EMWMF for disposal, 75 of which were shipped in 2005. Excess materials are also being removed from the buildings. Excess materials consist of nonprocess items, such as laboratory equipment, laboratory samples, office equipment, tools, wooden pallets and crates, and drums of chemicals. In 2006, 441 waste shipments, containing approximately 217,000 ft³ of waste, were transported to the EMWMF for disposal.

At the end of 2005, removal of fixed process equipment was awaiting completion of the Operational Readiness Review and transmittal of the Notice to Proceed from DOE-HQ. Approximately 1500 stages in the K-25 Building have been purged of residual process gas in preparation for fixed process equipment removal.

K-25 Building demolition continued in 2006 with the removal of approximately 4,000 ft² of transite panels from the exterior of the building and removal of transite enclosures from about half of the 150 interior stairways. The building demolition waste-handling plan was approved in FY 2005.

The memorandum of agreement regarding historical preservation of the K-25 Building was ratified on March 28, 2005. The memorandum allows the east and west wings of the K-25 Building to be demolished but retains the north wing for historic preservation purposes. It also allows the placement of concrete rubble within the vaults of the east and west wings. The vault walls of the east and west wings along the interior of the "U" will be preserved. Filling and grading of the vault areas will leave the upper portion of the wall available for use by others to portray the history of Oak Ridge (e.g., murals). The footprint of the K-25 Building will be preserved and nominated as a historic landmark.

3.2.1.2 K-29 Building Demolished

One of ETTP's former gaseous diffusion facilities, the K-29 Building, was demolished in

2006. The facility was part of a series of buildings to enrich uranium for weapons and fuel for nuclear power plants. The building went into operation in 1951 and was shut down in 1987. The 524 × 560 ft building was composed of two floors of approximately 290,000 ft² each.

After liquid and hazardous materials were removed from the building, excavators were used to rip through the concrete and steel structural elements that comprised the building's roof, walls, and floors. The demolition was completed in July 2006; the final volume of waste was disposed of in September 2006. The demolition debris, totaling 892,634 ft³, was disposed of at EMWMF; 567 ft³ of other material associated with the demolition was shipped to off-site vendors for disposition.

Uranium-processing equipment and other materials had been removed previously under an AM, signed by DOE in 1997, to decontaminate and remove equipment from the K-29, K-31, and K-33 gaseous diffusion buildings. The contractor, BNG America, completed that work in FY 2005. K-29 was then turned over to BJC. DOE continues to try to identify a future use for K-31 and K-33.

3.2.1.3 Group II Buildings, Phase II Buildings (K-1064 Peninsula)

The Group II Buildings, Phase II Buildings (otherwise referred to as the K-1064 Peninsula area facilities) are located in the northwest sector of ETTP and are bounded on three sides by Poplar Creek. In 2006, the last two of the remaining 19 facilities were demolished. The demolition debris and other waste dispositioned on the project included 8,864 ft³ disposed of at the EMWMF, 42,046 ft³ disposed of at the Y-12 Construction/Demolition Landfill, and 575 ft³ shipped to off-site vendors for disposition.

3.2.1.4 Remaining Facilities

In September 2003, DOE signed the Remaining Facilities Action Memorandum to demolish the approximately 500 remaining facilities at ETTP. The demolition of the facilities covered by this removal action is being accomplished by grouping similar facilities into various different subprojects (e.g., the Poplar Creek Facilities project, the Laboratory Facilities Project). In 2006, demolition was complete

on 54 of the facilities; the following are some highlights of those activities.

- The Laboratory Area facilities were centrally located in the southern portion of ETTP and were used to provide analytical services and R&D support to the uranium enrichment process as well as other activities that occurred at ETTP. Demolition of the Laboratory Area facilities, completed in August 2006, resulted in 455,402 ft³ of demolition debris disposed of at the EMWMF, 161,585 ft³ of demolition debris disposed of at the Y-12 Construction/Demolition Landfill, 30,064 ft³ of concrete used as on-site fill, and 6,641 ft³ shipped for off-site disposition.
- Building K-1420 was built in 1953. Its uses included converter conditioning and recovery, parts disassembly and cleaning, uranium recovery, aluminum leaching, and laboratory analysis. Demolition of K-1420, completed in December 2006, resulted in 195,989 ft³ of demolition debris disposed of at the EMWMF, 509 ft³ of demolition waste burned at the TSCA Incinerator, 7,651 ft³ of demolition debris disposed of at the Y-12 Construction/Demolition Landfill, and 9,186 ft³ shipped for off-site disposition.
- The Centrifuge Equipment Removal project continued. Most of the machines were removed and were sent for final disposition, and 69,000 lb of process equipment were removed and were shipped to the Nevada Test Site for disposal.
- Demolition of the Building K-1401 began in 2006 and is expected to continue through 2007.
- Characterization and utility deactivation continued in 2006 in preparation for other facility demolition work in 2007.

3.2.1.5 Building Transfers Continue Under the Reindustrialization Program

Building transfers to CROET under DOE's Reindustrialization Program are part of DOE's effort to transform ETTP into a private-sector industrial park. CROET is a not-for-profit corporation established to foster diversification of the regional economy by reutilizing DOE property for private-sector investment and job creation. DOE transferred two additional ETTP buildings

to CROET in FY 2006, bringing the total number of buildings transferred to six. The buildings, K-1036 and K-1400, offer an additional total of approximately 93,000 ft² of available space for private-sector use. The buildings were previously leased to CROET and are fully occupied by private-sector companies.

- Building K-1036 (80,000 ft²) was constructed in 1945 and served as the distribution center for the entire K-25 Site until it was leased to CROET in 1998. Building K-1036 now provides corporate office and manufacturing occupancy for several CROET tenant businesses.
- Building K-1400 (13,000 ft²) was constructed in 1954 and was used as an administrative office building. It was leased to CROET in 2001 and is being used as the local corporate headquarters for OMI as well as other private sector companies.

Previous transfers to CROET include Buildings K-1225, K-1330, K-1580, and K-1007. Seven additional buildings at ETTP are in various stages of the transfer process.

3.2.1.6 ETTP Soil Remediation

The soil at ETTP will be remediated to protect a future industrial workforce and to protect underlying groundwater. Two RODs have been signed that address soil, slabs, subsurface structures, and burial grounds.

The Zone 1 ROD was signed by DOE, the TDEC, and the EPA in November 2002. Zone 1 is the 567-hectare area surrounding ETTP outside the fence. The Zone 2 ROD was signed by DOE, TDEC, and EPA in April 2005. Zone 2 includes the area within the main fence of ETTP (approximately 324 hectares). In 2006, work was completed on the characterization of the K-1007 area, the Powerhouse area, the K-901-A area, and the Duct Island area. Phased construction completion reports were completed and were submitted to TDEC and EPA for approval. Seven areas requiring additional remediation were identified, and the completion of Blair Quarry was documented in the reports. In Zone 2, the characterization of 6 of 44 exposure units was documented in a phased construction completion report. The report cleared 93 acres and identified two areas requiring remedial actions. Remediation in the Balance of Site-Laboratories

area was initiated with the removal of building slabs.

3.2.1.7 ETTP Site-Wide ROD Project Under Way

The ETTP site-wide ROD addresses contamination in groundwater, surface water, and sediment for the protection of human health and the environment. In addition, it will determine whether additional soil action is necessary to protect the environment. The geographic areas included in this decision are Zone 1 (outside the main plant) and Zone 2 (inside the plant fencing).

After a series of data-quality-objective workshops focusing on groundwater, surface water, sediment, and soil actions were held, a work plan for additional investigations was developed and was submitted to EPA and TDEC for approval. Fish sampling and aquatic community surveys were conducted as stated in the work plan. Additionally, the three Federal Facility Agreement parties developed a detailed schedule of the ensuing activities to allow for signature of the ROD in early 2007.

3.2.1.8 ETTP Scrap Removal Project

The ETTP Scrap Removal Project began shipping contaminated scrap from the K-770 Scrap Yard to the EMWMF on July 26, 2004. Approximately 41.3 million lb of contaminated scrap metal were disposed at EMWMF during 2006 under the ETTP Scrap Removal Project. The project is responsible for disposing of approximately 47,000 tons of scrap metal from the K-770 Scrap Yard, K-1131 Area, K-1064 Scrap Yard, K-1300 Area, and K-1066-G Maintenance Yard. The project will be completed in early 2007.

3.2.1.9 ETTP Outdoor Legacy Waste

The ETTP Outdoor Legacy Waste is composed of 6209 containers of LLW that were the result of past operations at the site. This waste has been characterized to support disposal and shipment to the EMWMF, which is in progress.

3.2.1.10 UF₆ Cylinders Being Shipped Off Site

In December, 2,006 the last of 7,200 cylinders have been shipped off site for disposal or processing. The project was completed three years ahead of the schedule. Most (approximately 6,000) of the cylinders contained UF₆ and were shipped to the Portsmouth Site for disposition. Approximately 1,200 cylinders contained residual amounts of other materials and had earlier been shipped to the Nevada Test Site for disposal. These steel cylinders hold approximately 10 to 14 tons of depleted UF₆. More than 118 million lb of UF₆ were shipped with no accidents or significant incidents.

Natural uranium in the form of UF₆ was used as feed material during the gaseous diffusion process to enrich uranium at the former K-25 Site. The percentage of ²³⁵U was increased from the original feed material in the process (i.e., the uranium was enriched). The remaining material is depleted UF₆. It is stored as a white, crystalline solid that is slightly less radioactive than natural uranium.

3.2.1.11 Plan Submitted for Groundwater Remediation

In 2006, a remedial investigation/feasibility study and proposed plan for groundwater remediation were submitted to EPA and TDEC. The remedial investigation/feasibility study discusses the nature and extent of groundwater contamination and ecological concerns and evaluates alternatives for remediation. The proposed plan proposes the selected remedial alternative for remediation of groundwater and Mitchell Branch, and for the protection of ecology. The plan will be the basis for the final decision for ETTP. The documents are being reviewed by the EPA and TDEC, and a final ROD is planned for 2007 following the public review period for the proposed plan.

Remediation of the K-1007 Holding Ponds, K-901-A Holding Pond, K-720 Slough, and K-770 Embayment is planned as a removal action. The Engineering Evaluation/Cost Analysis was prepared in 2006. A public meeting will be held, and the Action Memorandum will be prepared in 2007.

3.2.1.12 Native Grasses and Wildflowers

In the fall of 2006 a project began to replace the fescue and weeds currently covering the nonpaved portions of the ETTP with native grasses and wildflowers. Native grasses are much less maintenance intensive than fescues, and the resultant savings in labor, mowing expenses, and gasoline are expected to save several thousand dollars annually and to reduce gas-burning emissions. In addition, native grasses and wildflowers provide better habitat and forage for wildlife.

3.2.1.13 TSCA Incinerator Hazardous Waste Treatment

The TSCA Incinerator, located at ETTP, treated 700,000 lb of liquid waste and 200,000 lb of solid waste in 2006. Plans are in place to increase the throughput at the incinerator to ensure cost-effective operations in support of the DOE complex's cleanup mission. In 2007, approximately 3.1 million lb of waste are planned for incineration. The incinerator plays a key role in treatment of radioactive PCB and hazardous wastes (mixed wastes) from the ORR as well as other facilities across the DOE complex, thus facilitating compliance with regulatory and site closure milestones.

In 2006 TDEC released *Air Dispersion Modeling and Risk Assessment of the TSCA Incinerator* (TDEC 2006), a study to determine the risks, if any, to area residents and local environment from operations of the TSCA Incinerator. The study included analyses of major components of the effluent and potential pathways of exposure, including air, surface water, soil, and food-chain effects. The results of the evaluation were that the incinerator operations posed an insignificant hazard to both human health and the environment.

3.2.1.14 Central Neutralization Facility

The Central Neutralization Facility (CNF) is ETTP's primary wastewater treatment facility and processes both hazardous and nonhazardous waste streams arising from multiple waste treatment facilities and remediation projects. The facility removes heavy metals and sus-

pended solids from the wastewater, adjusts pH, and discharges the treated effluent in accordance with NPDES requirements into the Clinch River. Sludge from the treatment facility is treated, packaged, and disposed of off site. The CNF treated approximately 16.3 million gal of wastewater in 2006.

3.3 Oak Ridge National Laboratory

3.3.1 Melton Valley Remedial Actions

Work was completed on the second of three major milestones of the Melton Valley Project in September, with the completion of the 7841 Scrapyard Project. It was the final field task in an overall cleanup project responsible for capping 145 acres of waste sites, demolishing and disposing of 6000 ft² of various buildings, and excavating 50,000 yd³ of soil. Other project achievements include

- grouting and stabilizing 30,000 ft of pipelines;
- performing in situ grouting of Trenches 5 and 7; and
- retrieving 204 casks, 8 boxes, and 1,500 ft³ of loose waste as part of the Transuranic Waste Retrieval Project.

3.3.2 New Hydrofracture Facility Decontamination and Decommissioning

The New Hydrofracture Facility was built at ORNL between 1979 and 1982 and operated from 1982 to 1984. It replaced the Old Hydrofracture Facility, which operated between the late 1950s to the mid-1970s. The New Hydrofracture Facility was designed to facilitate the injection of a mixture of radioactive waste solutions and grout into an impermeable shale formation at depths between 700 and 1,000 ft below grade. The hydrofracture process is essentially a batch process in which the waste-grout mixture is pumped down a tubing string in the injection well and out into the shale formation. The high injection pressure of approximately 3,000 psi fractures the subsurface shale and

forces the waste-grout mixture into the fractures, where it hardens into “grout sheets.”

Most of the New Hydrofracture Facility was demolished in previous years. The final three reinforced concrete rooms, or cells, of the main structure were demolished to 2 ft below grade in 2006, along with all remaining slabs. The New Hydrofracture Facility site was restored by placing a clean stone mix over the building footprint. A 100 × 80 ft ventilated enclosure over the building footprint was left in place in support of future activities planned for the site. The previously grouted injection well at the New Hydrofracture Facility, HF-4, was cut off at 4 ft below grade, and the wellhead was disposed of in 2006.

3.3.3 SWSA Hydrologic Isolation

Work has been completed on a hydrologic isolation project to decrease the rainwater infiltration to waste associated with the Melton Valley burial grounds, pits, and trenches.

Construction of 13 separate caps covering 145 acres in SWSA 4, SWSA 5, SWSA 6, and Seepage Pits and Trenches was completed in 2006, and all the caps were transferred to operations and maintenance. Collection and treatment of groundwater from Seepage Pits, Trench 7, SWSA 4, and SWSA 5 has been initiated and is now an ongoing process.

SWSAs 4, 5, and 6 were the principal waste burial sites in Melton Valley. Shallow land burial was used routinely at ORNL for disposal of solid LLW from 1943 to 1986, when improved disposal technologies were implemented. Early burial procedures used unlined trenches and auger holes for containment. The trenches and holes were then covered by soil from the trench excavation or by a combination of concrete caps and soil. The concrete caps were used for disposal of high-activity wastes or wastes with TRU elements. More than 850 trenches and 1500 auger holes exist in the three main Melton Valley burial grounds.

Four seepage pits (pits 1, 2, 3, and 4) and three trenches (trenches 5, 6, and 7) were used for the disposal of liquid LLW (LLLW) from 1951 to 1966. As intended, the LLLW seeped into the surrounding clay soil. The seepage pits and trenches were excavated in clayey soils to take advantage of the clay's low permeability

and high sorption capacity for some radionuclides in the LLLW.

The hydrologic isolation actions consisted of a combination of the following:

- multilayer caps over the waste units to minimize rainfall infiltration and to lower the water table;
- stormflow diversion trenches located along the uphill edge of the waste units to intercept and divert shallow groundwater before it flows into the waste units; and
- groundwater collection trenches located along the downhill side of the waste units to collect groundwater contaminated by leachate before the groundwater discharges to nearby streams. (Contaminated groundwater collected by the drains will be treated before it is released.)

The total capped area is about 145 acres. To facilitate cap installation, the project included a subproject to plug and abandon approximately 1,000 unnecessary shallow nonhydrofracture wells, the development and closure of a 33-acre soil borrow area, relocation of Lagoon Road, construction of haul roads, demolition of any structures situated within the cap boundaries, and rerouting of several power lines.

In situ grouting of Seepage Trenches 5 and 7, which are former waste disposal sites in Melton Valley, was completed in June 2006. In situ grouting of the Homogeneous Reactor Experiment (HRE) Fuel Wells, adjacent to Trench 5, was also completed.

In situ vitrification had been the initial remedial action selected for the trenches in the Melton Valley ROD. However, during a 2003 field investigation and procurement for design and construction services, new information resulted from those activities and prompted a reassessment.

The new information included the presence of standing water in the trenches and a higher-than-expected cost for in situ vitrification. After further evaluation, DOE proposed in an ROD amendment that in situ grouting be substituted as the remedial action.

In situ grouting is a treatment process in which materials, such as cement-based or chemical grouts, are injected at low pressures into the subsurface (or waste unit) to isolate the waste through reduction of hydraulic conductiv-

ity. the change to in situ grouting proposed in the ROD amendment was approved in 2004. The trenches were treated by the permeation grouting method, utilizing portland-cement-based grouts injected under low pressure into the crushed limestone trench material.

The soil adjacent to the trench walls was treated with a solution grout (e.g., polyacrylamide) to reduce migration of contaminants away from the trench by sealing off seepage pathways.

In situ grouting of the waste units was performed with a cement-based grout mix. Approximately 200 yd³ of grout was used at Trench 7; approximately 346 yd³ was used at Trench 5.

The completed hydrologic isolation project meets all regulatory performance objectives.

3.3.4 Homogeneous Reactor Experiment Ancillary Facilities

The HRE ancillary facilities consist of 11 separate structures external to the HRE reactor building and provided support capabilities (e.g., waste management, storage) during reactor operation. The ancillary facilities include a liquid waste evaporator, a charcoal absorber that cleaned up gaseous effluents prior to discharge to the atmosphere, a decontamination pad and storage shed, an office building, and other miscellaneous structures. D&D of three of the ancillary facilities was completed in 2005. The remaining eight facilities at three different locations were demolished in 2006, including the HRE Waste Evaporator, the most highly contaminated of the ancillary facilities. Each location was restored by placing clean stone mix over the building footprint.

3.3.5 Shielded Transfer Tanks

The shielded transfer tanks are five shipping casks that were originally used during the 1950s and 1960s to transport high-specific-activity radionuclide solutions by rail from Hanford to ORNL for further processing. Following approval of the Melton Valley ROD and the Remedial Design Report/Remedial Action Work Plan, waste characterization activities performed in preparation for emptying, grouting, and disposal of the tanks identified potential issues with the waste categorization. It was decided that a Waste Incidental to Reprocessing determination

was required by DOE Order 435.1 prior to disposal of the tanks. Due to the extended documentation and review period associated with the Waste Incidental to Reprocessing determination process, DOE has proposed to remove the shielded transfer tanks from the scope of the ROD and to address the disposal of the grouted tanks and contents under a NEPA process to be completed by September 30, 2008, following the completion of the Waste Incidental to Reprocessing determination. EPA and TDEC have concurred with the proposal.

3.3.6 Liquid Low-Level Waste Pumping Stations

Two separate LLLW pumping stations, Buildings 7567 and 7952, were constructed during the 1960s to support the collection and transfer of LLLW from the HFIR facility, the Radiochemical Engineering Development Center (REDC), the HRE, and the Molten Salt Reactor Experiment (MSRE). D&D of Building 7567, including decontamination and stabilization of the below-grade pump vault, was completed in early 2006.

3.3.7 Equipment Storage Yard

The 7841 Equipment Storage Yard was a fenced facility with an area of less than 1 acre used to store a wide variety of surplus items. The inventory of items in the 7841 area included shielded carriers, drums, high-integrity containers, shields, tanks, and nearly 200 pieces of specialized equipment ranging from fuel casks and storage cabinets to tanker trailers.

In 2006, each item was characterized, reduced in size or otherwise prepared for disposal, and disposed of. The storage yard was restored by placing clean stone mix over the original footprint. The ventilated enclosure used during characterization was left in place in support of future planned activities at the site.

3.3.8 Miscellaneous Storage Buildings

Demolition of two miscellaneous facilities, Building 7802F and Building 7831A, was completed in 2006. Building 7802F had been used for the storage of well drilling cores and other sampling-related materials. Building 7831A had been used as a waste repack facility.

3.3.9 Molten Salt Reactor Experiment Fuel and Flush Salts Removal

The MSRE operated from 1965 to 1969 to test the molten salt concept. MSRE differed from traditional reactors (that have fuel contained within fuel rods) in that its fuel was contained in molten salts. The salt flowed through the reactor chamber, where the fission occurred to produce heat. At the conclusion of the experiment, the fuel laden salt was drained into two storage tanks, where it cooled and solidified. The reactor was flushed with fresh (but not laden with uranium) salt, and the flush salt went into a third tank. Much of the salt was removed in 2005 and 2006. In December 2005 work was initiated to process Fuel Drain Tank 2, but in May 2006 a fluorine release caused a temporary cessation of the project. Recovery operations to complete the Tank 2 salt removal and preparations to remove the salt from Tank 1 occupied the remainder of 2006.

3.3.10 22-Trench Area Transuranic Waste Retrieval

TRU wastes that have been stored in the 22-Trench Area in SWSA 5 North were removed in 2006. A total of 204 concrete casks was retrieved, overpacked, and staged. The six waste packages with the highest radiological inventory were relocated to Building 7883. Retrieval and overpacking of all of the concrete casks, along with loose waste and other containers, were completed in 2006.

During the 1970s, packages of TRU waste were retrievably stored in unlined earthen trenches in the 22-Trench Area. Radionuclides in the TRU waste containers represent some of the most toxic and longest-lived radioisotopes stored on the ORR. DOE signed a consent agreement with the state of Tennessee in September 2000 committing to retrieve the TRU waste from the 22-Trench Area. Surrounding soil exceeding remediation levels designated in the Melton Valley ROD as well as debris waste associated with excavation were disposed at the EMWMF or at another appropriate facility. After retrieval, the overpacked TRU waste packages were staged pending transport to the TRU Waste Processing Facility, where the wastes will

be further characterized and repackaged for off-site disposal.

On July 28, 2006, DOE proposed to the regulators to maintain Trench 13 in interim in situ storage, pending further efforts to identify treatment and disposition pathways. DOE proposed that final disposition of the Trench 13 pyrophoric material be addressed in the future, prior to September 30, 2009. On August 11, 2006, TDEC acknowledged DOE's effort to retrieve drums containing jars of pyrophoric metallic carbides of uranium and plutonium with methane and agreed to the temporary storage approach as proposed by DOE.

3.3.11 Soils and Sediments Remediation

The Melton Valley Closure Soils and Sediments Project completed its work in FY 2006. The following examples were among the accomplishments.

- Excavation of the HFIR impoundments. The four unlined impoundments, located at the HFIR facility, received liquid process waste streams, mostly from floor and laboratory drains, steam condensates, and pressure vessel cooling waters. Remediation of the surface impoundments has been completed and the site has been restored. Remediation consisted of removing standing water and excavating and disposing of the contaminated sediment at the EMWMF.
- Remediation of the HRE Cryogenic Pond. The pond received contaminated condensate from the HRE waste evaporator and from discarded shielding water. It was taken out of service and backfilled. This backfilled pond later served as a demonstration for cryogenic stabilization, in which soil around the pond was frozen to form a barrier to groundwater for several years. The cryogenics system was shut down in February 2004 in preparation for system dismantling and pond excavation. Excavation of the pond, backfill, and cryogenics material has been completed.
- Remediation of the EPICOR-II Lysimeters. Five stainless steel lysimeters near SWSA 6 were used for a 10-year study of the in situ leaching properties of solidified waste forms from the cleanup of Three Mile Island. The solidified waste forms were removed in

1996 and were transported to another DOE facility for processing and disposal. The lysimeters and remaining contaminated soil were removed and disposed of at the EMWMF in 2006.

- Excavation of the Engineering Test Facility. Nine test trenches were excavated and filled with compactible LLW in a study of disposal techniques in the early 1980s. The trench wastes and associated contaminated soils were excavated and disposed of at EMWMF.
- Removal of contaminated soil. Six sites contaminated as a result of pipeline leaks or hydrofracture experiments were excavated. As a result of verification walkover surveys and sampling, 25 additional contamination areas were identified and excavated.
- Final verification. The project includes a final verification activity designed to confirm that all of Melton Valley has been cleaned up sufficiently to meet the remediation levels. Walkover surveys and sampling have been conducted on more than 500 acres of the watershed that lie outside the footprint of the hydrologic isolation caps. Data collected from the final verification activities are being used to confirm that the postremediation conditions in Melton Valley are compatible with the anticipated future land uses for Melton Valley.

The soil contamination sites were cleaned up to remediation levels designated in the Melton Valley ROD. These remediation levels are based on specific risk reduction and exposure limit goals derived from reasonably anticipated future land uses for Melton Valley. The designated land uses are a waste management area for the western two-thirds of the watershed addressed in the Melton Valley ROD and a controlled industrial area in the eastern third.

Sediment and soils from the HFIR surface impoundments and HRE Cryogenic Pond were disposed of in the EMWMF. Material excavated from the Melton Valley Pumping Station, Engineering Test Facility, Lysimeters, and Facility 7848 was disposed of at EMWMF. Selected soils from the remaining sites, generally containing only minor amounts of contamination, were used as contour fill beneath one of the hydrologic isolation caps.

3.3.12 Pipeline Grouting

In addition to the remediation of contaminated soils, the Melton Valley Soils and Sediment Project completed stabilizing and isolating inactive liquid waste transfer pipelines throughout Melton Valley. The inactive waste pipeline system consists of a complex series of buried waste pipelines and appurtenances (e.g., vents, valve pits, pump vaults) historically used to transport liquid process waste and LLW between generator facilities in Melton Valley, storage and disposal sites in Melton Valley, and storage/treatment facilities in Bethel Valley. The selected remedy in the ROD for inactive process and LLLW transfer pipelines is isolation, removal, or stabilization. A total of 27,736 linear ft of pipeline was grouted, and another 11,721 ft was isolated. In addition, more than 5,000 ft³ of void space was grouted in the various valve boxes, manholes, and pump pits associated with the inactive pipeline system.

3.3.13 Decontamination and Decommissioning Projects

A number of structures and facilities, including ancillary HRE facilities, the 7841 Equipment Storage Area, and Shielded Transfer Tanks, will undergo D&D. The remedial design report/remedial action work plans for these activities were approved by the regulators in 2004. Field mobilization was completed, and processing of material from the 7841 Equipment Storage Area began during 2005. D&D of five of the HRE ancillary facilities was completed in 2005. The HRE ancillary facilities consist of 11 separate structures external to the HRE reactor building, which provided support capabilities (e.g., waste management, storage) during reactor operation. The ancillary facilities include a liquid waste evaporator, a charcoal absorber that cleaned up gaseous effluents prior to discharge to the atmosphere, a decontamination pad and storage shed, an office building, and other miscellaneous structures. Planning and characterization of the remaining facilities was performed. D&D is scheduled to be completed in coming years.

3.3.14 Remediation of T-1, T-2, and HFIR Tanks Completed

Three inactive underground LLLW storage tanks identified as Tanks T-1 and T-2, and the HFIR Tank contained liquids and a mixture consisting primarily of spent TRU ion-exchange resin and sludge.

In 2005, the liquid waste from the HFIR tank was transferred into the ORNL LLLW system for treatment. The HFIR Tank and remaining sludge were stabilized in place with grout. The waste in Tanks T-1 and T-2 was mixed with liquid by using a pulse-jet system. The resulting slurry was transferred to the active ORNL LLLW system. Approximately 3,000 gal of sludge was transferred from the tanks and will undergo treatment at the TRU Waste Processing Facility prior to final disposal. The empty tanks were filled with grout and were closed in place. Associated equipment was removed from the site and either transferred to other projects for reuse or disposed of at the EMWMF along with the remaining secondary waste.

3.3.15 In Situ Grouting of Trenches 5 and 7

In situ grouting of Seepage Trenches 5 and 7, former waste disposal sites in Melton Valley, was completed in June 2006. In situ grouting of the HRE Fuel Wells, adjacent to Trench 5, was also completed.

In situ vitrification had been the initial remedial action selected for these trenches in the Melton Valley ROD. However, during a 2003 field investigation and procurement for design and construction services, new information resulted from these activities and prompted a reassessment.

The new information included the presence of standing water in the trenches and a higher-than-expected cost for in situ vitrification. After further evaluation, DOE proposed in a ROD amendment that in situ grouting be substituted as the remedial action.

In situ grouting is a treatment process where materials, such as cement-based or chemical grouts, are injected at low pressures into the subsurface (or waste unit) to isolate the waste through reduction of the hydraulic conductivity. This remedy change proposed in the ROD amendment was approved in 2004. The trenches

were treated by the permeation grouting method, utilizing portland-cement-based grouts injected under low pressure into the crushed limestone trench material.

The soil adjacent to the trench walls was treated with a solution grout (e.g., polyacrylamide) to reduce migration of contaminants away from the trench by sealing off seepage pathways.

In situ grouting of the waste units was performed with a cement-based grout mix. Approximately 200 yd³ of grout was used at Trench 7; approximately 346 yd³ was used at Trench 5.

The completed project meets all regulatory performance objectives.

3.3.16 Bethel Valley Remediation

The Bethel Valley ROD, signed by the Federal Facility Agreement parties in May 2002, presents the remedy selected for environmental remediation of various contaminated areas within the ORNL Bethel Valley area. Higher-risk sites will be addressed first. Remediation work mandated by the Bethel Valley ROD will continue through FY 2014. The first three projects to be performed under the ROD are the Bethel Valley Groundwater Engineering Study; remediation of the T-1, T-2, and HFIR Tanks; and partial remediation of the Hot Storage Garden.

3.3.17 Bethel Valley Groundwater Engineering Study Fieldwork Completed

The Bethel Valley ROD specified that a groundwater engineering study be conducted to satisfy data needs for the design of several remedial actions related to groundwater, including deep groundwater extraction at the Core Hole 8 Plume, in situ biodegradation at the East Bethel Valley volatile organic compound (VOC) plume, groundwater monitoring in West Bethel Valley, and soil excavation at known leak sites to minimize impacts to groundwater.

Planning for the groundwater engineering study was summarized in the *Engineering Study Work Plan for Groundwater Actions in Bethel Valley*, issued as a final document in 2003. The work plan includes an evaluation of existing, relevant data from previous characterization activities and defines the scope of work to be per-

formed to design groundwater and soil remedial actions under the ROD.

In 2005, the Bethel Valley Groundwater Engineering Study completed the remaining components of the required fieldwork. The components included an additional 48 soil push probes to make a total of 283 locations with approximately 450 soil samples collected and analyzed. Fifteen monitoring wells were installed and sampled. The data from the soil samples, process lines, storm sewer lines, surface water, and monitoring wells were received and evaluated. The results were published in comprehensive engineering study report and were approved by the regulatory agencies in 2006. The data and recommendations have determined the necessary soil/groundwater-related remediation activities to be performed as part of the signed Bethel Valley ROD.

3.3.18 Core Hole 8 Transuranic Waste Removal

The Core Hole 8 contaminated groundwater plume and its source were the focus of early actions taken by DOE at ORNL. The plume is located in the central portion of the ORNL main plant area. The plume emanates from contaminated soil surrounding Tank W-1A in the North Tank Farm and migrates westward to First Creek. The principal plume contaminants are strontium-90 and uranium isotopes. Since late 1994, DOE has been implementing various co-ordinated actions to minimize the release of contaminants, including intercepting, collecting, and treating approximately six million gal per year of contaminated groundwater migrating toward First Creek and removing a significant portion of the source (i.e., 90% of the contaminated soil surrounding Tank W-1A).

The first action implemented by DOE was to install a groundwater interceptor on the western part of ORNL to reduce contaminant discharge to First Creek. The next action was the construction of a groundwater interceptor trench near the existing Core Hole 8 plume interceptor system. A third action was implementation of hydraulic controls on the plume by pumping groundwater from an existing monitoring well. The last action, in 2001, addressed the contaminant source that contributed to the plume by removing a significant portion of the soil surrounding Tank W-1A.

The waste removal was a CERLCA removal action performed under an AM. Approximately 900 yd³ of the soil were removed. However, during excavation of soil adjacent to the tank, analytical results from grab samples of soil indicated that approximately 100 yd³ of soil around and under the tank contained very high concentrations of TRU radionuclides. Because there is no disposal facility that could accept soil at those levels, the soils and the tank were left in place.

In preparation for the upcoming completion of the removal action, in which the remaining 100 yd³ of soil will be removed, the project team obtained additional soil samples around the tank and submitted them for detailed analysis. This characterization effort will determine how much of the soil meets the definition of TRU waste and will provide radiological contaminant data. It will also provide characterization data on the soil that does not meet the definition of the TRU waste (low-level). Planning for the removal is expected to be performed in 2007; the removal action is currently planned to begin in 2008. The TRU soil will be containerized and stored until the waste disposal facility (the Waste Isolation Pilot Plant [WIPP]) is ready to receive it. The low-level soil is expected to be disposed of at EMWMF.

3.4 Y-12 National Security Complex

3.4.1 Upper East Fork Poplar Creek

Remediation of the Upper East Fork Poplar Creek Watershed is being conducted in stages using a phased approach. Phase 1 addresses interim actions for remediation of mercury-contaminated soil, sediment, and groundwater discharges that contribute contamination to surface water. The focus of the second phase is remediation of the balance of contaminated soil, scrap, and buried materials within the Y-12 Complex, the major contaminated area in the Upper East Fork Poplar Creek Watershed. Decisions regarding final land use and final goals for surface water, groundwater, and soils will be addressed in future decision documents.

During 2006, regulators provided comments on the draft proposed plan for Phase 2 interim remedial actions for accessible soil, buried

waste, or subsurface structures that contribute significantly to contamination above acceptable risk levels in Upper East Fork Poplar Creek. The Phase 2 ROD was finalized and approved in April 2006.

3.5 Off-Reservation Activities

3.5.1 David Witherspoon Inc. 901 Site Cleanup

The David Witherspoon, Inc., (DWI) 901 Site, located on Maryville Pike in Knoxville, Tennessee, consists of a 3.4-hectare parcel formerly owned and operated as the DWI Recycling Center and a 0.2-hectare parcel owned by CSX Transportation, Inc. The site is a former scrap metal and recycling facility that housed, among other things, waste from DOE operations. It was taken over by the Tennessee Division of Superfund in 1993. The scope of the project was to decontaminate and demolish the main building, a metal office building, the incinerator, the magnet house, the compactor house, the control house, the scale house and scale, the brazier house, and the breaker house. Contaminated soils were excavated and disposed of in the EMWMF as radioactive PCB mixed waste.

As of the end of 2006, all contaminated material at the site was excavated and disposed of, and the site was 95% restored. A small area of the site, less than one acre, where the office trailers were located, remained to be backfilled and restored once sampling verification results were received from the laboratory.

During FY 2006, approximately 5,650 truckloads of soil were shipped to the EMWMF, and more than 550,000 truck miles were logged without any incident. The DWI 901 Site has been backfilled with 50,000 yd³ of clean fill, contoured for proper drainage, and seeded to establish erosion control.

3.6 Waste Treatment and Disposal

3.6.1 Tons of Wastes Placed in the EMWMF and Other Landfills

The EMWMF, located in East Bear Creek Valley near the Y-12 Complex, is an on-site waste facility that is being used to contain the

wastes generated during cleanup of the ORR and associated sites in Tennessee. It is an engineered landfill that accepts both low-level and hazardous wastes in accordance with specific waste acceptance criteria under agreement with state and federal regulators. The EMWMF accepted its first waste shipment in May 2002. Since then, projects from all over the ORR have shipped waste to EMWMF for disposal. In FY 2006, approximately 151,219 tons of waste were disposed of at the EMWMF. This included 12,117 truckloads of waste from such projects as

- DWI 901 Site Remedial Action Project;
- ETTP Scrap Removal Project;
- ETTP Main Plant Facilities, including K-1064 Peninsula Facilities D&D;
- Melton Valley Soils and Sediments Project, Intermediate Holding Pond Project, Intermediate Holding Pond Remedial Action Project, and Surface Impoundments Operable Unit Remedial Action Project at ORNL;
- K-25/K-27 D&D Project;
- MSRE D&D Project at ORNL;
- ORNL D&D Project;
- K-29/31/33 D&D Project;
- K-1420 D&D Project; and
- Centrifuge D&D Project.

The EMWMF operation also collected, analyzed, and disposed of more than one million gal of leachate and contact water at the ORNL Liquids and Gases Treatment Facility during FY 2006. The operations also effectively controlled site erosion and sediments.

DOE also operates solid waste disposal facilities located near the Y-12 Complex, called the ORR Sanitary Landfills. In FY 2006, more than 143,000 yd³ of industrial, construction/demolition, classified, and spoil material waste were disposed of at this facility.

3.6.2 EMWMF Expansion

As waste disposal operations commenced in the newly constructed Cell 3 during 2006, the design and construction project's focus shifted to the future and the final build-out of EMWMF. The design for Cell 5 was completed and was sent to the regulators for approval.

This cell will add 500,000 yd³ of capacity to the previous 1,200,000 yd³ capacity to bring the total airspace at EMWMF to the ROD-approved

limit of 1,700,000 yd³. The design incorporates the lessons learned from both of the previous design/construction efforts. Timing for the start of Cell 5 construction will depend on how quickly the existing capacity is consumed as the Accelerated Cleanup ramps up.

3.6.3 Haul Road Completed

It became apparent in early 2004 that removing shipments of ETTP waste bound for the EMWMF from public roads would better serve project and public interests. Conceptual design work to identify feasible routes to construct a haul road between ETTP and the EMWMF was initiated in early summer. The road enhances public safety by eliminating the hazards presented by large trucks mixing with passenger vehicles on public roads. It also reduces cleanup costs by decreasing the cycle time for each load of ETTP waste that is disposed at the EMWMF. Construction was completed in January 2006, just in time for the start of the intensive waste-hauling campaign from the ETTP cleanup.

3.6.4 Millions of Gallons of Wastewater Treated in 2006

During FY 2006, the EM Program treated 20.8 million gal of contaminated groundwater at the Groundwater Treatment Facility, East End Mercury Treatment System, Central Mercury Treatment System, and East End VOC System.

The West End Treatment Facility and the Central Pollution Control Facility at the Y-12 Complex processed approximately 0.8 million gal of wastewater in FY 2006, primarily in support of NNSA operational activities. The wastewater included hazardous materials such as PCBs, cyanide, mercury, cadmium, chromium, and uranium. The hazardous materials end up in the sludge that results from wastewater treatment. These sludges are disposed of off site.

The Big Spring Water Treatment System processed about 107.7 million gal, and about 1 million gal of methanol-contaminated groundwater and sump water was put into inventory in the West End Tankage during FY 2006.

At ETTP, the CNF treated approximately 16.3 million gal of wastewater in 2006. The facility is ETTP's primary wastewater treatment facility and processes both hazardous and non-hazardous waste streams arising from multiple

waste treatment facilities and remediation projects. The facility removes heavy metals and suspended solids from the wastewater, adjusts pH, and discharges the treated effluent into the Clinch River. Sludge from the treatment facility is treated, packaged, and disposed of off site.

At ORNL, 148 million gal of wastewater was treated and released at the Process Waste Treatment Complex. The LLLW evaporator at ORNL also treated 141,000 gal of waste. A total of 2.3 billion m³ of gaseous waste was also treated at the ORNL 3039 Stack Facility. These important waste treatment activities supported both EM and Office of Science mission activities in a safe and compliant manner.

3.6.5 TSCA Incinerator Hazardous Waste Treatment Continues

The TSCA Incinerator, located at ETTP, treated 700,000 lb of liquid waste and 200,000 lb of solid waste in 2006. The TSCA Incinerator successfully demonstrated compliance with the MACT standards for Hazardous Waste Combustors in 2005. In 2007, approximately 3.1 million lb of waste are planned for incineration.

The TSCA Incinerator is a one-of-a kind thermal treatment unit in the United States. It plays a key role in treatment of radioactive PCB and hazardous wastes (mixed wastes) from the ORR as well as from other facilities across the DOE complex, thus facilitating compliance with regulatory and site closure milestones.

3.6.6 Transuranic, Low-Level, and Mixed Waste Operations

Operations at the ORR produce wastes that frequently contain radionuclides. Such wastes are characterized as either LLW or TRU wastes. Mixed low-level wastes (MLLWs) are those that contain materials deemed hazardous and are regulated under RCRA.

TRU wastes from throughout the DOE complex are to be disposed of at the WIPP, near Carlsbad, New Mexico. Before being shipped to the WIPP, however, TRU wastes must be treated, packaged, and certified to meet its waste acceptance criteria. The mission of the Oak Ridge TRU Program is to provide cost-effective, safe, and environmentally compliant treatment and disposal of all TRU waste stored at ORNL.

In 1998, DOE entered into a fixed-price privatization contract with Foster Wheeler Environmental Corporation to construct, operate, decontaminate, and decommission a waste processing facility (now called the TRU Waste Processing Center). Construction of the facility was completed in 2004.

The facility was designed and constructed to treat and dispose 900 m³ of remote-handled TRU sludge, 550 m³ of remote-handled TRU/alpha LLW solids, 1600 m³ of remote-handled LLW supernate, and 1000 m³ of contact-handled TRU/alpha LLW solids currently stored in Melton Valley. The forecast for waste quantities to be processed at the center has been updated to include the latest estimates: 2000 m³ of remote-handled TRU sludge, 700 m³ of remote-handled TRU solids, and 1,500 m³ of contact-handled TRU solids.

Supernate processing was completed in 2004. Since the start of 2005, the Foster Wheeler Environmental Corporation has been preparing the facility, safety documentation, and procedures for contact-handled TRU waste processing. In 2005 Foster Wheeler contracted with EnergX LLC to operate and manage the project. Processing of contact-handled TRU waste started December 2005. Approximately 120 m³ was processed in FY 2006.

On September 12, 2006, a new cost-plus-fixed-fee contract was signed. Due to many uncertainties about the waste characteristics and changing requirements, that type of contract is deemed more suitable. The new contract includes initiation of processing and packaging for the two remaining waste streams, remote-handled solids/debris and remote-handled TRU sludge, stored at ORNL, for transportation to and disposal at the WIPP.

Acceptance of the two remote-handled TRU waste streams at the WIPP up to now has been pending the outcome of permitting actions by DOE with the state of New Mexico. The revised permit approving remote-handled TRU disposal at WIPP was signed by the state of New Mexico on October 16, 2006.

The ORR has the largest inventory of legacy LLW (i.e., waste from historic reservation operations) in the DOE complex. In addition, active DOE missions at the Y-12 Complex and ORNL produce newly generated LLW that must be managed and disposed of safely and effi-

ciently. In 2004, DOE shipped 40 legacy LLW monoliths (2161 yd³) to the Nevada Test Site for disposal. The inventory of MLLW has been steadily declining through the use of on-site facilitated (e.g., the TSCA Incinerator) and off-site commercial treatment, storage, and disposal facilities.

3.7 Public Involvement

3.7.1 Public Input on EM Initiatives

3.7.1.1 Public Involvement Plays Key Role in Cleanup Decisions

Most remediation projects on the ORR have moved from the decision-making phase to actual fieldwork. However, DOE is still seeking public involvement in many decisions affecting cleanup of the reservation. Public input was sought in 2006 on a variety of initiatives, including the following:

- ETTP parking lot expansion at Portal 5,
- engineering evaluation/cost analysis for the demolition and disposal of the Central Pollution Control Facility at the Y-12 National Security Complex,
- covenant deferral request for the transfer of Building K-1652 to the city of Oak Ridge, and
- engineering evaluation/cost analysis for remediation of contaminated ponds at ETTP.

Other public involvement initiatives included the monthly distribution of *Public Involvement News*, distribution of the FY 2005 version of *Cleanup Progress*, and updates of project fact sheet that are made available at the DOE Information Center and other venues.

3.7.1.2 Oak Ridge Site Specific Advisory Board

In 2006, the Oak Ridge Site Specific Advisory Board (ORSSAB) posted several accomplishments in its mission to provide informed advice and recommendations to DOE on its Oak Ridge EM program and to involve the public in environmental decision-making.

3.7.1.2.1 ORSSAB Wins National EPA Award

In June 2006 ORSSAB and its Stewardship Committee were presented with the Citizens Excellence in Community Involvement Award. The national honor is given annually by EPA to recognize an individual or community group for outstanding achievement in the field of environmental protection. The award was presented at EPA's 2006 Community Involvement Conference in Milwaukee, Wisconsin.

The award recognizes two major achievements by the ORSSAB Stewardship Committee between October 2004 and September 2005.

The first achievement was development of the Stewardship Education Resource Kit, which was created to provide local educators with materials to teach students about environmental cleanup and long-term stewardship issues.

The second achievement focuses on maintaining information about contaminated land. In 2004, the Stewardship Committee worked with Anderson County to test a system where plat maps of contaminated land would be placed in the county geographical information system. The test was successful, and in 2005 the board recommended that DOE standardize its language for land with notices of contamination to ease searches in county land records. DOE adopted the recommendation and is standardizing its language when filing notices of contamination with Anderson County. The county also sends the same information to the city of Oak Ridge.

3.7.1.2.2 Educators Learn About Stewardship at ORSSAB Two-Day Workshop

In February 2006 ORSSAB sponsored a two-day workshop using the board's Stewardship Education Resource Kit in the classroom. The event was attended by twenty-four ecology and environmental science teachers representing public and private high schools in Knox and Anderson counties.

The kit, which was completed in March 2005, contains lesson plans, videos, a fictional case study based on actual cleanup operations, an appendix of supporting materials, and a video CD on the background and use of the kit.

During the workshop, ORSSAB members and facilitators from the University of Tennessee

explained how to use each lesson, showed videos included with the kit, and demonstrated the use of support materials and related Internet sites. The teachers participated in group activities and listened to a panel discussion on stewardship that included representatives from ORSSAB, DOE, and the state of Tennessee.

The lessons in the kit are not just for teachers and students; they are available to everyone. Individuals can access the kit materials on the ORSSAB web site (www.oakridge.doe.gov/em/ssab/stewardship-kit/kit.htm). Organizations that have an interest in stewardship and the environment may request a version of the kit.

More information about the kit and ORSSAB is available at the board's web site at www.oakridge.doe.gov/em/ssab or by calling (865) 241-4583 or 241-4584.

3.7.1.2.3 ORSSAB EM Committee Holds Public Meeting on K-25/K-27 Demolition

The former gaseous diffusion plants K-25 and K-27 at ETTP are undergoing D&D in preparation for eventual demolition. However, an accident that seriously injured a worker led DOE to reevaluate its method of accomplishment for taking the buildings down.

In July 2006 the board's EM Committee used its meeting as a public forum for DOE and its prime contractor, Bechtel Jacobs Company, to explain the new method of accomplishment and how it will be safer for workers involved in the project. A large group of interested citizens attended the meeting and asked numerous questions.

3.7.1.2.4 Eleven Recommendations Provided to DOE

In 2006 the ORSSAB generated several recommendations on cleanup-related issues, such as

- the Integrated Facilities Disposition Project,
- long-term stewardship of contaminated sites,
- the Natural Resources Damage Assessment process, and
- independent verification of cleanup activities at ETTP.

Complete text of all the board's recommendations is available on line at www.oakridge.doe.gov/em/ssab/recc.htm.

ORSSAB also worked with the chairs of the other six site-specific advisory boards in the national EM site-specific advisory board to draft joint recommendations to DOE. This year the chairs developed recommendations on three important topics.

- Recommendation 1 was a follow-up to a recommendation made last year that DOE convene a national stakeholder workshop on waste disposition, the goal of which is to formulate solutions to overcome the barriers to disposition.
- Recommendation 2 requested that EM ensure that the lessons learned from the site closure process at Fernald, Ohio, and Rocky Flats, Colorado, are considered and are incorporated in policies that ultimately will guide closure at other EM sites.
- Recommendation 3 asked that the development of EM budgets include site-specific advisory board participation to assist in establishing priorities and requested budgets for environmental actions.

3.7.1.3 DOE Information Center

The DOE Information Center, located at 475 Oak Ridge Turnpike, Oak Ridge, Tennessee, is a one-stop information facility that maintains a collection of more than 40,000 documents involving environmental activities in Oak Ridge. The center hosts various meetings, including the ORSSAB meetings, relevant to cleanup activities in Oak Ridge. Staff are available Monday through Friday, 8 a.m. to 5 p.m., to assist with information. During FY 2006, the center received more than 3,078 visitors and has responded to 2,717 requests for information. A web site for the Information Center is available at www.oakridge.doe.gov under the "Public Activities" tab.

4. ETTP Environmental Monitoring Programs

The East Tennessee Technology Park (ETTP), formerly known as the Oak Ridge Gaseous Diffusion Plant or K-25 Site, was originally built as part of the Manhattan Project. Uranium was enriched for weapons and nuclear reactor fuel elements and included recycling of reactor return fuel elements. Other activities included research and support operations. After the enrichment operations ceased in 1985, the primary focus of the plant shifted to environmental restoration, reindustrialization, and reuse of the facilities.

Environmental monitoring remains a major activity on the ETTP. Environmental monitoring encompasses two activities: effluent monitoring and environmental surveillance. Effluent monitoring consists of the collection and analysis of samples or measurements of liquid or gaseous effluents at the point of emission to determine and quantify contaminants released. Environmental surveillance consists of the collection and analysis of samples of air, water, soil, vegetation, biota, and other media from the ETTP and its surroundings. External direct radiation is also measured. Data from environmental monitoring activities are used to assess exposures to members of the public and the environment, to assess the effects of ETTP operations on the public and the environment, to help plan remediation projects, and to evaluate the efficacy of these projects.

In 2006, the emissions of radionuclides from ETTP operations were well within the allowable derived concentration guides (DCGs) published in DOE Order 5400.5 and were similar in most respects to 2005 emissions. Potential direct radiation to the public from uranium hexafluoride cylinder storage yards and the K-770 scrap metal yard at ETTP remained below the requirements in DOE orders. Nonradiological emissions were also within limits, and compliance with permit limits was better than 99%.

4.1 ETTP Radionuclide Airborne Effluent Monitoring

To demonstrate compliance with DOE Order 5400.5 and Tennessee Rule 1200-3-11-08, "Emission Standards for Emission of Radionuclides Other than Radon from Department of Energy Facilities" (i.e., NESHAP), all airborne radionuclide emissions from DOE sources at ETTP must be determined for purposes of estimating dose to the most exposed member of the public.

Locations of airborne radionuclide point sources at the ETTP are shown in Fig. 4.1. Radionuclide emission information for these release points is compiled under the direction of BJC from operators subject to NESHAP regulations. Point sources shown in Fig. 4.1 include both individual point sources and grouped point sources, such as laboratory hoods. Radionuclide emissions data were determined from either EPA-approved sampling results or EPA-approved calculation methods.

4.1.1 Radionuclide Emissions Monitoring Approach

4.1.1.1 Minor Sources

The number of minor sources in 2006 varied from the previous year's total because of fluctuations in site operations. For this reporting period, a total of five point sources and one grouped minor source subject to NESHAP regulations operated. Minor sources are grouped if they have similar characteristics (e.g., general location, type of activity, or type of control) and provided that any one group does not have potential radionuclide emissions that would cause a dose in excess of 0.1-mrem/year EDE as defined under the rule. An example of a minor group source is the TSCA Incinerator tank farm with 15 emission points.

Emissions from the various minor sources located at the ETTP were estimated by means of one of the following EPA-approved methods:

- radionuclide inventory (i.e., material balance)—five point sources,
- health physics air measurements where room ventilation emissions exceeded 10% of derived air concentration worker protection

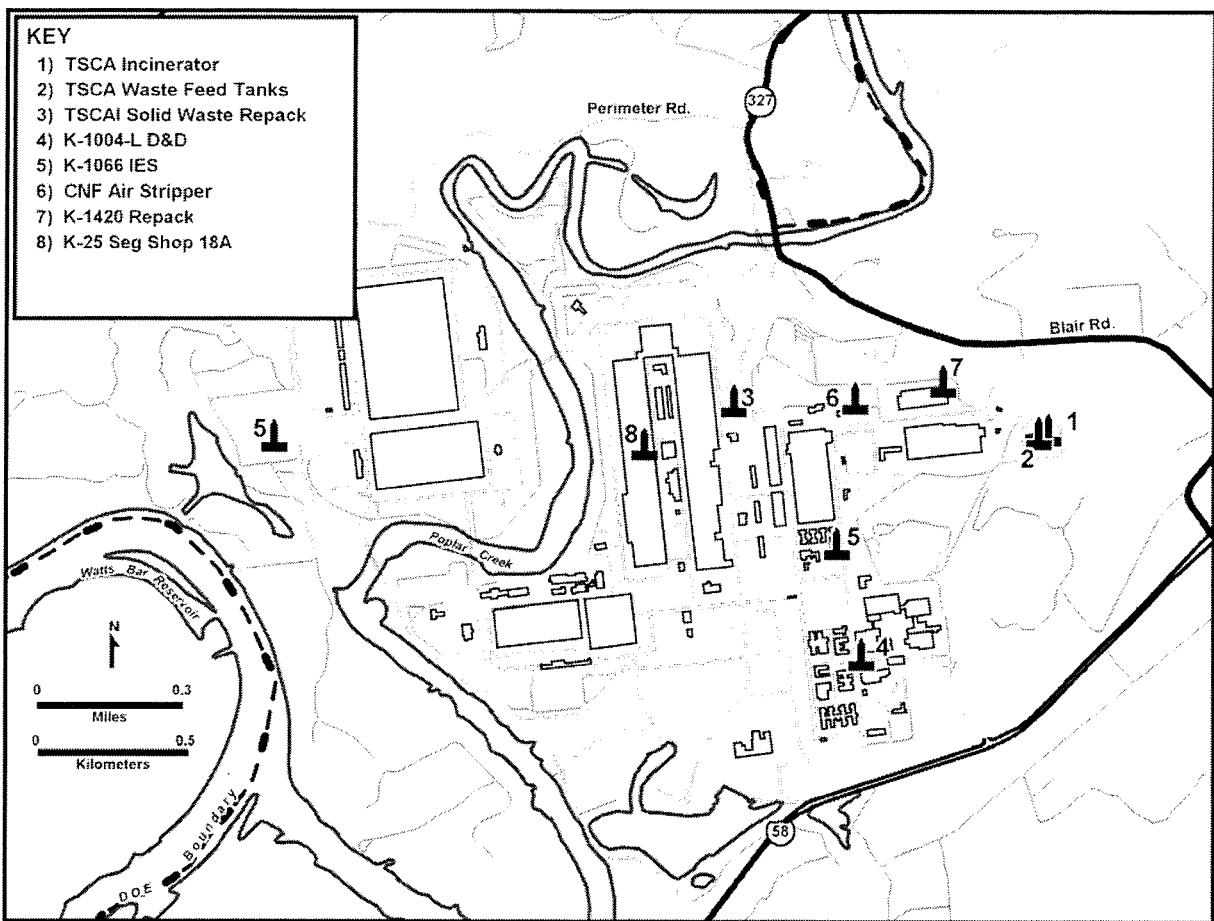


Fig. 4.1. Locations of airborne radionuclide point sources at the ETTP.

- guidelines—no sources,
- surrogate emission data from similar sources—no sources, and
- evaporative emissions—one grouped source.

All techniques are conservative methods of estimating emissions based on the physical form of the radionuclides and the maximum operating temperature of the process or activity.

Any remaining emissions were classified as major sources or diffuse/fugitive sources that are spatially distributed in nature or that were not emitted with forced air from a stack, vent, or other confined conduit. Typical examples of diffuse/fugitive sources include

- emissions from shutdown buildings;
- resuspension of contaminated soils, debris, or other materials;
- unventilated tanks;
- wastewater treatment systems;

- outdoor storage and processing areas;
- emissions from piping, valves, or other piping equipment and pump components; and
- decontamination and demolition activities.

Fugitive emission sources are monitored by way of the ORR and ETTP ambient air surveillance programs.

4.1.1.2 Major Sources

Two ETTP major sources operated during 2006. Radionuclide emission measurements from the TSCA Incinerator were determined by means of a continuous stack-sampling system. The system is designed to automatically adjust sample flow rate to maintain near-isokinetic sampling conditions at the stack. The effluent is passed through filter media to collect particulate matter and through impingers with absorbing and adsorbing media to collect gaseous radionu-

clides. Measurements of TSCA Incinerator emissions were based on monthly composites of weekly stack samples. The K-1423 Solid Waste Repack facility was redesignated as a major source based on a change in the on-site member of the public location. Emissions were determined both by tracking the waste processing radiological characterization for assessing the dose to an off-site member of the public and by ambient air sampling at a location conservatively representative of the impact to the on-site location.

4.1.2 Results

The ETTP 2006 radionuclide emissions from the major and minor emission sources are shown in Table 4.1. Additionally, Figs. 4.2 and 4.3 show a comparison of the total discharges of uranium with those of previous years. The total curies and mass of uranium discharged to the air can vary from year to year. Emissions during 2006 showed a slight upturn, but the upturn was within historical variations. The variations are attributable to changes in project activities and source process rates. The resulting airborne dose from all ETTP radionuclide emissions was less than the reservation maximum limit of 10 mrem/year.

4.2 ETTP Nonradiological Airborne Emissions Monitoring

Under an application shield granted by the TDEC Division of Air Pollution Control, the ETTP has five major air emission sources listed as subject to Tennessee Title V Major Source Operating Permit program rules as of the end of this reporting period.

No direct monitoring of airborne emissions is required for nonradionuclide air contaminants from permitted sources. Instead, monitoring of key process and air pollution control device parameters is performed to ensure compliance with all permitted emission limits.

The ETTP is required to pay a major source emission fee each year for all regulated pollutants, excluding carbon monoxide and pollutants from exempt emission sources. To verify the air emission fee that is based on a combination of permitted allowable and actual emissions for air

pollutants, an inventory of regulated emissions from the permitted sources at the ETTP is updated annually. Table 4.2 shows the results of the annual inventory of emissions of criteria pollutants from ETTP operations for the past 5 years. The ETTP paid an annual fee in 2006 amounting to \$4,500 based on the fee rate of \$21.50 per ton of emissions but not less than \$4,500 during that period for a facility subject to Title V Major Source Operating Permit requirements. Table 4.3 shows the inventoried regulated emissions during the 2006 reporting period from the ETTP.

The TSCA Incinerator is permitted as a major source of air emissions from the ETTP. Emissions from the incinerator are controlled by extensive exhaust-gas treatment. For fee-reporting purposes, permitted allowable limits are used to determine the total potential emissions from the incinerator. A comparison of actual and allowable TSCA Incinerator emissions is presented in Table 4.4. All other permitted sources have emissions inventoried based on permit allowable limits.

4.3 Liquid Discharges—ETTP Radiological Monitoring Summary

The ETTP conducts radiological monitoring of liquid effluent and storm water discharges to determine compliance with applicable dose standards. It also applies the “as low as reasonably achievable” (ALARA) process to minimize potential exposures to members of the public.

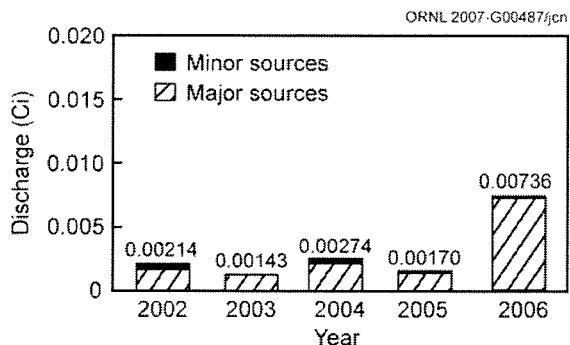
4.3.1 Sample Collection and Analytical Procedure

The ETTP monitored the treated effluent from the K-1407-J CNF (outfall 001). Weekly samples were collected from the CNF and were composited into monthly samples. The samples were then analyzed for radionuclides. Results of these sampling efforts were compared with the DCGs listed in DOE Order 5400.5.

The Storm Water Pollution Prevention Program, which is described in more detail in Sect. 4.5, included sampling for gross alpha and beta radioactivity as well as specific radionuclides at selected storm water outfalls. Results were used to estimate the total discharge of each

Table 4.1. ETTP radionuclide air emission totals, 2006 (Ci)^a

Radionuclide	Total major	TSCAI (major) ^b	Total minor	Total ETTP
²²⁸ Ac	—	—	2.21E-08	2.21E-08
²⁴¹ Am	5.42E-09	—	1.12E-07	1.17E-07
²⁴³ Am	1.36E-09	—	—	1.36E-09
¹⁴ C	4.84E-05	4.84E-05	7.41E-04	7.90E-04
¹³⁷ Cs	7.13E-05	7.13E-05	—	7.13E-05
⁶⁰ Co	—	—	1.32E-11	1.32E-11
²⁴⁴ Cm	—	—	3.76E-08	3.76E-08
²⁴⁵ Cm	1.10E-09	—	—	1.10E-09
²⁴⁷ Cm	1.62E-09	—	—	1.62E-09
²⁴⁸ Cm	7.28E-10	—	—	7.28E-10
⁸⁵ Kr	4.99E-03	4.99E-03	—	4.99E-03
²¹⁰ Pb	—	—	2.00E-07	2.00E-07
²³⁷ Np	2.52E-06	2.52E-06	1.44E-07	2.67E-06
²³⁸ Pu	1.23E-06	1.23E-06	5.52E-08	1.29E-06
²³⁹ Pu	4.61E-06	4.61E-06	3.70E-07	4.98E-06
²⁴² Pu	2.58E-09	—	—	2.58E-09
²³¹ Pa	5.97E-10	—	6.19E-08	6.25E-08
^{234m} Pa	5.52E-03	5.52E-03	—	5.52E-03
²²⁶ Ra	4.46E-08	—	4.56E-06	4.61E-06
^{89/90} Sr	7.32E-06	7.32E-06	—	7.32E-06
⁹⁹ Tc	9.86E-03	9.85E-03	1.34E-03	1.12E-02
²²⁸ Th	1.35E-05	1.35E-05	1.20E-07	3.36E-05
²³⁰ Th	1.66E-04	1.66E-04	2.37E-07	1.66E-04
²³² Th	2.88E-05	2.88E-05	4.64E-08	2.88E-05
²³⁴ Th	1.76E-03	1.76E-03	8.38E-05	1.84E-03
³ H	2.97E+02	2.97E+02	—	2.97E+02
²³² U	7.97E-09	—	—	7.97E-09
²³³ U	1.34E-08	—	2.55E-06	2.57E-06
²³⁴ U	3.17E-03	3.17E-03	3.75E-05	3.21E-03
²³⁵ U	4.45E-04	4.44E-04	2.60E-06	4.47E-04
²³⁶ U	—	—	5.50E-07	5.50E-07
²³⁸ U	3.60E-03	3.60E-03	1.04E-04	3.70E-03
Totals	2.97E+02	2.97E+02	2.32E-03	2.97E+02

^a1 Ci = 3.7×10^{10} Bq.^bToxic Substances Control Act Incinerator.**Fig. 4.2. Total curies of uranium discharged from the ETTP to the atmosphere, 2002–2006.**

radionuclide from ETTP via the storm water discharge system. Figure 4.4 shows the location of the major NPDES outfalls.

4.3.2 Results

The sum of the fractions of the DCGs at the CNF was calculated at 37% for 2006, up from 14.8% in 2005. Table 4.5 lists radionuclides discharged from the ETTP CNF to off-site surface waters in 2006. Total uranium discharges from the CNF were 0.0074 Ci in 2006. Total discharge of transuranics was 0.0000025 Ci, which is more than three orders of magnitude less than the contribution from uranium.

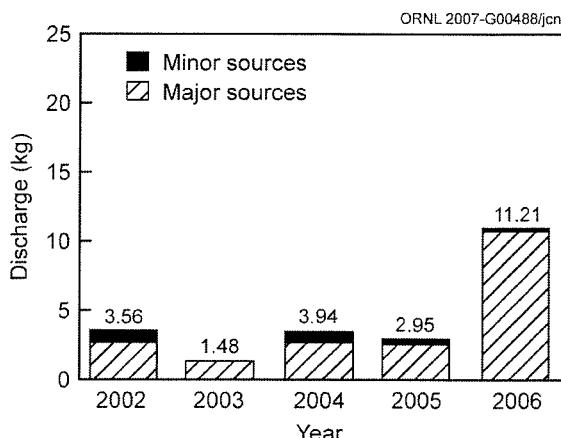


Fig. 4.3. Total kilograms of uranium discharged from the ETTP to the atmosphere, 2002–2006.

In terms of total activity of the discharges, ^3H , ^{14}C , and ^{99}Tc were the greatest contributors. However, their allowable DCGs are greater than those for the uranium isotopes, so their contribution to the sum of the fractions of the DCGs is relatively small. Technetium-99 accounted for 5.8% of the sum of the fractions, ^{14}C for 5.6%, while ^3H accounted for 0.081%. Uranium discharges from the CNF during a 5-year period were investigated to observe their trend (Fig. 4.5). Uranium isotopes were the major contributors to the fraction of the DCG, contributing 24% of the sum of the fraction of the DCG (Fig. 4.6). All of the remaining isotopes cumulatively accounted for just over 12% of the allowable DCG. TSCA Incinerator wastewater, which is sent to the CNF for treatment before being discharged to the Clinch River, is a major contributor of uranium; other operations contribute smaller amounts.

4.4 Nonradiological Liquid Discharges—ETTP Surface Water Effluents

The current ETTP NPDES permit (Permit Number TN0002950) for storm water discharges went into effect on April 1, 2004. This permit authorizes the ETTP to discharge storm water runoff, groundwater infiltration, groundwater from sumps, noncontact cooling water, and steam condensate to the Clinch River, Poplar Creek, and Mitchell Branch through 121 storm water outfalls. The 121 outfalls were divided into four groups based on the volume and nature of the monitored discharge. Of the 121 total outfalls, 39 are monitored as being representative of the 4 outfall groups. Samples from these outfalls are collected and analyzed as specified in NPDES permit TN0002950.

The storm drain groupings in the ETTP NPDES Permit allow storm water discharges from outfalls that are similar to be monitored at representative outfalls. Based on historical sampling data, outfall flow characteristics, and outfall locations, the storm water outfalls that provide the most accurate representation of the water quality of the outfall group were selected as the representative outfalls to be sampled for the group. The representative outfalls for each group are designated in the NPDES permit tables. All storm water monitoring and characterization sampling for the storm water outfall groupings are performed at the designated representative outfalls. Sheet flow and runoff from

Table 4.2. Allowable emissions of criteria pollutants from the ETTP, 2002–2006

Pollutant	Allowable emissions (tons/year) ^a				
	2002	2003	2004	2005	2006
Particulate matter	13	13	13	14	14
Volatile organic compounds	14	14	14	11	11
Sulfur dioxide	39	39	39	39	39
Nitrogen oxides	20	20	20	20	20
Carbon monoxide	19	19	19	19	19
Hazardous air pollutants	21	21	21	21	21
Miscellaneous	0	0	0	0	0
Total	126	126	126	124	124

^a1 ton = 907.2 kg.

Table 4.3. Actual emissions of criteria pollutants from permitted ETTP sources, 2006

Pollutant	Actual emissions	
	lb/year ^a	tons/year ^b
Particulate matter	530.5	0.265
Volatile organic compounds	711.8	0.356
Sulfur dioxide	18.9	0.009
Nitrogen oxides	23,505	11.75
Carbon monoxide	5,876	2.94

^a1 lb = 0.435359237 kg.

^b1 ton = 907.2 kg.

small drainage swales in the drainage area of the groupings are considered to be part of the total flow of the grouping. Unless otherwise stated, all storm water outfall groups also receive general site runoff, which may include storm water runoff from grassy areas, roads, and paved areas within ETTP.

The current NPDES permit (Permit Number TN0074255) for the CNF went into effect on November 1, 2003. The permit authorizes treated industrial effluent from outfall 001 to be discharged to the Clinch River. Table 4.6 details the requirements and compliance records for the two NPDES permits for 2006. The table provides a list of the discharge points, effluent parameters, effluent limits, number of noncompliances, and the percentage of compliance for 2006. Samples from outfall 001 are collected and analyzed as specified in NPDES permit TN0074255.

4.4.1 Results

The ETTP had one NPDES noncompliance in 2006 under NPDES Permit No. TN0002950. On November 27, 2006, during routine weekly sampling required by ETTP NPDES Permit No. TN0002950, a noncompliance with the NPDES Permit limit for TRC concentration was identified at storm water outfall 100. The sample result, 0.20 mg/L, exceeded the NPDES Permit limit for TRC for outfall 100, which is a daily maximum concentration of 0.140 mg/L.

On November 27, 2006, field investigations were initiated to identify the source of the TRC in the discharge from outfall 100. Dechlorination tablets were placed in the outfall 100 drainage network immediately after the discovery of the noncompliance. Field investigations indicated that the source of the TRC was an underground sanitary water line break. On December 15,

2006, repairs to the broken sanitary water line were completed.

On December 11, 2006, during routine NPDES Permit compliance sampling activities, several dead fish were observed in the riprapped channel that transports discharges from the outfall 100 storm drain network to the K-1007-P1 Pond. It was estimated that the total mortality was in excess of 1000 fish. The vast majority of the dead fish were determined to be shad. The cause of the fish kill is believed to be related to the sanitary water line break that discharged chlorinated water into the outfall 100 piping network.

4.5 Storm Water Pollution Prevention Program

4.5.1 Storm Water Monitoring Strategy

Development and implementation of the ETTP Storm Water Pollution Prevention Program is required by Part IV of ETTP NPDES Permit No. TN0002950. The objective of the program is to minimize the discharge of pollutants in storm water runoff from the ETTP.

The purpose of the ETTP Storm Water Pollution Prevention Program is to assess the quality of storm water discharges from ETTP, determine potential sources of pollutants affecting storm water, and provide effective controls to reduce or eliminate these pollutant sources. It provides a means whereby sources of pollutants that are likely to affect the quality of storm water discharges are identified, best management practices to control the entry of pollutants into storm water discharges are developed, and methods for implementing pollution prevention practices are devised. The sampling effort incorporates an increased emphasis on the identification of specific sources of pollutants that may be transported by storm water. This information is used to support the site cleanup program that is being conducted in accordance with CERCLA requirements.

During 2006, the ETTP Storm Water Pollution Prevention Program sampling was conducted in support of two primary goals.

- Sampling for the ETTP Water Quality Program (EWQP)—Surface water samples were collected at locations that are exit pathways

Table 4.4. Actual vs allowable air emissions from the Toxic Substances Control Act Incinerator at the ETTP, 2006

Pollutant	Emissions (tons/year) ^a		Percentage of allowable
	Actual ^b	Allowable	
Semivolatile metals			
(As, Be, and Cr)	0.0018	0.116	1.5
Beryllium	0.00002	0.00021	9.6
Low-volatile metals			
(Cd and Pb)	0.0064	0.286	2.2
Mercury	0.00037	0.155	0.2
Hydrogen fluoride	0.011	2.98	0.4
Hydrogen chloride	0.014	0.092	15.1
Sulfur dioxide	0.009	38.5	<0.1
Volatile organic compounds			
	0.356	5.0	7.1
Dioxin/furan	<i>c</i>	<i>c</i>	n/a
Particulate matter	0.265	5.64	4.7

^a1 ton = 907.2 kg.

^bActual emissions based on removal efficiencies measured during permit required air emission tests conducted during 2005.

The criterion for dioxin and furan is the "destruction/removal efficiency."

Actual: 99.999%; allowable: 99.99%.

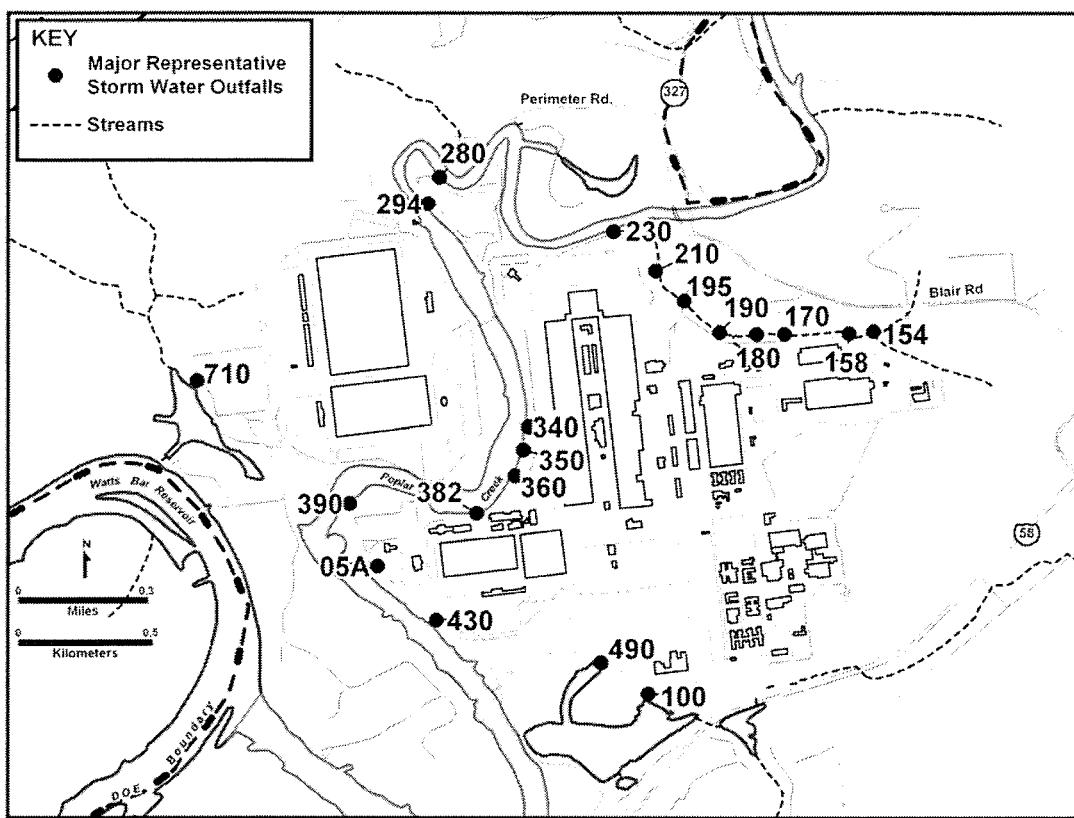


Fig. 4.4. ETTP National Pollutant Discharge Elimination System major representative storm water outfalls.

Table 4.5. Radionuclides released to off-site surface waters from the ETTP, 2006

Effluent discharge location: Central Neutralization Facility			
Radionuclide	Amount (Ci) ^a	Radionuclide	Amount (Ci) ^a
¹⁴ C	2.5 E-1	²³⁰ Th	1.5E-4
¹³⁷ Cs	8.1 E-5	²³⁴ U	1.9 E-3
³ H	1.4 E-1	²³⁵ U	1.3 E-4
²³⁷ Np	6.5 E-7	²³⁶ U	4.4 E-5
²³⁹ Pu	1.9 E-6	²³⁸ U	5.3 E-3
⁹⁹ Tc	3.8 E-1		

^a1 Ci = 3.7×10^{10} Bq.

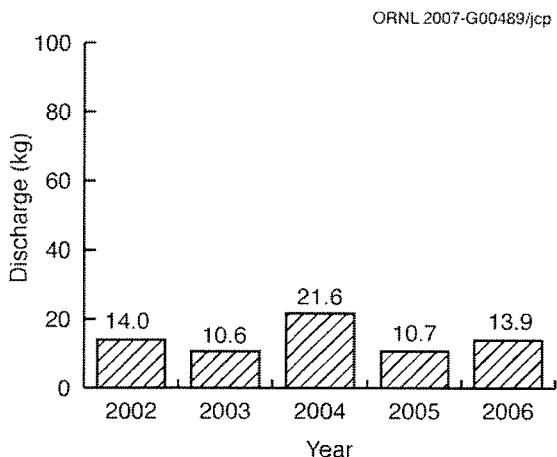


Fig. 4.5. Five-year trend of uranium releases to surface waters from the K-1407-J Central Neutralization Facility.

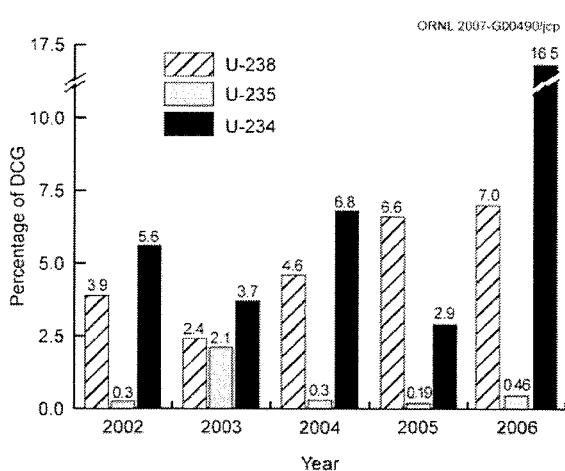


Fig. 4.6. Percentage of DOE derived concentration guides for uranium isotopes from the K1407-J Central Neutralization Facility.

for contaminants from ETTP. The locations have a direct discharge or potential for direct discharge to Poplar Creek or the Clinch River.

- Sampling in preparation for the application for ETTP NPDES permit renewal—Selected outfalls that were designated as group representatives in the reissued ETTP NPDES Permit Number TN0002950 were sampled, and the results will be incorporated in the ETTP NPDES permit renewal application. The current ETTP NPDES permit expires on March 31, 2008; the permit renewal application must be submitted to TDEC 180 days prior to permit expiration.

4.5.2 ETTP Water Quality Program Monitoring Program Results

In 2006 surface water samples were collected from selected locations around the ETTP as part of the Storm Water Pollution Prevention Program and in association with the EWQP monitoring program. These samples were analyzed for selected analytes which have the potential to be present at these particular locations. Data from this monitoring will be used to identify contaminants that may be discharging to surface waters within ETTP boundaries, and also that may have the potential to migrate off-site, as well as to evaluate changes in contaminant concentrations near potential contaminant sources.

In CY 2006, gross alpha radiation was detected above the screening level of 15 pCi/L at storm water outfalls 180 and 190. No gross alpha or gross beta contamination above the screening levels was found at any of the other storm water outfalls that were sampled in CY 2006 as part of the EWQP sampling effort. In

Table 4.6. National Pollutant Discharge Elimination System compliance at the ETTP, 2006

Effluent parameter	Effluent limits ^a		Number of noncompliances	Compliance (%)
	Monthly average	Daily maximum		
Outfall 001 (K-1407-J Central Neutralization Facility to the Clinch River)				
Benzene		0.005		100
Cadmium	0.18	0.69		100
Carbon tetrachloride	0.5	0.5		100
Chloride, total	35,000	70,000		100
Chloroform	0.5	0.5		100
Chromium	1.71	2.77		100
Copper	1.34	2.15		100
Cyanide, total	0.650	1.200		100
Ethylbenzene		0.01		100
Lead	0.38	0.69		100
Nickel	2.38	3.98		100
Oil and grease	26	30		100
PCB	0.00022	0.00045		100
pH, standard units		6.0–9.0		100
Silver	0.24	0.43		100
Suspended solids	31	40		100
Tetrachloroethylene		0.7		100
Toluene		0.01		100
Total toxic organics		2.13		100
Trichloroethylene	0.5	0.5		100
Vinyl chloride	0.2	0.2		100
Zinc	1.48	2.61		100
Group I storm water outfalls				
pH, standard units		4.0–9.0		100
Group II storm water outfalls				
pH, standard units		4.0–9.0		100
Group III storm water outfalls				
pH, standard units		4.0–9.0		100
Group IV storm water outfalls				
Chlorine, total residual		0.14	1	98
pH, standard units		6.0–9.0		100

^aUnits are mg/L unless otherwise stated.

addition, no levels of transuranics or isotopic uranium exceeding 4% of the DCG level were detected in samples from any of the other storm water outfalls sampled in CY 2006 as part of the EWQP sampling effort. Volatile organic compounds (including 1,2-dichloroethene, cis-1,2-dichloroethene, trichloroethene, and vinyl chloride) were found at levels above screening criteria at storm water outfall 190 in samples collected as part of the EWQP sampling effort during CY 2006. Field measurements for dissolved oxygen were below the screening level of 6.0 mg/L at outfalls 170 and 190 during EWQP

monitoring performed during CY 2006. No PCBs were detected at levels above detection limits at any of the locations sampled as part of the EWQP monitoring effort during CY 2006. Analytical results for the EWQP sampling effort are presented in Tables 4.7 and 4.8.

4.5.3 Radiological Monitoring of Storm Water Discharges

In 2006, radiological monitoring of storm water discharges was performed as part of the Storm Water Pollution Prevention Program

Table 4.7 EWQP storm water monitoring—radiological monitoring results that exceeded screening criteria, 2006^a

Storm water outfall	Gross alpha radiation (pCi/L)
180 ^b	16.6
190 ^b	36.7/42.7
190 ^c	16.5

^aScreening level is 15 pCi/L alpha radiation.^b1 pCi = 3.7×10^{-2} Bq.^bSample collected during first quarter of CY 2006.^cSample collected during third quarter of CY 2006.

results of natural components of the soils and sediments in the area. Analytical results above the screening criteria for the nonradiological parameters are presented in Table 4.11.

4.6 ETTP Biological Monitoring and Abatement Program

BMAP is a requirement of the NPDES permit. Its purpose is to assess the ecological health

Table 4.8. EWQP storm water monitoring—nonradiological monitoring results that exceeded screening criteria, 2006

Storm water outfall	Dissolved oxygen (mg/L) ^a	1,2 Dichloroethene (µg/L) ^b	cis-1,2 Dichloroethene (µg/L) ^b	Trichloroethene (µg/L) ^b	Vinyl chloride (µg/L) ^b
170 ^c	5.7				
190 ^d		390	390	140	120
190 ^c	5.4	940	930	260	180

^aScreening criteria for dissolved oxygen is < 6.0 mg/L.^bScreening criteria for 1,2 dichloroethene, cis-1,2-dichloroethene, trichloroethene, and vinyl chloride is 100 µg/L.^cSample collected during third quarter of 2006.^dSample collected during first quarter of 2006.

NPDES permit renewal sampling effort. Gross alpha radiation above screening criteria was found in storm water collected from outfall 760. Uranium-233/234 and uranium-238 levels above screening criteria were also found in samples collected from outfall 760. Analytical results above screening criteria for the radiological monitoring are presented in Table 4.9. A synopsis of the results from radiological monitoring at all the storm water outfalls is given in Table 4.10.

4.5.4 Nonradiological Monitoring of Storm Water Discharges

Storm water from several outfalls that were sampled in 2006 contained metals and organic compounds in concentrations above the screening criteria levels. The exact sources of the materials are unknown. It is likely that some are the

of the ETTP's receiving streams and ponds. In 2006, the BMAP consists of three tasks:

- toxicity monitoring,
- bioaccumulation monitoring, and
- ecological surveys of instream communities (both fish and benthic macroinvertebrates).

The BMAP is conducted by the ORNL Environmental Sciences Division under the direction of the ETTP Environmental Compliance and Protection Organization.

4.6.1 BMAP Toxicity Monitoring

The toxicity monitoring task for BMAP includes annual tests of effluent from storm water outfalls 170 and 190 concurrently with surface water from ambient sites in Mitchell Branch. The sites are Mitchell Branch kilometer (MIK) 0.12, 0.45, 0.71, and 0.78. The number following "MIK" indicates the distance in kilometers

Table 4.9. NPDES permit renewal sampling, 2006—Maximum exceedances of radiological screening criteria for storm water outfalls, (pCi/L)^a

Storm water outfall	Alpha	Beta	U-233/234	U-238
760	64.4		38.7	24.3

^aScreening levels are 15 pCi/L alpha radiation, 20 pCi/L ^{234}U , and 24 pCi/L ^{238}U . 1 pCi = 3.7×10^{-2} Bq.

Table 4.10. Radionuclides released to off-site surface waters from the ETTP storm water system, 2006

Radionuclide	Amount ^a (Ci)	Radionuclide	Amount ^a (Ci)
^{137}Cs	3.0E-6	^{235}U	3.1E-4
^{99}Tc	3.9E-2	^{236}U	2.8E-6
^{234}U	6.8E-3	^{238}U	3.7E-3

^a 1 Ci = 3.7×10^{10} Bq.

from the mouth of Mitchell Branch on Poplar Creek. *Ceriodaphnia dubia* were used to evaluate effluent from storm water outfalls 170 and 190, and the ambient monitoring locations, for toxicity.

In April, survival and reproduction toxicity tests using *Ceriodaphnia dubia* on water from storm water outfall 170 and all ambient locations revealed no toxicity (Table 4.12). However, effluent from storm water outfall 190 reduced both reproduction and survival. Effluent from storm water outfall 190 reduced reproduction at all tested concentrations and survival in all but the lowest two tested concentrations (12% and 6%). Thus, the overall trend is one of some level of toxicity to *Ceriodaphnia* from storm water outfall 190, with no or very infrequent toxicity from the ambient locations and occasional toxicity at storm water outfall 170. Although the source of the problem at storm water outfall 190 was not positively identified, the data gathered in previous studies indicated that groundwater was percolating through waste in the K-1070-B Burial Ground and leaching out small quantities of metals. Some of this groundwater was then flowing into the storm drain system and could contribute to the toxicity. Nickel and zinc are present in water collected from the storm drain system near K-1070-B, at levels that have been shown to be toxic to *Ceriodaphnia*.

4.6.2 BMAP Bioaccumulation Studies

In June and July 2006, caged clams (*Corbicula fluminea*) were placed at several locations around ETTP. After 4 weeks, they were removed and analyzed for PCBs. Results from the 2006 monitoring were generally lower than the results of earlier monitoring, but the overall distribution pattern was similar. The highest concentrations (3.4 $\mu\text{g/g}$) were found in the clams from storm water outfall 100, with lesser concentrations found in clams from other locations in the P1 pond and Mitchell Branch. Although the concentrations of PCBs in the clams from storm water outfall 100 have consistently been the highest on the ETTP, the analytical results have shown some decrease in concentrations in recent years. Mitchell Branch clams from areas upstream of storm water outfall 190 had relatively low concentrations of PCBs, while clams from MIK 0.45 (immediately downstream of storm water outfall 190) averaged 1.0 ppm PCBs, and clams from further downstream at MIK 0.2 averaged concentrations of 2.75 ppm PCBs. The concentrations in clams from MIK 0.2 are surpassed at ETTP only by the concentrations in clams from storm water outfall 100. In the K-901-A Pond, clams from near the two major storm water outfalls that discharge into the pond (storm water outfalls 700 and 710) contain higher concentrations than in the clams from the K-901-A Pond outfall, indicating that these two storm water outfalls may be the proximate source of PCB contamination in the pond. Clams from the K-1007-P3 Pond exhibit levels (0.015 ppm) that are roughly consistent with those in clams from the Sewee Creek reference stream (0.01 ppm).

Fish were collected from Mitchell Branch, K-1007-P1 Pond, and K-901-A Pond in May 2006. Largemouth bass were collected from the pond sites, and redeye sunfish were collected

Table 4.11. Maximum exceedances of nonradiological screening criteria for each storm water outfall, 2006 (µg/L)

Outfall	Parameter	Monitoring result	Criteria
390	Zinc	151	65
410	Aluminum	2920	750
410	Iron	4520	1000
410	Zinc	131	65
532	Aluminum	886	750
532	Iron	1820	1000
710	Zinc	161	65

Table 4.12. Mitchell Branch and associated storm water outfall toxicity test results, April 2006^a

Test	MIK 0.78	SD 170	MIK 0.71	SD 190	MIK 0.45	MIK 0.12
<i>Ceriodaphnia</i> survival	NR	NR	NR	R	NR	NR
<i>Ceriodaphnia</i> reproduction	NR	NR	NR	R	NR	NR

^aNR: No significant reduction compared with the control population. R: Significant reduction compared with the control population.

from Mitchell Branch. Game fish of a size large enough to be taken by sportsfishermen were selected both to provide more accurate data of potential human health concerns and to reduce the amount of variation in contamination levels in the individual fish due to age and size differences. Fillets taken from each game fish were analyzed for PCBs. Table 4.13 gives a synopsis of the results. Results from the K-901-A Pond monitoring (an average concentration of 0.5 ppm PCBs) are similar to historical results. Results from the fish taken from Mitchell Branch were the lowest since 1996. However, even at 1.6 ppm PCBs, these were still the highest concentrations found in any sunfish from the ORR. In the bass from K-1007-P1 pond, the 2004 results showed a significant decrease in PCB concentrations when compared with previous year's monitoring results. Results from the 2005 monitoring (an average of 16.1 ppm) returned to the range of historical levels, while results from the 2006 monitoring again showed a significant decrease (an average of 7.1 ppm). Fluctuations in the bass from K-1007-P1 may reflect variations in the availability of gizzard shad as prey. Gizzard shad, due to their physiology and ecology, are more likely to accumulate large amounts of PCBs than are most other species of forage fish. The state of Tennessee posting limit for PCBs in

fish is 1 ppm. Levels in sunfish from the Hinds Creek reference location averaged less than 0.01 ppm PCBs.

In 2006, an engineering evaluation/cost analysis was completed for the K-1007-P1 Pond. The analysis evaluated various options for addressing the human health concerns associated with the high concentrations of PCBs in K-1007-P1 Pond fish. It was determined from the analysis that ecological enhancement was the preferred alternative for the pond. That alternative will be implemented as a non-time-critical removal action under CERCLA. Ecological management provides an alternative approach to more conventional pond remediation options, such as sediment removal, draining and capping, and point source/discharge actions. The basic premise of that option is that ecological manipulations can interrupt the contaminant exposure pathways that lead to ecological or human receptors. The focus of the contaminant pathway interdiction is at the higher food chain level, in contrast to conventional options, where interdiction is at the soil or sediment source level. At the K-1007-P1 Pond, the greatest food chain risk to humans and ecological receptors, largemouth bass and gizzard shad, will be removed from the

Table 4.13. PCB concentrations in biota at ETTP, 2006

Location	Species	Mean concentration (ppm) ^a	Range	Number >1 ppm/N
MIK 0.2	Redbreast sunfish (<i>Lepomis auritus</i>)	1.6	0.76–2.9	5/6
K-1007-P1	Largemouth bass (<i>Micropterus salmoides</i>)	7.1	2.6–10.8	6/6
K-901-A	Largemouth bass (<i>Micropterus salmoides</i>)	0.5	0.1–0.96	0/6
Hinds Creek (reference)	Redbreast sunfish (<i>Lepomis auritus</i>)	<0.01	<0.001–0.01	0/6
MIK 0.78	Asiatic clams (<i>Corbicula fluminea</i>)	0.06	N/A	N/A
MIK 0.71 (SD170)	Asiatic clams (<i>Corbicula fluminea</i>)	0.1	N/A	N/A
MIK 0.45 (SD190)	Asiatic clams (<i>Corbicula fluminea</i>)	0.96	N/A	N/A
MIK 0.2	Asiatic clams (<i>Corbicula fluminea</i>)	2.8	N/A	N/A
SD100 (inside drain)	Asiatic clams (<i>Corbicula fluminea</i>)	0.8	N/A	N/A
SD100 (discharge to P1 Pond)	Asiatic clams (<i>Corbicula fluminea</i>)	2.7	N/A	N/A
SD120	Asiatic clams (<i>Corbicula fluminea</i>)	0.8	N/A	N/A
K-1007P3	Asiatic clams (<i>Corbicula fluminea</i>)	0.02	N/A	N/A
SD490	Asiatic clams (<i>Corbicula fluminea</i>)	0.9	N/A	N/A
K-1007P1	Asiatic clams (<i>Corbicula fluminea</i>)	0.5	N/A	N/A
K-901-A	Asiatic clams (<i>Corbicula fluminea</i>)	0.2	N/A	N/A
SD700	Asiatic clams (<i>Corbicula fluminea</i>)	0.2	N/A	N/A
SD710	Asiatic clams (<i>Corbicula fluminea</i>)	0.2	N/A	N/A
Little Sewee Creek (reference)	Asiatic clams (<i>Corbicula fluminea</i>)	0.01	N/A	N/A

^a1 ppm = 1 mg/L.

system and will pose no risks to humans or wildlife after removal. Pond bioaccumulation processes will be further minimized by ecological management actions that prevent future bioaccumulation to unacceptable levels. Ecological actions include fish management, vegetation management, wildlife management, water quality manipulations, and preventive actions. Once the system has been changed to a steady-state, highly vegetated pond, contaminated sediments will be stabilized, and cleaner sediments will overlay and further isolate contaminated sediments over time. Preventive actions such as fish barriers and the isolating effects of dams will also ensure that undesirable fish cannot reenter the pond. The strategy should enhance the pond environment, providing substantial natural resource benefits over the long-term.

4.6.3 BMAP Ecological Surveys of Instream Communities

Although past ETTP operations had adversely affected the communities of Mitchell Branch, and although there continue to be some impacts, the results to date overall indicate that

the institution of best management practices and remediation efforts have resulted in gradual, but more or less continuous, improvement of conditions in the stream.

In April 2006, the benthic macroinvertebrate communities at four Mitchell Branch locations (MIKs 0.45, 0.71, 0.78, and 1.43) were sampled. MIK 1.43 serves as the reference location. In the last ten years, the benthic macroinvertebrate community at all locations in Mitchell Branch has generally shown increases in diversity and numbers of individuals. Results from this year's sampling showed similar species richness and richness of pollution-intolerant species at the two most upstream sites, with lower values at the downstream locations (Figs. 4.7 and 4.8). Results from the 2006 monitoring show a decline from 2005 in most metrics at both MIK 0.45 and MIK 0.71. Mitchell Branch has historically shown the effects of impacts from past operations, and results indicate that conditions at these two monitoring locations continue to be suboptimal. However, the patterns of stonefly density merit comment. Stonefly species typically are sensitive to a range of environmental

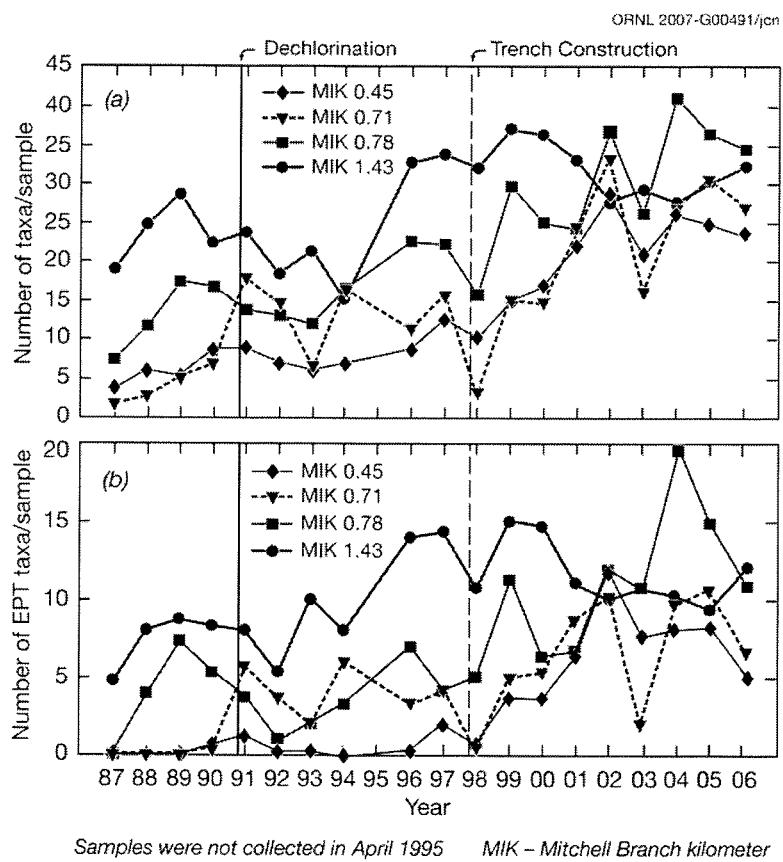


Fig. 4.7. Total taxonomic richness (a) and richness of pollution-sensitive taxa (b) in Mitchell Branch.

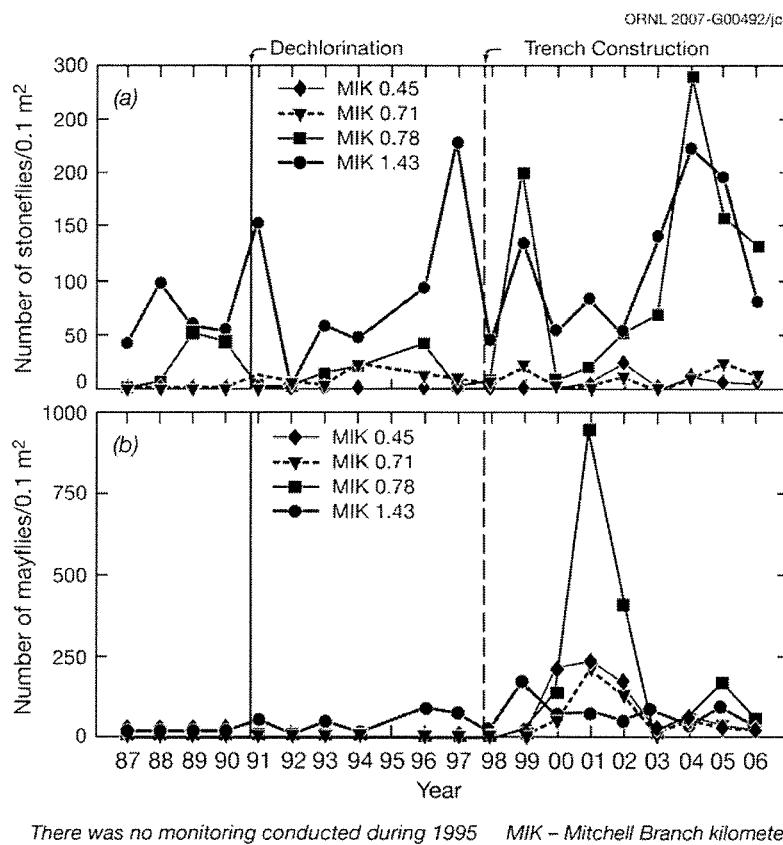
parameters, including nutrient enrichment, pollutants, pH, dissolved oxygen levels, and physical characteristics (including fluctuations in stream flow, sedimentation, and substrate instability). Stonefly densities at both MIK 0.45 and 0.71 were markedly lower than at the reference location at MIK 1.43, but levels at MIK 0.78 were actually higher than at the reference location.

Fish communities in Mitchell Branch (MIK 0.45 and 0.71) were sampled in April 2006. Species richness, density, and biomass were examined. The communities at both MIK 0.45 and MIK 0.71 showed a decrease in both density and biomass when compared with last years' results. In the 2005 monitoring, density at MIK 0.71 was the highest recorded for that location, and the density at MIK 0.45 was the second highest. In 2006, the density and biomass at both locations showed a decrease to values more consistent with the trends of recent years, and were similar to values seen in un-impacted streams. These wide swings are typical of streams that have

been severely impacted, are in the process of recovery, but have not yet reached the long-term stable state. Species richness appears to have more or less stabilized, with results from the 2005 and 2006 sampling similar at both locations. The stream is still dominated by more tolerant fish species, so although the conditions and fish community structure are improving, they have not yet reached a stable community structure typical of less impacted streams in the area.

4.7 ETTP Ambient Air Monitoring

DOE Order 450.1 requires surveillance of ambient air to assess the impact of DOE operations on air quality. In addition, airborne radionuclide monitoring is required for compliance with radionuclide NESHAP regulatory agreements. DOE Order 5400.5 also specifies requirements for airborne radionuclide surveillance. The ETTP ambient air monitoring program is designed to monitor selected air con-



There was no monitoring conducted during 1995 MIK – Mitchell Branch kilometer

Fig. 4.8. Density of pollution-intolerant stoneflies (a) and pollution-tolerant mayflies (b) in Mitchell Branch.

taminants for the ongoing monitoring of the impact of plant operations on the immediate environment. Specific locations were selected to determine air contaminant concentrations in the prevailing directions, upwind and downwind of the site, and to obtain airborne radiological measurements in the direction of both the nearest and most exposed member of the public. The current locations of these monitoring stations are shown in Fig. 4.9. The ETTP ambient air monitoring program complies with all requirements of DOE orders. One station activated in November of 2005 is representative of DOE facility access changes that require on-site monitoring of radiological emissions. This station ensures compliance with NESHAP regulations and is consistent with previously approved sampling methodologies defined in the *ORR NESHAP Compliance Plan* (DOE 1994).

National ambient air quality standards are referenced by DOE orders as guidance with respect to ambient air concentrations of certain air contaminants. These regulations specify 24-h,

quarterly, and annual standards for specific or criteria pollutants. Additionally, results are compared with any applicable risk-specific dose and reference air concentration listed in 40 CFR 266, Subpart H.

The ambient air sampling schedule and monitored parameters are listed in Table 4.14. All parameters were chosen with consideration of existing and proposed regulations and the nature of operations in and around the ETTP. Changes in emissions, wind profile, site activities, or any other parameter that may alter the potential impact of ETTP activities within the facility and on nearby communities, or the environment may warrant periodic changes of air contaminants measured, number of stations, or relocation of existing stations. The principal parameters monitored during 2006 were arsenic, beryllium, cadmium, chromium, lead, and uranium. Uranium was analyzed by both inorganic and radiochemical methods. Radiochemical analyses included isotopes of uranium (^{234}U ,

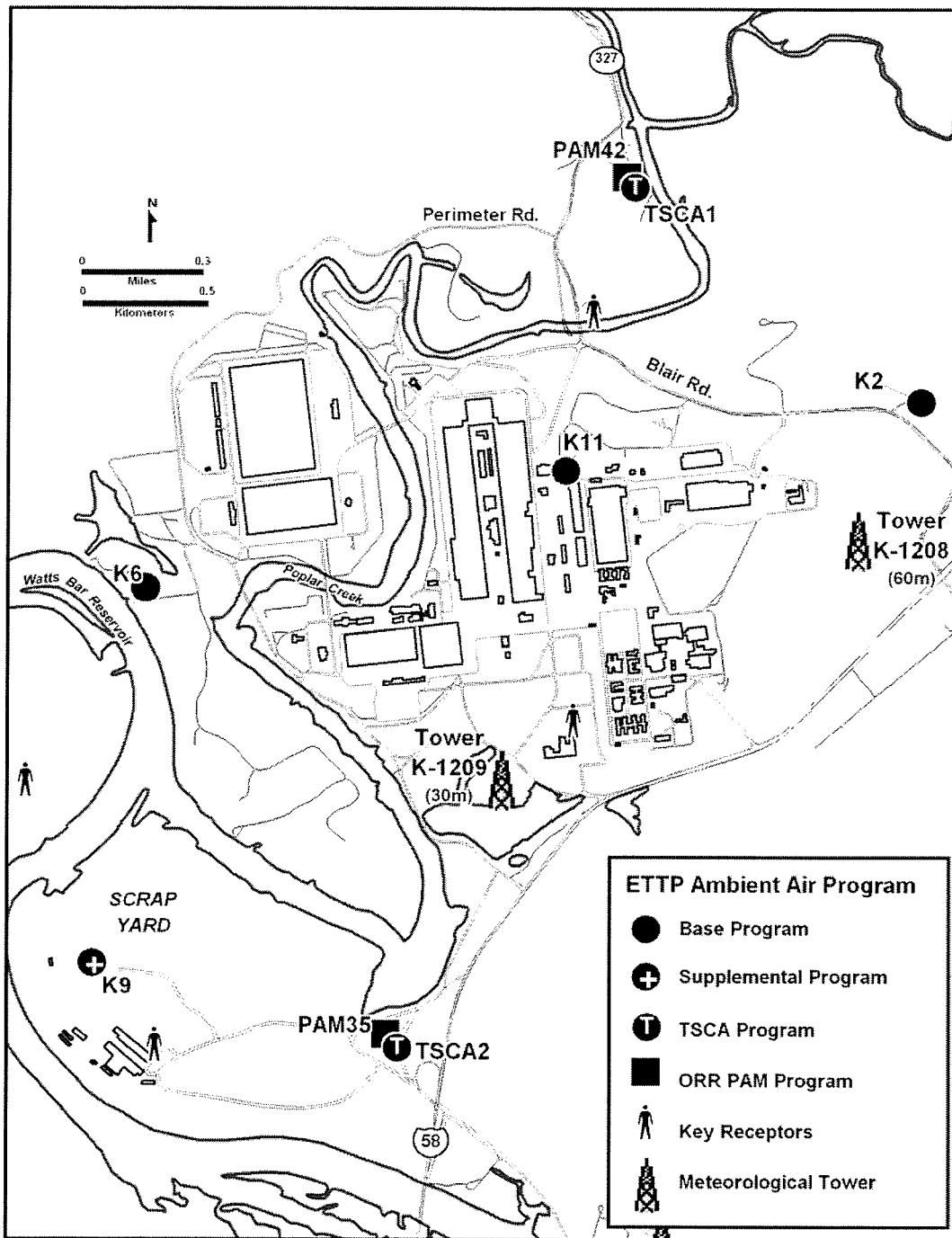


Fig. 4.9. Locations of ambient air monitoring stations at the ETTP.

Table 4.14. Summary of types and frequencies of samples collected at ETTP perimeter ambient air monitoring stations, 2006

Parameter	Sampling locations	Sampling period	Collection frequency	Analysis frequency ^a
Criteria pollutants				
Lead	K2, K6, K9, K11	Continuous	Weekly	Quarterly
Hazardous air pollutants carcinogen metals				
Arsenic	K2, K6, K9, K11	Continuous	Weekly	Quarterly
Beryllium	K2, K6, K9, K11	Continuous	Weekly	Quarterly
Cadmium	K2, K6, K9, K11	Continuous	Weekly	Quarterly
Chromium	K2, K6, K9, K11	Continuous	Weekly	Quarterly
Organic compounds				
Polychlorinated biphenyls	TSCAI ^b 1, 2	c	c	c
Furan	TSCAI 1, 2	c	c	c
Dioxin	TSCAI 1, 2	c	c	c
Hexachlorobenzene	TSCAI 1, 2	c	c	c
Radionuclides (by inorganic analysis)				
Uranium (total)	TSCAI 1, 2	c	c	c
Radionuclides (by radiochemical analysis)				
⁹⁹ Tc, ²³⁷ Np, ^{238,239} Pu, ^{234,235,236,238} U	K2, K6, K9, K11	Continuous	Weekly	Quarterly

^a Quarterly frequencies are composite sample analyses of all weekly samples collected over the identified period.

^b Toxic Substances Control Act (TSCA) Incinerator.

^c Stations are activated automatically only if a TSCA Incinerator operational upset occurs. Identified samples are then immediately submitted for analysis.

²³⁵U, ²³⁶U, and ²³⁸U), ⁹⁹Tc, ²³⁷Np, ²³⁸Pu, and ²³⁹Pu.

During this reporting period, the ambient air monitoring network consisted of four ETTP sampling stations and utilized information obtained from two ORR perimeter air monitoring (PAM) stations. Samples were collected weekly from the following stations: K2, K6, K9, K11, and PAM 35 and 42. During 2006, sample compositing was performed quarterly (every 3 months) prior to analysis for all pollutant analyses.

4.7.1 Results

No standards were exceeded, and, with the exception of uranium levels, there were no significant variations of annual pollutant concentrations associated with site operations when compared with data from the previous year. Sampling results assessing the impact of specific site activities on air quality show that the ETTP, including project-specific measurements, did not have any impact of concern on local air quality.

Also, radiochemical analyses of ambient air samples confirm low radiological emissions from the ETTP.

4.7.2 Criteria Pollutant Levels

Lead results were determined from analyses of quarterly composites of continuous weekly samples from stations K2, K6, K9, and K11. The total mass quantities of lead for each sample were determined by the inductively coupled plasma mass spectrometry (ICP-MS) analytical technique. Lead analytical results are summarized in Table 4.15 and are compared with the Tennessee and national quarterly ambient air quality standard of 1.5 $\mu\text{g}/\text{m}^3$. There are no 24-h, monthly, or annual ambient air quality standards for lead. The maximum individual lead result was 0.0016 $\mu\text{g}/\text{m}^3$. This value was only 0.11% of the quarterly standard for lead. No lead concentrations of environmental concern were measured (see Fig. 4.10 for a 5-year lead trend).

Table 4.15. Lead concentrations in ambient air at the ETTP, 2006

Station	Quarterly averages of monthly composites ($\mu\text{g}/\text{m}^3$)				Maximum quarterly result ($\mu\text{g}/\text{m}^3$)	Maximum percent of quarterly standard ^a
	1	2	3	4		
K2	0.00024	0.00032	0.00038	0.00051	0.00051	0.03
K6	0.00033	0.00023	0.00086	0.00048	0.00086	0.06
K9	0.00164	0.00034	0.00071	0.00031	0.00164	0.11
K11	0.00035	0.00083	0.00096	0.00035	0.00096	0.06
Quarterly average	0.00064	0.00043	0.00073	0.00041	0.00073	0.05
Quarterly maximum	0.00164	0.00083	0.00096	0.00051	0.00164	0.11

^aTennessee and national air quality standard for lead is $1.5 \mu\text{g}/\text{m}^3$ quarterly arithmetic average.

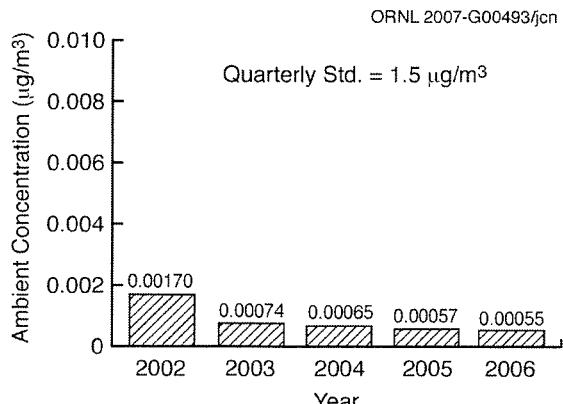


Fig. 4.10. Ambient air monitoring 5-year trend results for lead at the ETTP.

4.7.3 Hazardous Air Pollutant Carcinogenic Metal Levels

Analyses of hazardous air pollutant carcinogenic metals (arsenic, beryllium, cadmium, and chromium) were performed on quarterly composite samples of continuous weekly samples from stations K2, K6, K9, and K11. Total mass of each selected metal was determined by the ICP-MS analytical technique.

There are no Tennessee or national ambient air quality standards for these hazardous air pollutant carcinogenic metals. However, comparisons have been made against risk-specific doses and reference air concentrations.

The annual average arsenic concentration for all measurement sites was $0.00016 \mu\text{g}/\text{m}^3$, well below the risk-specific dose of $0.0023 \mu\text{g}/\text{m}^3$. The individual maximum measured result was $0.00044 \mu\text{g}/\text{m}^3$. Annual beryllium measurements were at or near the minimum detectable concentrations of the analytical

method, orders of magnitude below the risk-specific dose of $0.0042 \mu\text{g}/\text{m}^3$. The combined beryllium average for all sites was $< 0.000001 \mu\text{g}/\text{m}^3$ with the individual maximum result of $0.000003 \mu\text{g}/\text{m}^3$. The maximum cadmium concentration result was $0.00007 \mu\text{g}/\text{m}^3$. The cadmium annual average was $0.00003 \mu\text{g}/\text{m}^3$. Both results are well below the risk-specific dose of $0.0056 \mu\text{g}/\text{m}^3$. Individual chromium measurements ranged from approximately 0.00001 to $0.00022 \mu\text{g}/\text{m}^3$. The annual average result for chromium was $0.00007 \mu\text{g}/\text{m}^3$, well below the risk-specific dose of $0.00088 \mu\text{g}/\text{m}^3$ for chromium VI. The form of chromium was not determined, and therefore the most conservative risk-specific dose (chromium VI) was used. A summary of the hazardous air pollutant carcinogenic metals measurements is presented in Table 4.16.

4.7.4 Radionuclide Levels

Total uranium metal was measured as quarterly composites from stations K2, K6, K9, and K11. The total uranium mass for each sample was determined by the ICP-MS analytical technique. The annual uranium averages and maximum individual concentration measurements for all sites are presented in Table 4.17. The average annual results for each station ranged from a minimum of approximately 0.000007 to $0.000059 \mu\text{g}/\text{m}^3$. The highest single quarterly result, $0.000167 \mu\text{g}/\text{m}^3$, was measured at Station K9, which is in one of the prevailing wind directions from the TSCA Incinerator. The annual average value for all stations due to uranium was $0.000030 \mu\text{g}/\text{m}^3$. The ICP-MS results are compared with a dose based on the DCG for natural

Table 4.16. Hazardous air pollutant concentrations in ambient air at the ETTP, 2006

Parameter	Ambient air concentration ($\mu\text{g}/\text{m}^3$)			Percentage of standard ^a
	Annual average (all stations)	Quarterly maximum	Maximum station	
Arsenic	0.00016	0.00044	K11	6.8
Beryllium	0.000001	0.000003	K9	<0.1
Cadmium	0.000028	0.000070	K11	0.5
Chromium	0.000067	0.000217	K11	<0.1
Cr-111				
Cr-VI				7.7

^aThere are no Tennessee or national ambient air quality standards; however, annual averages are compared to risk-specific doses for As, Be, Cd, and Cr-VI and the reference air concentration for Cr-III as listed in 40 CFR 266.

Table 4.17. Total uranium in ambient air by inductively coupled plasma mass spectrometry analysis at the ETTP, 2006

Station	Samples	Concentration ^a				Percent of DCG ^b	
		($\mu\text{g}/\text{m}^3$)		($\mu\text{Ci}/\text{mL}$)		(%)	
		Average	Maximum ^c	Average	Maximum ^c		
K2	4	0.000038	0.000102	2.54E-17	6.78E-17	0.03	0.07
K6	4	0.000007	0.000015	4.63E-18	9.68E-18	<0.01	0.01
K9	4	0.000059	0.000167	3.95E-17	1.11E-16	0.04	0.11
K11	4	0.000016	0.000024	1.07E-17	1.58E-17	0.01	0.02
ETTP total	16	0.000030	0.000167	2.01E-17	1.11E-16	0.02	0.11

^aMass-to-curie concentration conversions assume a natural uranium assay of 0.717% ^{235}U . 1 $\mu\text{Ci} = 3.7 \times 10^4 \text{Bq}$.

^bDOE Order 5400.5 Derived Concentration Guide (DCG) for naturally occurring uranium is an annual concentration of $1 \times 10^{-13} \mu\text{Ci}/\text{mL}$, which is equivalent to a 100-mrem annual dose.

^cMaximum individual sample analysis result with dose calculations conservatively assuming the value to be an annual concentration.

uranium. (The DCG is based on an annual air concentration exposure that would give a dose of 100 mrem.) The sampling location with the highest annual average concentration of uranium was at K9. The annual result was only 0.000030 $\mu\text{g}/\text{m}^3$, which corresponds to 0.02% of the DCG (see Fig. 4.11 for 5-year uranium trend).

Periodic radiochemical analyses were initiated during 2000 on selected monthly composite samples collected at Stations K2, K6, K9, and K11. For 2006, analyses were based on quarterly composite samples from these stations. The selected isotopes of interest were ^{237}Np , ^{238}Pu , ^{239}Pu , ^{99}Tc , and isotopic uranium (^{234}U , ^{235}U , ^{236}U , and ^{238}U). The resulting annual concentrations for all nuclides measured are presented in Table 4.18. Results from stations K2, K6, K9,

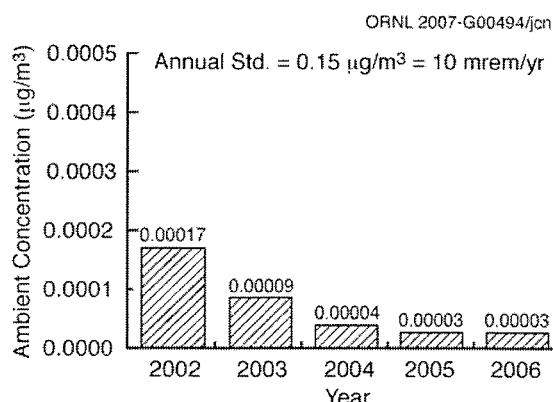
**Fig. 4.11. Ambient air monitoring 5-year trend results for uranium at the ETTP.**

Table 4.18. Radionuclides in ambient air by radiochemistry at the ETTP, 2006

Station ^a	Concentration ($\mu\text{Ci/mL}$) ^b									Total U
	^{237}Np	^{238}Pu	^{239}Pu	^{99}Tc	^{234}U	^{235}U	^{236}U	^{238}U		
K2	c	6.58E-19	1.06E-18	3.28E-16	3.46E-17	3.91E-18	5.67E-19	6.87E-17	1.08E-16	
K6	c	c	6.35E-19	1.71E-16	6.57E-18	3.47E-19	5.21E-19	6.58E-18	1.40E-17	
K9	c	6.35E-19	2.49E-18	5.09E-16	5.28E-17	4.01E-18	1.83E-18	4.60E-17	1.05E-16	
K11	c	c	1.05E-18	7.08E-16	3.51E-17	3.81E-18	c	3.41E-17	7.30E-17	

^aK2, K6, K9, and K11 annual results are the average of four quarterly composite analyses.

^b1 $\mu\text{Ci} = 3.7 \times 10^4$ Bq.

cNot detected.

and K11 are averages of four quarterly composite sample analyses and represent an annual average for this report. For comparison, the total uranium results associated with ICP-MS analyses of composite samples are comparable with the uranium results determined by radiochemical techniques.

4.7.5 Organic Compound Levels

Currently, measurements of selected semi-volatile organics are performed only during an operational upset of the TSCA Incinerator. The incinerator experienced one automatic thermal relief vent opening during 2006 due to a power loss in the ETTP distribution grid. This event occurred during the incineration of liquid wastes. If an unplanned release occurred, organic compound ambient air sampling stations TSCA1 and TSCA2 (see Fig. 4.9) would be activated automatically or manually. However, the potential release of organic compounds from this event was established to be below levels that would be detectable by ambient air monitoring. This decision was based on the characterizations of the wastes being processed at that time of the event and on the current inventory in the incinerator. The calculated waste inventory could not produce a detectable off-site impact. Additionally, meteorological conditions would not carry any potential release from the vent in the direction of either sampling station. Therefore, the samplers were not activated for this event.

4.7.6 Five-Year Trends

Five-year summaries of ETTP ambient air monitoring data are shown in Figs. 4.10 and 4.11 for lead and uranium, respectively. Variations of lead measurements were insignificant and most likely reflect background concentration variations of air quality. Uranium levels reflect

typical levels that can be associated with normal ETTP operations.

Arsenic, beryllium, and cadmium measurements were initiated in 1993, and chromium measurements were initiated in 1986. Over the last 5 years, arsenic, cadmium, and chromium have been typically indistinguishable from background levels except during specific projects that have included major demolition activities. All beryllium measurements, historical and current, have been at or near analytical minimum detectable concentrations. During the 5-year period, no ambient air measurements have indicated any level of concern based on comparisons with any applicable standards.

4.8 ETTP Surface Water Monitoring

Surface water surveillance was conducted at eight locations at the ETTP (Fig. 4.12). Stations K-1710, MIK 1.4, and Clinch River kilometer (CRK) 23 provide information on conditions upstream of the ETTP. Stations K-716 and CRK 16 are located downstream from most ETTP operations and provide information on the cumulative effects of the ETTP activities 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 (Stations K-1007-B, and K-1700) or to the Clinch River (Station K-901-A).

At most surveillance stations, semiannual sampling and analyses for radionuclides, metals, and field readings (dissolved oxygen, temperature, and pH) were conducted. At the Clinch River sites (CRK 16 and 23) volatile organic compounds were also monitored semiannually. Quarterly monitoring for volatile organics, metals, radionuclides, and field readings is con-

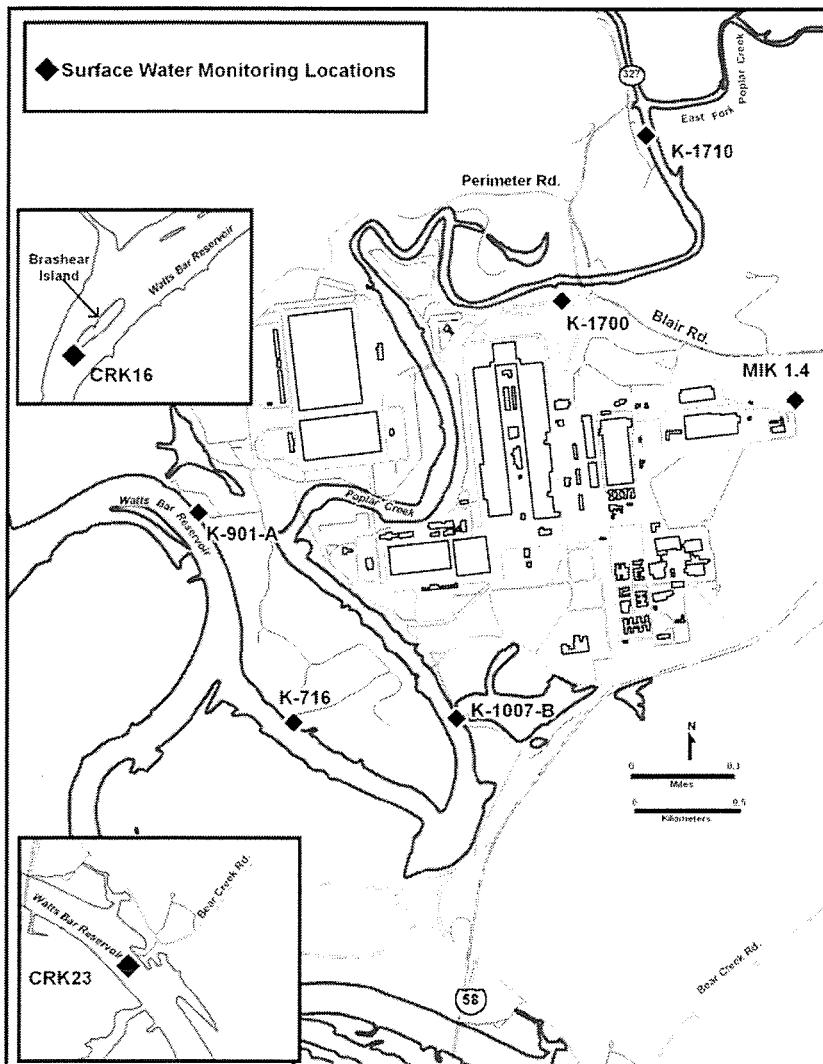


Fig. 4.12. Monitoring locations for surface water at the ETTP.

ducted at the K-1700 and MIK 1.4 locations. In November 2006, analytical results for chromium at K-1700 were 0.095 mg/L. The appropriate water quality standard at this location is 0.1 mg/L. Results from 2007 monitoring will be closely evaluated to determine whether chromium levels return to historic background levels. Further investigations will be initiated as appropriate based upon those results. Radionuclide results are compared with the DCGs. Nonradiological results are compared with Tennessee water quality standards for fish and aquatic life. The water quality standards use the numeric values given in the Tennessee general water quality criteria (TDEC 2004), which are a subset of the water quality standards.

In most instances, results of the monitoring for nonradiological parameters are well within the applicable standards. Heavy metals were often detected at CRK 16, K-901-A, and K-1700 (barium was the most common heavy metal detected), and certain volatile organics (primarily trichloroethane, vinyl chloride, and 1,2-dichloroethane) were regularly detected at K-1700, but in all instances the results were below the applicable water quality standard. Dissolved oxygen measurements at K-1700 fell below the minimum water quality standard of 5.0 mg/L during one summer sampling event due to a combination of elevated temperatures and the stagnation due to very low flows at that location. Water bodies in the vicinity of the

ETTP are regularly inspected for signs of stress on aquatic organisms during low-flow periods. For the remaining analyses, results were within the reference standards or below detection limits for the instrument and method. Moreover, analytical results for samples collected upstream of the ETTP were chemically similar in most respects to those collected below the ETTP.

The sum of the fractions of the DCGs for most stations remained below 1% of the DCG values for ingestion (Fig. 4.13). The highest sum of the fractions, 6.4% of the DCGs, was reported for sampling location K-1700. The results at the other surface water surveillance locations are all below 1% of the DCGs. These data are consistent with the historical results, except for the increase at K-1700. Due to this stasis, monitoring at the surveillance locations will continue to be maintained at the reduced frequency until significant changes are detected or until ETTP operations change to include activities with the potential to affect discharges.

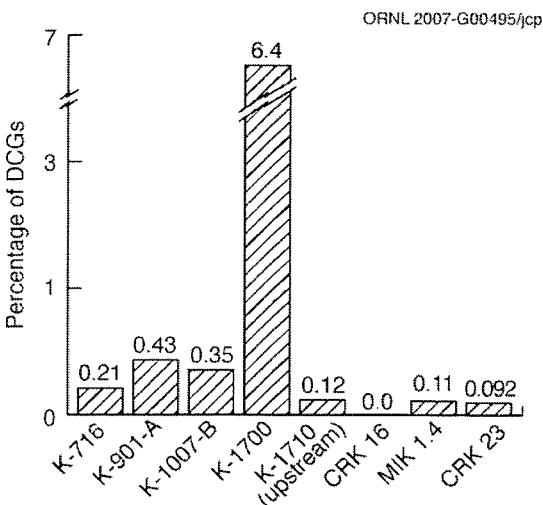


Fig. 4.13. Percentage of DOE derived concentration guides for ETTP surface water monitoring locations.

4.9 ETTP Groundwater Monitoring

Groundwater monitoring at the ETTP is focused primarily on investigating and characterizing sites for remediation under CERCLA. As a result of the Federal Facility Agreement and certification of closure of the K-1407-B and K-1407-C Ponds, the principal driver at the ETTP is CERCLA.

The cleanup strategy described in Accelerating Cleanup: Paths to Closure (DOE 1999) has been developed to accelerate the transition of areas of concern (AOCs) from characterization to remediation by making decisions at the watershed scale based on recommended land use. The watershed is a surface-drainage basin that includes an AOC or multiple AOCs to be investigated and/or remediated. ETTP groundwater monitoring is conducted by the Water Resources Restoration Program to assess the performance of completed CERCLA actions. Groundwater data can be found discussed in the *2007 Remedial Effectiveness Report for the U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE 2007a).

ETTP Groundwater Protection Program requirements are incorporated into the Water Resources Restoration Program. The Water Resources Restoration Program, which was established to provide a consistent approach to watershed monitoring across the ORR, is responsible for conducting groundwater surveillance monitoring at the ETTP, including exit pathway monitoring wells. Groundwater discharges into Poplar Creek, the Clinch River, and the three main surface water bodies at ETTP (the K-901 Pond, K-1007 Pond, and Mitchell Branch). Many of the contaminants at ETTP migrate toward one of these surface water bodies, which are monitored by the ETTP Environmental Monitoring Plan surface water surveillance program. The *2005 Remediation Effectiveness Report* (DOE 2007a) includes summaries of groundwater monitoring actions required for individual cleanup actions at the ETTP, along with recommendations to modify any requirements that would further ensure protection of human health and the environment.

4.10 ETTP Direct Radiation

The UF₆ cylinder storage yards and K-770 Scrap Yard at ETTP are potential sources of direct gamma and neutron radiation exposure to the public. Measured exposure rates and a hypothetical model of a maximally exposed individual were used to calculate theoretical doses. The calculated EDEs were based on gamma and neutron dose rates measured at the K-1066-J and K-1066-E Cylinder Yards along the near bank of Poplar Creek, the parking lot adjacent to the K-1066-K Cylinder Yard, and the near bank of

the Clinch River in the vicinity of the K-770 Scrap Yard. The dose levels to the public calculated from the measured exposure rates are less than the 100 mrem/year limit established by DOE Order 5400.5.

Gamma and neutron dose rates from each area were measured in January 2006 with tissue-equivalent dose rate meters. Background readings were established at the ambient air monitoring stations north and northeast of ETTP off Blair Road, south and southwest of ETTP in the Powerhouse Area, and west of ETTP at the K-901 pumping station. The average gamma background was 0.004 mrem/h. The average neutron background was 0.001 mrem/h.

The potential maximally exposed individual model used for exposure from the K-1066-J or K-1066-E Cylinder Yard is a hypothetical fisherman who was assumed to have spent 250 h/year near the point of average exposure. This hypothetical individual could have received an EDE above background of about 0.25 mrem from gamma radiation and 0.50 mrem from neutron radiation along the bank of Poplar Creek near the K-1066-E Cylinder Yard during 2006. That section of the creek runs through the ETTP plant and is used at times by fishermen; however, it is very unlikely that anyone would fish this stretch of Poplar Creek for 250 h/year. At the time of the January surveys, no cylinders were being stored in the K-1066-J Cylinder Yard, and consequently there was no potential dose above background levels at that location.

General area dose rates were recorded in the vicinity of the K-770 Scrap Yard, along the near bank of the Clinch River. A hypothetical fisherman who was assumed to have spent 250 h/year near the point of average exposure along the bank of the Clinch River near the K-770 Scrap Yard could have received an EDE above background of about 0.50 mrem from gamma radiation and no dose from neutron radiation during 2006.

The parking lot adjacent to the K-1066-K Cylinder Yard is used by workers and the public; therefore, it was included in the survey. This parking lot is intended for employees and has no public facilities. A potential maximally exposed individual is someone assumed to have spent 30 min per work day (125 h/year) waiting in the parking lot at the point of average exposure

along the edge closest to the K-1066-K Cylinder Yard. This hypothetical individual could have received an EDE above background of no dose above background levels from gamma radiation and 0.13 mrem from neutron radiation during 2006. At the time of the survey, no cylinders were being stored in the K-1066-K Cylinder Yard.

4.11 Modernization and Reindustrialization

DOE-ORO established the Reindustrialization Program in 1996 as an innovative way to address some of the environmental and financial challenges left at the end of the Cold War. Under the program, transfers of excess or underutilized land and facilities are made available. The goal is to accelerate cleanup by reducing costs, while allowing for the productive use of the assets by the private sector. The process helps to offset negative impacts on the community caused by DOE downsizing, facility closeouts, and workforce restructuring. DOE-ORO worked with local officials and business leaders to establish CROET. Through CROET, the Reindustrialization Program has successfully leased land and facilities at the ETTP. DOE-ORO has transitioned to a cleanup of ETTP in preparation for its closure as a DOE site. ETTP will then be available for use as a private-sector industrial park. As part of this accelerated process, the emphasis is on facility transfer of ownership (title transfer).

In 2003, DOE-ORO completed a FONSI to allow the transfer of property to Horizon Center LLC. The property, in the past known as Parcel ED-1, only consists of the portions suitable for development. The remainder of the property, known as the Natural Area, will continue to be leased by Horizon Center LLC and owned by DOE.

DOE has been working with the state of Tennessee to grant the state an indefinite-term conservation easement of approximately 1214 hectares to be located on the west end of the ORR. This action, the result of an agreement-in-principle related to the Natural Resources Damage Act affecting the ORR, was granted in early 2005.

5. ORNL Environmental Monitoring Programs

Compliance and environmental monitoring programs required by federal and state regulations and by DOE orders are conducted for air, water, and a variety of environmental media at ORNL. These programs include regulatory and monitoring activities for ORNL site facilities and other locations in Bethel Valley, Melton Valley, and the ORR.

5.1 ORNL Radiological Airborne Effluent Monitoring

Airborne discharges from DOE Oak Ridge facilities, both radioactive and nonradioactive, are subject to regulation by EPA and the Tennessee Department of Environment and Conservation (TDEC) Division of Air Pollution Control. Radioactive emissions are regulated by EPA under National Emissions Standards for Hazardous Air Pollutants (NESHAP) regulations in 40 CFR 61, Subpart H, and by the rules of the TDEC Division of Air Pollution Control, 1200-3-11.08. (See Appendix G, Table G.1 for a list of radionuclides and their radioactive half-lives.)

Radioactive airborne discharges at ORNL consist primarily of ventilation air from radioactively contaminated or potentially contaminated areas, vents from tanks and processes, and ventilation for hot cell operations and reactor facilities. These airborne emissions are treated and then filtered with high-efficiency particulate air filters and/or charcoal filters before discharge. Radiological airborne emissions from ORNL consist of solid particulates, adsorbable gases (e.g., iodine), tritium, and nonadsorbable gases (e.g., noble gases). In 2006, construction of the Spallation Neutron Source (SNS) project was completed. The purpose of the project was to design, construct, and commission into operation an accelerator-based, pulsed neutron facility for studies of the structure and dynamics of materials. Activities that will lead to SNS start-up were initiated in April 2006. Emissions from these activities are included in this report. Radionuclide emissions from the SNS are discharged through a single emission point, the SNS Central Exhaust Facility stack (8915), which has the potential to emit radionuclides that would result in a dose equal to or greater than 0.1 mrem/year (0.001 mSv/year) to the most exposed member

of the public, and therefore continuous emission sampling or monitoring is required.

The major radiological emission point sources for ORNL consist of the following five stacks located in Bethel and Melton Valleys (Fig. 5.1) and the SNS Central Exhaust Facility stack located on Chestnut Ridge:

- 2026 Radioactive Materials Analytical Laboratory;
- 3020 Radiochemical Development Facility;
- 3039 central off-gas and scrubber system, which includes the 3500 and 4500 areas cell ventilation system, isotope solid-state ventilation system, 3025 and 3026 areas cell ventilation system, 3042 ventilation system, and 3092 central off-gas system;
- 7503 (formerly 7512) Molten Salt Reactor Experiment Facility;
- 7911 Melton Valley complex, which includes the High Flux Isotope Reactor (HFIR) and the Radiochemical Engineering Development Center (REDC); and
- 8915 SNS Central Exhaust Facility stack.

In 2006, there were 19 minor point/group sources, and emission calculations/estimates were made for each of them.

5.1.1 Sample Collection and Analytical Procedure

Five of the major point sources (2026, 3020, 3039, 7503, and 7911) are equipped with a variety of surveillance instrumentation. Only data resulting from analysis of the continuous samples are used in this report. ORNL in-stack source-sampling systems comply with criteria in the American National Standards Institute (ANSI) standard ANSI N 13.1 (ANSI 1969). The sampling systems generally consist of a multipoint in-stack sampling probe, a sample

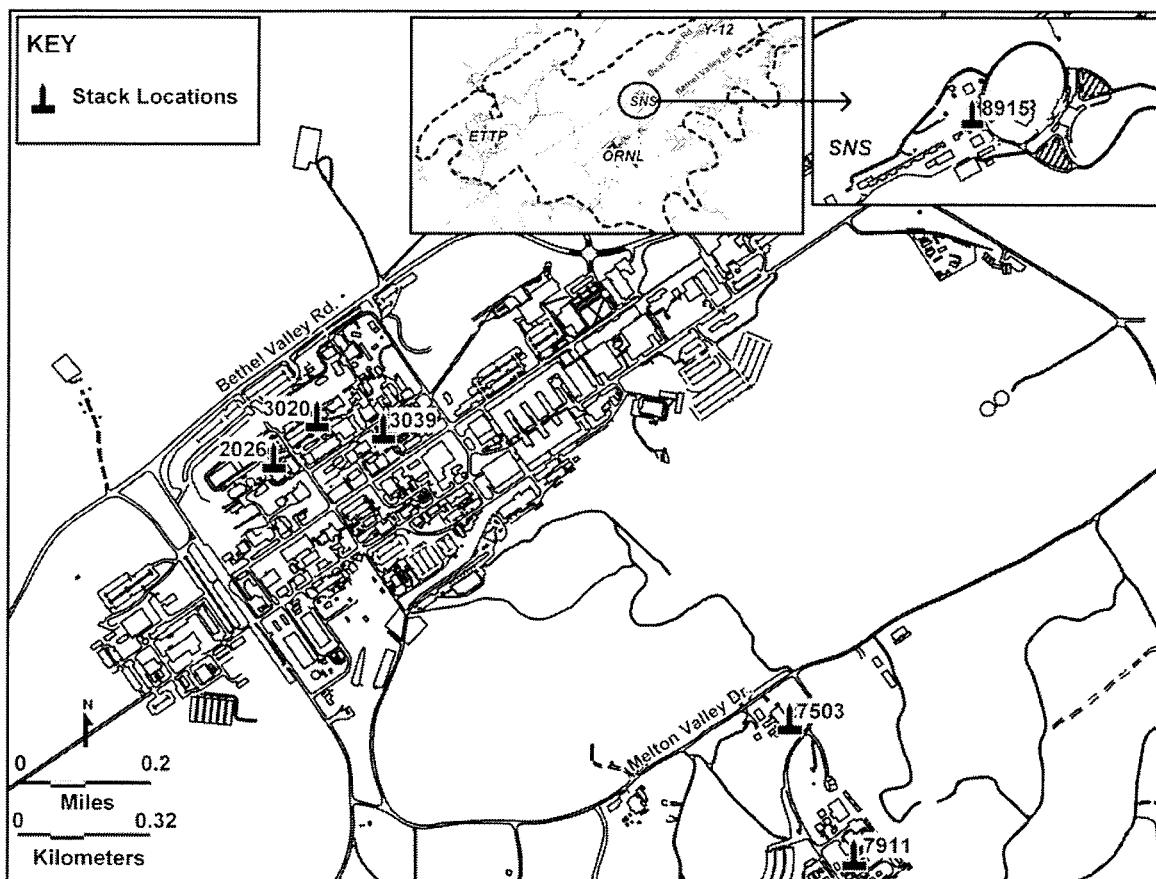


Fig. 5.1. Locations of major stacks (radiological emission points) at ORNL.

transport line, a particulate filter, activated charcoal cartridges, a silica-gel cartridge (if required), flow-measurement and totalizing instruments, a sampling pump, and a return line to the stack. In addition to that instrumentation, the system at Stack 7911 includes a high-purity germanium detector with a NOMAD™ analyzer, which allows continuous isotopic identification and quantification of radioactive noble gases (e.g., ^{41}Ar) in the effluent stream. The sample probes are annually removed, inspected, and cleaned. The 8915 stack is equipped with an in-stack radiation detector. The detector monitors radioactive gases flowing through the exhaust stack and provides a continual readout of detected activity using a scintillator probe. The detector is calibrated to correlate with isotopic emissions.

Velocity profiles are performed quarterly following the criteria in EPA Method 2 at major and some minor sources. The profiles provide

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.

In addition to the major sources, ORNL has a number of minor sources that have the potential to emit radionuclides to the atmosphere. A minor source is defined as any ventilation system or component such as a vent, laboratory hood, room exhaust, or stack that does not meet the approved regulatory criteria for a major source but that is located in or vents from a radiological control area as defined by Radiological Support Services of the ORNL Nuclear and Radiological Protection Division. A variety of methods are used to determine the emissions from the various minor sources. Methods used for minor source-emission calculations comply with criteria agreed upon by EPA. These minor sources are evaluated on a 1- to 5-year basis. Emissions, major and minor, are compiled annu-

ally to determine the overall ORNL source term and associated dose.

The charcoal cartridges, particulate filters, and silica-gel traps are collected weekly to bi-weekly. The use of charcoal cartridges is a standard method for capturing and quantifying radioactive iodine in airborne emissions. Gamma spectrometric analysis of the charcoal samples quantifies the adsorbable gases. Analyses are performed weekly to biweekly. Particulate filters are 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 filters are then composited quarterly and are analyzed for alpha-, beta-, and gamma-emitting isotopes. Compositing provides a better opportunity for quantification of the low-concentration isotopes. Silica-gel traps are used to capture tritium water vapor. Analysis is performed weekly to biweekly. At the end of the year, the sample probes for all of the stacks are rinsed, except for 8915, and the rinsate is collected and submitted for isotopic analysis identical to that performed on the particulate filters. A probe-cleaning program has not been determined necessary for 8915 since the sample probe is a scintillator probe used to detect radiation and not to collect a sample of stack exhaust emissions. It is not anticipated that contaminant deposits would collect on the scintillator probe.

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.

5.1.2 Results

Annual radioactive airborne emissions for ORNL in 2006 are presented in Table 5.1. All data presented were determined to be statistically different from zero at the 95% confidence level. Any number not statistically different from zero was not included in the emission calculation. Because measuring a radionuclide requires a process of counting random radioactive emissions from a sample, the same result may not be obtained if the sample is analyzed repeatedly. This deviation is referred to as the “counting uncertainty.” Statistical significance at the

95% confidence level means that there is a 5% chance that the results could be erroneous.

Historical trends for tritium and ^{131}I are presented in Figs. 5.2 and 5.3, respectively. The tritium emissions for 2006 totaled approximately 63.9 Ci (Fig. 5.2), which is a decrease from 2005. The ^{131}I emissions for 2006 totaled 0.05 Ci (Fig. 5.3), which is in line with reported emissions for the past four years. The major contributor to the off-site dose at ORNL historically has been ^{41}Ar , which is emitted as a nonadsorbable gas from the 7911 Melton Valley complex stack. However, due to changes in HFIR operations, ^{138}Cs has remained the major contributor to the off-site dose since 2001. Emissions of ^{41}Ar result from HFIR operations and research activities. Emissions of ^{138}Cs result from REDC research activities, which also exhaust through the 7911 Melton Valley complex stack. The ^{41}Ar emissions for 2006 were 229 Ci; ^{138}Cs emissions were 1210 Ci (Fig. 5.4). Emissions of ^{41}Ar were very low in 2006 because the HFIR was in an extended outage for installation of the Cold Neutron Source. The calculated radiation dose to the maximally exposed off-site individual from all radiological airborne release points at ORNL during 2006 was 0.06 mrem. This dose is well below the NESHAP standard of 10 mrem and is less than 0.02% of the 300 mrem that the average individual receives from natural sources of radiation. (See Sect. 8.1.2.1 for an explanation of how the airborne radionuclide dose was determined.)

5.2 ORNL Nonradiological Airborne Emissions Monitoring

ORNL holds a Title V permit for ten emission sources. ORNL also holds one construction permit for the Central Exhaust Facility at the SNS (see Appendix F, Table F.2). The ORNL Steam Plant (six boilers) and four small package-unit boilers account for 75% of ORNL's allowable emissions. Boiler 6, a 125-MBtu/h boiler, is subject to 40 CFR 60 Subpart Db continuous emission monitoring requirements for NO_x and opacity. During CY 2006, no permit limits were exceeded.

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Table 5.1. Radiological airborne emissions from all sources at ORNL, 2006 (Ci)^a

Isotope	Stack						Total Minor Sources	Total ORNL
	X-2026	X-3020	X-3039	X-7503	X-7911	X-8915		
²²⁵ Ac							1.20E-06	1.20E-06
²²⁸ Ac							1.09E-05	1.09E-05
²²⁸ Ac							1.45E-08	1.45E-08
^{110m} Ag							2.51E-06	2.51E-06
²⁴¹ Am	2.01E-07	1.44E-07	7.28E-07	5.41E-09	8.71E-09		7.27E-07	1.81E-06
²⁴³ Am							2.52E-11	2.52E-11
³⁹ Ar							1.80E-05	1.80E-05
⁴¹ Ar					2.29E+02	5.00E-02	3.36E-02	2.29E+02
⁴³ Ar ^b						5.10E-01		5.10E-01
⁴⁴ Ar ^b						2.40E-01		2.40E-01
¹³³ Ba							7.43E-09	7.43E-09
¹³⁹ Ba					2.71E-01			2.71E-01
¹⁴⁰ Ba						1.25E-04	4.90E-16	1.25E-04
⁷ Be	8.00E-08	1.67E-07	8.86E-06	1.18E-08	3.78E-07		4.68E-07	9.97E-06
²¹² Bi							4.44E-08	4.44E-08
²¹² Bi							3.34E-08	3.34E-08
²¹³ Bi							1.12E-05	1.12E-05
²¹⁴ Bi							3.43E-08	3.43E-08
⁷² Br ^c						3.00E-02		3.00E-02
¹¹ C						1.25E+00	4.48E-02	1.29E+00
¹⁴ C							1.20E-07	1.20E-07
¹³⁹ Ce							2.08E-09	2.08E-09
¹⁴¹ Ce							3.45E-08	3.45E-08
¹⁴⁴ Ce							4.75E-11	4.75E-11
²⁴⁹ Cf							7.95E-14	7.95E-14
²⁵⁰ Cf							3.61E-07	3.61E-07
²⁵¹ Cf							1.47E-14	1.47E-14
²⁵² Cf					9.74E-10		1.00E-07	1.01E-07
²⁴² Cm							3.96E-11	3.96E-11
²⁴³ Cm							3.69E-11	3.69E-11
²⁴⁴ Cm	1.22E-06	1.86E-08	1.55E-07	2.69E-08	8.50E-08		6.68E-05	6.83E-05
²⁴⁵ Cm							1.73E-09	1.73E-09
²⁴⁶ Cm							1.79E-09	1.79E-09
²⁴⁸ Cm							1.66E-13	1.66E-13
⁵⁶ Co							9.99E-09	9.99E-09
⁵⁷ Co							1.05E-06	1.05E-06
⁵⁸ Co							1.20E-09	1.20E-09
⁶⁰ Co			2.53E-06				1.52E-04	1.55E-04
⁵¹ Cr							1.08E-08	1.08E-08
¹³⁴ Cs							7.25E-05	7.25E-05
¹³⁶ Cs							2.76E-05	2.76E-05
¹³⁷ Cs	3.76E-06	9.78E-07	2.26E-04	1.66E-08	8.30E-05		3.51E-03	3.83E-03
¹³⁸ Cs						1.21E+03		1.21E+03
¹⁵² Eu							1.90E-05	1.90E-05
¹⁵⁴ Eu							1.05E-04	1.05E-04
¹⁵⁵ Eu							2.71E-05	2.71E-05
⁵⁵ Fe							3.27E-06	3.27E-06

Table 5.1 (continued)

Isotope	Stack						Total Minor Sources	Total ORNL
	X-2026	X-3020	X-3039	X-7503	X-7911	X-8915		
⁵⁹ Fe							8.80E-06	8.80E-06
⁶⁷ Ga							1.82E-15	1.82E-15
¹⁵³ Gd							3.00E-09	3.00E-09
⁶⁸ Ge							3.75E-15	3.75E-15
³ H	1.39E+00		3.96E+01	1.54E+00	1.96E+01	1.10E-01	1.67E+00	6.39E+01
¹⁷² Hf							6.85E-14	6.85E-14
¹⁷⁵ Hf							8.09E-13	8.09E-13
^{178m} Hf							5.14E-15	5.14E-15
¹⁸¹ Hf							3.51E-15	3.51E-15
²⁰³ Hg							4.04E-12	4.04E-12
¹¹⁷ I ^d						5.00E-02		5.00E-02
¹¹⁹ I ^d						4.00E-02		4.00E-02
¹²⁴ I							5.27E-16	5.27E-16
¹²⁵ I							5.22E-06	5.22E-06
¹²⁶ I							2.33E-08	2.33E-08
¹²⁹ I							2.60E-05	2.60E-05
¹³¹ I				5.19E-02			2.10E-04	5.21E-02
¹³² I				5.83E-01				5.83E-01
¹³³ I				2.76E-01				2.76E-01
¹³⁴ I				8.06E-01				8.06E-01
¹³⁵ I				8.26E-01				8.26E-01
¹⁹² Ir						1.04E-08		1.04E-08
⁴⁰ K						8.08E-05		8.08E-05
⁷⁵ Kr ^e					3.00E-01			3.00E-01
⁷⁷ Kr ^f					2.50E-01			2.50E-01
⁸¹ Kr						1.08E-12		1.08E-12
⁸⁵ Kr				1.80E+02			9.17E-02	1.80E+02
^{85m} Kr				1.11E-01				1.11E-01
⁸⁷ Kr				5.67E+01	1.10E-01			5.68E+01
⁸⁸ Kr				5.04E+01				5.04E+01
⁸⁹ Kr				2.52E+01	6.30E-01			2.58E+01
¹⁴⁰ La				2.41E-03			4.63E-05	2.46E-03
¹⁷³ Lu							7.57E-13	7.57E-13
¹⁷⁴ Lu							1.60E-13	1.60E-13
^{177m} Lu							1.34E-14	1.34E-14
⁵⁴ Mn							2.86E-06	2.86E-06
⁹³ Mo							3.11E-08	3.11E-08
⁹⁹ Mo							6.20E-03	6.20E-03
¹³ N					3.00E-02	1.69E-01		1.99E-01
²² Na							4.53E-09	4.53E-09
⁹² Nb							6.24E-09	6.24E-09
^{92m} Nb							3.41E-13	3.41E-13
^{93m} Nb							4.88E-09	4.88E-09
⁹⁴ Nb							2.37E-06	2.37E-06
⁹⁵ Nb							8.55E-09	8.55E-09
⁵⁹ Ni							6.00E-11	6.00E-11
⁶³ Ni							1.60E-08	1.60E-08

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Table 5.1 (continued)

Isotope	Stack						Total Minor Sources	Total ORNL
	X-2026	X-3020	X-3039	X-7503	X-7911	X-8915		
²³⁹ Np							1.03E-11	1.03E-11
¹⁵ O						1.00E-01		1.00E-01
¹⁸⁵ Os							2.18E-12	2.18E-12
¹⁹¹ Os			1.40E-02					1.40E-02
²¹⁰ Pb							1.11E-06	1.11E-06
²¹² Pb			9.27E-01	7.08E-02			1.87E-03	1.00E+00
²¹² Pb	2.23E-01				6.67E-02		5.95E-06	2.90E-01
²¹⁴ Pb							9.58E-09	9.58E-09
¹⁴⁴ Pm							7.47E-09	7.47E-09
²³⁸ Pu	7.86E-08	1.07E-08	8.94E-08	3.91E-09			1.05E-06	1.23E-06
²³⁹ Pu	2.48E-07	1.20E-07	1.66E-06	1.43E-08	5.39E-09		9.70E-07	3.02E-06
²⁴⁰ Pu							6.75E-10	6.75E-10
²⁴¹ Pu							6.48E-10	6.48E-10
²⁴² Pu							6.97E-13	6.97E-13
²⁴⁴ Pu							1.88E-09	1.88E-09
²²⁵ Ra							1.00E-06	1.00E-06
²²⁶ Ra							4.55E-05	4.55E-05
²²⁸ Ra							4.27E-08	4.27E-08
²²⁸ Ra							1.45E-08	1.45E-08
⁸⁸ Rb							1.76E-13	1.76E-13
⁸⁹ Rb							2.10E-13	2.10E-13
¹⁸⁸ Re							1.51E-05	1.51E-05
¹⁰³ Ru							5.35E-11	5.35E-11
¹⁰⁶ Ru							2.38E-05	2.38E-05
³⁵ S							5.00E-06	5.00E-06
¹²⁴ Sb							1.01E-07	1.01E-07
¹²⁵ Sb							6.33E-06	6.33E-06
¹²⁶ Sb							1.90E-16	1.90E-16
⁴⁶ Sc							2.67E-10	2.67E-10
⁷⁵ Se		2.20E-03						2.20E-03
¹¹³ Sn							4.00E-14	4.00E-14
⁸⁵ Sr							2.00E-09	2.00E-09
⁸⁹ Sr							3.82E-05	3.82E-05
⁹⁰ Sr	4.14E-07	6.65E-07	3.79E-05	9.98E-09	5.55E-06		2.08E-03	2.13E-03
⁹¹ Sr							5.48E-08	5.48E-08
⁹² Sr							1.90E-13	1.90E-13
¹⁷⁹ Ta							9.49E-14	9.49E-14
¹⁸² Ta							3.40E-08	3.40E-08
^{95m} Tc							2.30E-14	2.30E-14
⁹⁶ Tc							1.97E-14	1.97E-14
⁹⁹ Tc							2.41E-05	2.41E-05
^{99m} Tc							1.20E-16	1.20E-16
^{125m} Te							1.20E-06	1.20E-06
^{129m} Te							3.76E-07	3.76E-07
²²⁸ Th	3.11E-08	4.22E-09			2.57E-09		6.18E-11	3.80E-08
²²⁸ Th			8.43E-09	1.03E-09			3.83E-06	3.84E-06
²²⁹ Th							1.02E-08	1.02E-08

5-6 ORNL Environmental Monitoring Programs

Table 5.1 (continued)

Isotope	Stack						Total Minor Sources	Total ORNL
	X-2026	X-3020	X-3039	X-7503	X-7911	X-8915		
²³⁰ Th	5.83E-09	3.94E-09			1.74E-08		1.02E-09	2.82E-08
²³¹ Th			1.36E-08	3.09E-09			1.16E-08	2.83E-08
²³² Th	3.01E-10	1.08E-09			3.00E-09		8.97E-12	4.39E-09
²³² Th			3.48E-09	7.27E-11			1.08E-05	1.08E-05
²³⁴ Th							2.34E-05	2.34E-05
²³⁴ Th							2.51E-07	2.51E-07
²⁰⁸ Tl							5.46E-11	5.46E-11
²⁰⁸ Tl							2.54E-06	2.54E-06
²³² U							8.07E-16	8.07E-16
²³³ U							1.06E-05	1.06E-05
²³⁴ U	1.95E-07	6.91E-08			2.09E-07		1.36E-04	1.36E-04
²³⁴ U			2.91E-07	1.86E-08			1.07E-05	1.10E-05
²³⁵ U	2.76E-09	1.69E-09	2.39E-08	1.70E-10	3.40E-08		1.83E-06	1.89E-06
²³⁶ U							3.26E-07	3.26E-07
²³⁸ U	3.68E-09	7.75E-09			7.74E-08		2.04E-05	2.05E-05
²³⁸ U			4.52E-08	1.63E-09			1.52E-06	1.56E-06
⁴⁹ V							2.30E-10	2.30E-10
¹⁸¹ W							5.75E-09	5.75E-09
¹⁸⁵ W							3.33E-08	3.33E-08
¹⁸⁸ W							1.01E-05	1.01E-05
¹¹⁸ Xe ^g					3.00E-02			3.00E-02
¹¹⁹ Xe ^g					2.30E-01			2.30E-01
¹²¹ Xe ^h					5.00E-02			5.00E-02
¹²³ Xe					8.00E-02			8.00E-02
¹²⁷ Xe						7.28E-09		7.28E-09
^{129m} Xe						2.29E-09		2.29E-09
^{131m} Xe				4.50E-06	4.79E+00	2.82E-06		4.79E+00
¹³³ Xe					1.59E+00	2.42E-08		1.59E+00
^{133m} Xe					1.84E+00			1.84E+00
¹³⁵ Xe					2.57E+01	4.00E-02		2.57E+01
^{135m} Xe					1.76E+01			1.76E+01
¹³⁷ Xe					9.91E+01			9.91E+01
¹³⁸ Xe					1.27E+02			1.27E+02
⁸⁷ Y						1.90E-16		1.90E-16
⁸⁸ Y						2.81E-06		2.81E-06
⁹⁰ Y	4.14E-07	6.65E-07	3.79E-05	9.98E-09	5.55E-06		2.08E-03	2.13E-03
⁶⁵ Zn							6.33E-06	6.33E-06
⁸⁸ Zr							8.15E-08	8.15E-08
⁹⁵ Zr							6.27E-06	6.27E-06

^a1 Ci = 3.7E+10 Bq^bAr⁴¹ was used as a surrogate for Ar⁴³ and Ar⁴⁴.^cY⁸⁶ was used as a surrogate for Br⁸².^dI¹²² was used as a surrogate for I¹¹⁷ and I¹¹⁹.^eRb⁸⁶ was used as a surrogate for Kr⁷⁵.^fGa⁶⁸ was used as a surrogate for Kr⁷⁷.^gCs¹²⁶ was used as a surrogate for Xe¹¹⁸ and Xe¹¹⁹.^hXe¹²³ was used as a surrogate for Xe¹²¹.

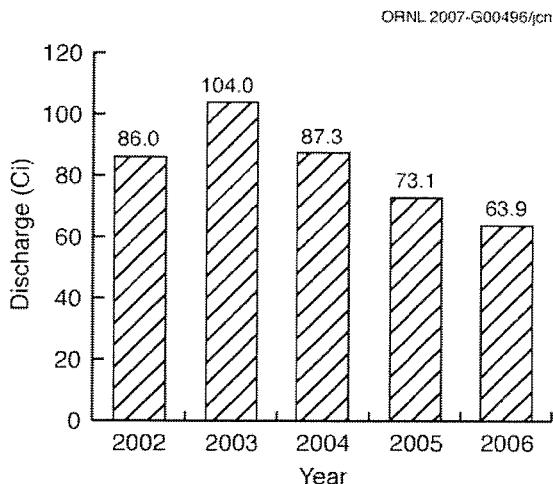


Fig. 5.2. Total discharges of ^{3}H from ORNL to the atmosphere, 2002–2006

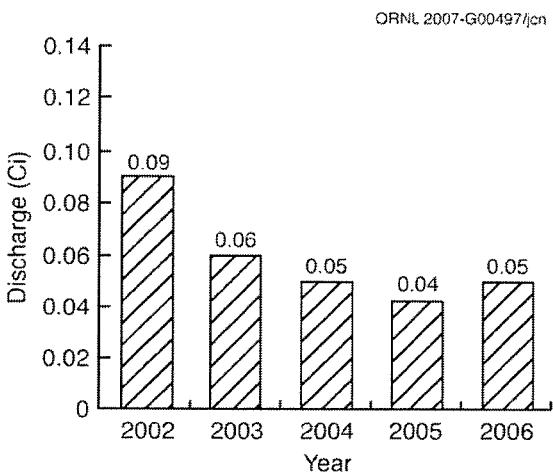


Fig. 5.3. Total discharges of ^{131}I from ORNL to the atmosphere, 2002–2006.

For the period from July 1, 2005, through June 30, 2006, ORNL paid \$5,643.49 in annual emission fees to TDEC. These fees are based on a combination of actual and allowable emissions. During 2006, TDEC inspected all permitted emissions sources; all were found to be in compliance.

As required by Title VI of the Clean Air Act Amendments of 1990, actions have been implemented to comply with the prohibition against releasing ozone-depleting substances during

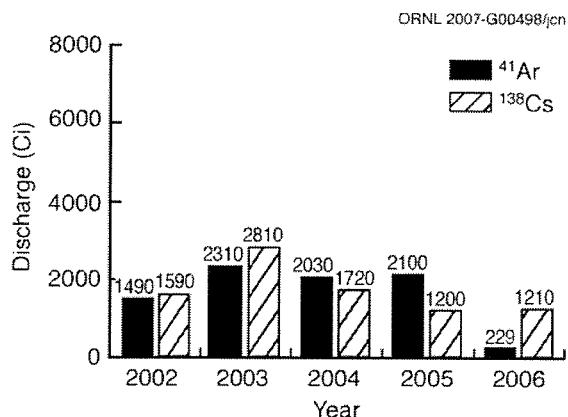


Fig. 5.4. Total discharges of ^{41}Ar and ^{138}Cs from ORNL to the atmosphere, 2002–2006.

maintenance activities performed on refrigeration equipment. In addition, service requirements for refrigeration systems (including motor vehicle air conditioners), technician certification requirements, and labeling requirements have been implemented. ORNL has implemented a plan to phase out the use of all Class I ozone-depleting substances. All critical applications of Class I ozone-depleting substances have been eliminated, replaced, or retrofitted with other materials. Work is progressing as funding becomes available for noncritical applications with no disruption of service.

Another UT-Battelle-operated facility, the National Transportation Research Center, is in Knox County and is permitted with the local regulatory agency there.

5.2.1 Results

The primary sources of nonradioactive emissions at ORNL include the steam plant, boilers 1–6 on the main ORNL site, two boilers located at the 7600 complex, and four boilers located at the SNS site. These units use fossil fuels; therefore, criteria pollutants are emitted.

Actual and allowable emissions from these sources are compared in Table 5.2. Actual emissions were calculated from fuel usage and EPA emission factors. All ORNL emission sources operated in compliance with permit conditions during 2006.

Table 5.2. Actual vs allowable air emissions from ORNL steam production, 2006

Pollutant	Emissions (tons per year) ^a		Percentage of allowable
	Actual	Allowable	
SO ₂	6	1277	0.5%
PM	4	71	5.6%
CO	33	196	16.8%
VOC	2	14	14.3%
NO _x	66	380	17.4%

^a1 ton = 907.2 kg.

5.3 ORNL Ambient Air Monitoring

The objectives of the ORNL ambient air monitoring program are to collect samples at perimeter air monitoring (PAM) stations most likely to show impacts of airborne emissions from the operation of ORNL and to provide for emergency response capability. Four stations, identified as Stations 1, 2, 3, and 7 (Fig. 5.5) make up the ORNL PAM network. Sampling is conducted at each ORNL station to quantify levels of tritium; adsorbable gases (e.g., iodine); and gross alpha-, beta-, and gamma-emitting radionuclides (Table 5.3).

The sampling system consists of a low-volume air sampler for particulate collection in a 47-mm glass-fiber filter. The filters are collected biweekly, composited annually, then submitted to the laboratory for analysis. Following the filter is a charcoal cartridge that collects adsorbable gases and is collected and analyzed on a bi-weekly basis. A silica-gel column is used for collection of tritium as tritiated water. These samples are collected biweekly or weekly and composited quarterly for tritium analysis.

5.3.1 Results

The ORNL PAM stations are designed to provide data for collectively assessing the specific impact of ORNL operations on local air quality. Sampling data from the ORNL PAM stations (Table 5.3) are compared with the derived concentration guides (DCGs) for air established by DOE as reference values for conducting radiological environmental protection programs at DOE sites. (DCGs are listed in DOE Order 5400.5.) Average radionuclide concentrations measured for the

ORNL network were less than 1% of the applicable DCG in all cases.

5.4 ORNL NPDES Summary

5.4.1 NPDES Permit Monitoring

ORNL submitted the application for renewal of NPDES Permit TN0002941 on June 1, 2001, fulfilling the requirement that an application be made 6 months prior to permit expiration. The December 6, 1996, ORNL NPDES Permit expired in December 2001, but the limits and conditions of that permit remain in effect until renewal by TDEC. The 1996 NPDES permit includes 164 separate outfalls and monitoring points. Data collected to meet the requirements of the permit are submitted to the state of Tennessee in the monthly NPDES Discharge Monitoring Report.

The ORNL NPDES Permit requires sampling of point-source outfalls before discharge into receiving waters or before mixing with any other wastewater stream (see Fig. 5.6). Under the existing permit, there are numeric and narrative effluent limits applied at the following locations:

- X01—Sewage Treatment Plant,
- X02—Coal Yard Runoff Treatment Facility (CYRTF),
- X12—Process Waste Treatment Complex (PWTC),
- X13—Melton Branch (MB1),
- X14—White Oak Creek,
- X15—White Oak Dam,
- in-stream chlorine monitoring points (X16–X26),
- steam condensate outfalls,
- groundwater from building foundation drains,
- Category I outfalls (storm drains, water discharged under best management practices, groundwater, steam, and water condensate),
- Category II outfalls (storm drains, water discharged under best management practices, groundwater, steam, and water condensate),
- Category III outfalls (storm drains, water discharged under best management practices, groundwater, steam, water condensate, cooling water, and cooling tower blow-down),

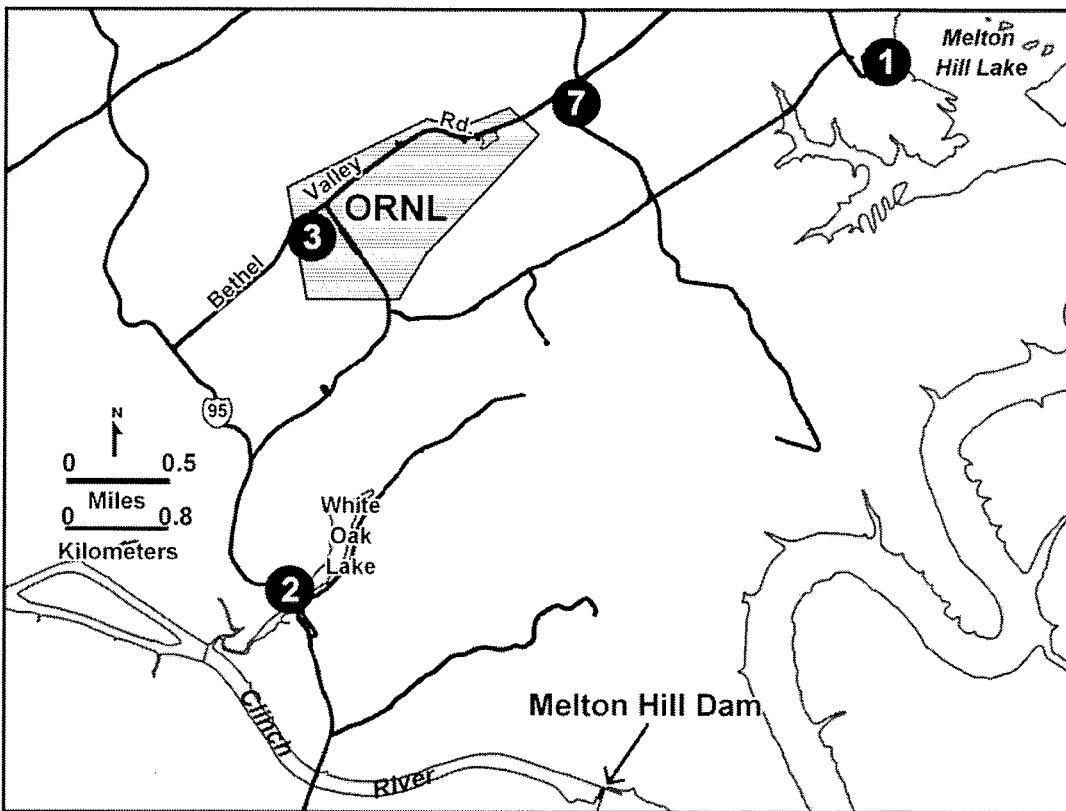


Fig. 5.5. Locations of ambient air monitoring stations at ORNL.

- Category IV outfalls (storm drains, water discharged under best management practices, groundwater, steam, water condensate, cooling water, and cooling tower blowdown), and
- cooling systems (cooling water and cooling tower blowdown).

Permit limits and compliance statistics are shown in Table 5.4. In-stream data collection points X-13, X-14, and X-15 are not included in the table because only flow measurements and narrative conditions are required at these three points. Permit noncompliances in 2006 are discussed below and are shown in Appendix E.

During 2006, ORNL had five measurements that exceeded numeric NPDES permit limits. Based on approximately 7000 compliance measurements and analyses, the rate of compliance with the ORNL NPDES permit was approximately 99.9%. The noncompliances occurred at the ORNL Sewage Treatment Plant (STP),

where routine testing indicated a transient or temporary condition of effluent toxicity, and four temperature profile measurements on a single day indicating criterion exceedance at cooling tower blowdown outfall 281. Confirmatory toxicity testing at the sewage plant did not indicate effluent toxicity; therefore, no cause was determined for the initial condition. STP operating parameters were normal during both the initial and confirmatory toxicity tests. Additional operational modifications are being evaluated in cooperation with TDEC in an attempt to mitigate the temperature issue at outfall 281.

Under the NPDES permit, ORNL conducts several monitoring plans and programs. These include the Radiological Monitoring Plan, the Chlorine Control Strategy, and the Storm Water Pollution Prevention Plan. These are discussed in the following sections.

Table 5.3. Radionuclide concentrations measured at ORNL perimeter air monitoring stations, 2006 (pCi/mL)^a

Parameter	Average concentration	No. detected/total
Station 1		
Alpha	1.64E-09	1/1
⁷ Be	1.99E-08	1/1
Beta	1.94E-08	1/1
³ H	1.32E-07	0/4
⁴⁰ K	3.25E-07	26/26
²³⁴ U	1.06E-11	1/1
²³⁵ U	1.76E-12	1/1
²³⁸ U	1.03E-11	1/1
Tot U	2.27E-11	1/1
Station 2		
Alpha	9.44E-10	1/1
⁷ Be	2.14E-08	1/1
Beta	2.08E-08	1/1
³ H	3.60E-06	3/4
⁴⁰ K	3.82E-07	26/26
²³⁴ U	1.67E-11	1/1
²³⁵ U	1.51E-12	1/1
²³⁸ U	8.12E-12	1/1
Tot U	2.63E-11	1/1
Station 3		
Alpha	8.14E-10	1/1
⁷ Be	1.84E-08	1/1
Beta	1.60E-08	1/1
³ H	1.73E-06	1/4
⁴⁰ K	3.35E-07	26/26
²³⁴ U	1.26E-11	1/1
²³⁵ U	2.20E-12	1/1
²³⁸ U	1.96E-11	1/1
Tot U	3.43E-11	1/1
Station 7		
Alpha	1.78E-09	1/1
⁷ Be	2.21E-08	1/1
Beta	2.09E-08	1/1
³ H	-6.73E-07	1/4
⁴⁰ K	3.39E-07	25/26
²³⁴ U	9.15E-12	1/1
²³⁵ U	1.15E-12	1/1
²³⁸ U	1.34E-11	1/1
Tot U	2.37E-11	1/1

^a1 pCi = 3.7×10^{-2} Bq.

5.4.1.1 Radiological Monitoring Plan

ORNL monitors radioactivity at NPDES outfalls that have the potential to discharge radioactivity and at in-stream monitoring stations under a radiological monitoring plan required by Part III, Section J, of the ORNL NPDES permit. The current version of the plan was implemented on November 1, 1999. Table 5.5 details the monitoring frequency and target analyses for 27 category outfalls (dry-weather component of discharge), three treatment facility outfalls, and three in-stream monitoring locations.

Category outfalls are outfalls that discharge effluents with relatively minor constituents that receive little or no treatment prior to discharge. Dry-weather discharges from category outfalls are primarily cooling water, groundwater, and steam condensate. In 2006, samples were collected at 21 of the 27 category outfalls. The remaining six outfalls were not sampled, either because they are no longer in service, or because there was not any discharge or were otherwise not able to be sampled during sampling attempts.

The three treatment facilities included in the ORNL radiological monitoring plan are the STP, the CYRTF, and the PWTC. Three in-stream locations are also monitored under the Radiological Monitoring Plan: X13 on Melton Branch, X14 on White Oak Creek (WOC), and X15 at White Oak Dam (Fig. 5.6).

The DOE DCG values are used in this section as a means of standardized comparison for effluent points with different radioisotope signatures. Annual average concentrations were compared with DCG concentrations where applicable (there are no DCGs for gross alpha and gross beta activities) when at least one individual measurement indicated detectable activity [i.e., one individual measurement where the measured concentration was greater than or equal to the measurement's minimum detectable activity (MDA)]. For analyses that cannot differentiate between two radioisotopes (e.g., ^{89/90}Sr) and for radioisotopes that have more than one DCG for different gastrointestinal tract absorption factors, the most restrictive (lowest) DCG was used in the comparisons. DCGs are not thresholds for in-stream values but are useful as a frame of reference. The comparison of effluent and

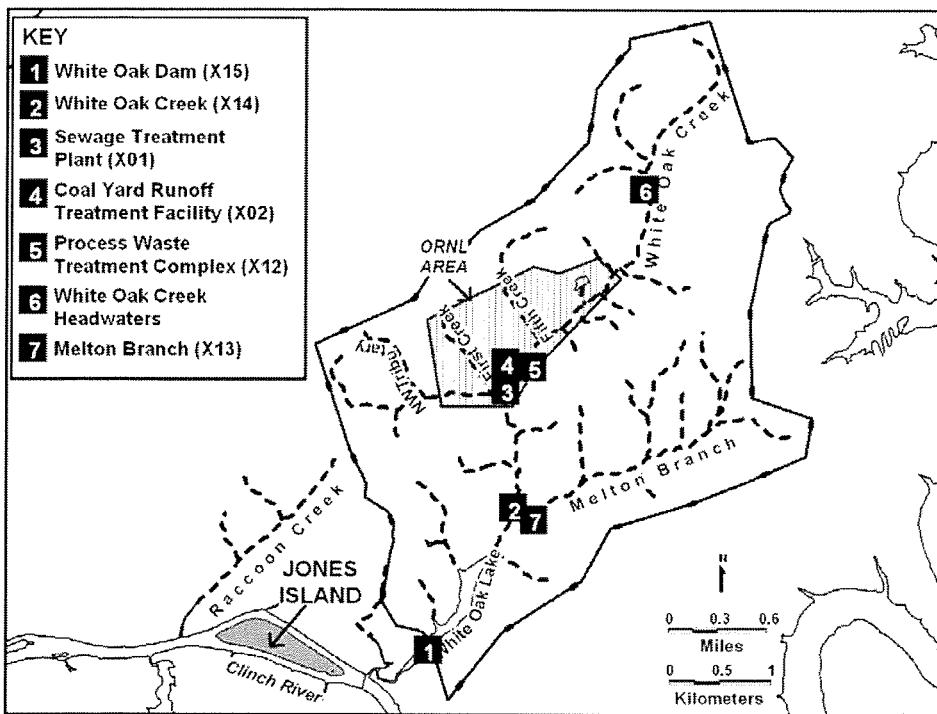


Fig. 5.6. ORNL surface water, National Pollutant Discharge Elimination System, and reference sampling locations.

instream concentrations with DCGs for ingestion of water does not imply that effluents from ORNL outfalls or ORNL ambient-water-sampling stations are sources of drinking water.

In 2006, one NPDES outfall had measured annual average concentrations of radioactivity equaling or exceeding 100% of DCG concentrations. The average of three measurements of $^{243/244}\text{Cm}$ at outfall 080 was 1,100 pCi/L (18 times the DCG for ^{244}Cm or 22 times the DCG for ^{243}Cm . (Although the analytical test does not differentiate between ^{243}Cm and ^{244}Cm , the analyst who ran the test believed that most of the activity was from the ^{244}Cm isotope.) The average concentration of three measurements of ^{241}Am at outfall 080 was also significant (87% of the DCG) as was $^{239/240}\text{Pu}$ (50% of the DCG, which is the same for both isotopes). The flow rates at the outfall when the elevated concentrations were measured were approximately 0.1 gal/min; therefore significant changes in contaminant concentrations have not been detected in downstream monitoring. Evaluation of these data, along with data from additional water

samples and a sediment sample collected by Bechtel Jacobs (the Oak Ridge environmental management contractor) indicates that the contamination present at outfall 080, although greater than the DCG, is within the target human health risk range for the Record of Decision for Interim Actions in Melton Valley. The increase in contaminant concentrations at outfall 080 was first detected in June following the grouting of a nearby abandoned waste pipeline earlier in the year. It is theorized that some residual contaminated material was pushed out of the pipeline through an unknown line break as grout was pumped into the pipe, and contamination migrated into the Outfall 080 pipe network. The radiological signatures of the waste in the abandoned pipeline and the outfall effluent since June are consistent. The DOE Office of Science and DOE-EM are working together to determine appropriate monitoring and actions.

In addition to outfall 080, the annual average concentration of at least one radionuclide exceeded 4% of the relevant DCG concentration at six NPDES outfalls (X01, X12, 085, 204, 302,

Table 5.4. National Pollutant Discharge Elimination System (NPDES) compliance at ORNL, 2006
(NPDES permit effective February 3, 1997)

Effluent parameters ^a	Permit limits					Permit compliance		
	Monthly average (kg/d)	Daily max (kg/d)	Monthly average (mg/L)	Daily max (mg/L)	Daily min (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance ^b
X01 (Sewage Treatment Plant)								
LC ₅₀ for <i>Ceriodaphnia</i> (%)				41.1		1 ^c	5	80
LC ₅₀ for fathead minnows (%)				41.1		0	4	100
Ammonia, as N (summer)	2.84	4.26	2.5	3.75		0	79	100
Ammonia, as N (winter)	5.96	8.97	5.25	7.9		0	77	100
Carbonaceous BOD	8.7	13.1	10	15		0	156	100
Dissolved oxygen				6		0	156	100
Fecal coliform (col/100 mL)			1000	5000		0	156	100
NOEC for <i>Ceriodaphnia</i> (%)				12.3		0	5	100
NOEC for fathead minnows (%)				12.3		0	4	100
Oil and grease	8.7	13.1	10	15		0	156	100
pH (std. units)				9	6	0	156	100
Total residual chlorine			0.038	0.066		0	156	100
Total suspended solids	26.2	39.2	30	45		0	156	100
X02 (Coal Yard Runoff Treatment Facility)								
LC ₅₀ for <i>Ceriodaphnia</i> (%)				4.2		0	4	100
LC ₅₀ for fathead minnows (%)				4.2		0	4	100
Copper, total		0.07	0.11			0	24	100
Iron, total		1.0	1.0			0	24	100
NOEC for <i>Ceriodaphnia</i> (%)				1.3		0	0 ^d	100
NOEC for fathead minnows (%)				1.3		0	0 ^d	100
Oil and grease		10	15			0	52	100
pH (std. units)			9.0	6		0	52	100
Selenium, total		0.22	0.95			0	24	100
Silver, total			0.008			0	24	100
Total suspended solids			50			0	52	100
Zinc, total		0.87	0.95			0	24	100

Oak Ridge Reservation

Table 5.4 (continued)

Effluent parameters ^a	Permit limits					Permit compliance		
	Monthly average (kg/d)	Daily max (kg/d)	Monthly average (mg/L)	Daily max (mg/L)	Daily min (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance ^b
X12 (Process Waste Treatment Complex)								
LC ₅₀ for <i>Ceriodaphnia</i> (%)					100	0	4	100
Cadmium, total	0.79	2.09	0.008	0.034		0	52	100
Chromium, total	5.18	8.39	0.22	0.44		0	52	100
Copper, total	6.27	10.24	0.07	0.11		0	52	100
Cyanide, total	1.97	3.64	0.008	0.046		0	4	100
Lead, total	1.3	2.09	0.028	0.69		0	52	100
Nickel, total	7.21	12.06	0.87	3.98		0	52	100
NOEC for <i>Ceriodaphnia</i> (%)					30.9	0	4	100
NOEC for fathead minnows (%)					30.9	0	4	100
Oil and grease	30.3	45.4	10	15		0	52	100
pH (std. units)				9.0	6.0	0	156	100
Silver, total	0.73	1.3		0.008		0	52	100
Temperature (°C)				30.5		0	156	100
Total toxic organics		6.45		2.13		0	12	100
Zinc, total	4.48	7.91	0.87	0.95		0	52	100
Instream chlorine monitoring points								
Total residual oxidant		0.011	0.019			0	264	100
Steam condensate outfalls								
pH (std. units)			9.0/8.5	6.0/6.5		0	12	100
Groundwater/pumpwater outfalls								
pH (std. units)			9.0/8.5	6.0/6.5		0	6	100
Cooling tower blowdown outfalls								
pH (std. units)			9.0	6.0		0	4	100
Category I outfalls								
pH (std. units)			9.0	6.0		0	19	100
Category II outfalls								
pH (std. units)			9.0	6.0		0	20	100
Category III outfalls								
pH (std. units)			9.0	6.0		0	49	100
Category IV outfalls								
pH (std. units)			9.0	6.0		0	331	100
Cooling tower blowdown/ cooling water outfalls								
pH (std. units)			9.0	6.0		0	48	100
Total residual oxidant		0.011	0.019			0	48	100

^aLC₅₀ = the concentration (as a percentage of full-strength wastewater) that kills 50% of the test species in 96 h.

NOEC = no-observed-effect concentration; the concentration as a percentage of full-strength wastewater that caused no reduction in *Ceriodaphnia* survival or reproduction or fathead minnow survival or growth.

^bPercentage compliance = 100 – [(number of noncompliances/number of samples) × 100].

^c*Ceriodaphnia* reproduction was statistically lower than the control at all concentrations for the sample collected at X01 in May 2006. A confirmatory sample was collected later in the month and the results were within permit requirements.

^dInsufficient discharge for chronic test and determination of NOEC for each of the quarterly tests.

Table 5.5. ORNL National Pollutant Discharge Elimination System Radiological Monitoring Plan

Location	Frequency	Gross alpha ^a	Gross beta ^a	Gamma scan	Tritium	Total rad Sr	Isotopic uranium	Carbon - 14
Outfall 001	Annually	X						
Outfall 080	Monthly	X	X	X	X	X		
Outfall 081	Annually		X					
Outfall 085	Quarterly	X	X			X	X	
Outfall 086 ^b	When discharges		X		X			
Outfall 087	Annually		X	X				
Outfall 203	Annually		X					
Outfall 204	Quarterly	X	X			X		
Outfall 205	Annually		X					
Outfall 207	Quarterly	X	X	X		X		
Outfall 211	Quarterly		X			X		
Outfall 217	Annually		X					
Outfall 219	Annually		X					
Outfall 234	Annually	X						
Outfall 241 ^c	Annually		X					
Outfall 265	Annually		X	X				
Outfall 281	Quarterly	X	X	X		X		
Outfall 282	Quarterly	X	X					
Outfall 284 ^c	Annually		X					
Outfall 290 ^c	Annually			X				
Outfall 302	Monthly	X	X	X	X	X		
Outfall 304	Monthly	X	X	X	X	X		
Outfall 365	Quarterly	X	X					
Outfall 368	Quarterly	X	X	X				
Outfall 381 ^d	Quarterly		X	X		X		
Outfall 382 ^c	Annually		X	X				
Outfall 383	Annually		X			X		
Sewage Treatment Plant (X01)	Monthly	X	X		X ^f	X		X ^f
Coal Yard Runoff Treatment Facility (X02)	Monthly	X	X					
Process Waste Treatment Complex (X12)	Monthly	X	X	X	X	X	X	
Melton Branch 1 (X13)	Monthly	X	X	X	X	X		
White Oak Creek (X14)	Monthly	X	X	X	X	X		
White Oak Dam (X15)	Monthly	X	X	X	X	X		

^aIsotopic analyses are performed to identify contributors to gross activities when results exceed screening criteria described in the Radiological Monitoring Plan, June 1999.

^bOutfall no longer exists.

^cNo discharge present.

^dPhysically removed in late 2004; eliminated as part of the HFIR ponds remediation project.

^eNo longer discharges (plugged).

^fAdded to the plan in January 2006.

and 304) and at in-stream sampling locations X13 and X15 (Fig. 5.7). Four percent of the DCG is roughly equivalent to the 4-mrem dose limit on which the EPA radionuclide drinking water standards are based (4% of a DCG is a convenient comparison point, but it should not

be concluded that ORNL effluents or ambient waters are direct sources of drinking water). The annual average concentration of ^{89/90}Sr in the ORNL STP Discharge (outfall X01) was 12% of the DCG. Concentrations of three radionuclides measured in the discharge from the PWTC

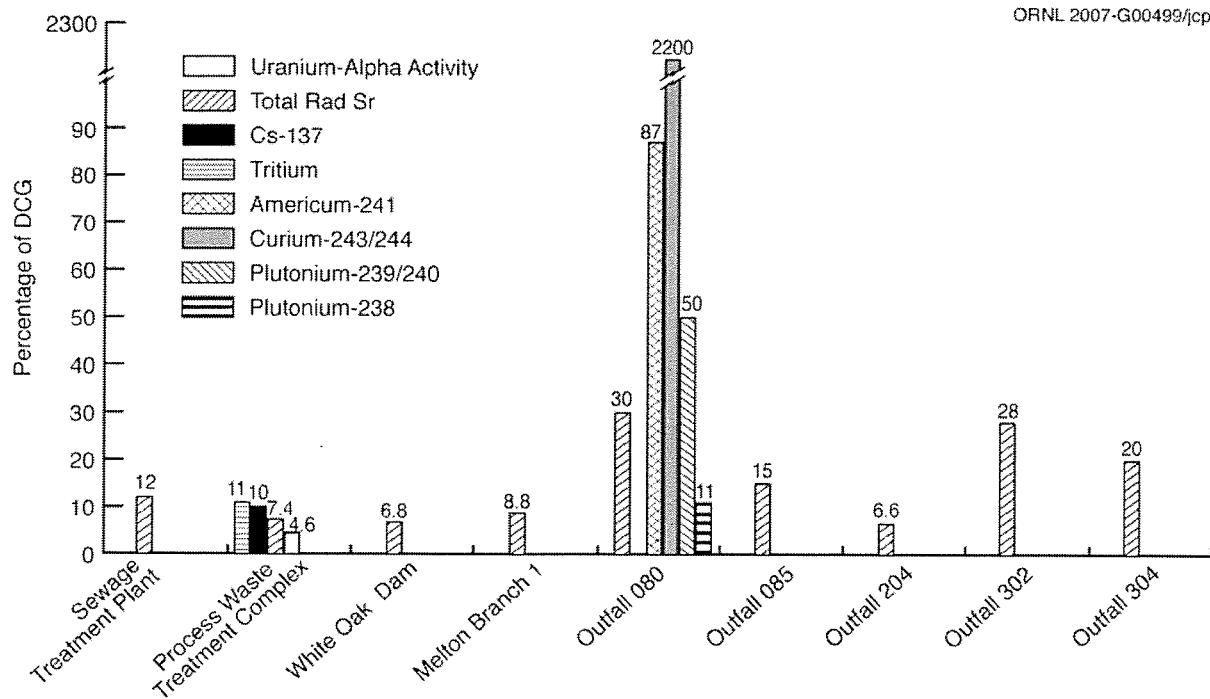


Fig. 5.7. Radionuclides at ORNL sampling sites having average concentrations greater than 4% of the relevant derived concentration guides in 2006.

(outfall X12) were greater than 4% of the DCG: ^{137}Cs (10%), $^{89/90}\text{Sr}$ (7.4%), and tritium (11%). In addition to outfall 080 discussed in the paragraph above, four category outfalls had measured concentrations of a parameter that were greater than 4% of a DCG: outfall 085 ($^{89/90}\text{Sr}$, 15%), outfall 204 ($^{89/90}\text{Sr}$, 6.6%), outfall 302 ($^{89/90}\text{Sr}$, 28%), and outfall 304 ($^{89/90}\text{Sr}$, 20%). At the in-stream monitoring station on Melton Branch (Location X13), $^{89/90}\text{Sr}$ was measured at 8.8% of the DCG, and at the X15 monitoring station at White Oak Dam, $^{89/90}\text{Sr}$ was measured at 6.8% of the DCG.

The amounts of radioactivity in stream water passing White Oak Dam, the final monitoring point on WOC before the stream flow leaves ORNL, were calculated from concentration and flow. The total annual discharges (or amounts) of radioactivity released at White Oak Dam during each of the past 5 years are shown in Figs. 5.8 through 5.13. The amounts of radioactivity passing this monitoring station in 2006 show a general decrease in levels from recent years, with the exception of ^{137}Cs , which is closer to the average. The reductions are presumably the result of the remediation activities in the WOC watershed.

The ORNL Radiological Monitoring Plan also includes monitoring of radioactivity at category outfalls during storm conditions. There were 102 outfalls targeted for periodic storm water sampling when the plan was developed. Since that time, two of those outfalls were physically removed (outfalls 115 and 381) and another was plugged (outfall 382). The storm water outfalls were grouped into eight different categories with the knowledge that outfalls would be moved from one category to another as storm water data were collected. The storm water categories were defined by the availability of historic data and, when data were available, by the levels of radioactivity detected in past monitoring. The goal set for storm water monitoring in the Radiological Monitoring Plan is to perform monitoring at the rate of 20 outfalls per NPDES permit year (February 3 to February 2). The plan set frequency goals rather than strict requirements because opportunities for storm water sampling depend on the weather.

Monitoring storm water runoff through NPDES-permitted outfalls for radioactivity is

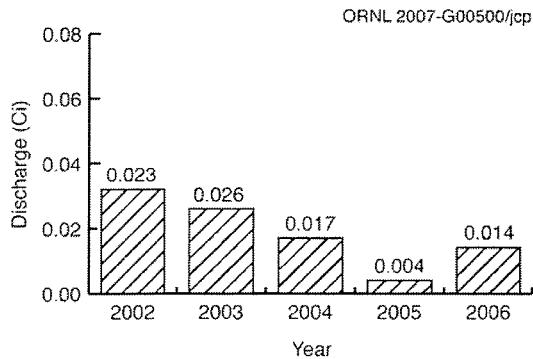


Fig. 5.8. Cobalt-60 discharges at White Oak Dam, 2002–2006.

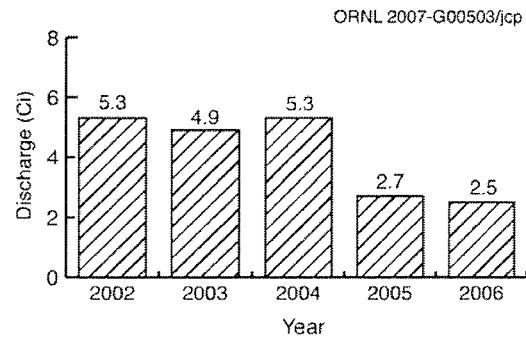


Fig. 5.11. Gross beta discharges at White Oak Dam, 2002–2006.

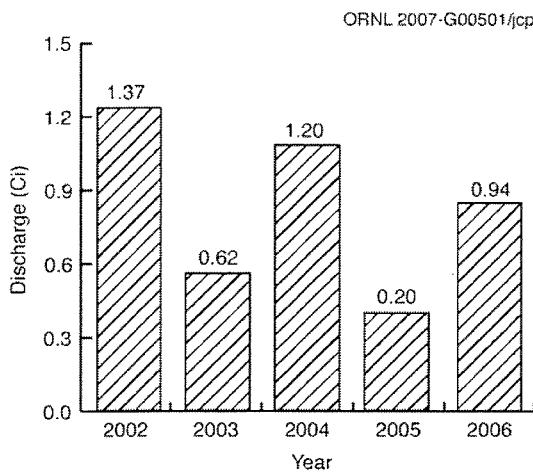


Fig. 5.9. Cesium-137 discharges at White Oak Dam, 2002–2006.

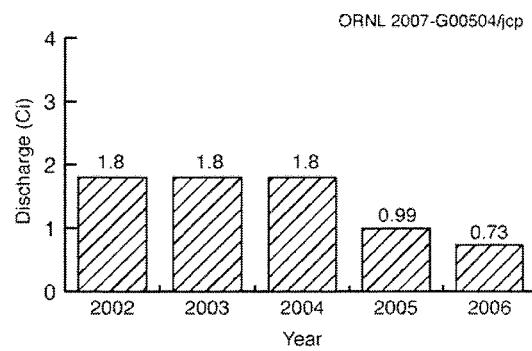


Fig. 5.12. Total radioactive strontium discharges at White Oak Dam, 2002–2006.

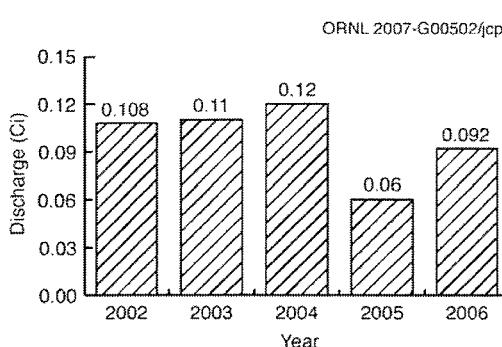


Fig. 5.10. Gross alpha discharges at White Oak Dam, 2002–2006.

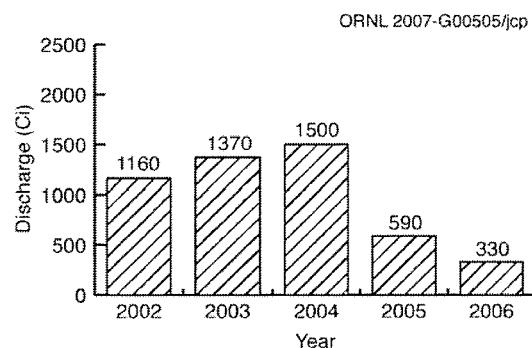


Fig. 5.13. Tritium discharges at White Oak Dam, 2002–2006.

conducted on an NPDES permit-year basis; however, storm water results are discussed on a calendar year basis in this report. A total of 24 storm water outfalls were monitored in CY 2006.

When storm water monitoring locations are selected, outfalls are chosen so that various areas of the ORNL site are represented. Storm water samples are analyzed for gross alpha, gross beta, and tritium activities. A gamma scan is also routinely performed. Under the Radiological Monitoring Plan, additional analyses are added when there is enough gross alpha and/or gross beta activity in an outfall's discharges to indicate that DCG levels may be exceeded. In 2006, additional analyses were performed on samples from one outfall—outfall 165—in an attempt to identify the radioisotopes contributing to the gross alpha activities in the sample. The gross alpha activity was found to be from uranium isotopes, particularly $^{233/234}\text{U}$.

Of the 127 individual storm water sample results collected in 2006, 94 (74%) were less than the MDAs of the tests. Concentrations of radioactivity in storm water discharges were compared with DCGs if a DCG existed for that parameter (there are no DCGs for gross alpha and gross beta activities) and if the concentration was greater than or equal to the MDA for the measurement. Two outfalls had measurements of radionuclide concentrations in storm water that were greater than 4% of DCG levels: outfall 165 ($^{89/90}\text{Sr}$, 52% and $^{233/234}\text{U}$, 4.8%) and outfall 362 (^{40}K , 5.4%).

5.4.1.2 Chlorine Control Strategy

The NPDES permit regulates the discharge of chlorinated water at ORNL by setting either total residual chlorine concentration limits or total residual oxidant mass-loading action levels, depending on outfall location and the volume of discharge. At ORNL, total residual oxidant measurements may include both chlorine and bromine residuals. Most outfalls with total residual oxidant mass-loading action levels are monitored semiannually; the rest are monitored either weekly, semimonthly, or quarterly. A number of outfalls that do not have dry-weather total residual oxidant discharges were dropped from the Chlorine Control Strategy during the duration of the NPDES permit. Outfalls included in the Chlorine Control Strategy have a mass-

loading action level for total residual oxidants that requires ORNL to reduce or eliminate total residual oxidants in the discharge if they exceed the action level. The 1.2-g/day action level is calculated by multiplying the instantaneously measured concentration by the instantaneous flow rate of the outfall.

ORNL monitored 146 measurable dry-weather discharges during 2006 at 15 outfalls. The action level was exceeded seven times at four outfalls. A report detailing monitoring results, corrective actions, and proposed modifications is submitted to TDEC annually.

5.4.1.3 Storm Water Pollution Prevention Plan

The Storm Water Pollution Prevention Plan (SWP3) is a requirement of the ORNL NPDES Permit to document existing material management practices and to evaluate the vulnerability of those practices in contributing pollutants to area streams via storm water runoff. The plan consists of four major components:

- assessment and mapping of outdoor material storage/handling at ORNL,
- characterization of storm water runoff by monitoring,
- training of employees, and
- implementation of measures to minimize storm water pollution in areas of ORNL that may be vulnerable.

These four components of the plan were initiated in 1997 and are reviewed and updated by the facility at least annually. The SWP3 was last revised in August 2006. The document is available to personnel on the ORNL internal web.

For sampling purposes, storm water outfalls are grouped into four broad categories based on common land uses or pollutant sources and storm water pollutant potential. These four groups are further subdivided based on permit categorizations that have different monitoring schedule requirements. The permit requires that Category I and II outfalls be characterized over a 5-year period and that Category III and IV outfalls be characterized over a 3-year period. The outfalls chosen to be sampled are thought to be representative of the group or were thought to be more vulnerable to runoff pollution. Other factors considered in selecting representative outfalls from each group include interest in a par-

ticular runoff quality at an outfall and ease of obtaining a representative sample. A rotation of representative outfalls occurs each sampling period as directed by the permit. The results of the storm water outfall effluent sampling as of 2006 are provided in Attachment 6.0 of the SWP3.

Various water-quality reference values are used to compare to ORNL storm water data collected under this SWP3 program for purposes of better characterizing outfalls and for targeting additional actions such as focused investigations into storm water pollution sources, monitoring, or best management practices. One such reference includes report levels adopted by the TDEC Multi-Sector General Storm Water Permit for Industrial Activities, which are developed specific to “sectors” or classifications of industrial activity. ORNL storm water data has been consistently lower than TDEC report levels for applicable sectors.

Reference values also include a summary of typical concentrations of pollutants compiled in a published study that undertook an international literature search of all storm water research that had been published in the 25 years prior to 1995 and that identified and quantified contaminant parameters. Although ORNL is an industrial setting, many attributes of its watersheds are comparable to urban watersheds such as its green spaces, traffic areas, large parking lots, office buildings, and a wide variety of potential storm water pollutants. ORNL’s storm water data generally lie in between but toward the lower end of the broad concentration ranges published in the study.

Qualitative observations from a comparison between outfall storm water data collected to date show that grab samples generally have higher concentrations of analytes than flow-proportional composite samples. This is expected since grab samples are designed to collect and characterize the “first-flush” runoff from a watershed.

The EPA Nationwide Urban Runoff Program was developed to expand the understanding of urban runoff pollution by instituting data collection and applied research projects in the urban areas of the United States. Urban stormwater runoff pollutant-loading factors for 10 standard water quality constituents, called “event mean concentrations” (EMCs), were developed for the 1983 program’s final report.

Program findings were updated in 1999 by using results of storm water data collected by the U.S. Geological Survey and the NPDES Storm Water Program to refine the EMCs.

In a comparison of recent ORNL data with data from the Nationwide Urban Runoff Program, most values for the 10 water quality constituents measured are well below the EMCs. Patterns of values exceeding the EMCs can be generalized by exceedances of copper, nitrate/nitrite, or zinc. Copper is found naturally in the soils and could also occur from coal-burning activities or corrosion of copper pipes. Nitrate is an inorganic form of nitrogen in water solution that can be attributed to the breakdown of many nitrogen-bearing sources (fertilizers, organic decay, etc.). Zinc can be attributed to vehicular degradation. There were also a few exceedances of suspended solids that can probably be attributed to the numerous construction projects in and around the main ORNL campus.

5.4.2 Results and Progress in Implementing Programs and Corrective Actions: ORNL Sink and Drain Survey Program

In 1997, ORNL completed a comprehensive verification of the routing of all wastewater discharges from points of entry such as sinks and floor drains. As a result, more than 9000 sink and drain records were produced and are stored in a central database. In 2006, an annual division-by-division recertification of ORNL sinks and drains was continued to ensure discharges are routed to the proper wastewater collection systems. Program management continues to communicate sink and drain responsibilities to the ORNL site population.

5.5 ORNL Wastewater Biomonitoring

Under the NPDES permit, wastewaters from the STP, the Steam Plant Wastewater Treatment Facility (SPWTF: the former CYRTF), and the PWTC were evaluated for toxicity. The results of the toxicity tests of wastewaters from the three treatment facilities are given in Table 5.6, which provides, for each wastewater location, the month the test was conducted, the waste-

water's no-observed-effect concentration (NOEC), and the concentration that kills 50% of the test organisms (LC₅₀) for fathead minnows (*Pimephales promelas*) and daphnia (*Ceriodaphnia dubia*). The NOEC is the highest concentration tested that does not significantly reduce survival or growth of fathead minnows or survival or reproduction of *Ceriodaphnia*. The 96-h LC₅₀ is the concentration of wastewater that kills 50% of the test organisms in 96 h. The NPDES permit defines the limits for the bio-monitoring tests. For the outfall X01 (STP) discharge, toxicity is demonstrated if more than 50% lethality of the test organisms occurs in 96 h in 41.1% effluent or if the NOEC is less than 12.3%. For the outfall X02 discharge (SPWTF), toxicity is demonstrated if more than 50% lethality of the test organisms occurs in 96 h in 4.2% effluent or if the NOEC is less than 1.3%. Because of the batch mode of discharge at the SPWTF, the limit for the NOEC applies only if the facility discharges for a sufficient length of time. For the outfall X12 discharge (PWTC), toxicity is demonstrated if more than 50% lethality of the test organisms occurs in 96 h in 100% effluent (LC₅₀) or if the NOEC is less than 30.9%.

During 2006, the STP, SPWTF, and PWTC were each tested four times. Numeric biomonitoring limits in the NPDES permit were met in all cases except the initial *Ceriodaphnia* test conducted on STP wastewater in May 2006. Toxicity was not detected in the confirmatory re-testing of the STP required by the permit.

5.6 ORNL Biological Monitoring and Abatement Program

As a condition of the NPDES permit issued to ORNL in April 1986, the Biological Monitoring and Abatement Program (BMAP) was established to assess the condition of aquatic life in WOC, the Northwest Tributary of WOC, Melton Branch, Fifth Creek, and First Creek (Loar et al. 1991); the BMAP continued as a condition of the most recent NPDES permit that was effective February 3, 1997 (Kszos et al. 1997). The program addresses the following objectives as described in the NPDES permit part III (I):

- Temperature loadings shall be within state water criteria for protection of fish and aquatic life for warm summer conditions. This should be verified and reported annually (see Table 5.4).
- In-stream water analysis for mercury shall be part of the BMAP so that it can be determined whether mercury at the site is being contributed to the stream and, if so, whether it will impact fish and aquatic life or violate the recreation criteria.
- Sediment and oil and grease from storm discharges shall not create stream impacts.
- The status of PCB contamination in fish tissue in the WOC watershed shall be determined.
- The Chlorine Control Strategy's protection of the stream in the main plant area shall be assessed.

In addition to the above objectives, the BMAP conducts ecological assessments of and data collection for the receiving streams throughout the duration of the permit as appropriate. The results for bioaccumulation and macroinvertebrate and fish community studies in the WOC watershed for the BMAP in 2006 are summarized in the following sections.

5.6.1 Bioaccumulation Studies

The bioaccumulation task for the BMAP addresses two NPDES permit requirements at ORNL: (1) evaluate whether mercury (Hg) at the site is contributing to a stream so that it will impact fish and aquatic life or violate the recreational criteria (in-stream water analyses for mercury should be part of this activity), and (2) monitor the status of PCB contamination in fish tissue in the WOC watershed.

5.6.1.1 Mercury in Water

Water samples were collected from WOC at four sites on six occasions in 2006. Stream conditions were representative of seasonal baseflow conditions (dry weather, clear flow) at the time of the sampling on all dates. However, very heavy rainfall occurred three days before the September sampling event.

Mercury concentrations exceeded the Tennessee water quality standard (51 ng/L) at

Table 5.6. Toxicity test results of ORNL wastewaters, 2006

Test date	Test species	NOEC ^a	LC ₅₀ ^b
Sewage Treatment Plant (outfall X01)			
January	<i>Ceriodaphnia</i>	41.1	>41.1
	Fathead minnow	41.1	>41.1
May	<i>Ceriodaphnia</i>	<9.8	>41.1
	<i>Ceriodaphnia</i> (confirmatory re-test)	41.1	>41.1
	Fathead minnow	41.1	>41.1
August	<i>Ceriodaphnia</i>	41.1	>41.1
	Fathead minnow	41.1	>41.1
November	<i>Ceriodaphnia</i>	41.1	>41.1
	Fathead minnow	41.1	>41.1
Steam Plant Wastewater Treatment Facility (outfall X02)			
January	<i>Ceriodaphnia</i>	NA ^c	>4.2 ^d
	Fathead minnow	NA ^c	>4.2 ^d
May	<i>Ceriodaphnia</i>	NA ^c	>4.2 ^d
	Fathead minnow	NA ^c	>4.2 ^d
August	<i>Ceriodaphnia</i>	NA ^c	>4.2 ^d
	Fathead minnow	NA ^c	>4.2 ^d
November	<i>Ceriodaphnia</i>	NA ^c	>4.2 ^d
	Fathead minnow	NA ^c	>4.2 ^d
Process Waste Treatment Complex (outfall X12)			
January	<i>Ceriodaphnia</i>	100	>100
	Fathead minnow	100	>100
May	<i>Ceriodaphnia</i>	100	>100
	Fathead minnow	100	>100
August	<i>Ceriodaphnia</i>	100	>100
	Fathead minnow	100	>100
November	<i>Ceriodaphnia</i>	100	>100
	Fathead minnow	30.9	>100

^aNOEC = no-observed-effect concentration; the concentration (as percentage of full-strength wastewater) that caused no reduction in *Ceriodaphnia* survival or reproduction or fathead minnow survival or growth.

^bLC₅₀ = the concentration (as percentage of full-strength wastewater) that kills 50% of the test species in 96 h.

^cInsufficient duration of discharge for chronic test and determination of NOEC.

^d48-h LC₅₀.

White Oak Creek kilometer (WCK) 4.1 (Monitoring Station 3619) on all six dates and WCK 3.4 (weir at Melton Valley Road) on three (Fig. 5.14). The longitudinal pattern of Hg concentration in WOC observed in the most recent monitoring continued to resemble the historical pattern, with highest concentrations occurring at the site nearest source areas. Total Hg concentration in White Oak Lake is heavily influenced by resuspension of sediments, as well as, upstream inputs. Long-term trends show little evidence of an increase or decrease in the last six years.

Bioaccumulation

Fish were collected for contaminant analysis on April 7, 2006, and May 11, 2006. To provide data directly applicable to assessing human health concerns, redbreast sunfish (*Lepomis auritus*) were collected from WCK 2.9, and bluegill sunfish (*Lepomis macrochirus*) and largemouth bass (*Micropterus salmoides*) were collected from White Oak Lake (WCK 1.5). Collections were restricted to fish of a size large enough to be kept by sport fishermen (> 50 g for sunfish, and > 500 g for bass). Fillet tissue was taken from six individual fish of each species for both Hg and PCB analysis. The stoneroller

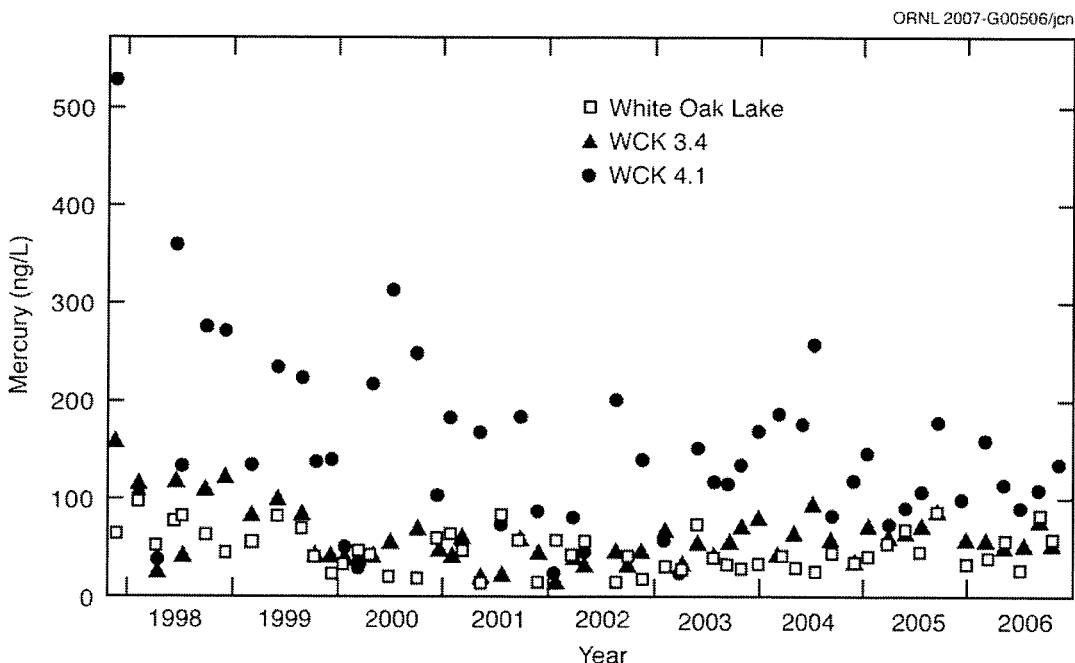


Fig. 5.14. Total aqueous mercury concentrations at sites in White Oak Creek downstream from ORNL, 1998–2006.

minnow (*Campostoma oligolepis*) is a forage species that readily accumulates particle-associated contaminants such as PCBs. Specimens were collected at WCK 3.9 to provide a measure of the possible exposure of fish-eating wildlife to PCBs. For stonerollers, 10 whole-body fish comprised each of 3 composite samples.

Mercury. Mean total Hg concentrations in WOC fish collected in 2006 are reported in Table 5.7. Average Hg concentrations in redbreast sunfish from WCK 2.9 were approximately five-fold higher ($0.51 \pm 0.06 \mu\text{g/g}$) than in redbreast sunfish from Hinds Creek ($0.08 \pm 0.02 \mu\text{g/g}$). Concentrations of Hg in bluegill collected further downstream in White Oak Lake were far lower than at the upstream site, with Hg concentrations approaching those at the reference stream ($0.10 \pm 0.00 \mu\text{g/g}$). Concentrations of Hg in largemouth bass from White Oak Lake reflected their higher position in the food chain, averaging $0.31 \pm 0.06 \mu\text{g/g}$. Nine (of 18) fish from the WOC watershed exceeded $0.5 \mu\text{g/g}$, the Hg level currently used by the state of Tennessee in issuing fish consumption advisories. All six redbreast sunfish from WCK 2.9, and 3 of 6 largemouth bass from White Oak Lake attained or exceeded the EPA Hg fish tissue criterion for

methylmercury of 0.3 mg/kg (ppm) ; no bluegill collected from White Oak Lake in 2006 exceeded this level.

Compared with 2005, mean total Hg concentrations in fish were slightly lower in 2006 in White Oak Lake, but higher at WOC sites (Fig. 5.15). Since 1998, a modest increase in Hg concentrations in fish (1.5 to 2-fold) continues, particularly at WCK 2.9.

PCBs. Mean PCB concentrations in WOC fish collected in 2006 are reported in Table 5.7. The mean PCB concentrations in sunfish from WCK 2.9 and White Oak Lake were $0.28 \pm 0.04 \mu\text{g/g}$ and $0.34 \pm 0.06 \mu\text{g/g}$, respectively. Such levels of PCBs are relatively high for short-lived, lipid-poor fish such as sunfish. Largemouth bass from White Oak Lake typically have substantially higher levels of PCBs, and averaged $1.21 \pm 0.30 \mu\text{g/g}$ in 2006. Reference site sunfish analyzed concurrently had average PCB concentrations of $< 0.01 \mu\text{g/g}$. PCB concentrations in stonerollers collected near the main ORNL Campus averaged $1.17 \pm 0.33 \mu\text{g/g}$. Although resuspension of sediments in White Oak Lake and food chain factors undoubtedly affect PCB levels in largemouth bass, the presence of high concentrations of PCBs in stonerollers in

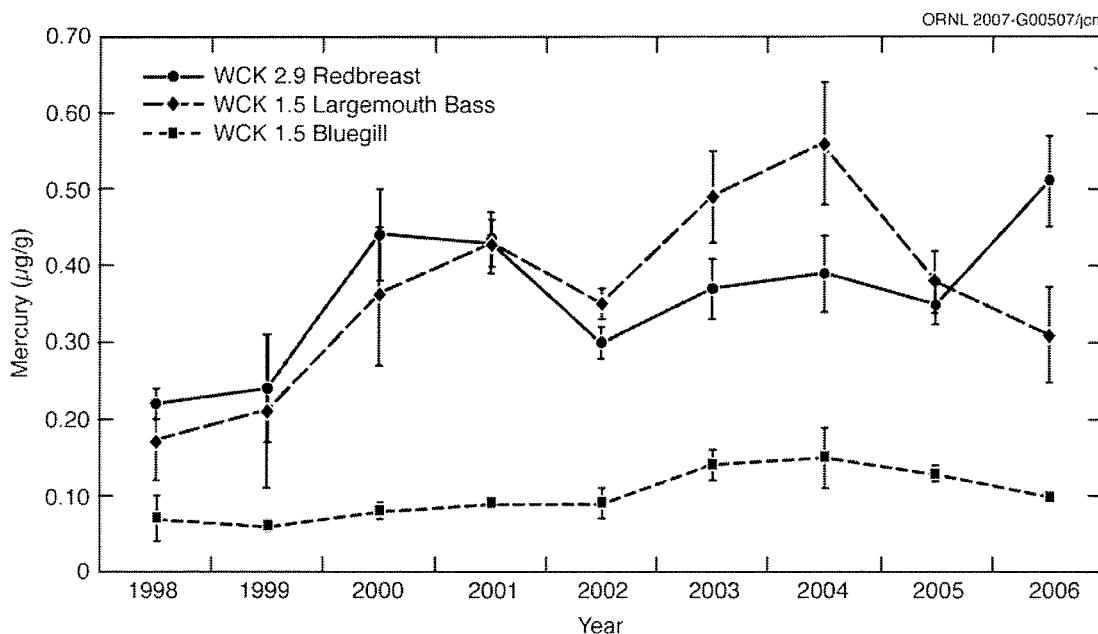


Fig. 5.15. Mean mercury concentrations ($\mu\text{g/g}$, $\pm \text{SE}$) in fish fillets collected from the WOC watershed, 1998–2006.

^aTable 5.7. Total mercury and PCB (Aroclor 1254 + 1260) concentrations in fish (mean $\pm \text{SE}$; range in parenthesis) from sites in White Oak Creek and a reference stream, Hinds Creek, April 2006^a

Site ^b	Species ^c	Mercury ($\mu\text{g/g}$)	PCBs ($\mu\text{g/g}$) ^d
WCK 3.5	Stoneroller	Not analyzed	1.17 \pm 0.33
	Redbreast sunfish	0.32 \pm 0.03 (0.22 - 0.41)	0.18 \pm 0.08 (0.06 - 0.56)
WCK 2.9	Redbreast sunfish	0.51 \pm 0.06 (0.34 - 0.66)	0.28 \pm 0.04 (0.11 - 0.36)
	Bluegill	0.10 \pm 0.00 (0.09 - 0.11)	0.34 \pm 0.06 (0.16 - 0.58)
WOL	Largemouth bass	0.31 \pm 0.06 (0.12 - 0.16)	1.21 \pm 0.30 (0.53 - 2.30)
WCK 3.8	Stoneroller	Not analyzed	<0.01
Hinds Creek	Redbreast sunfish	0.08 \pm 0.02 (0.02 - 0.16)	<0.01

^aN = 6 individual fish for each site/species combination, and samples are of fillets only. Stoneroller samples are mean $\pm \text{SE}$ of three 10-fish composites.

^bWCK = White Oak Creek kilometer; WOL = White Oak Lake.

^cLargemouth bass (*Micropterus salmoides*), bluegill sunfish (*Lepomis macrochirus*), redbreast sunfish (*Lepomis auritus*), and stoneroller (*Campostoma oligolepis*).

^dPCB = polychlorinated biphenyl.

WOC near ORNL indicates the likelihood of continuing inputs into the stream.

Mean PCB concentrations in 2006 were lower than in 2005 at both sites in all species but

were well within the historical range (Fig. 5.16). The dramatic year-to-year differences in largemouth bass (Fig. 5.16) concentrations are most likely due to annual changes in prey. Gizzard

shad and bluegill are favorite prey species for bass but differ greatly in their PCB concentrations (shad are lipid rich and can accumulate higher levels of PCBs).

5.6.2.1 Benthic Macroinvertebrate Communities

Monitoring of the benthic macroinvertebrate communities in WOC, First Creek, and Fifth Creek continued in 2006. Benthic macroinvertebrate samples are collected at sites upstream and downstream of the influence of ORNL operations. These sites include impacted and unimpacted (reference site) locations. The objectives of this activity are to (1) help assess ORNL's compliance with the current NPDES permit requirements and (2) evaluate and verify the effectiveness of pollution abatement and remedial actions taken at ORNL.

The benthic macroinvertebrate communities in First Creek, Fifth Creek, and WOC downstream of effluent discharges have recovered significantly since 1986, but community characteristics indicate that ecological impairment remains (Figs. 5.17, 5.18, and 5.19). Relative to reference sites, total taxonomic richness and richness of the pollution-intolerant taxa (i.e., Ephemeroptera, Plecoptera, and Trichoptera [EPT] richness) continue to be low at sites adjacent to and downstream of the main ORNL Campus. Except for First Creek, trends in annual changes in total and EPT taxa richness at downstream sites over the past 5 years have generally been similar to those at the reference sites, suggesting that no unusual changes have occurred. While both metrics increased at First Creek kilometer (FCK) 0.1 and decreased at FCK 0.8, values at both sites were within their historic ranges observed during the past five years, suggesting that like the downstream sites in WOC and Fifth Creek, the macroinvertebrate community in lower First Creek also remains stable.

Samples collected from Melton Branch at Melton Branch kilometer (MEK) 0.6 in April 2006 using routine ORNL protocols, and a sample collected from that site in August 2006 using TDEC protocols were processed in FY 2006; results are presented in Table 5.8. Since this sta-

tion is currently the only one in WOC watershed monitored with TDEC protocols, the results were compared with results from other nearby streams on the ORR that are monitored for other projects to put them into better perspective with conditions in this geographic area (Table 5.8). Results of samples collected in April 2006 following BMAP protocols suggested that the condition of the macroinvertebrate community at MEK 0.6 compared favorably with the macroinvertebrate communities in nearby reference streams and McCoy Branch. McCoy Branch is a small stream located in Bethel Valley just east of ORNL. Since major abatement actions were taken in the early 1990s to improve that stream's water quality, the macroinvertebrate community has recovered significantly (Smith 2003). The Biotic Index score calculated following TDEC protocols gave a slightly different result from the results obtained with ORNL protocols. Based on TDEC protocols, the macroinvertebrate community at MEK 0.6 is slightly impaired, and as such, would be classified by the state as partially supportive of healthy biological conditions. Biotic Index scores for slightly impaired conditions range from 21 to 31, thus, the score for MEK 0.6 was only slightly lower than scores classified by TDEC as indicative of nonimpaired conditions (i.e., ~32). Comparison of results for MEK 0.6 with those for a stream in Bear Creek Valley that also has been subjected to major stream channel restoration efforts within the past 5 years (i.e., NT3), suggests that recovery of MEK 0.6 has progressed at a faster rate (Table 5.8).

5.6.2.2 Fish Communities

Monitoring of the fish communities in WOC and its major tributaries continued in 2006. Samples were taken at nine sites in WOC watershed in the spring and fall. Mill Branch, a stream located on the north side of Pine Ridge within the city of Oak Ridge, was also sampled as a reference site.

In WOC, the fish community continued to display characteristics of degraded conditions,

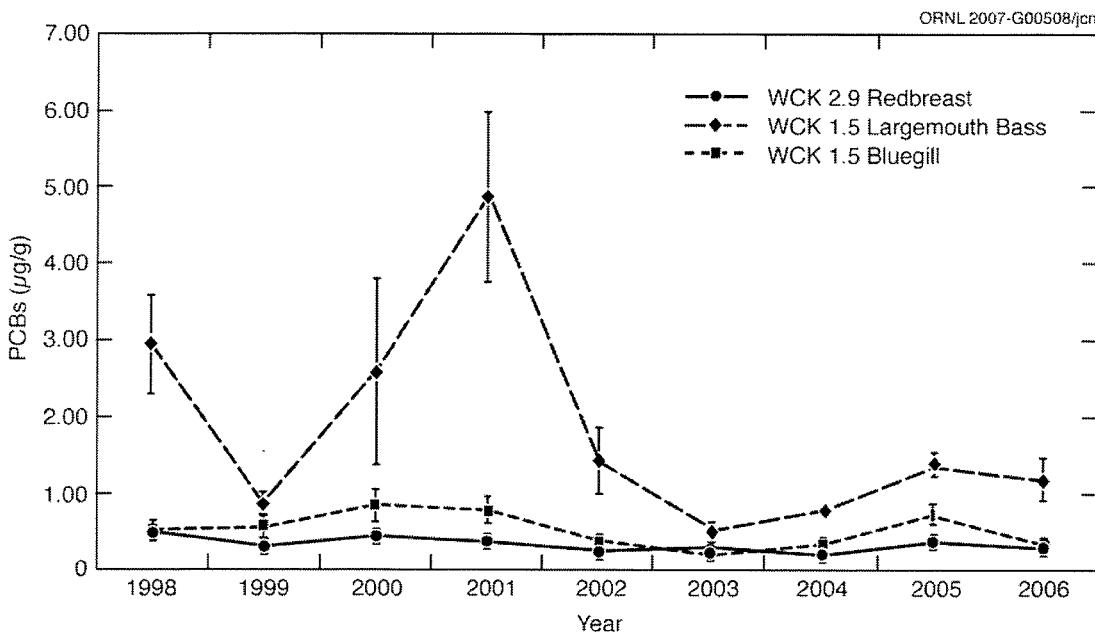


Fig. 5.16. Mean total PCB concentrations ($\mu\text{g/g}$, $\pm \text{SE}$) in largemouth bass and sunfish fillets collected from the WOC watershed, 1998–2006.

with sites closest to the outfalls having lower species richness (number of species), fewer pollution-sensitive species, more pollution-tolerant species, and elevated density (number of fish per square meter) compared with similar-sized reference streams. After decreasing in the early 2000s, densities at WOC sites have generally stabilized over the past couple of years, although at most sites they remain ~ 2 times higher than at the respective reference site (Fig. 5.20). In the past, these sites had very high densities (~ 14 – 17 fish/ m^2) that were at least tenfold higher than at reference sites. Often in recovering streams, as fish density declines, species richness will increase, reflecting an overall improvement. However, in WOC, there has not been a corresponding increase in species richness as density has decreased. The low species richness seen in WOC watershed, relative to off-site reference locations, is partially a result of barriers that limit immigration of new species from the Clinch River drainage.

Generally, the fish communities in tributary sites adjacent to and downstream of ORNL outfalls remained somewhat impacted in 2005 relative to reference streams or upstream sites. Species richness of fish in tributaries to WOC remained slightly lower in 2005 relative to reference streams not in the WOC watershed. The

primary difference between these tributaries and their reference streams is the absence of pollution-sensitive species, such as darters, from the tributaries. The density of fish community in First Creek showed little change in 2006 relative to 2005 (Fig. 5.21), and the density in Fifth Creek continues to fluctuate considerably, especially in lower Fifth Creek (FFK 0.2; Fig. 5.22). Compared with previous years, fish density in Melton Branch (Melton Branch kilometer 1.4) has been higher in the most recent sampling periods (Fig. 5.23).

5.7 ORNL Surface Water Monitoring at NPDES Reference Location

WOC headwaters were monitored in 2006 as a reference location for ORNL NPDES surface water monitoring.

In an effort to provide a basis for evaluation of analytical results and for assessment of non-radiological surface water quality, Tennessee general water quality criteria (TDEC 2004) have been used as reference values. The criteria for fish and aquatic life have been used at WOC headwaters. [See Appendix D, Table D.2, for Tennessee General Water Quality Criteria for all parameters in water. See Tables 2.3 and 3.4

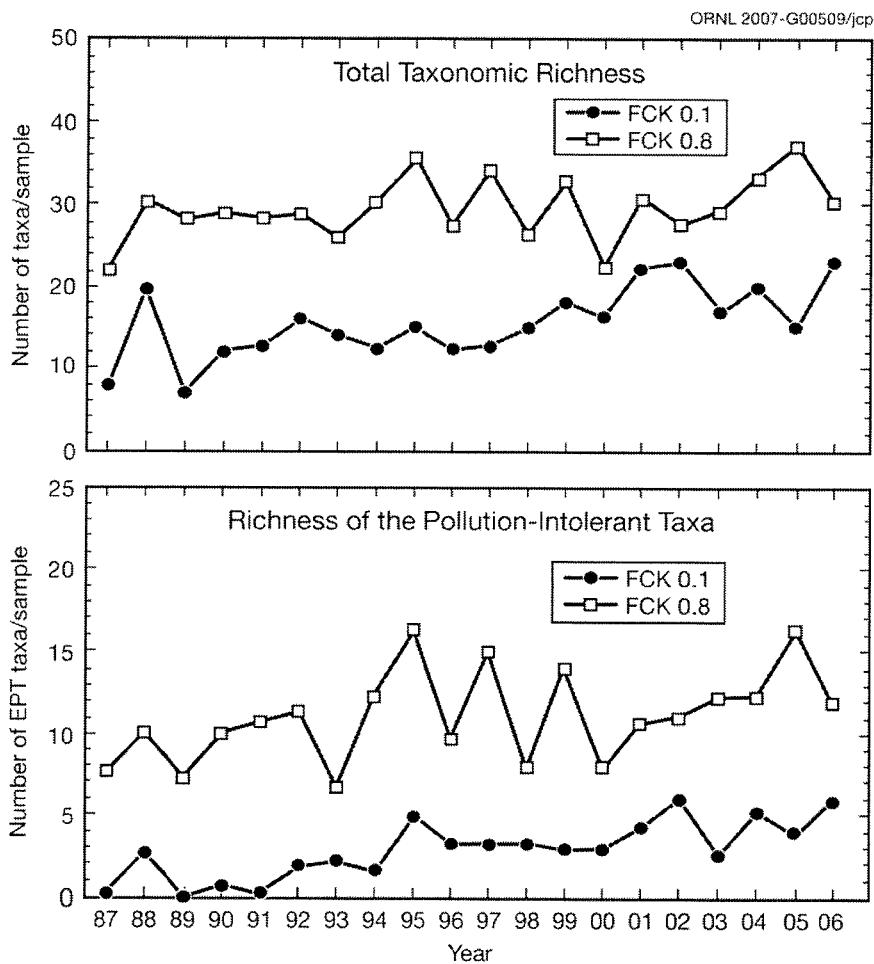


Fig. 5.17. Taxonomic richness (top) and richness of the pollution-intolerant taxa (bottom) of the benthic macroinvertebrate community in First Creek, April sampling periods, 1987–2006. (FCK = First Creek kilometer; EPT = Ephemeroptera, Plecoptera, and Trichoptera; FCK 0.8 = reference site.)

in *Environmental Monitoring on the Oak Ridge Reservation: 2006 Results* (DOE 2007b) for surface water analyses.

5.8 ORNL Surface Water Surveillance Monitoring

The ORNL surface water monitoring program includes sample collection and analysis from 18 locations at ORNL and around the ORR. This program is conducted in conjunction with the ORR surface water monitoring activities discussed in Sect. 7.4 to enable assessing the impacts of past and current DOE operations on the quality of local surface water. These pro-

grams are conducted in addition to surface water monitoring required by NPDES permits at ORNL facilities; sampling location, frequency, and analytical parameters vary among them. Sampling locations include streams downstream of ORNL waste sources, reference points on streams and reservoirs upstream of waste sources, and public water intakes (see Fig. 5.24).

Sampling frequency and parameters vary by site. Grab samples are collected and analyzed for general water quality parameters at all locations and all are screened for radioactivity and analyzed for specific radionuclides when appropriate. Samples from White Oak Lake at White Oak Dam are also checked for volatile organic

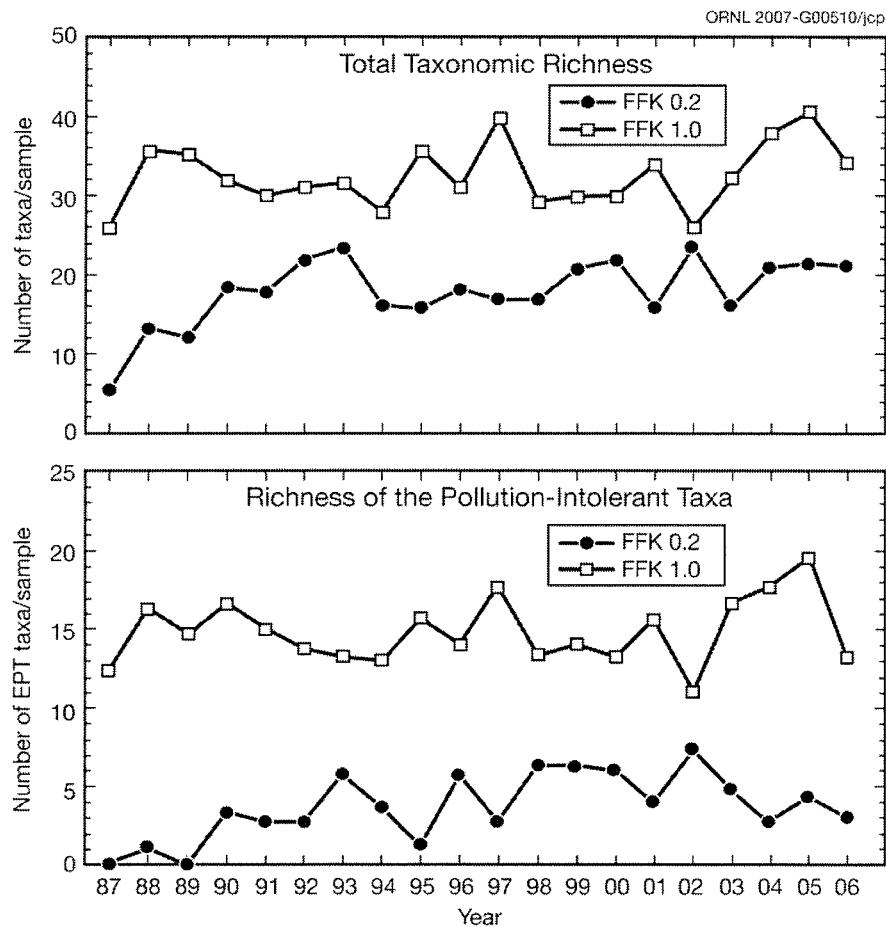


Fig. 5.18. Taxonomic richness (top) and richness of the pollution-intolerant taxa (bottom) of the benthic macroinvertebrate community in Fifth Creek, April sampling periods, 1987–2006. (FFK = Fifth Creek kilometer; EPT = Ephemeroptera, Plecoptera, and Trichoptera; FFK 1.0 = reference site.)

compounds (VOCs), PCBs, and metals. Table 5.9 lists the specific locations and their sampling frequencies and parameters.

Ten of the 18 sampling locations are classified by the state of Tennessee for certain uses (e.g., domestic water supplies or recreational use). Tennessee water quality criteria for domestic water supplies, for freshwater fish and aquatic life, and for recreation (water and organisms) are used as references for locations where applicable (TDEC 2004). The Tennessee water quality criteria do not include criteria for radionuclides. Four percent of the DOE derived concentration guide (DCG) is used for radionuclide comparison because this value is roughly

equivalent to the 4-mrem dose limit from ingestion of drinking water on which the EPA radionuclide drinking water standards are based.

5.8.1 Results

Radionuclides were detected above MDAs at all surface water locations in 2006. The levels of gross beta, total radioactive strontium, and tritium continue to be highest at Melton Branch kilometer (MEK) 0.2, WOC at White Oak Dam (WCK 1.0), and WCK 2.6. These data are consistent with historical data and with the processes or legacy activities nearby or upstream from these locations.

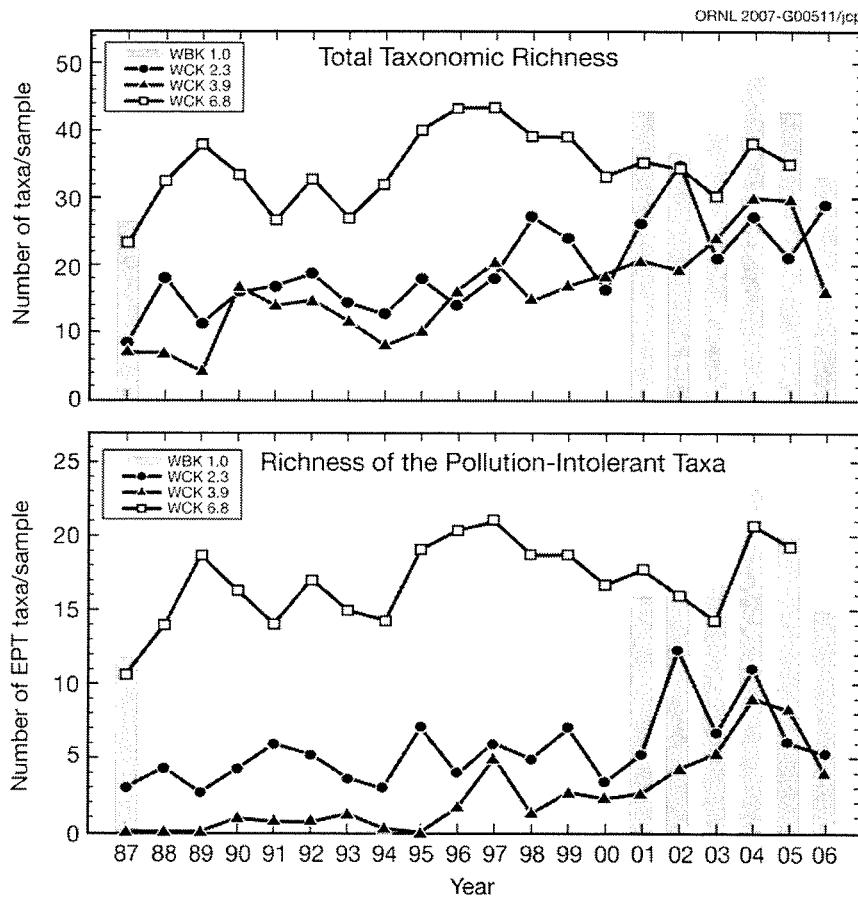


Fig. 5.19. Taxonomic richness (top) and richness of the pollution-intolerant taxa (bottom) of the benthic macroinvertebrate communities in White Oak Creek, April sampling periods, 1987–2006. (WCK = White Oak Creek kilometer; WBK = Walker Branch kilometer; EPT = Ephemeroptera, Plecoptera, and Trichoptera; WBK 1.0 = reference site.)

Remediation efforts by BJC, including removal of contaminated soil in the North Tank Farm and pumping groundwater from Well 4411 to a treatment system, have resulted in decreases in levels of gross alpha, gross beta, and total radioactive strontium at the First Creek location. Although greatly diminished from concentrations measured in the mid 1990s, the levels remain seasonally variable because of dilution in First Creek flow. Ongoing monitoring and investigations performed during the Bethel Valley Groundwater Engineering Study confirm that there is infiltration of approximately 2.5 gpm of plume water into storm drains that discharge into outfall 341, which discharges into First Creek.

The Groundwater Engineering Study has identified additional contaminated soil near the North Tank Farm that may contribute to the plume and needs to be removed for groundwater protection consistent with the Interim Record of Decision for the Bethel Valley Watershed, Oak Ridge National Laboratory, Oak Ridge, Tennessee. The Engineering Study also identified options for optimizing management of the Core Hole 8 plume.

The VOCs chloroform, bromodichloromethane, tetrachloroethene, and common laboratory contaminants acetone and methylene chloride were detected at WOC at White Oak Dam in 2006, mostly at low estimated levels.

Table 5.8. Benthic macroinvertebrate results for lower Melton Branch (MEK 0.6) in 2006
 Results from other Oak Ridge Reservation streams are included for comparison

Site ^a	BMAP protocols (April)		TDEC protocols (August) ^c	
	Total richness (no. taxa/sample)	EPT richness ^b (no. EPT taxa/sample)	Biotic Index score	Narrative rating
WOC Watershed				
MEK 0.6	38.3	17.3	30	Slightly-impaired
Bear Creek reference sites				
GHK 1.6	46.0	23.7	NS ^d	NS ^d
GHK 2.9	37.3	15.3	NS	NS
MBK 1.6	40.7	17.3	NS	NS
Bear Creek tributary				
NT3	21.7	7.3	22	Slightly-impaired
McCoy Branch				
MCK 1.4	39.0	14.7	32	Non-impaired
MCK 1.9	33.0	13.7	40	Non-impaired

^aMEK = Melton Branch kilometer; GHK = Gum Hollow Branch kilometer; MBK = Mill Branch kilometer; NT3 = Bear Creek North Tributary number 3; MCK = McCoy Branch kilometer.

^bEPT = Ephemeroptera, Plecoptera, and Trichoptera (i.e., mayflies, stoneflies, and caddisflies). EPT richness is an indicator-metric of a stream's ability to support pollution-intolerant invertebrate species, and is typically ≥ 11 in small relatively undisturbed streams on the Oak Ridge Reservation.

^cDetails of the Tennessee Department of Conservation (TDEC) protocols can be found at <http://www.state.tn.us/environment/wpc/publications/bugsop06.pdf>.

^dNS = Samples using TDEC protocols were not collected from these sites.

Two locations, one on Northwest Tributary (Northwest Tributary kilometer [NWTK] 0.1) and one on Raccoon Creek (Raccoon Creek kilometer [RCK] 2.0), also had elevated levels of gross beta and total radioactive strontium. Historically, results at both locations have a seasonal pattern; however this pattern appears to be disrupted in the past several years perhaps due to change in rainfall precipitation pattern. Both of these locations are impacted by contaminated groundwater from SWSA 3.

5.9 ORNL Sediment

Stream and lake sediments act as a record of some aspects of water quality by concentrating and storing certain contaminants. Sampling sites for sediment are the Clinch River downstream

from all DOE inputs (Clinch River kilometer [CRK] 16), the Clinch River downstream from ORNL (CRK 32), and the Clinch River at the Solway Bridge, upstream from all DOE inputs (CRK 70) (Fig. 5.25). The locations are sampled annually, and gamma scans are performed on the samples.

In addition, each year, two samples containing settleable solids are collected in conjunction with a heavy rain event to characterize sediments that exit ORNL during a storm event. The sampling locations are Melton Branch upstream from ORNL (MEK 2.1), White Oak Lake at White Oak Dam (WCK 1.0), WOC downstream from ORNL (WCK 2.6), and WOC Headwaters as a reference location (Fig. 5.25). These samples are filtered, and the residue (settleable

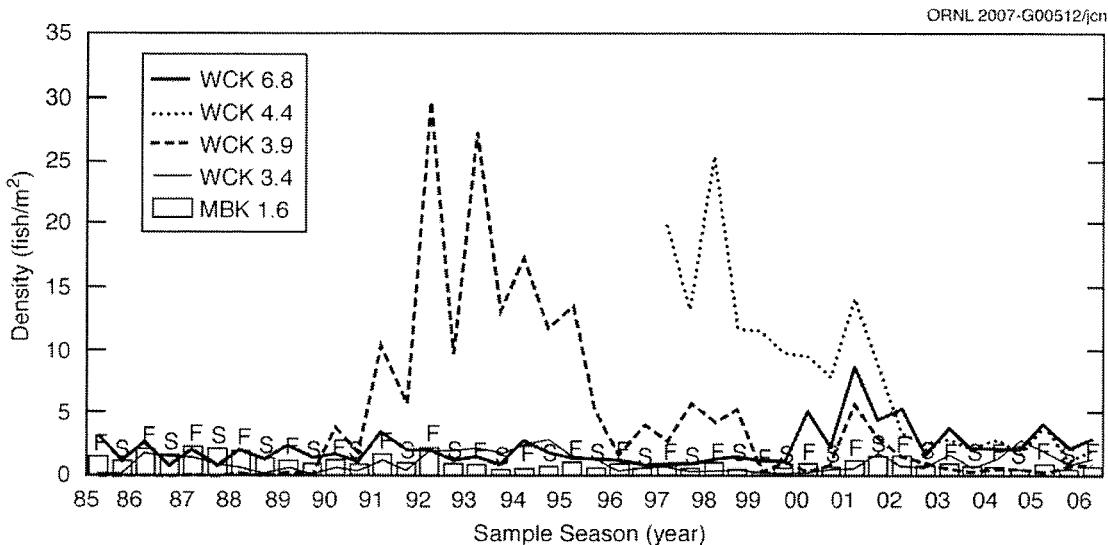


Fig. 5.20. Density (fish/m²) estimates for fish in spring and fall samples from upper White Oak Creek and from a reference site on Mill Branch (MBK 16), 1985–2006. (WCK = White Oak Creek kilometer; MBK = Mill Branch kilometer.).

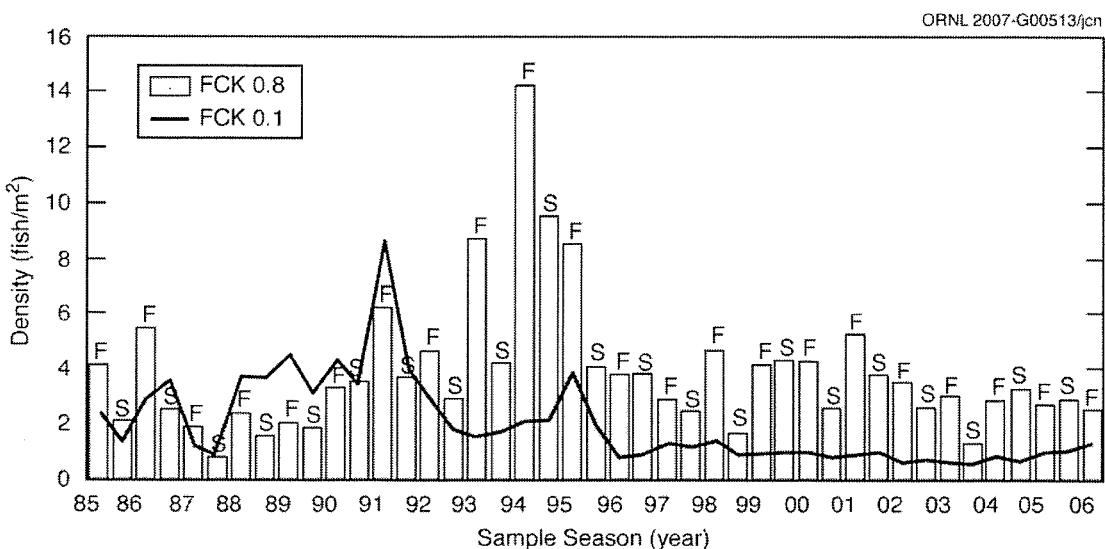


Fig. 5.21. Density (fish/m²) estimates for fish in spring and fall samples from First Creek, 1985–2006. (FCK = First Creek kilometer; FCK 0.8 is a reference site.).

solids) is analyzed for gross alpha, gross beta, and gamma emitters.

5.9.1 Results

Potassium-40, a naturally occurring radionuclide, was detected in sediments at all three locations. Cesium-137 was also detected in the samples collected at CRK 16 and CRK 32.

These radionuclide detections are consistent with historical detections in Clinch River sediment sampling programs.

Heavy-rain-event sampling took place in January and April 2006. The concentrations of radionuclides associated with each of these rain events are higher at the locations downstream of ORNL than at the upstream locations.

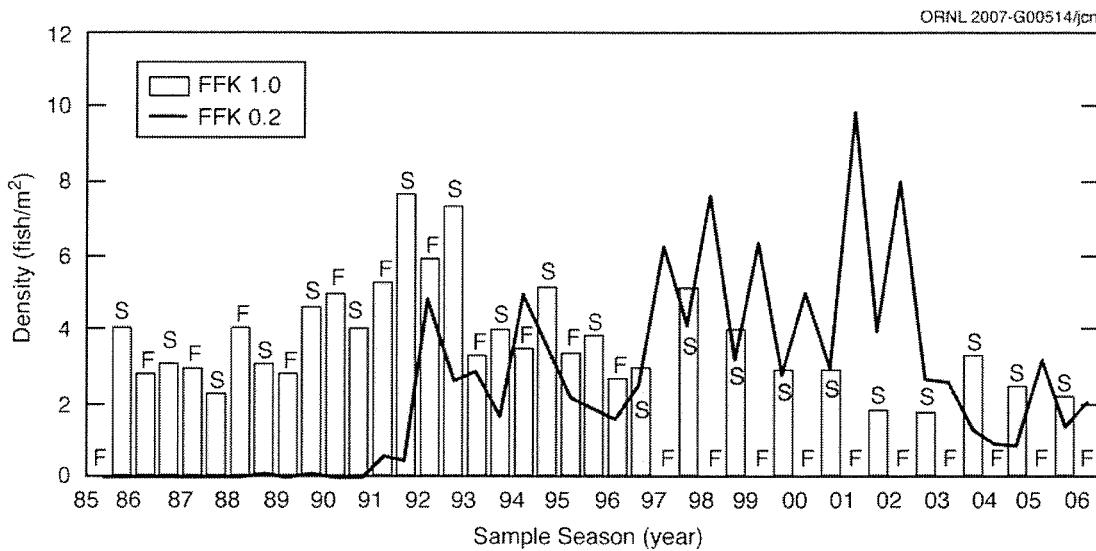


Fig. 5.22. Density (fish/m²) estimates for fish in spring and fall samples from Fifth Creek; 1985–2006. (FFK = Fifth Creek kilometer; FFK 1.0 is a reference site.)

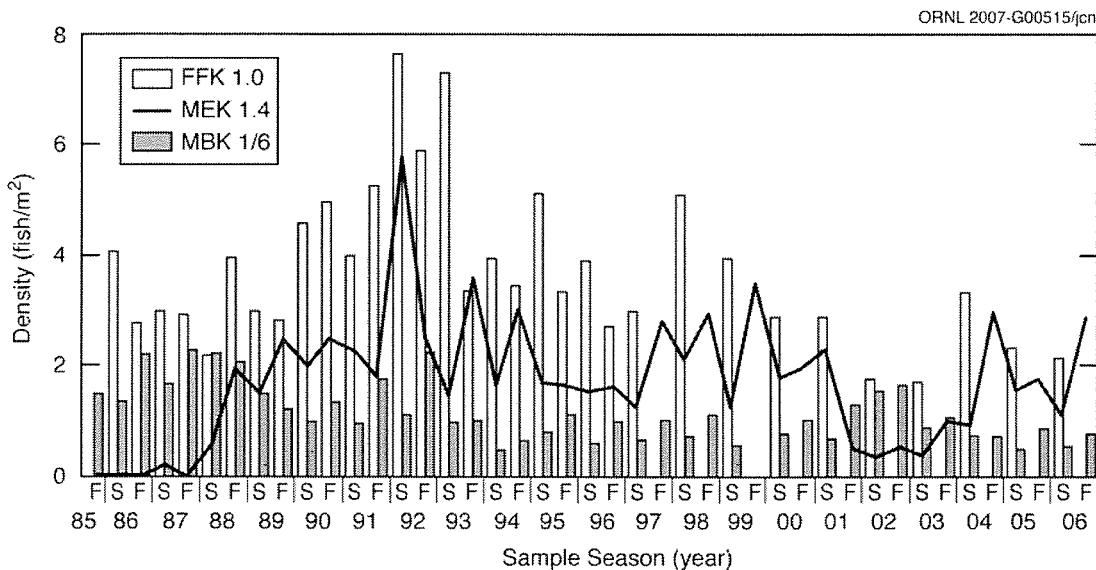


Fig. 5.23. Density (fish/m²) estimates for fish in spring and fall samples from Melton Branch, 1985–2006. (MEK = Melton Branch kilometer; Upper Fifth Creek [FFK 1.0]; and Mill Branch [MBK 1/6] are reference sites.)

5.10 Groundwater Monitoring at ORNL

5.10.1 Background

Groundwater monitoring at ORNL consisted of two programmatic components in 2006: the DOE Environmental Management and Enrichment Facilities (EMEF) groundwater monitoring

program and the DOE Office of Science (OS) groundwater monitoring surveillance program. Bechtel Jacobs Company (BJC) is the contractor responsible for monitoring conducted under the auspices of the EMEF program. Under the EMEF program, groundwater monitoring has been performed as part of a comprehensive cleanup effort, and the scope has largely been remediation effectiveness monitoring at con-

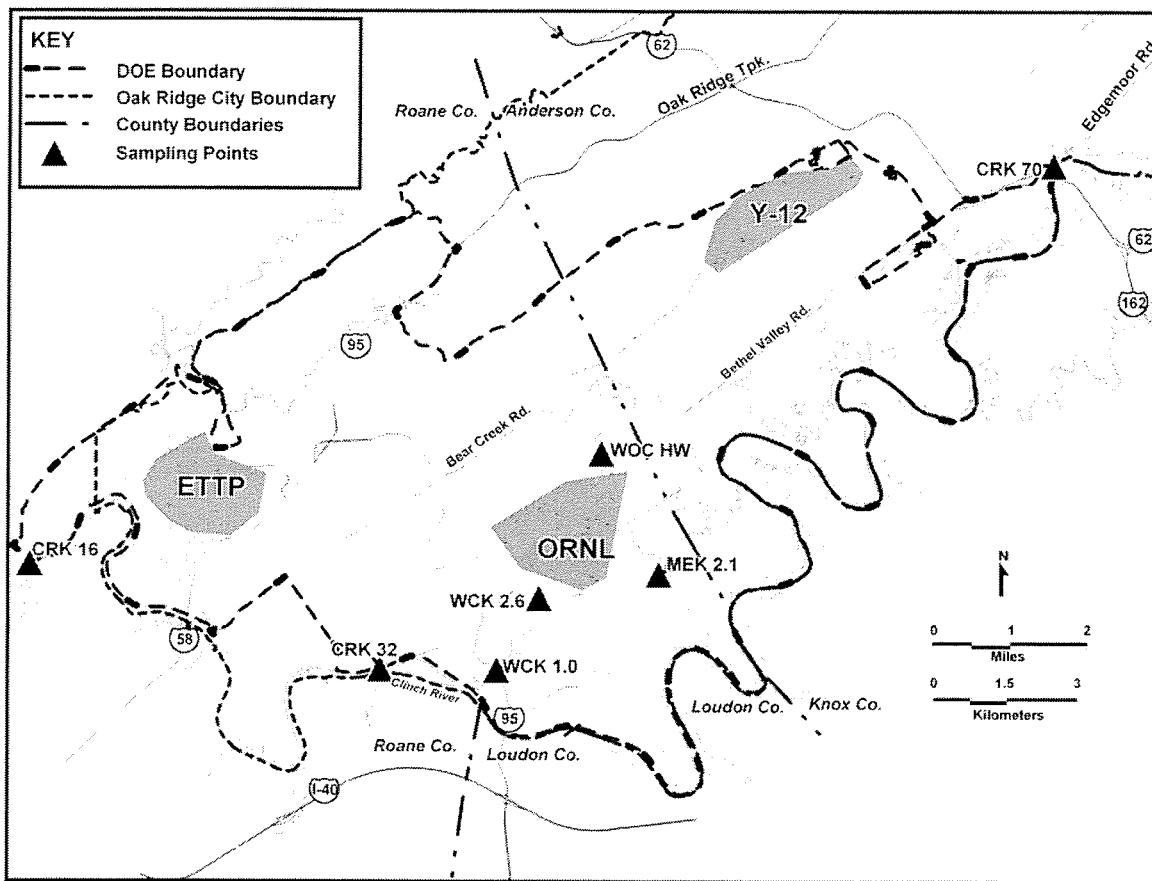


Fig. 5.24. ORNL surface water sampling locations.

taminated sites undergoing cleanup. The Water Resources Restoration Program (WRRP) has been managed by BJC for the EMEF program since its inception and is the vehicle for DOE to carry out the regulatory monitoring requirements outlined in the Federal Facility Agreement to conduct remedial action monitoring. The WRRP uses a watershed approach to environmental monitoring, which has resulted in the assignment of two watersheds to ORNL: Bethel Valley and Melton Valley. Groundwater and surface water monitoring results for remedial actions that are in progress or that have been completed during 2006 are reported annually in the EMEF Program 2006 *Remediation Effectiveness Report/Second Reservation-wide CERCLA Five Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE 2007a) (RER). In the case of waste area grouping (WAG) 6, which is regulated under

both the RCRA and the CERCLA, specific monitoring results and interpretations required by RCRA are reported in the annual *Groundwater Quality Assessment Report for Solid Waste Storage Area 6 at the Oak Ridge National Laboratory, Oak Ridge, Tennessee CY 2006* (BJC 2007b), which is also issued annually to TDEC, Division of Solid Waste Management. The OS monitoring effort is managed by UT-Battelle and has two functions: exit pathway groundwater surveillance and “active sites” groundwater surveillance monitoring. Groundwater surveillance monitoring conducted by UT-Battelle for the OS is reported herein and is the focus of this section.

From 1996 until 2004, the WAG concept was used as the basis of the OS groundwater monitoring program at ORNL. A WAG consists of multiple contaminated sites that are

Table 5.9. ORNL surface water sampling locations, frequencies, and parameters, 2006

Location ^a	Description	Frequency	Parameters
BCK 0.6	Bear Creek downstream from DOE inputs	Semiannually (April, Oct)	Gross alpha, gross beta, gamma scan, field measurements ^b
CRK 32	Clinch River downstream from ORNL	Monthly	Gross alpha, gross beta, gamma scan, total radioactive strontium, ³ H, field measurements ^b
CRK 58	Water supply intake for Knox County	Monthly	Gross alpha, gross beta, gamma scan, field measurements ^b
CRK 66	Melton Hill Reservoir above city of Oak Ridge water intake	Monthly	Gross alpha, gross beta, gamma scan, field measurements ^b
EFK 0.1	East Fork Poplar Creek prior to entering Poplar Creek	Semiannually (April, Oct)	Gross alpha, gross beta, gamma scan, field measurements ^b
EFK 5.4	East Fork Poplar Creek downstream from floodplain	Semiannually (April, Oct)	Gross alpha, gross beta, gamma scan, field measurements ^b
MEK 0.2	Melton Branch downstream from ORNL	Bimonthly (Jan, Mar, May, Jul, Sep, Nov)	Gross alpha, gross beta, gamma scan, total radioactive strontium, ³ H, field measurements ^b
WCK 1.0	White Oak Lake at White Oak Dam	Monthly	Volatiles, metals, PCBs, gross alpha, gross beta, gamma scan, total radioactive strontium, ³ H, field measurements ^b
WCK 2.6	White Oak Creek downstream from ORNL	Bimonthly (Jan, Mar, May, July, Sep, Nov)	Gross alpha, gross beta, gamma scan, total radioactive strontium, ³ H, field measurements ^b
WCK 6.8	White Oak Creek upstream from ORNL	Quarterly (Feb, May, Aug, Nov)	Gross alpha, gross beta, total radioactive strontium, gamma scan, ³ H, field measurements ^b
WBK 0.1	Walker Branch prior to entering CRK 53.4	Semiannually (April, Oct)	Gross alpha, gross beta, gamma scan, field measurements ^b
GCK 3.6	Grassy Creek upstream of SEG and IT Corp. at CRK 23	Semiannually (April, Oct)	Lead, gross alpha, gross beta, gamma scan, field measurements ^b
ICK 0.7	Ish Creek prior to entering CRK 30.8	Semiannually (April, Oct)	Gross alpha, gross beta, gamma scan, field measurements ^b
MCCBK 1.8	McCoy Branch prior to entering CRK 60.3	Semiannually (April, Oct)	Gross alpha, gross beta, gamma scan, field measurements ^b
RCK 2.0	Raccoon Creek sampling station prior to entering CRK 31	Semiannually (April, Oct)	Gross alpha, gross beta, total radioactive strontium, gamma scan, ³ H, field measurements ^b
NWTK 0.1	Northwest Tributary prior to the confluence with First Creek	Semiannually (April, Oct)	Gross alpha, gross beta, total radioactive strontium, gamma scan, ³ H, field measurements ^b
FCK 0.1	First Creek prior to the confluence with Northwest Tributary	Semiannually (April, Oct)	Gross alpha, gross beta, total radioactive strontium, gamma scan, ³ H, field measurements ^b
FFK 0.1	Fifth Creek just upstream of White Oak Creek (ORNL)	Semiannually (April, Oct)	Gross alpha, gross beta, total radioactive strontium, gamma scan, ³ H, field measurements ^b

^aLocations identify bodies of water and locations on them (e.g., CRK 32 = 32 km upstream from the confluence of the Clinch and the Tennessee Rivers).

^bField measurements consist of dissolved oxygen, pH, and temperature.

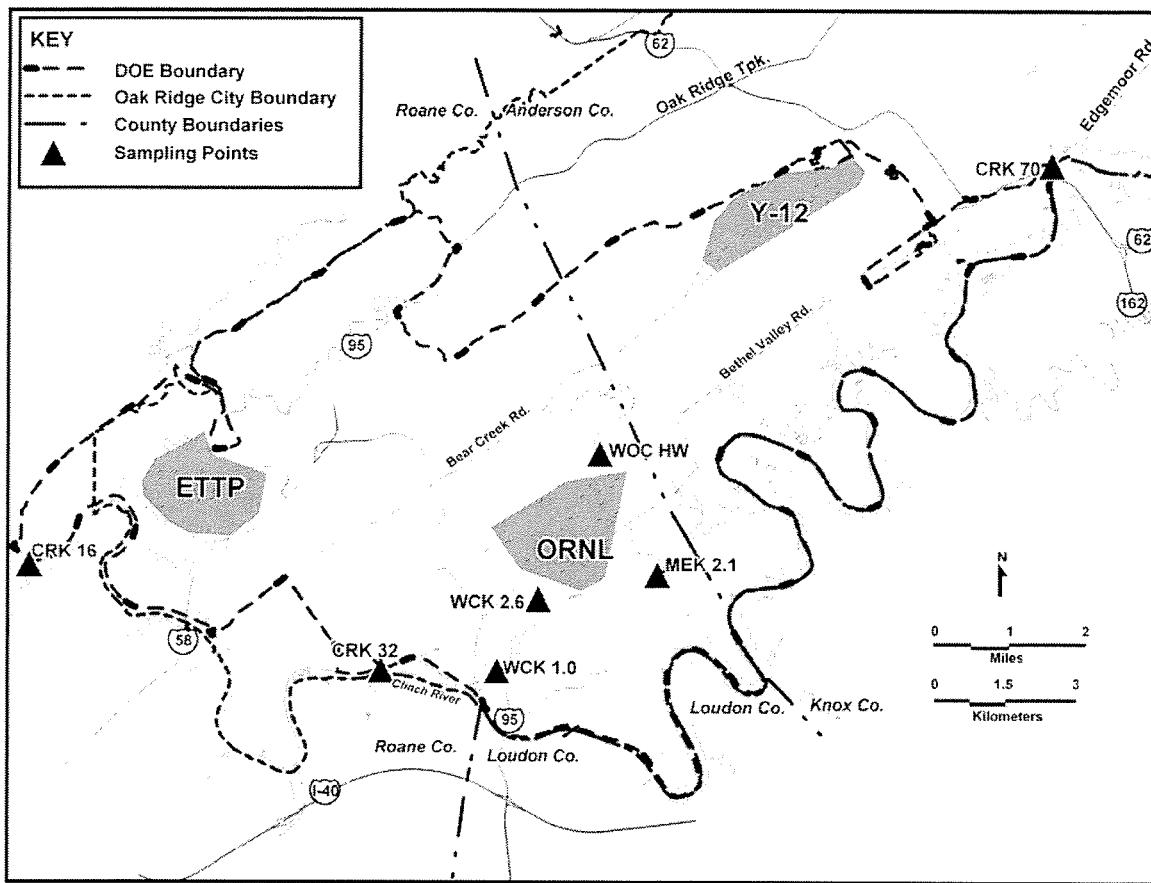


Fig. 5.25. ORNL sediment sampling locations.

geographically contiguous and/or that occur within geohydrologically defined areas. At ORNL, 20 WAGs were identified by the RCRA Facility Assessment conducted in 1987. The WAG concept was developed to facilitate evaluation of potential sources of releases to the environment. Discussion of past WAG-based monitoring results can be found in previous editions of this document.

The groundwater monitoring approach was reviewed in 2004 and revised to meet DOE Order 450.1 requirements and UT-Battelle management objectives. DOE Order 450.1 is the primary contractual requirement document specifying the implementation of a site-wide groundwater protection program at ORNL. As part of the site-wide groundwater protection program, and to be consistent with UT-Battelle management objectives, a groundwater surveillance monitoring strategy was developed to en-

able groundwater exit pathways and UT-Battelle facilities potentially posing risk to groundwater resources at ORNL (“active sites”) to be assessed and monitored. The changes to the OS groundwater monitoring strategy were documented in the Data Quality Objectives for the UT-Battelle Groundwater Surveillance Monitoring Program at ORNL (Bonine 2004).

The exit pathway and active sites groundwater surveillance monitoring points sampled during 2006 included selected seep/spring and surface water monitoring locations as well as groundwater surveillance monitoring wells. Seep/spring and surface water monitoring locations were used in the absence of monitoring wells located in appropriately selected groundwater discharge areas. The network of groundwater monitoring wells sampled by UT-Battelle consists of water quality wells constructed to RCRA specifications and piezometer wells. In

the past the water quality wells were used in site characterization and compliance monitoring, while the piezometers sampled in 2006 were used to characterize groundwater flow.

Groundwater monitoring performed under the exit pathway groundwater surveillance and active sites monitoring programs is not regulated by federal or state regulations. Consequently, no permit or 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 monitored by UT-Battelle for the OS, federal drinking water standards and Tennessee water quality criteria for domestic water supplies (TDEC 2004) are used as reference values in the following discussions. Four percent of the DOE DCG was used for comparison if no federal or state standards have been established for a radionuclide. Although drinking water standards are used for comparative purposes, it is important to note that no members of the public consume groundwater from ORNL wells, nor do any groundwater wells furnish drinking water to personnel at ORNL.

Monitoring conducted by BJC and the exit pathway and active sites monitoring approach used by UT-Battelle comprise the site-wide monitoring program for ORNL. The combination of both monitoring programs meets the DOE Order 450.1 requirement of a comprehensive site-wide groundwater monitoring program.

5.10.2 Exit Pathway Monitoring

During 2006, exit pathway groundwater surveillance monitoring was performed under the auspices of *UT-Battelle Sampling and Analysis Plan for Surveillance Monitoring of Exit Pathway Groundwater at Oak Ridge National Laboratory* (Bonine 2006b) (Exit Pathway SAP). Groundwater exit pathways at ORNL include watersheds or portions of watersheds (sub-watersheds) where groundwater discharges to the Clinch River/Melton Hill Reservoir to the west, south, and east of the main campus of ORNL. The exit pathway monitoring points were chosen based on hydrologic features, screened intervals (for wells), and locations relative to discharge areas proximal to the ORNL main campus. The groundwater exit pathways at ORNL include four discharge zones identified by the groundwater data quality objectives proc-

ess. In addition, one of the original exit pathway zones was split into two zones for the sake of geographic expediency. The five zones include (1) the WOC Discharge Area Exit Pathway (Wells 857, 858, 1190, 1191, and 1239), (2) the 7000 Area/Bearden Creek Watershed Discharge Area Exit Pathway (Wells 1198 and 1199 and Spring BC-01), (3) the East End Discharge Area Exit Pathway (Well 923 and Springs/Surface Water Monitoring Points EE-01 and EE-02), (4) the Northwestern Discharge Area Exit Pathway (Wells 531 and 535), and (5) the Southern Discharge Area Exit Pathway (Springs/Surface Water Monitoring Points S-01 and S-02), which was originally part of the East End Discharge Area exit pathway. Figure 5.26 shows the locations of the specific monitoring points sampled in 2006.

Samples were collected during 2006 from seven multi-port monitoring wells (BJC Wells 4537, 4538, 4539, 4540, 4541, 4542, and 4579) installed west of the main campus of ORNL by BJC. The inclusion of the multiport wells enables multiple shallow to deep water-bearing strata to be monitored. Sampling data generated by these wells were used to supplement the data generated by the WOC Discharge Area Exit Pathway. These data were reviewed by UT-Battelle, but are not reported herein. The multiport monitoring well analytical data are reported in the annual RER.

Samples collected from the UT-Battelle exit pathway groundwater surveillance monitoring points in 2006 were analyzed for VOCs, semi-volatile organic compounds, metals (including mercury), and radionuclides (including gross alpha/gross beta activity, gamma emitters, total radioactive strontium, and tritium). Under the monitoring strategy in place per the Exit Pathway SAP, samples were collected semiannually during wet and dry seasons during 2006.

5.10.3 Active Sites Monitoring—HFIR and SNS

Active sites groundwater surveillance monitoring was performed in 2006 at the HFIR and SNS sites. These UT-Battelle–managed facilities were monitored based on known releases of contaminants to the subsurface (HFIR) or the potential for adverse impact on groundwater resources at ORNL should a release occur (SNS).

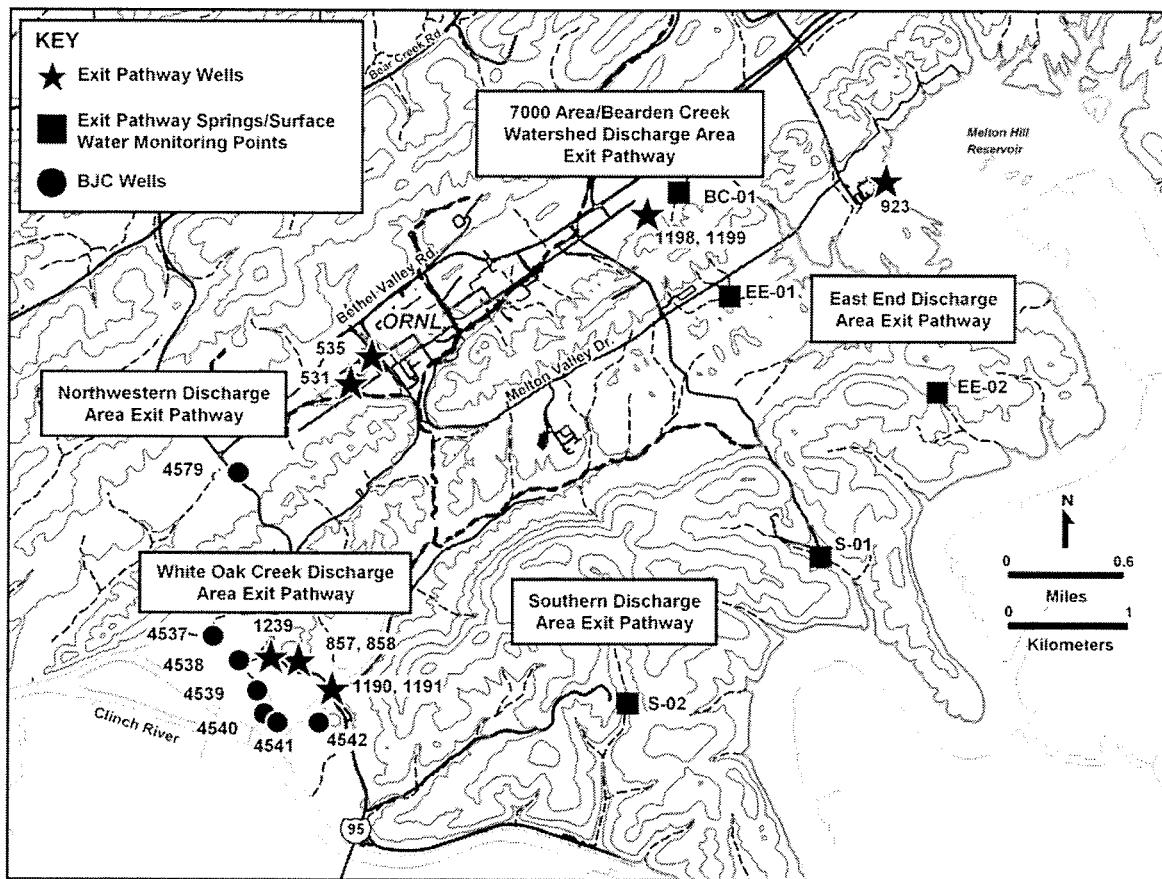


Fig. 5. 26. UT-Battelle exit pathway groundwater monitoring locations at ORNL, 2006.

The HFIR monitoring activities were initiated following the discovery in 2000 of a tritium release to the subsurface environment (tritium release sites were repaired in 2001). During 2006 HFIR monitoring was performed under the Annual Monitoring Plan for the High Flux Isotope Reactor Site, Monitoring Period: 2005-2006 (Bonine 2006a) (Annual Monitoring Plan). Sampling under the Annual Monitoring Plan began in December 2005 and was completed in December 2006.

Monitoring at the SNS site continued in 2006 under the *Baseline Groundwater Monitoring Plan for the Spallation Neutron Source Site: Monitoring Period 2004–2006* (Baseline Monitoring Plan) (Bonine, Ketelle, and Trotter 2005). Baseline monitoring ended and coincided with the initiation of operational monitoring in April 2006 due to the operational startup of the SNS. Operational monitoring was initiated under the draft *Operational Groundwater Monitoring Plan*

for the Spallation Neutron Source Site (Bonine, Ketelle, and Trotter, 2007) (Operational Monitoring Plan). Operational monitoring will continue during SNS operations.

5.10.3.1 HFIR Site

The HFIR site is located in Melton Valley about one-half mile south of the main ORNL facilities, which are located in Bethel Valley. The site slopes to the southeast, and small stream valleys lie to the east and west of the HFIR complex. Surface water drainage from the site flows into Melton Branch via these small streams or through storm drains. Melton Branch is located south of the HFIR site and flows west into WOC. WOC ultimately discharges into the Clinch River.

The water table surface in Melton Valley is typically a subdued replica of surface topography. The dry season water table typically occurs

at or slightly above the top of bedrock. Groundwater data gathered before the tritium release indicate a water table high to the north of HFIR and a general gradient toward the adjacent streams. Estimates of groundwater flow directions are based on the generally observed tendency for groundwater to flow parallel to geologic strike (parallel to the orientation of the rock beds). Extensive historic investigations performed at Oak Ridge over several decades indicate that 90% or more of infiltrating precipitation (groundwater recharge) flows directly to the nearest stream. Because of this, in small watersheds, groundwater contaminants not subject to geochemical transport retardation, such as tritium, are readily detected in surface water samples.

The tritium release sites were on the southwest side of the HFIR Building near Wells 4531 and 658 (see Figure 5.27). The releases occurred in two sections of the HFIR process waste drain system.

The most significant observation for the HFIR facility, based on water table conditions and other data related to the reactor building, is that two interrelated flow regimes exist within the uppermost portion of the aquifer underlying the HFIR complex. A rapid-flow pathway is associated with the shallowest groundwater flow into subsurface piping traces (the HFIR building foundation drain and auxiliary piping to the south), and a slower-flow pathway is associated with deeper groundwater flow beneath the site.

The objectives of the monitoring program outlined in the Annual Monitoring Plan include (1) early detection of releases to groundwater from HFIR operational activities or system failures, (2) tracking the mass of the tritium plume in the vicinity of HFIR, and (3) monitoring potential sources of groundwater contamination located hydraulically up-gradient of the HFIR. Figure 5.27 shows the locations of the specific monitoring points sampled in 2006 at the HFIR site. Tritium was the only contaminant of concern monitored at all HFIR monitoring points.

The HFIR Building foundation drain and auxiliary waste piping system gravity-feed into Melton Branch, and this piping system forms a capture zone beneath and around the building. Leakage from HFIR would therefore seep into the foundation drain system and waste piping ditch lines, resulting in flow to the southeast and

south toward ultimate discharge through NPDES outfalls at Melton Branch. The HFIR's east foundation drain intercepts the rapid-flow pathway and has been monitored at J-1, a monitoring point proximal to the HFIR, for several years. Likewise, waste piping ditch lines associated with the HFIR intercept the rapid-flow pathway and have been monitored regularly for several years at NPDES outfall 383 (OF-383). Both J-1 and OF-383 were sampled on a routine basis during 2006 (although OF-383 was sampled under the aegis of NPDES monitoring program and not under the Annual Monitoring Plan). Four down-gradient groundwater monitoring wells (Wells 658, 661, 892, and 1152) were also sampled routinely during 2006 to monitor the deeper, slower-flow pathway. Well 4533 is an up-gradient well located proximal to the HFIR site sampled during 2006. All samples were analyzed using EPA analytical methods by a certified laboratory. In addition, field parameter measurements were made during sampling events. Dissolved oxygen, pH, conductivity, turbidity, redox, and temperature measurements were made at monitoring wells sampled under the Annual Monitoring Plan with a calibrated and standardized flow cell/meter during each sampling event.

5.10.3.2 SNS Site

SNS Baseline Groundwater Monitoring. SNS operations have the potential for inducing radioactivity (neutron activation) in the shielding berm surrounding the SNS linac, accumulator ring, and/or beam transport lines. A principal concern is the potential for water infiltrating the berm soils to transport radionuclide contamination generated by neutron activation to saturated groundwater zones. The ability to accurately model the fate and transport of neutron activation products generated by beam interactions with the engineered soil berm is confounded by uncertainty associated with potential contaminant interactions. These interactions include existing pore water, percolating precipitation, earth materials encountered, and diffusive and advective flow in the vadose and phreatic zones attributable to the presence of karst geomorphic features found on the SNS site. These uncertainties necessitated the initiation of a groundwater

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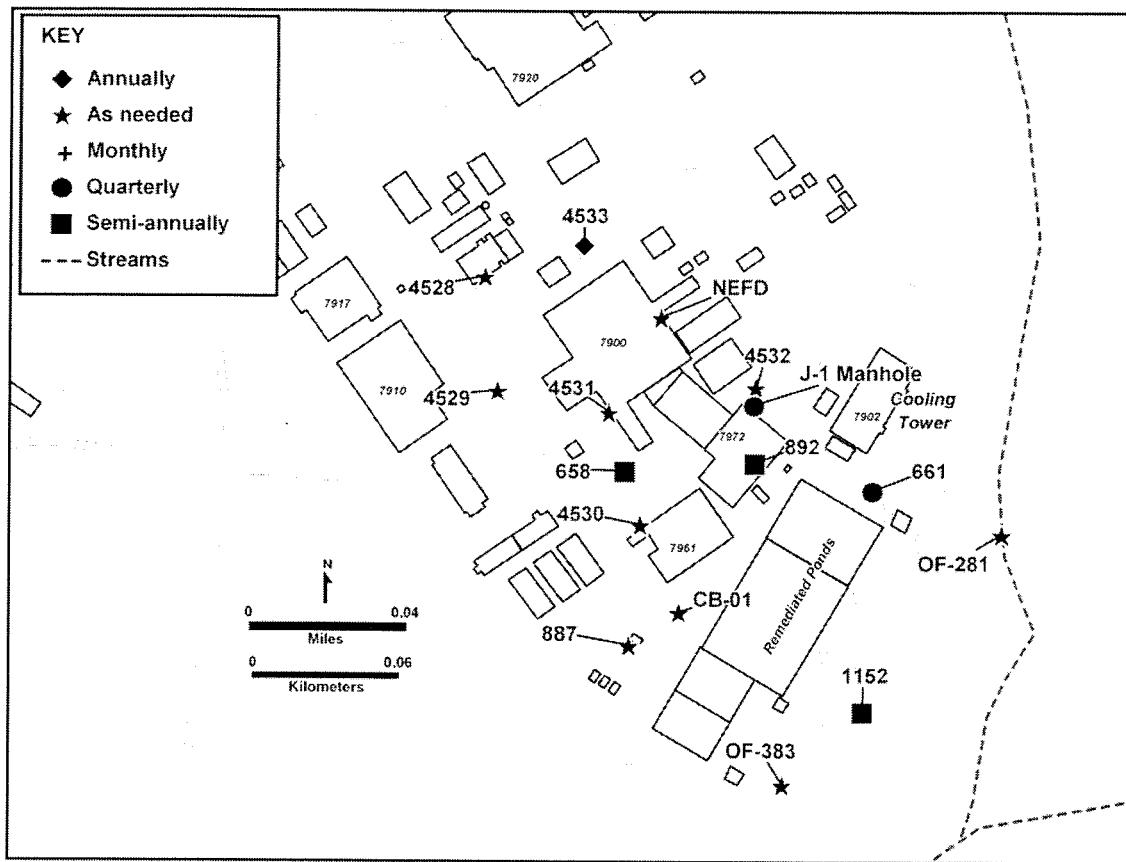


Fig. 5.27. Groundwater monitoring locations at HFIR, 2006.

surveillance monitoring program at the SNS site. Groundwater surveillance monitoring started as the baseline monitoring program. Objectives of the baseline groundwater monitoring program at the SNS include: 1) determination of compliance with applicable environmental quality standards and public exposure limits outlined in DOE Orders 450.1 and 5400.5, respectively; 2) determination of background levels and site contributions of contaminant radionuclides to the environment (obtain baseline data); and 3) determination of trends in pre-operational groundwater quality. The baseline monitoring program was conducted during the April 2004–April 2006 period prior to startup of the SNS. Operational monitoring was initiated at SNS startup (April 2006) and will continue during SNS operations.

A total of seven seeps/springs and surface water sampling points (seeps/springs S-1, S-2, S-3, S-4, S-5, and SP-1 and surface water point

SW-1) were routinely monitored as analogues to, and in lieu of, groundwater monitoring wells during the baseline monitoring period (see Fig. 5-28). Another monitoring point, spring S-6, was sampled sporadically during baseline monitoring. Since the inception of baseline monitoring at SNS, monitoring point S-6 has been periodically inundated by beaver activity on Bear Creek creating difficulties in collecting representative samples of the spring. Because representative samples were difficult to collect, monitoring was discontinued at this monitoring point during the baseline monitoring period.

The locations of the SNS monitoring points were chosen based on hydrogeological factors and proximity to the beam line. Sampling locations were within the seeps/springs or in surface water bodies immediately adjacent to these features. Fig. 5.28 shows the locations of the

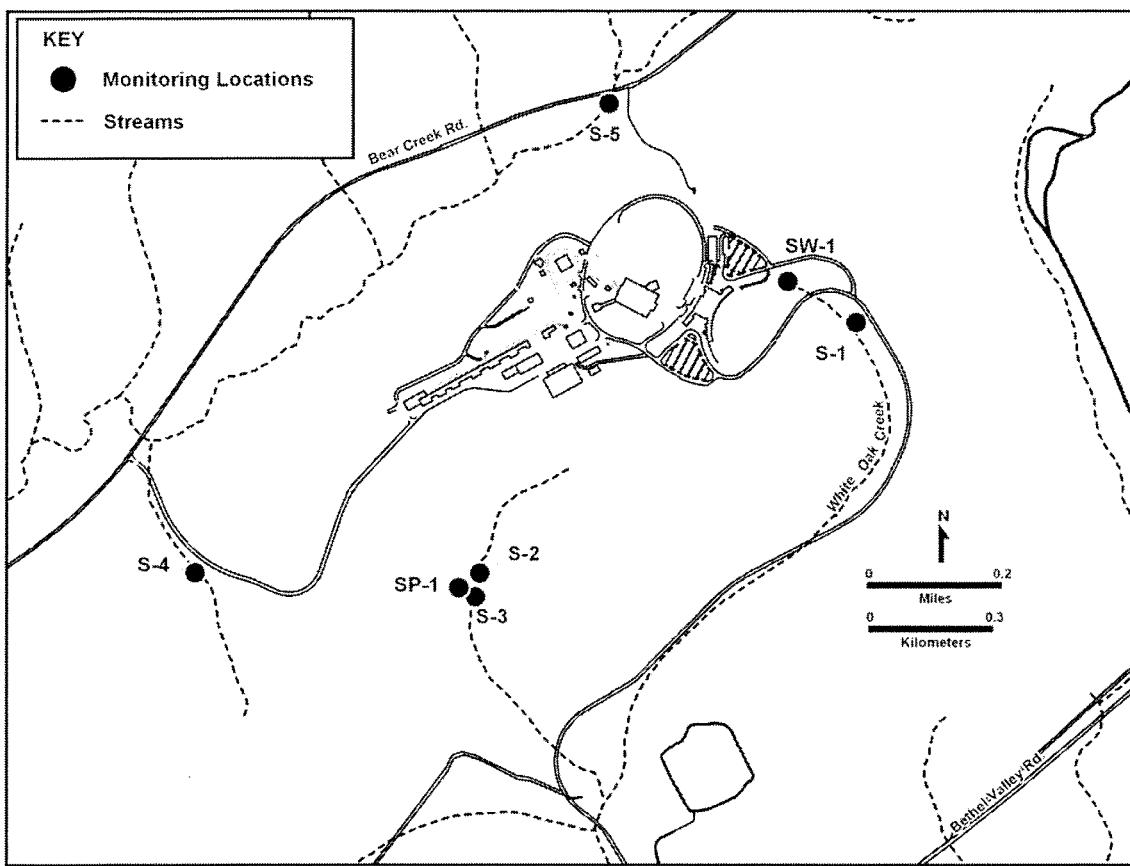


Fig. 5. 28. Groundwater monitoring locations at SNS, 2006.

specific monitoring points sampled during the baseline 2004–2006 period at the SNS site.

Because of the presence of karst geomorphic features at the SNS site, sampling of the seeps/springs was performed to characterize water quality throughout the expected range of flow observed at the selected monitoring locations. A minimum of three grab samples was collected from each seep/spring per quarter—one representing base flow; samples were collected at higher stage/flow rates (i.e., one representing the rising limb of the storm hydrograph and one representing the recession [falling] limb of the storm hydrograph). These monitoring points were sampled on a quarterly basis during the 2004–2006 monitoring period in accordance with the Baseline Monitoring Plan. The parameters of interest included neutron activation products consisting of H-3, C-14, gross alpha and beta activity, and gamma emitters (Na-22, Al-26, Mn-54, K-40, etc). Initially none of the samples collected were filtered. However, due to the

presence of higher than expected gross alpha and beta activity in samples collected at several monitoring points, filtered and unfiltered samples were collected to determine the source of the gross activity. All samples were analyzed using EPA analytical methods by a certified laboratory. In addition to the aforementioned analytical suite of interest, field parameter measurements were made during sampling events. Dissolved oxygen, pH, conductivity, turbidity, and temperature measurements were made with calibrated and standardized portable water quality meters during each sampling event.

SNS Operational Groundwater Monitoring. SNS began operational testing in April 2006. Concurrent with the initiation of operational testing and the completion of baseline monitoring, operational monitoring began under the Operational Monitoring Plan. All seven monitoring points sampled under the Baseline Monitoring Plan were retained under the Opera-

tional Monitoring Plan. Fig. 5.28 shows the locations of these monitoring points. The flow-based sampling scheme described above was maintained under the Operational Monitoring Plan. Based on observations made during baseline monitoring, monitoring frequency changes, vis-à-vis parameters of interest, are outlined in the Operational Monitoring Plan. Tritium and ^{14}C are the principal groundwater constituents of concern at the SNS site. Sample collection began in April 2006 on a quarterly basis for ^3H and ^{14}C analyses. In accordance with the Operational Monitoring Plan, samples will be collected annually during the wet season base flow conditions for gross activity (alpha and beta) and gamma spectroscopy analyses. Unfiltered samples will be collected and analyzed using EPA analytical methods by a certified laboratory. In addition to the aforementioned analytical suite of interest, field parameter measurements will continue to be made during sampling events. Dissolved oxygen, pH, conductivity, turbidity, and temperature measurements will be made with calibrated/standardized water quality meters during each sampling event.

5.10.4 Monitoring Results

5.10.4.1 2006 Exit Pathway Groundwater Surveillance Monitoring

From the 49 wells sampled under the previous WAG-based monitoring program, only Wells 857, 858, 1190, 1191, 1198, 1199, and 1239 were retained in the exit pathway groundwater surveillance monitoring program. Wells 531, 535, and 923 were added to the exit pathway monitoring program in 2005 as well as a number of springs and/or surface water bodies (BC-01, EE-01, EE-02, S-01, and S-02). Trend analyses were performed on 2006 exit pathway data that exceeded reference values using historical data collected from 1991 through the 2006. Where there was insufficient data density to perform statistical trend analysis, trending was not performed. Concentrations of naturally occurring metals (e.g., aluminum, iron, manganese, zinc, magnesium, etc.) that exceeded reference values were not subjected to trend analysis because these constituents are relatively common in the soil and rock composing the Valley

and Ridge Physiographic Province and are regularly found in groundwater samples collected from wells at ORNL. In addition, requested detection limits were not met for several semi-volatile organic compounds during the 2006 monitoring period. Requested detection limits were not met for atrazine, benzo(a)pyrene, hexachlorobenzene, and pentachlorophenol in any of the exit pathway monitoring points sampled during 2006. The detection limits for the aforementioned compounds exceeded their reference values (Tennessee water quality criteria for domestic water supplies). No trending was performed on data for these parameters. A common plasticizer [bis(2-ethylhexyl) phthalate], acetone, and toluene were routinely detected in low, estimated concentrations in many groundwater samples collected from the exit pathway wells. Less frequently, benzyl alcohol and carbon disulfide were also reported by the laboratory at low, estimated concentrations in several exit pathway wells. This is suggestive of low-level contamination of samples during laboratory analysis. Due to dry conditions encountered, samples were not collected at BC-01 and S-01 during the dry season, and EE-02 during the wet and dry seasons because of the climatic-based moisture deficit effecting East Tennessee during 2006.

Results of EMEF Program monitoring at Bechtel Jacobs well locations proximal to the WOC Discharge Area Exit Pathway exit pathways are summarized in the 2006 RER.

5.10.4.1.1 WOC Discharge Area Exit Pathway Results

Monitoring wells 857, 858, 1190, 1191, and 1239 were sampled in April and September 2006 by UT-Battelle. Three radiological constituents were found in two wells at concentrations greater than the reference values used for comparison. The three radiological constituents that exceeded reference values were tritium in Well 1190 and gross beta activity, total radioactive strontium, and tritium in Well 1191. A statistically significant downward trend exists for all three radiological constituents. Other radiological constituents were detected but did not exceed their reference values (^{214}Bi , ^{214}Pb , and ^{40}K). The presence of the radiological constituents in these wells is related to continued discharges of legacy contamination associated with

past waste disposal activities within Melton Valley (gross beta activity, tritium and total radioactive strontium), or occur naturally (^{214}Bi , ^{214}Pb , and ^{40}K). One metal of interest (lead) exceeded its reference value in Well 857 in samples collected during 2006. Lead exhibits a statistically significant downward trend in Well 857. Several other metals exceeded their reference values during 2006, but these metals (aluminum, iron, and manganese) are commonly found in the soil, rock, and groundwater at ORNL. As mentioned above, detection limits for several semi-volatile organic compounds exceeded their reference values. No other organic compounds were present above their reference values in samples collected from WOC Discharge Area monitoring points.

5.10.4.1.2 7000 Area/Bearden Creek Watershed Discharge Area Exit Pathway Results

Wells 1198 and 1199 and Spring BC-01 were sampled by UT-Battelle in April and August 2006 (BC-01 was not sampled in August 2006 because the spring was dry). One radiological parameter (^{241}Am) was reported above its reference value in the sample collected from Well 1198 in April 2006; however the counting uncertainty reported by the laboratory exceeded the reported value casting doubt as to the validity of the reported value. Americium-241 was not reported in the sample collected from Well 1198 in August 2006. Trace levels of tritium were detected in samples collected from all three monitoring locations. Two metal constituents (aluminum and iron) exceeded reference values, but these metals are common in groundwater at ORNL. As noted in Sect. 5.10.4.1, detection limits for several semi-volatile organic compounds exceeded their reference values. No other organic compounds were present above their reference values in samples collected from the 7000 Area/Bearden Creek Watershed Discharge Area monitoring points.

5.10.4.1.3 East End Discharge Area Exit Pathway Results

Well 923 and EE-01 were sampled by UT-Battelle in April and August 2006. EE-02 was not sampled in 2006 because this monitoring point was dry during the wet and dry seasons.

No radiological constituents were present above reference values in samples collected from East End Discharge Area monitoring points, however very low concentrations of tritium were detected in the sample collected from EE-01 in August 2006. The concentration of lead exceeded its reference value in the April 2006 sample collected from Well 923 (trending of lead data was not performed due to a lack of data density). Aluminum, iron, manganese, and thallium also exceeded reference values, but these metals are relatively common in the soil, rock, and groundwater at ORNL. As mentioned above, detection limits for several semi-volatile organic compounds exceeded their reference values. No other organic compounds were detected in samples collected from East End Discharge Area monitoring points.

5.10.4.1.4 Northwestern Discharge Area Exit Pathway Results

Wells 531 and 535 were sampled in May and August 2006 by UT-Battelle. No radiological constituents were present above reference values in samples collected from Wells 531 and 535; however, low levels of tritium were detected in the samples collected in Well 535. The concentration of lead exceeded its reference value in the August 2006 sample collected from Well 535 (trending of lead data was not performed due to a lack of data density). Aluminum, iron, and manganese exceeded reference values, but as stated above, these metals are common in groundwater at ORNL. As mentioned above, detection limits for several semi-volatile organic compounds exceeded their reference values. No other organic compounds were present above reference levels in samples collected from Northwestern Discharge Area monitoring points. However, a low, estimated concentration of nitrobenzene was detected in a sample collected at Well 531 in addition to the common laboratory contaminants acetone, carbon disulfide, and toluene. Plasticizers diethyl phthalate, and dimethyl phthalate were detected at low, estimated levels in Well 535 along with low, estimated concentrations of benzidine, acetone, and toluene. There are no known active or legacy sources of these compounds near either well, however, the casings for both wells are made of polyvinyl chloride which may explain

the presence of the phthalates in the groundwater samples.

5.10.4.1.5 Southern Discharge Area Exit Pathway Results

Monitoring point S-01 was sampled by UT-Battelle in April 2006 but not in August 2006 because the monitoring point was dry. Monitoring point S-02 was sampled in April and August 2006; aluminum, iron, and manganese exceeded their reference values at S-02 in 2006. As stated above, these metals are common constituents of earth materials at ORNL. No radiological constituents or organic compounds were present above their detection limits in samples collected from Southern Discharge Area monitoring points. As mentioned above, detection limits for several semi-volatile organic compounds exceeded their reference values.

5.10.4.2 Active Sites Monitoring—HFIR and SNS

Monitoring continued at the HFIR and SNS sites during 2006 under the HFIR Annual Monitoring Plan and the SNS Baseline Monitoring Plan, respectively. Operational monitoring at SNS coincided with the completion of baseline monitoring in April 2006.

Trend analysis was performed on a subset of HFIR monitoring locations—those in the pathway of the tritium plume migration (i.e., monitoring point J-1 and Wells 658, 892, and 661). Because of changes in monitoring strategy at HFIR in 2006 where there was sufficient data density to perform the trend analysis on 2006 data, those data were used exclusively. Where there was not sufficient data density, biennial (2004–2006) or historical (pre-2005) data were used.

Well 658 is located nearest to the tritium release sites, Well 892 is located down-gradient of the release sites, and Well 661 is located further down-gradient and near the remediated liquid waste storage ponds and Melton Branch. The east foundation drain monitoring point, J-1, is the closest monitoring point to the HFIR—within the rapid flow pathway described above. Action levels (Action Level 1 – 40,000 pCi/L and Action Level 2 – 80,000 pCi/L) established for J-1 in past Annual Monitoring Plans continued to be used as the basis for making decisions re-

garding contingency actions to be taken in the event of an observed excursion above the action levels.

Comparison of baseline SNS data to reference values was performed; however, trending of data was not performed on the baseline 2006 SNS data set.

5.10.4.2.1 HFIR Site Results

During 2006, no evidence of tritium releases to the subsurface from the HFIR was observed – there were no exceedences of Action Level 1 or 2 thresholds at J-1 during in 2006 and the trend in tritium concentrations at J-1 is downward.

Observations of tritium plume behavior were made by trending the tritium concentration data for Wells 658, 892, and 661. Trend analysis of biennial tritium concentration data for Wells 658 and 892 reveal a statistically significant downward trend in tritium concentration. A trend analysis of 2006 tritium data for Well 661 revealed a statistically insignificant increasing trend in tritium concentration at 661. With time, the main mass of the tritium plume has migrated from the release area near Well 658 and the HFIR through the area monitored by Well 892, and has caused the increased trend in tritium concentrations observable in Well 661.

Tritium concentrations fell during 2006 at J-1 and the aforementioned wells. It is postulated that the recent remediation of the liquid waste ponds located down-gradient of the HFIR site has hastened the reduction of tritium concentrations in the nearby monitoring points. Removal of the hydraulic barrier posed by the ponds appears to have allowed groundwater to flow more easily toward Melton Branch, essentially emptying the reservoir of contaminated groundwater previously held by the ponds.

5.10.4.2.2 SNS Site Results

SNS Baseline Monitoring Plan Results (sampling conducted April 2004 through March 2006). Tritium and C-14 are considered to be important potential neutron activation products produced by beam/earth material interactions, and given their fate and transport characteristics, results for these constituents are summarized below. Results of gross alpha and beta activity are summarized given the number of detected results reported by the laboratory for

these constituents. Given the relatively low presence in samples collected, only those gamma emitters whose analytical results exceeded reference values are summarized in the following paragraph. The summaries provided are for all flow conditions described above.

Results of the baseline monitoring program at SNS indicate that ^3H was detected in 3 of 191 total samples collected during the monitoring period (0 of 44 filtered samples and 3 of 147 unfiltered samples). Likewise, ^{14}C was detected in 4 of 183 samples collected (2 of 44 filtered samples and 2 of 139 unfiltered samples). Tritium and ^{14}C concentrations did not exceed their reference values during the 2004–2006 monitoring period. ^3H and ^{14}C act effectively as tracers in groundwater, and if produced by the neutron activation of the earth materials surrounding the beam line and beam dump, these two radionuclides would be transported via the karst groundwater flow system without significant retardation by earth materials on site.

Gross alpha activity was detected in 55 of 157 total samples collected during the monitoring period (10 of 44 filtered samples and 45 of 113 unfiltered samples). Gross beta activity was detected in 70 of 157 samples collected (19 of 44 filtered samples and 51 of 113 unfiltered samples). Gross alpha activity was detected at concentrations that exceeded its reference value 9 out of 157 times at monitoring point S-5. Monitoring point S-5 is a spring that is connected to both Bear Creek Valley and the SNS site via karst conduits. As such, the gross alpha activity found in S-5 is attributed to uranium-contaminated groundwater from Y-12 facilities in Bear Creek Valley. The only other monitoring location where gross alpha and beta activities were present in excess of their reference values was monitoring point S-2 (1 out of 157 samples collected).

Filtration of samples was instituted to determine if the source of the higher observed alpha and beta activities were alpha and beta emitting radionuclides sorbed onto the suspended solids in the groundwater. Generally, gross alpha and beta activities were observed at lower concentrations in filtered samples collected during the monitoring period. Consequently, the suspended solids were deemed to be the contributor to the increased activity in the unfiltered samples. Suspended solids in samples collected dur-

ing higher water flow velocities associated with storm flow conditions contribute to the higher suspended solid loading in the samples and therefore, the higher gross activities measured.

Several gamma-emitting radionuclides exceeded their reference values at different times during the baseline monitoring period at SNS monitoring locations: ^{238}U at S-1, S-3, S-4, and S-5 as well as ^{228}Ra and ^{232}Th at S-2. The reference value for ^{230}Th was exceeded at all monitoring stations during the monitoring period. These radiological constituents are naturally occurring in carbonate-based groundwater on the Oak Ridge Reservation. Additionally, ^{241}Am exceeded its reference value in one sample collected from S-4 during the monitoring period. ^{241}Am was likely misidentified by the reporting laboratory.

Table 5.10 summarizes the mean values for concentrations of ^{13}H , ^{14}C , gross alpha activity, and gross beta activities detected over the baseline monitoring period. For comparison, Table 5.11 displays averaged background concentrations of these radionuclides in groundwater in the main campus area of ORNL. Mean tritium and ^{14}C concentrations at the SNS site were lower during baseline monitoring than the averaged results found in background monitoring wells at ORNL. Likewise, mean ^3H concentrations in samples collected at the SNS site were lower than those reported for mean concentrations of ^3H in background surface water samples at the ORNL main campus area (839.7 pCi/L) (Bechtel National, Inc., 1992). Gross beta and alpha activity mean concentrations in groundwater at the SNS site are slightly higher than the averaged results in background monitoring wells at ORNL (see Table 5.11).

Operational Groundwater Monitoring Plan Results (Sampling conducted April 2006 through December 2006). Results of the 2006 operational monitoring program at SNS indicate the presence of ^{238}U at concentrations that exceeded its reference value at monitoring point S-3. Thorium-230 was the only other radionuclide that exceeded its reference value during operational monitoring at SNS. This exceedence occurred at SW-1. Both of these radiological constituents are naturally occurring in carbonate-based groundwater on the ORR. No other radiological constituents were observed to exceed their reference values. Table 5.12 outlines the

Table 5.10. Mean concentrations for radiological parameters detected at SNS (all flow conditions) – April 2004 through March 2006

Parameter	F/U ^a	Mean Concentration (pCi/L)
Tritium	F	-
Tritium	U	254.3
Carbon-14	F	9.7
Carbon-14	U	6.6
Alpha	F	8.7
Alpha	U	9.8
Beta	F	9.3
Beta	U	12.5

^aF = filtered samples, U = unfiltered samples

Table 5.11. Mean radionuclide concentrations in groundwater sampled from background wells at ORNL^a

Parameter	Filtered (pCi/L)	Unfiltered (pCi/L)
Tritium	797.5	1161.7
Carbon-14	100	100
Gross alpha	2.9	3.5
Gross beta	4.4	3.3

^aSource: Bechtel National Inc., Sept. 1992.

radionuclides detected, their frequency of detection, and their average concentrations during operational monitoring activities in 2006.

5.11 Modernization and Reindustrialization Activities at ORNL

During 2006, SNS went into operation as did the newly constructed Center for Nanophase Materials Sciences (CNMS). The Chestnut Ridge Utility Expansion project extended branch electrical, water, sewer and natural gas lines as part of the master campus site plan. Design of a 25 bed user housing facility will start in 2007 with construction scheduled to be completed prior to 2009.

The state-funded Joint Institute for Biological Sciences is under construction in West Campus. It is scheduled to be completed during the fourth quarter of 2007. Renovations to existing laboratory buildings and the construction of a new 5,500 ft² West End Research Support Facility will support the West Campus co-location of

biosciences and environmental sciences capabilities. Planned projects will upgrade First Street, the entrance into the West Campus, parking and landscaping as well as the disposition of ponds and structures excess to current mission.

A portion of the Central Campus has been leased to the Community Reuse Organization of East Tennessee (CROET) to create the Innovation Valley Science and Technology Park. Construction of two 100,000 ft² facilities is planned during 2007 and 2008. The park boundaries will eventually expand to 40 acres.

The privately funded 200,000 ft² Multiprogram Research Facility was completed with initial occupancy in September 2006. Construction of the North Hill Parking lot, scheduled to be completed in June 2007, will provide an additional 200 parking slots west of the Multiprogram Research Facility. Planned reconfiguration and expansion of East Campus electrical substations and chilled water distribution systems will be started during 2007 to support growing computer and computational capacity. These upgrades follow the 2006 completion of the

Table 5.12. Radiological Constituents Detected in Groundwater at SNS—Operational Monitoring, April through December 2006

Constituent	No. Detected/N	Mean Concentration (pCi/L)
Tritium	11/63	191
Gross alpha	3/63	5.5
Gross beta	5/63	7.5
Bismuth-214	2/63	13.6
Thorium-230	3/63	11.5
Uranium-238	1/63	182

TVA substation, which replaced ORNL's 1940 vintage primary electrical substation. A DOE-funded, 140,000 ft² Multiprogram Research Laboratory Facility is planned to relocate a portion of the chemical and material science laboratories located in the Building 4500N/S Complex. The Flagpole Parking Lot on Central Avenue is the planned building site. FY 2009 is the proposed start of construction.

During 2006, ORNL's excess facility disposition program removed several Freels Bend out buildings which were deemed a public nuisance. Demolition of the old cafeteria Building 2010 is also planned for 2007.

5.12 Spallation Neutron Source

On May 31, 2006, construction of the SNS, a state-of-the-art pulsed-neutron facility located on Chestnut Ridge at ORNL, was completed. This major new accelerator-based neutron research facility significantly increases the capability for neutron beam research in the United States and worldwide. The primary mission of SNS is to provide a reliable, high-intensity source of pulsed neutrons for neutron beam research, with intensity and resolution unmatched in any major research facility in the world. The SNS facility is composed of an ion source, linear accelerator (linac), storage ring, target, and instrument facilities, as well as support facilities. The facility is currently being commissioned, with beam power increasing, with a goal of achieving full power operations in FY 2008-2009.

Construction of the SNS access roads affected wetlands. Routes were evaluated, and improving the Chestnut Ridge Road was selected as the action affecting the smallest area of wet-

lands. Construction affected 0.055 acres, and careful attention to erosion control and equipment movement limited impacts to other nearby wetland areas. The SNS developed a wetlands mitigation plan to compensate for the impacts to the 0.055 acres by restoring 0.138 acres (a mitigation ratio of 2.511) of wetlands located in the same watershed. TDEC accepted the wetlands mitigation plan on June 29, 2000, and the 0.138 acres of wetlands were restored in August 2000. This mitigation action is complete, and the restored areas are routinely monitored to ensure the survival rate of the indigenous shrubs and vegetation planted in the restored area. No significant impacts on the wetlands have resulted from construction and commissioning activities. The wetlands mitigation activities were evaluated and reported in 2002, 2003, 2004, and 2005. These reviews have found that the SNS mitigation wetland is functioning as a viable wetland community. The site has the necessary wetland vegetation, soils, and hydrology to be classified as a jurisdictional wetland. In 2006, the fifth and final annual wetland monitoring report was prepared and submitted to the state, thereby fulfilling monitoring and reporting requirements as delineated in the respective Aquatic Resource Alteration Permit.

On November 3, 2003, the TDEC Division of Water Pollution Control issued an NPDES permit that became effective on December 1, 2003. It authorized DOE to discharge cooling tower blowdown and heating, ventilation, and air-conditioning condensate water from the SNS to a storm water detention pond that discharges to WOC at approximate stream mile 4.2 through outfall 435. Furthermore, the pond emergency spillway, designated as outfall 437, will discharge in large storm runoff situations to

Oak Ridge Reservation

mile 0.6 of a tributary to WOC. The SNS began discharging blowdown waters to the retention pond in December 2, 2003. Since then, the SNS has been fully compliant with all permit limits (see Table 5.13). The current NPDES permit expired on October 31, 2006. An application for renewal was submitted to and received by the TDEC on April 19, 2006.

The SNS has implemented a series of engineering controls designed to prevent any migration of radionuclides to groundwater. Furthermore, as reported above, the SNS implemented a baseline groundwater monitoring program that began in 2004 and was completed in 2006. At present, the groundwater monitoring program has transitioned from a preliminary monitoring program to establish the baseline to an operational monitoring program designed to ensure that any releases of contaminants from the facility do not cause an unacceptable impact to

groundwater or surface water on, or adjacent to, the site. No impacts to groundwater have been detected.

The SNS operates two 8.37-MMBTU/h natural-gas-fired-only boilers located in the Central Utilities Building and two 14.65-MMBTU/h natural-gas-fired-only boilers located in the Central Laboratory and Office Building. All these emission sources are permitted under the Title V Permit for 73-0112 (Office of Science) issued by the TDEC. In addition, the SNS has a permit for construction of the SNS Central Exhaust Facility. The facility will collect, monitor, and discharge radionuclides from operational components of the SNS. Sources will include accelerator tunnels, beam dumps, and the target building. The start-up of this air contaminant source will occur in late 2007.

Table 5.13. National Pollutant Discharge Elimination System (NPDES) compliance at SNS, 2006
(NPDES permit effective December 1, 2003)

Effluent parameters	Permit limits						Permit compliance		
	Monthly average (kg/d)	Daily max (kg/d)	Monthly average (mg/L)	Daily max (mg/L)	Daily min (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance ^a	
pH (std. units)				9	6.5	0	104	100	
Total residual chlorine			0.011	0.019		0	104	100	

^aPercentage compliance = 100 – [(number of noncompliances/number of samples) × 100].

6. Y-12 Environmental Monitoring Programs

Compliance and environmental monitoring programs required by federal and state regulation and by DOE orders are conducted at the Y-12 National Security Complex for air, water, and groundwater environmental media.

6.1 Y-12 Complex Radiological Airborne Effluent Monitoring

The release of radiological contaminants, primarily uranium, into the atmosphere at the Y-12 National Security Complex (Y-12 Complex) 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 more than 0.1 mrem/year effective dose equivalent to an off-site individual). As of January 1, 2006, the Y-12 Complex had continuous monitoring capability on a total of 53 stacks, 41 of which were active and twelve of which were temporarily shut down. Stacks US-017 and US-127 were permanently taken out of service in 2005. During 2006, 40 of the 53 stacks suitable for continuous monitoring were judged to be major sources. Sixteen of the stacks with 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 investigation and correction of the problem before a significant release occurs.

Emissions from 50 unmonitored processes, categorized as minor emission sources, are estimated according to calculation methods approved by the EPA. In 2006, there were 16 unmonitored processes operated by Y-12. These are included as minor sources in the Y-12 Complex source term.

During the year 2006, a change of programmatic responsibility occurred for several facilities located at the Y-12 Complex from Bethel Jacobs Company, LLC, (BJC) to BWXT Y-12. The change included four minor sources, specifically the Central Pollution Control Facility Lab Hood, the West End Treatment Facility

Degasser and Lab Hood, and the East End Volatile Organic Compound Air Stripper.

Uranium and other radionuclides are handled in millicurie quantities at facilities within the boundary of the Y-12 Complex as part of BWXT Y-12 laboratory activities. Twenty-eight minor emission points were identified from laboratory activities at facilities within the boundary of the Y-12 Complex as being operated by BWXT Y-12. In addition, the BWXT Y-12 Analytical Chemistry Organization laboratory is operated in a leased facility that is not within the ORR boundary; it is located approximately a mile east of the Y-12 Complex on Union Valley Road. The emissions from the Analytical Chemistry Organization Union Valley laboratory are included in the Y-12 Complex source term. Two minor emission points were identified at the laboratory. The releases from those emission points are minimal, however, and have a negligible impact on the total Y-12 Complex dose.

Emissions from Y-12 Complex room ventilation systems are estimated from radiation control data collected on airborne radioactivity concentrations in the work areas. Areas where the monthly average concentration exceeded 10% of the DOE derived air concentration worker-protection guidelines are included in the annual emission estimate. In 2006, one emission point where room ventilation emissions exceeded 10% of the guidelines was identified in Building 9212. However, because the emissions were vented to stack UB-027, its distributions were not specifically identified in the stack emissions.

6.1.1 Sample Collection and Analytical Procedure

Uranium stack losses were measured continuously on monitored operating process exhaust stacks in 2006. Particulate matter (including uranium) was filtered from the stack emissions. Filters at each location were changed

routinely, from one to two times per week, and were analyzed for total uranium. In addition, the sampling probes and tubing were removed quarterly and were 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.

6.1.2 Results

An estimated 0.02 Ci (1.46 kg) of uranium was released into the atmosphere in 2006 as a result of Y-12 activities (Figs. 6.1 and 6.2). The specific activity of enriched uranium is much greater than that of depleted uranium, and about 96% of the curie release was composed of emissions of enriched uranium particulate, even though approximately 18% of the total mass of uranium released was enriched material.

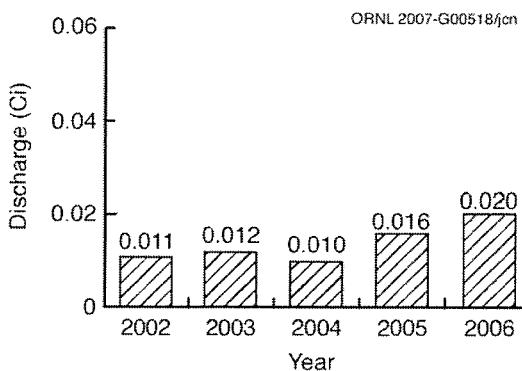


Fig. 6.1. Total curies of uranium discharged from the Y-12 Complex to the atmosphere, 2002–2006.

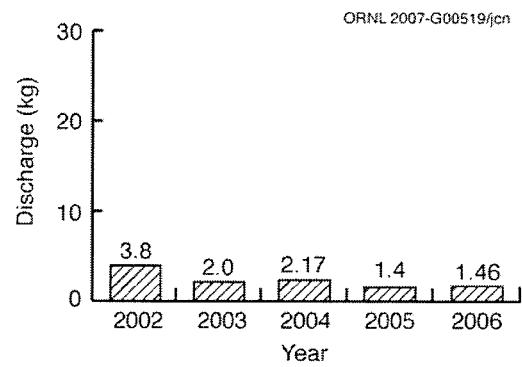


Fig. 6.2. Total kilograms of uranium discharged from the Y-12 Complex to the atmosphere, 2002–2006.

6.2 Y-12 Complex Nonradiological Airborne Emissions Monitoring

The release of nonradiological contaminants into the atmosphere at the Y-12 Complex occurs as a result of plant production, maintenance, waste management operations, and steam generation. Most process operations are served by ventilation systems.

In CY 2006, the Y-12 Complex implemented complete compliance and reporting activities for its first Major Source (Title V) Operating Air Permit. The permit covers 37 air emission sources and more than 100 air emission points. Other emission sources at the Y-12 Complex are categorized as being insignificant and exempt from air permitting. Under the Title V operating permit for the complex, sampling, continuous monitoring, and record keeping of key process parameters are recorded and reported to TDEC in quarterly, semiannual, and annual reports.

Approximately three-fifths of the permitted air sources release primarily nonradiological contaminants. The remaining two-fifths of the permitted sources process primarily radiological materials. TDEC air permits for the nonradiological sources do not require stack sampling or monitoring except for the two opacity monitors and three NO_x monitors used at the steam plant to ensure compliance with visible emission standards and ozone season emission limits, respectively. For nonradiological sources where direct monitoring of airborne emissions is not required, monitoring of key process parameters is done to ensure compliance with all permitted emission limits.

The 2006 Y-12 Complex annual emission fee was calculated based on 3,017.71 tons per year of actual emissions and 809.26 tons per year of allowable emissions of regulated pollutants, with an annual emission fee of \$113,965.81. In accordance with TDEC regulations, Rule 1200-3-26-.02(9)(i), when there is no applicable standard or permit condition for a pollutant, the allowable emissions are based on the maximum actual emissions calculations (maximum design capacity for 8760 h/year). More than 90% of the Y-12 Complex pollutant emissions to the atmosphere are attributed to the operation of the steam plant. The fee rates for

2006 were \$32 per ton for actual emissions and \$21.50 per ton for allowable emissions. In CY 2006, the Y-12 Complex paid fees on a mix of allowable and actual emissions. This requires the Y-12 Complex to file and include with the fee payment an emission fee analysis that summarizes the actual and allowable emissions of regulated pollutants.

The fee rates for 2006 were \$32 per ton for actual emissions and \$21.50 per ton for allowable emissions. In CY 2006, the Y-12 Complex paid fees on a mix of allowable and actual emissions. This requires the CY-12 Complex to file and include with the fee payment an emission fee analysis that summarizes the actual and allowable emissions of regulated pollutants.

6.2.1 Results

The primary source of criteria pollutants at the Y-12 Complex is the steam plant, where coal and natural gas are burned. Information regarding actual vs allowable emissions from the steam plant is provided in Table 6.1. In addition, the annual toxic release inventory report (required by EPCRA Sect. 313) provides information on other nonradiological Y-12 Complex air emissions (Sect. 2.2.15.3).

Condition E12-49 of the Y-12 Title V operating air permit for the Y-12 Steam Plant requires the opacity monitoring systems to be fully operational 95% of the operational time of the monitored units during each month of the calendar quarter. During 2006, the opacity

monitoring systems were operational for more than 95% of the operational time of the monitored units during each month.

Condition E12-50 of the Y-12 Title V operating air permit requires that calibration error tests of the opacity monitoring systems be performed on a semiannual basis. The calibration error tests were performed on March 27 and 31, 2006, for both the west and east stack opacity monitors, respectively. They were performed again on September 14 and 28, 2006, for the west and east monitor, respectively; the reports were submitted to the technical secretary for his approval and records. During 2006, 103 6-min periods of excess emissions occurred. Quarterly reports of the status of the Y-12 Steam Plant opacity monitors are submitted to personnel at TDEC within 30 days after the end of each calendar quarter. Table F.4 in Appendix F is a record of excess emissions and inoperative conditions for the east and west stack opacity monitors for 2006.

Condition E12-42 of the Y-12 Title V operating air permit requires continuous monitoring of NO_x mass emissions during the ozone season (May 1 through September 30). The cumulative NO_x mass emissions measured from the steam plant for the 2006 ozone season were 153.4 tons of NO_x; the limit is 232 tons.

The results of monitoring a number of key process parameters were provided in a report to TDEC in November 2006. All monitored results were in compliance with the Title V permit.

Table 6.1. Actual vs allowable air emissions from the Oak Ridge Y-12 Steam Plant, 2006

Pollutant	Emissions (tons/year) ^a		Percentage of allowable
	Actual	Allowable	
Particulate	32	945	3.4
Sulfur dioxide	2,286	20,803	11.0
Nitrogen oxides ^b	654	5,905	11.1
Nitrogen oxides (ozone season only)	153.4 ^c	232	66.1
Volatile organic compounds ^b	2.3	41	5.6
Carbon monoxide ^b	20	543	3.7

^a1 ton = 907.2 kg.

^bWhen there is no applicable standard or enforceable permit condition for some pollutants, the allowable emissions are based on the maximum actual emissions calculation as defined in Tennessee Department of Environment and Conservation Rule 1200-3-26-02(2)(d)3 (maximum design capacity for 8760 h/year). The emissions for both the actual and allowable emissions were calculated based on the latest EPA compilation of air pollutant emission factors. (EPA 1995 and 1998. *Compilation of Air Pollutant Emission Factors AP-42, Fifth Edition, Volume 1: Stationary Point and Area Sources*. Environmental Protection Agency, Research Triangle Park, N.C. January 1995 and September 1998.)

^cMonitored emissions.

6.3 Y-12 Complex Ambient Air Monitoring

There are no federal regulations, state regulations, or DOE orders that require ambient air monitoring within the Y-12 complex. All ambient air monitoring systems at the Y-12 Complex are operated as a best management practice. 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, major processes that result in emission of enriched and depleted uranium are equipped with stack samplers that have been reviewed and approved by EPA to meet requirements of the NESHAP regulations. ORR air sampling stations (see Chap. 7), operated in accordance with DOE orders, are located around the reservation. Their locations were selected so that areas of potentially high exposure to the public are monitored continuously for parameters of concern.

BWXT Y-12 maintains three uranium ambient air monitors within the Y-12 Complex boundary that, since 1999, have been utilized by TDEC personnel in their environmental monitoring program. Each of the monitors use 47-mm borosilicate glass fiber filters to collect particulates as air is pulled through the units. The monitors control airflow with a pump and rotometer set to average approximately two standard cubic feet per minute. These samplers were operated by TDEC in 2006. In addition, two boundary mercury-monitoring stations (stations 2 and 8) remain in operation and monitor long-term spatial and temporal trends in ambient mercury vapor. The locations of the monitoring stations are shown in Fig. 6.3.

In preparation for the restart of the Oxide Conversion Facility (OCF), an ambient fluoride monitor was co-located with an existing ORR ambient air station in the Scarboro Community. (The ORR ambient network is discussed in Sect. 7.3.) As a measure to quantify any off-site fluoride dispersions, monitoring capability for fluorides was initiated in November 2004 and continued through 2006. In 2005 the OCF was loaded with hydrogen fluoride, and in March 2006, the OCF began the restart phase. It is anticipated that monitoring will continue through 2007 as a minimum.

6.3.1 Mercury

The Y-12 Complex ambient air monitoring program for mercury was established in 1986 as a best management practice. The objectives of the program have been to maintain a database of mercury concentration in ambient air, to track long-term spatial and temporal trends in ambient mercury vapor, and to demonstrate protection of the environment and human health from releases of mercury at the Y-12 Complex to the atmosphere. Originally, four monitoring stations were operated at the Y-12 Complex, including two within the former mercury-use area. The two atmospheric mercury monitoring stations currently operating at the Y-12 Complex, Ambient Air Station No. 2 (AAS2) and Ambient Air Station No. 8 (AAS8), are located near the east and west boundaries of the Y-12 Complex, respectively (see Fig. 6.3). Since their establishment in 1986, AAS2 and AAS8 have monitored mercury in ambient air continuously with the exception of short periods of downtime because of electrical or equipment outages. In addition to the Y-12 Complex monitoring stations, a control or reference site (Rain Gauge No. 2) was operated on Chestnut Ridge in the Walker Branch Watershed for a 20-month period in 1988 and 1989 to establish a reference concentration at that time.

At the two current monitoring sites, airborne mercury vapor is collected by pulling ambient air through a sampling train consisting of a Teflon filter, a flow-limiting orifice, and an iodated-charcoal sampling trap. The flow-limiting orifice restricts airflow through the sampling train to ~ 1 L/min. Actual flow rates are measured weekly in conjunction with trap changeout with a calibrated Gil mont flowmeter. The charcoal in each trap is analyzed for total mercury using cold vapor atomic fluorescence after acid digestion. Average concentration of mercury vapor in the ambient air for each 7-day sampling period is calculated by dividing the total mercury per trap by the volume of air pulled through the charcoal trap during the corresponding 7-day period.

As reported in previous annual environmental reports, average ambient mercury concentration at the monitoring sites has declined significantly since the late 1980s, with average mercury vapor concentration at AAS8 declining almost tenfold and at AAS2 approximately

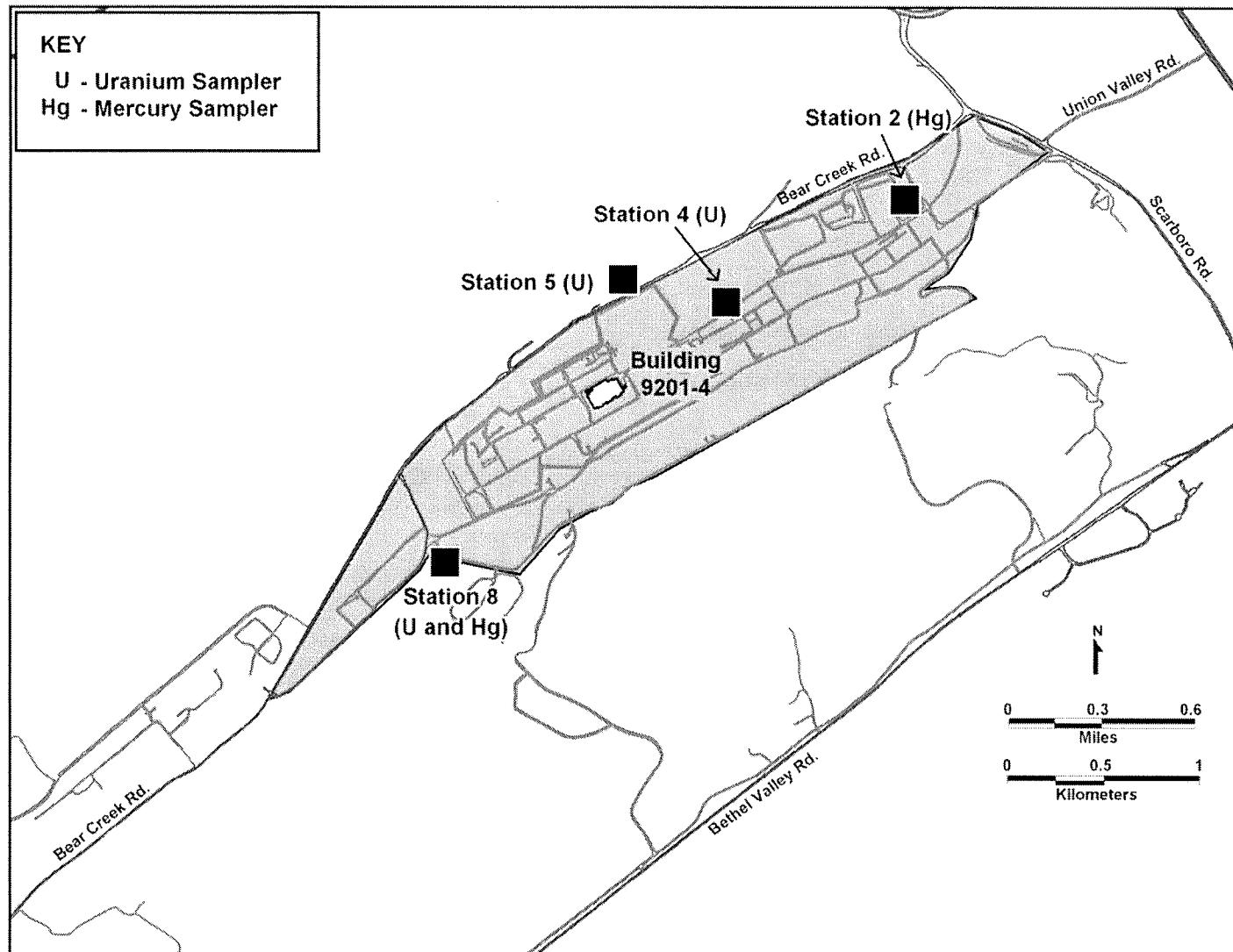


Fig. 6.3. Locations of ambient air monitoring stations at the Y-12 Complex.

threefold. Recent average annual concentration at the two boundary stations are comparable to concentrations measured in 1988 and 1989 at the Chestnut Ridge reference site (Table 6.2) but slightly elevated above concentrations reported for continental background ($\sim 0.002 \text{ }\mu\text{g}/\text{m}^3$). Average mercury concentration measured at the AAS2 site during 2006 was $0.0036 \text{ }\mu\text{g}/\text{m}^3$ ($N = 51$; S.E. = ± 0.0002) and has remained unchanged since year 2002 when it was slightly higher at $0.0040 \text{ }\mu\text{g}/\text{m}^3$. At monitoring station AAS8, located at the west end of the Y-12 Complex, the average concentration for CY 2006 was $0.0058 \text{ }\mu\text{g}/\text{m}^3$ ($N = 52$; S.E. = ± 0.0004) and represents a slight, but not significant (Student's *t*-test), increase over the average concentration for 2004 and 2005. Though the difference in the average concentration from 2004 to 2006 is not significant, there has been an upward trend in mercury concentration at AAS8 dating back several years. This upward trend may reflect a temporary increase in ambient concentrations at AAS8 because of increased demolition and excavation in the western end of the Y-12 Complex as part of the Y-12 Complex infrastructure reduction program. A very large increase in Hg concentration at AAS8 was observed in the late 1980s (Fig. 6.4, plot B) and was thought to be related to disturbances of Hg-contaminated soils and sediments during the Perimeter Intrusion Detection and Assessment System and utility restoration projects in progress then. Hg concentrations measured at AAS8 should continue to be tracked closely, especially if demolition and excavation occur in the old Hg-use areas of the Y-12 Complex as part of infrastructure reduction. Significant increases may warrant the reestablishment of sites within

the old mercury-use areas and a reassessment of reference concentrations at the former reference site on Chestnut Ridge. Table 6.2 summarizes the 2006 mercury results and the results from the 1986 through 1988 period for comparison. In Fig. 6.4, plots A, B, and C illustrate temporal trends in mercury concentration for the two active mercury monitoring sites since the inception of the program in 1986 through December 2006 (plots A, B) and seasonal trends at AAS8 from 1993 thru 2006 (plot C).

In conclusion, 2006 average mercury concentrations at the two mercury monitoring sites are comparable to reference levels measured for the Chestnut Ridge reference site in 1988 and 1989. Measured concentrations continue to be well below current environmental and occupational health standards for inhalation exposure to mercury vapor; for example, the National Institute for Occupational Safety and Health recommended exposure limit of $50 \text{ }\mu\text{g}/\text{m}^3$ (time-weighted average for up to a 10-h workday, 40-h workweek), the American Conference of Governmental Industrial Hygienists workplace threshold limit value of $25 \text{ }\mu\text{g}/\text{m}^3$ as a time-weighted average for a normal 8-h workday and 40-h workweek, and the current EPA reference concentration ($0.3 \text{ }\mu\text{g}/\text{m}^3$) for elemental mercury for daily inhalation exposure without appreciable risk of harmful effects during a lifetime.

6.3.2 Fluorides

State of Tennessee regulation 1200-3-3-01 does not define primary standards (affecting public health) for hydrogen fluoride. However, secondary standards (affecting public welfare, i.e., vegetation, aesthetics) are defined in 1200-3-3-02 for gaseous fluorides expressed as

Table 6.2. Summary results for the Oak Ridge Y-12 Complex mercury in ambient air monitoring program, 2006

Results of the 1986 through 1988 monitoring period are shown for reference

Ambient air monitoring stations	Mercury vapor concentration ($\mu\text{g}/\text{m}^3$)			
	2006 average	2006 maximum	2006 minimum	1986–1988 average
AAS2 (east end of the Y-12 Complex)	0.0036	0.0084	0.0018	0.010
AAS8 (west end of the Y-12 Complex)	0.0058	0.0193	0.0024	0.033
Reference Site, Rain Gauge No. 2 (1988 ^a)	N/A	N/A	N/A	0.006
Reference Site, Rain Gauge No. 2 (1989 ^b)	N/A	N/A	N/A	0.005

^aData for period from February 9 through December 31, 1988.

^bData for period from January 1 through October 31, 1989.

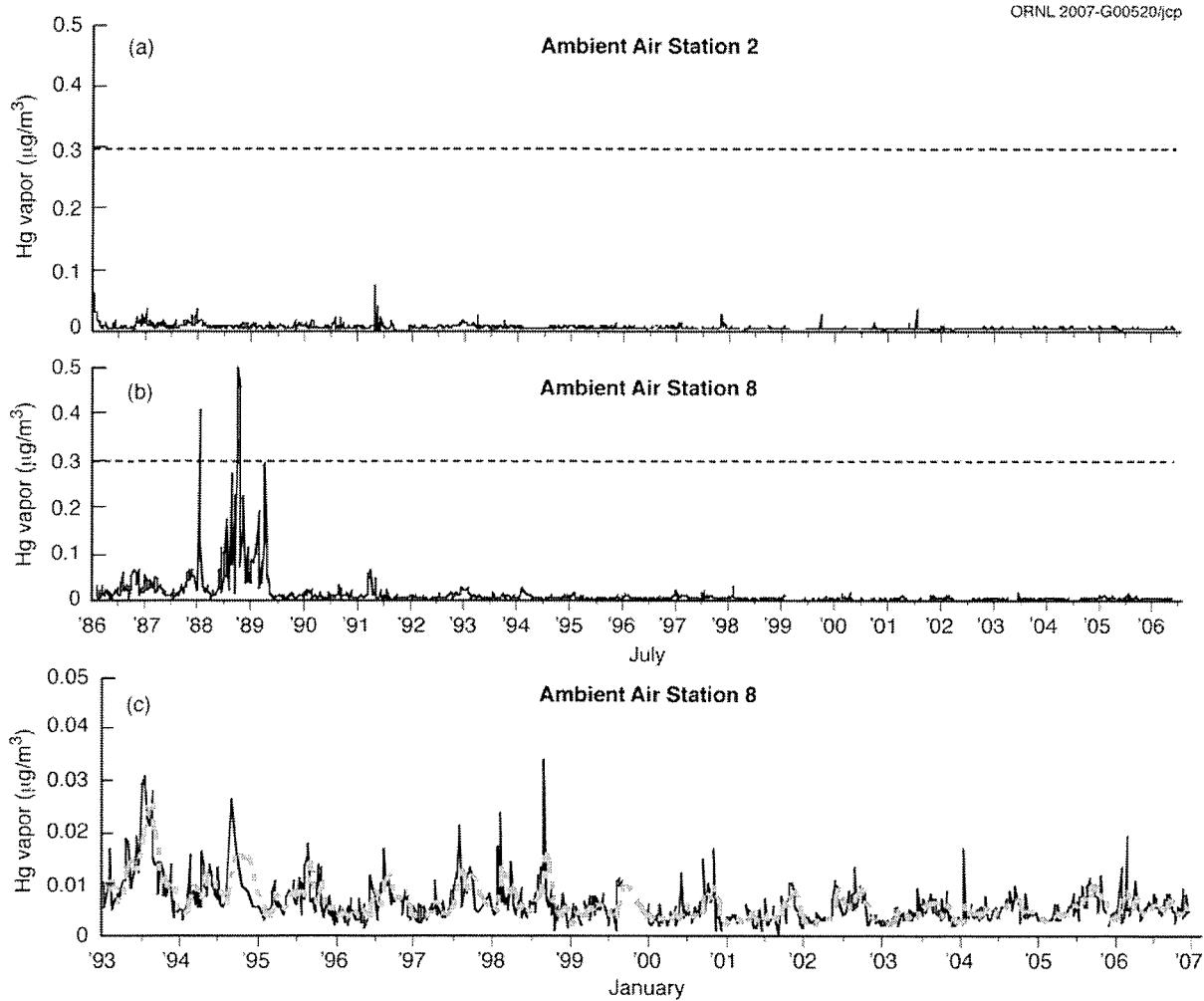


Fig. 6.4. Temporal trends in mercury vapor concentration for the boundary mercury monitoring stations at the Y-12 National Security Complex, July 1986 to January 2007 (Graphs A and B) and January 1993 to January 2007 for AAS8 (Graph C).

hydrogen fluoride. In anticipation of the startup of the hydrogen fluoride system during CY 2005, arrangements were made to monitor the community adjacent to the Y-12 Complex for the presence of fluorides.

The monitoring methodology chosen for use is in accordance with the American Society for Testing and Materials (ASTM) Standard D3266, which designates the use of a dual-tape sampler. The time period over which the monitoring occurs is 7 days, and results in a total of fifty-six samples being generated per week (3 h per sample, 8 samples per day; 7 days per week). Table 6.3 presents the results of the analyses of the samples for the year 2006. The results represent a composite (7-day average) and serve to provide background information on the presence

of fluorides in the surrounding area. The regulatory secondary standard for the 7-day average is $1.6 \mu\text{g}/\text{m}^3$. Actual monitoring data indicate a maximum of $0.048 \mu\text{g}/\text{m}^3$.

6.4 Liquid Discharges—Y-12 Complex Radiological Monitoring Summary

A radiological monitoring plan is in place at the Y-12 Complex to address compliance with DOE orders and NPDES Permit TN002968. The permit requires the Y-12 Complex to submit results from the monitoring program quarterly as an addendum to the NPDES discharge monitoring report. There were no discharge limits set by the NPDES permit for radionuclides; the

Table 6.3. Summary results for HF measured as fluorides (7-day average) in the Scarboro Community, 2006

Date	Run time (h)	Volume (m ³)	Fl (µg)	Result (µg/m ³)
1/3/2006	168.8	151.64	2.93	0.019
1/10/2006	165.4	148.69	2.43	0.016
1/17/2006	169.7	151.73	2.47	0.016
1/24/2006	168.4	151.36	1.59	0.011
1/31/2006	167.8	150.81	2.92	0.019
2/7/2006	168.2	151.14	2.1	0.014
2/14/2006	167.5	149.89	1.85	0.012
2/21/2006	168.3	151.31	1.18	0.008
2/28/2006	167.4	150.48	2.86	0.019
3/7/2006	168.8	151.7	4.35	0.029
3/14/2006	166.9	150.04	7.17	0.048
3/21/2006	168.7	148.19	1.94	0.013
3/28/2006	167	146.1	1.59	0.011
4/4/2006	168.1	143.21	2.87	0.020
4/11/2006	167.1	142.84	2.22	0.016
4/18/2006	145.3	130.23	4.84	0.037
4/25/2006	167.1	150.18	2.84	0.019
5/2/2006	168.5	151.41	3.03	0.020
5/9/2006	167.1	150.17	3.44	0.023
5/16/2006	168.7	151.58	3.48	0.023
5/23/2006	167.4	150.17	4.04	0.027
5/30/2006	168.2	150.27	3.62	0.024
6/6/2006	167.1	150.46	3.6	0.024
6/13/2006	168.5	151.49	4.56	0.030
6/20/2006	167.1	150.18	4.64	0.031
6/27/2006	48	60.47	1.07	0.018
7/5/2006	190.4	167.19	4.32	0.026
7/11/2006	145	115.87	2.78	0.024
7/18/2006	167.4	142.61	3.62	0.025
7/25/2006	168.7	151.35	5.4	0.036
8/1/2006	167.5	151.75	2.54	0.017
8/8/2006	167.8	150.7	1.86	0.012
8/15/2006	167.4	150.45	2.68	0.018
8/22/2006	169	151.95	2.6	0.017
8/29/2006	166.9	149.63	4.12	0.028
9/5/2006	166.9	150.03	3.48	0.023
9/12/2006	167.7	150.64	2.78	0.018
9/19/2006	168.1	151.02	2.48	0.016
9/26/2006	168.1	151.08	2.26	0.015
10/3/2006	168.4	151.08	1.89	0.013
10/10/2006	166.7	149.89	3.09	0.021
10/17/2006	168.8	151.7	1.98	0.013
10/24/2006	167.2	150.23	1.89	0.013
10/31/2006	169.7	152.5	1.71	0.011
11/7/2006	167.1	150.24	1.58	0.011
11/14/2006	168.7	151.65	3	0.020

Table 6.3 (continued)

Date	Run time (h)	Volume (m ³)	F1 (μg)	Result (μg/m ³)
11/21/2006	166.9	149.99	3.12	0.021
11/28/2006	168.9	151.36	2.96	0.020
12/5/2006	167.8	150.84	3.21	0.021
12/12/2006	167.9	150.07	2.04	0.014
12/19/2006	167	150.1	3.92	0.026
12/26/2006	170.3	153.01	3.63	0.024

requirement is to monitor and report. The radiological monitoring plan was developed based on an analysis of operational history, expected chemical and physical relationships, and historical monitoring results. Under the existing plan, effluent monitoring is conducted at three types of locations: (1) treatment facilities, (2) other point-source and area-source discharges, and (3) instream locations. Operational history and past monitoring results provide a basis for parameters routinely monitored under the plan (Table 6.4). As required by the new NPDES permit, which became effective May 1, 2006, the *Radiological Monitoring Plan for Y-12 Complex* (Y-12 2006) was revised and reissued in June 2006.

The Y-12 Complex is permitted to discharge domestic wastewater to the city of Oak Ridge publicly owned treatment works under Industrial and Commercial User Wastewater Discharge Permit No. I-91. As required by the discharge permit, radiological monitoring of the sanitary sewer system discharge is conducted and

reported to the city of Oak Ridge, although there are no city-established radiological limits. Potential sources of radionuclides discharging to the sanitary sewer have been identified in previous studies at the Y-12 Complex as part of an initiative to meet the “as low as reasonably achievable” goals.

Radiological monitoring during storm water events is accomplished as part of the storm water monitoring program. Uranium is monitored at three major East Fork Poplar Creek storm water outfalls, four instream monitoring locations as well as raw water flow augmentation, and at S06 (an instream outfall on Bear Creek). Results of storm event monitoring during 2006 were reported in *Annual Storm Water Report for the National Security Complex* (Y-12 2007) Y/TS 2035, which was issued in January 2007. In addition, the monthly 7-day composite sample for radiological parameters taken at Station 17 on East Fork Poplar Creek will likely include rain events.

Table 6.4. Radiological parameters monitored at the Y-12 Complex in 2006

Parameters	Specific isotopes	Rationale for monitoring
Uranium isotopes	²³⁸ U, ²³⁵ U, ²³⁴ U, total U, weight % ²³⁵ U	These parameters reflect the major activity, uranium processing, throughout the history of Y-12 and are the dominant detectable radiological parameters in surface water
Fission and activation products	⁹⁰ Sr, ³ H, ⁹⁹ Tc, ¹³⁷ Cs	These parameters reflect a minor activity at Y-12, processing recycled uranium from reactor fuel elements, from the early 1960s to the late 1980s, and will continue to be monitored as tracers for beta and gamma radionuclides, although their concentrations in surface water are low
Transuranium isotopes	²⁴¹ Am, ²³⁷ Np, ²³⁸ Pu, ^{239/240} Pu	These parameters are related to recycle uranium processing. Monitoring has continued because of their half-lives and presence in groundwater
Other isotopes of interest	²³² Th, ²³⁰ Th, ²²⁸ Th, ²²⁶ Ra, ²²⁸ Ra	These parameters reflect historical thorium processing and natural radionuclides necessary to characterize background radioisotopes

6.4.1 Results

Radiological monitoring plan locations sampled in 2006 are noted in Fig. 6.5. Table 6.5 identifies the monitored locations, the frequency of monitoring, and the sum of the percentages of the DCGs for radionuclides measured in 2006. Radiological data were well below the allowable DCGs.

In 2006, the total mass of uranium and associated curies released from the Y-12 Complex at the easternmost monitoring station, Station 17 on Upper East Fork Poplar Creek, was 131 kg or 0.050 Ci (Table 6.6). Figure 6.6 illustrates a 5-year trend of these releases. The total release is calculated by multiplying the average concentration (grams per liter) by the average flow (million gallons per day). Converting units and multiplying by 365 days per year yields the calculated discharge. Bear Creek kilometer (BCK) 4.55, the former NPDES outfall 304, had in previous years been used as the westernmost monitoring station. In June 2006 monitoring was suspended at the BCK 4.55 location and was moved to NPDES outfall S24.

The City of Oak Ridge Industrial and Commercial User Wastewater Discharge Permit allows the Y-12 Complex to discharge wastewater to be treated at the Oak Ridge publicly owned treatment works through the East End Sanitary Sewer Monitoring Station, also identified as SS6 (Fig. 6.5). Compliance samples are collected there. Results of radiological monitoring are reported to the city of Oak Ridge in quarterly monitoring reports.

6.5 Nonradiological Liquid Discharges—Y-12 Complex Surface Water and Liquid Effluents

The current Y-12 NPDES permit, issued on March 13, 2006, and effective on May 1, 2006, requires sampling, analysis, and reporting for approximately 65 outfalls. Major outfalls are noted in Fig. 6.7. The number is subject to change as outfalls are eliminated or consolidated or if permitted discharges are added. Currently, the Y-12 Complex has outfalls and monitoring points in the following water drainage areas: East Fork Poplar Creek, Bear Creek, and several unnamed tributaries on the south side of

Chestnut Ridge. These creeks and tributaries eventually drain to the Clinch River.

Discharges to surface water allowed under the permit include storm drainage, cooling water, cooling tower blowdown, steam condensate, and treated process wastewaters, including effluents from wastewater treatment facilities. Groundwater inflow into sumps in building basements and infiltration to the storm drain system are also permitted for discharge to the creek. The monitoring data collected by the sampling and analysis of permitted discharges are compared with NPDES limits if a limit exists for each parameter. Some parameters, defined as “monitor only,” have no specified limits.

The water quality of surface streams in the vicinity of the Y-12 Complex is affected by current and historical legacy operations. Discharges from the Y-12 Complex processes flow into East Fork Poplar Creek before the water exits the Y12 Complex. East Fork Poplar Creek eventually flows through the city of Oak Ridge to Poplar Creek and into the Clinch River. Bear Creek water quality is affected by area source runoff and groundwater discharges. The NPDES permit requires regular monitoring and storm water characterization in Bear Creek and several of its tributaries.

The effluent limitations contained in the permit are based on the protection of water quality in the receiving streams. The permit emphasizes storm water runoff and biological, toxicological, and radiological monitoring. Some of the requirements in the new permit and the status of compliance are as follows:

- chlorine limitations based on water quality criteria at three outfalls located near the headwaters of East Fork Poplar Creek (monitoring ongoing); new dechlorination facilities are being constructed;
- reduction of the measurement frequency for pH and chlorine at East Fork Poplar Creek outfalls with addition of requirement for measurements in stream at the Station 17 location;
- a radiological monitoring plan requiring monitoring and reporting of uranium and other isotopes at pertinent locations (see Sect. 6.4);
- implementation of a storm water pollution prevention plan requiring sampling and characterization of storm water and

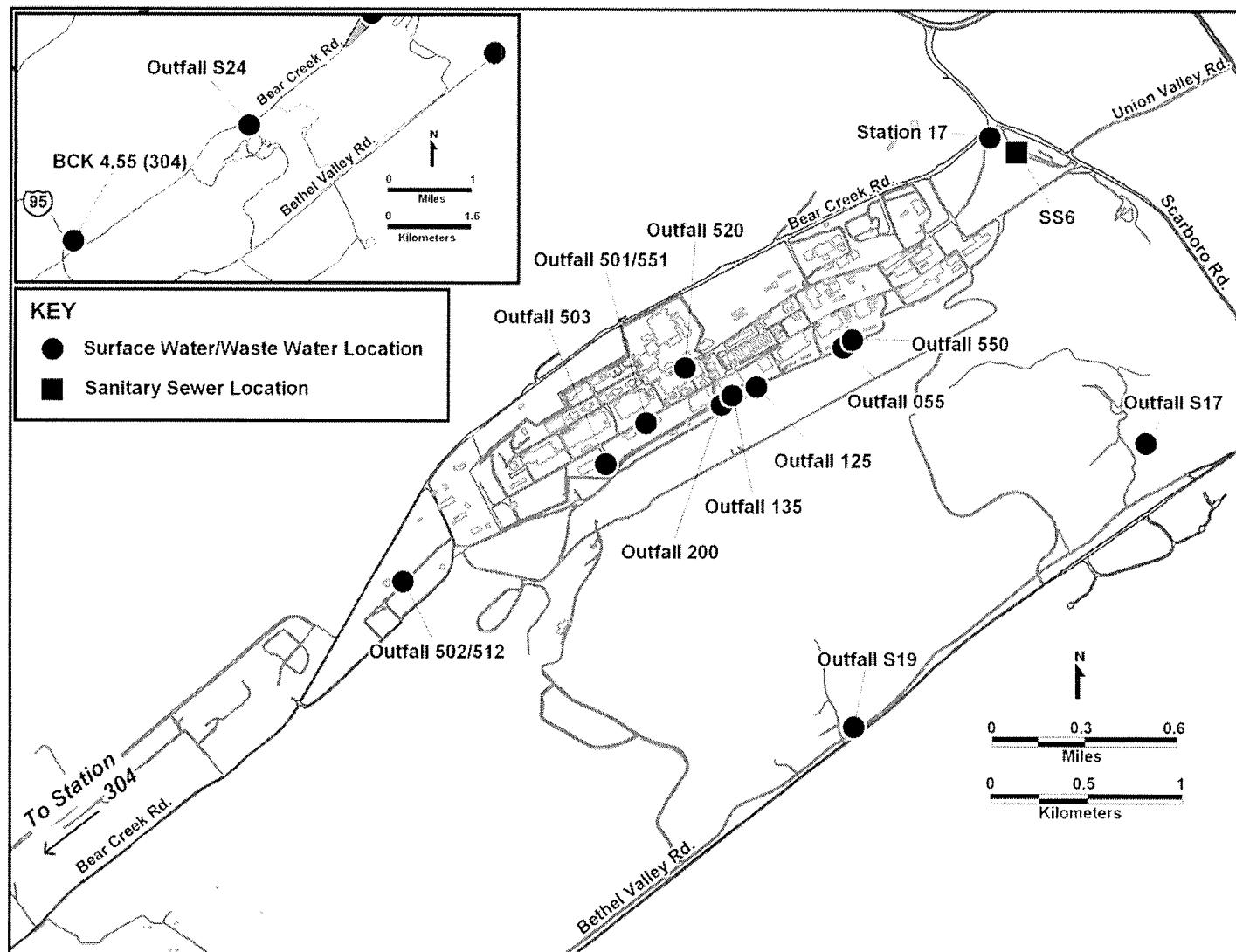


Fig. 6.5. Surface water and sanitary sewer radiological sampling locations at the Y-12 Complex.

Oak Ridge Reservation

Table 6.5. Summary of Y-12 Complex radiological monitoring plan sample requirements^a

Outfall No.	Location	Sample frequency	Sample type	Sum of DCG percentage
Y-12 Complex wastewater treatment facilities				
501	Central Pollution Control Facility	1/month	Composite during batch operation	No flow
502	West End Treatment Facility	1/batch	24-hour composite	No flow
503	Steam Plant Wastewater Treatment Facility	4/year	24-hour composite	No flow
512	Groundwater Treatment Facility	4/year	24-hour composite	2.5
520	Steam condensate	1/year	Grab	0.5
550	East End Mercury Treatment	4/year	24-hour composite	1.9
551	Central Mercury Treatment Facility	4/year	24-hour composite	-2.6
Other Y-12 Complex point and area source discharges				
055	Outfall 055	4/year	24-hour composite	1.1
125	Outfall 125	4/year	24-hour composite	4.4
135	Outfall 135	4/year	24-hour composite	1.1
S17	Kerr Hollow Quarry	1/year	24-hour composite	0.95
S19	Rogers Quarry	1/year	24-hour composite	0.67
Y-12 Complex instream locations				
BCK 4.55	Bear Creek, complex exit (west)	1/week ^b	7-day composite	4.4
S24	Outfall S24	4/year	7-day composite	8.5
Station 17	East Fork Poplar Creek, complex exit (east)	1/month	7-day composite	0.77
200	North/south pipes	1/month	24-hour composite	4.2
Y-12 Complex sanitary sewer				
SS6	East End Sanitary Sewer Monitoring Station	1/week	7-day composite	3.9

^aRadiological monitoring plan was updated in June 2006.

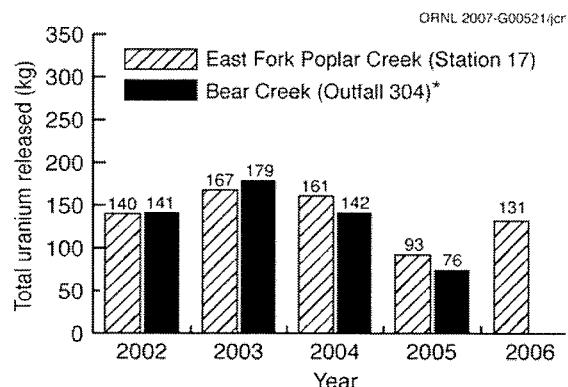
^bDiscontinued June 2006.

Table 6.6. Release of uranium from the Y-12 Complex to the off-site environment as a liquid effluent, 2002–2006

Year	Quantity released	
	Ci ^a	kg
Station 17		
2002	0.062	140
2003	0.073	167
2004	0.067	161
2005	0.043	93
2006	0.050	131
Outfall 304^b		
2002	0.070	141
2003	0.078	179
2004	0.133	142
2005	0.034	76
2006	Not available	Not available

^a1 Ci = 3.7E+10 Bq.

^bStation 304 is no longer configured for flow measurements.



*Monitoring at this location was suspended in June 2006.

Fig. 6.6. Five-year trend of Y-12 Complex release of uranium to surface water. Due to stream-restoration efforts conducted by the DOE-EM program, the weir at outfall 304 has been removed. As a result, flow data are no longer available. Monitoring at outfall 304 was suspended in June 2006.

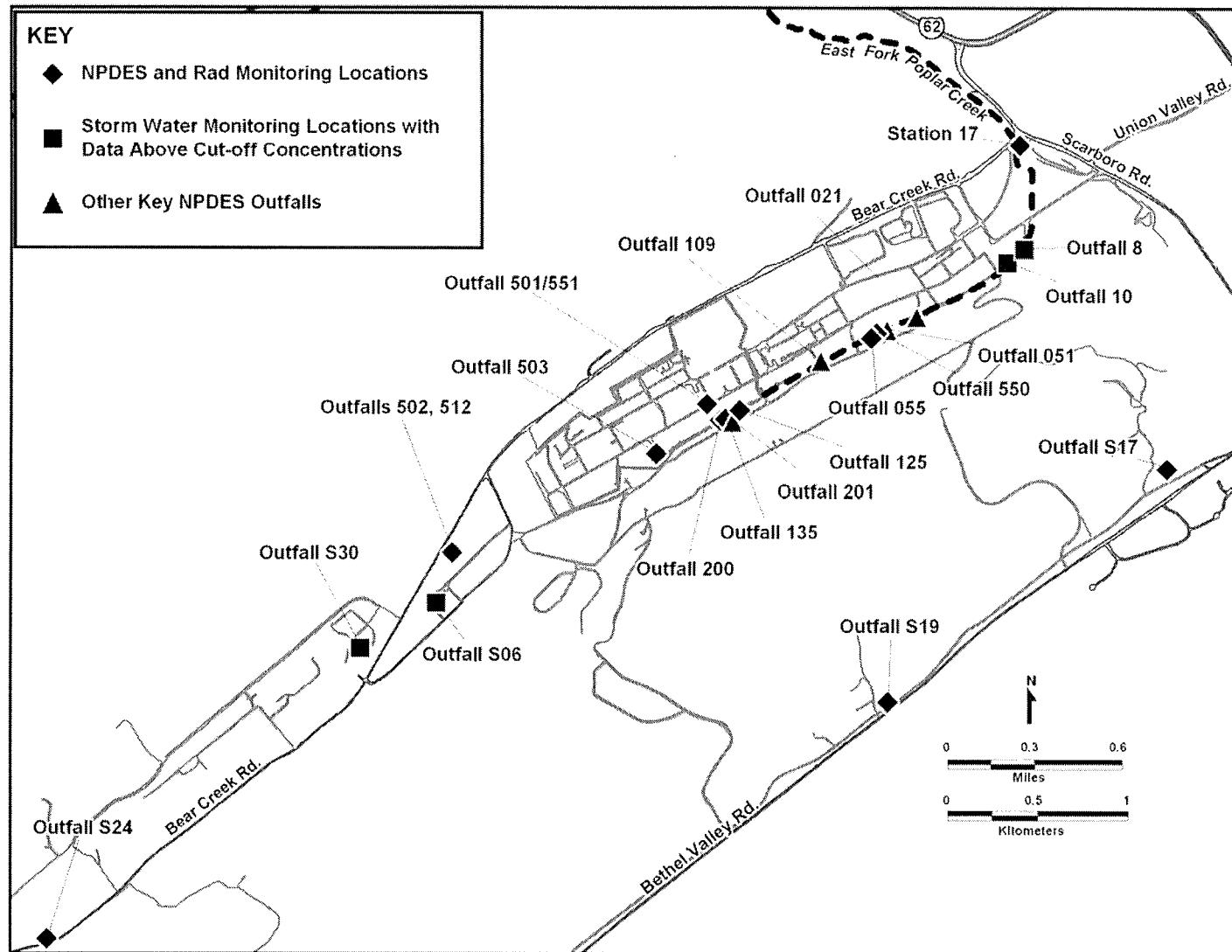


Fig. 6.7. Major Y-12 Complex National Pollutant Discharge Elimination System (NPDES) outfalls.

- sampling of stream baseload sediment at four instream East Fork Poplar Creek locations (see Sect. 6.5.2);
- requirement for an annual storm water monitoring report, an annual report of the BMAP data, and twice annual letter report to update BMAP progress; all submitted to TDEC.
- a requirement to manage the flow of East Fork Poplar Creek such that a minimum flow of 7 million gal/day (26.5 million L/day) is guaranteed by adding raw water from the Clinch River to the headwaters of East Fork Poplar Creek (see Sect. 6.5.4);
- whole effluent toxicity testing limitation for the three outfalls headwaters of East Fork Poplar Creek (see Sect. 6.6).

A notice of appeal of certain permit limits was filed by NNSA in April 2006. The permit limits for mercury at several outfalls, PCB at outfall 200, and toxicity limits at three outfalls were appealed because legacy contamination is addressed under CERCLA. Chlorine limits at headwaters of the creek were appealed, and a compliance schedule was requested so that a dechlorination unit could be put in place to handle a more stringent chlorine limit at outfall 109.

6.5.1 Sanitary Wastewater

Sanitary wastewater from the Y-12 Complex is discharged to the city of Oak Ridge publicly owned treatment works 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. During 2006, the wastewater flow in this system averaged about 595,000 gal/day.

Compliance sampling is conducted at the East End Sanitary Sewer Monitoring Station (SS-6, Fig. 6.5) weekly. The SS-6 station is also used for 24-h flow monitoring. As part of the city of Oak Ridge pretreatment program, city personnel use that monitoring station to perform compliance monitoring as required by pretreatment regulations.

6.5.2 Storm Water

The development and implementation of a storm water pollution prevention plan at the Y-12 Complex is designed to minimize the

discharge of pollutants in storm water runoff. The plan identifies areas that can reasonably be expected to contribute contaminants to surface water bodies via storm water runoff and describes the development and implementation of storm water management controls to reduce or eliminate the discharge of such pollutants. This plan requires (1) characterization of storm water by sampling during storm events, (2) implementation of measures to reduce storm water pollution, (3) facility inspections, and (4) employee training.

The NPDES permit defines the primary function of the Y-12 Complex to be a fabricated metal products industry. However, it also requires that storm water monitoring be conducted for three additional sectors: scrap/waste recycling activities; landfill and land application activities; and discharges associated with treatment, storage and disposal facilities. They are defined in the Tennessee Storm Water Multi-Sector General Permit for Industrial Activities, Permit No. TNR050000. Each sector has prescribed cut-off concentration values, and some have defined sector mean values. The "rationale" portion of the NPDES permit for the Y-12 Complex states "...cut-off concentrations were developed by the EPA and the State of Tennessee and are based on data submitted by similar industries for the development of the multi-sector general storm water permit. The cut-off concentrations are target values and should not be construed to represent permit limits." Similarly, sector mean values are defined as "...a pollutant concentration calculated from all sampling results provided from facilities classified in this sector during the previous term limit."

6.5.3 Results and Progress in Implementing Corrective Actions

In 2006, the Y-12 Complex experienced one NPDES excursion. The excursion was related to total residual chlorine at outfall 200 during February. Tables 6.7 and 6.8 list the NPDES compliance monitoring requirements and 2006 compliance record. Appendix E provides additional detail on the NPDES compliance.

During 2006, the Y-12 Complex experienced no exceedance of the Industrial and

Table 6.7. NPDES compliance monitoring requirements and record for the Y-12 Complex, January through April 2006

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily av (lb/d)	Daily max (lb/d)	Daily av (mg/L)	Daily max (mg/L)		
Outfall 066	pH, standard units			<i>a</i>	9.0	<i>b</i>	0
Outfall 068	pH, standard units			<i>a</i>	9.0	<i>b</i>	0
Outfall 117	pH, standard units			<i>a</i>	9.0	<i>b</i>	0
Outfall 073	pH, standard units			<i>a</i>	9.0	<i>b</i>	0
	Total residual chlorine				0.5	<i>b</i>	0
Outfall 077	pH, standard units			<i>a</i>	9.0	100	4
	Total residual chlorine				0.5	100	4
Outfall 122	pH, standard units			<i>a</i>	9.0	<i>b</i>	0
	Total residual chlorine				0.5	<i>b</i>	0
Outfall 133	pH, standard units			<i>a</i>	9.0	<i>b</i>	0
	Total residual chlorine				0.5	<i>b</i>	0
Outfall 125	pH, standard units			<i>a</i>	9.0	100	4
	Total residual chlorine				0.5	100	4
Category I outfalls (Storm water, steam condensate, cooling tower blowdown, and groundwater)	pH, standard units			<i>a</i>	9.0	<i>b</i>	0
Category I outfalls (Outfalls S15 and S16)	pH, standard units			<i>a</i>	10.0	<i>b</i>	0
Category II outfalls (cooling water, steam condensate, storm water, and groundwater)	pH, standard units			<i>a</i>	9.0	100	26
	Total residual chlorine				0.5	100	18
Category II outfalls (S21, S22, S25, S26, S27, S28, and S29)	pH, standard units			<i>a</i>	10.0	100	5
Outfall S19 (Rogers Quarry)	pH, standard units			<i>a</i>	9.0	100	4
Category III outfalls (storm water, cooling water, cooling tower blowdown, steam condensate, and groundwater)	pH, standard units			<i>a</i>	9.0	100	47
	Total residual chlorine				0.5	100	47
Outfall 201 (below the North/South pipes)	Total residual chlorine				0.011	98	58
	Temperature, °C			<i>a</i>	30.5	100	51
	pH, standard units	8.5		<i>a</i>		100	51
Outfall 200 (North/ South pipes)	Oil and grease			10	15	100	51
	Hexane extractable material						

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Table 6.7 (continued)

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily av (lb/d)	Daily max (lb/d)	Daily av (mg/L)	Daily max (mg/L)		
Outfall 021	Total residual chlorine			0.080	0.188	100	51
	Temperature, °C		<i>a</i>	30.5	100	51	
	pH, standard units			9.0	100	51	
Outfall 017	pH, standard units		<i>a</i>	9.0	100	17	
	Ammonia as N		32.4	64.8	100	17	
Outfall 055	pH, standard units		<i>a</i>	9.0	100	34	
	Mercury			0.004	100	34	
	Total residual chlorine			0.5	100	32	
Outfall 55A	pH, standard units		<i>a</i>	9.0	<i>b</i>	0	
	Mercury			0.004	<i>b</i>	0	
Outfall 550	pH, standard units		<i>a</i>	9.0	100	17	
	Mercury		0.002	0.004	100	17	
Outfall 551	pH, standard units			9.0	100	6	
	Mercury		0.002	0.004	100	7	
	pH, standard units		<i>a</i>	9.0	100	34	
Outfall 501 (Central Pollution Control Facility)	pH, standard units		<i>a</i>	9.0	<i>b</i>	0	
	Total suspended solids			31.0	40.0	<i>b</i>	0
	Total toxic organics				2.13	<i>b</i>	0
	Oil and grease			10	15	<i>b</i>	0
	Cadmium	0.16	0.4	0.075	0.15	<i>b</i>	0
	Chromium	1.0	1.7	0.5	1.0	<i>b</i>	0
	Copper	1.2	2.0	0.5	1.0	<i>b</i>	0
	Lead	0.26	0.4	0.1	0.2	<i>b</i>	0
	Nickel	1.4	2.4	2.38	3.98	<i>b</i>	0
	Nitrate/Nitrite				100	<i>b</i>	0
Outfall 502 (West End Treatment Facility)	Silver	0.14	0.26	0.05	0.05	<i>b</i>	0
	Zinc	0.9	1.6	1.48	2.0	<i>b</i>	0
	Cyanide	0.4	0.72	0.65	1.20	<i>b</i>	0
	PCB				0.001	<i>b</i>	0
	pH, standard units		<i>a</i>	9.0	<i>b</i>	0	
	Total suspended solids	18.6	36.0	31.0	40.0	<i>b</i>	0
	Total toxic organics				2.13	<i>b</i>	0
	Nitrate/nitrite			100	150	<i>b</i>	0
	Hexane extractables			10	15	<i>b</i>	0
	Cadmium	0.16	0.4	0.075	0.15	<i>b</i>	0

Table 6.7 (continued)

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily av (lb/d)	Daily max (lb/d)	Daily av (mg/L)	Daily max (mg/L)		
Outfall 503 (Steam Plant Wastewater Treatment Facility)	pH, standard units			<i>a</i>	9.0	<i>b</i>	0
	Total suspended solids	125	417	30.0	40.0	<i>b</i>	0
	Oil and grease	62.6	83.4	10	15	<i>b</i>	0
	Iron	4.17	4.17	1.0	1.0	<i>b</i>	0
	Cadmium			0.075	0.15	<i>b</i>	0
	Chromium	0.83	0.83	0.20	0.20	<i>b</i>	0
	Copper	4.17	4.17	0.20	0.40	<i>b</i>	0
	Lead			0.10	0.20	<i>b</i>	0
	Zinc	4.17	4.17	1.0	1.0	<i>b</i>	0
	pH			<i>a</i>	9.0	100	45
Outfall 512 (Groundwater Treatment Facility)	Iron				1.0	100	45
	PCB				0.001	100	4
	pH, standard units				9.0	<i>b</i>	0
Outfall 520	pH				9.0	<i>b</i>	0
Outfall 05A	pH				9.0	<i>b</i>	0

*a*Not applicable.

*b*No discharge.

Table 6.8. NPDES compliance monitoring requirements and record for the Y-12 Complex, May through December 2006

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily av (lb/d)	Daily max (lb/d)	Daily av (mg/L)	Daily max (mg/L)		
Outfall 501 (Central Pollution Control Facility)	pH, standard units			<i>a</i>	9.0	<i>b</i>	0
	Total suspended solids			31.0	40.0	<i>b</i>	0
	Total toxic organics				2.13	<i>b</i>	0
	Oil and grease			10	15	<i>b</i>	0
	Cadmium	0.16	0.4	0.075	0.15	<i>b</i>	0
	Chromium	1.0	1.7	0.5	1.0	<i>b</i>	0
	Copper	1.2	2.0	0.5	1.0	<i>b</i>	0
	Lead	0.26	0.4	0.1	0.2	<i>b</i>	0
	Nickel	1.4	2.4	2.38	3.98	<i>b</i>	0
	Nitrate/nitrite				100	<i>b</i>	0
	Silver	0.14	0.26	0.05	0.05	<i>b</i>	0
	Zinc	0.9	1.6	1.48	2.0	<i>b</i>	0
	Cyanide	0.4	0.72	0.65	1.20	<i>b</i>	0
	PCB				0.001	<i>b</i>	0

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Table 6.8 (continued)

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily av (lb/d)	Daily max (lb/d)	Daily av (mg/L)	Daily max (mg/L)		
Outfall 502 (West End Treatment Facility)	pH, standard units			<i>a</i>	9.0	<i>b</i>	0
	Total suspended solids	19	36.0	31.0	40.0	<i>b</i>	0
	Total toxic organics				2.13	<i>b</i>	0
	Nitrate/nitrite				100	<i>b</i>	0
	Hexane extractables			10	15	<i>b</i>	0
	Cadmium	0.16	0.4	0.075	0.15	<i>b</i>	0
	Chromium	1.0	1.7	0.5	1.0	<i>b</i>	0
	Copper	1.2	2.0	0.5	1.0	<i>b</i>	0
	Lead	0.26	0.4	0.10	0.20	<i>b</i>	0
	Nickel	1.4	2.4	2.38	3.98	<i>b</i>	0
	Silver	0.14	0.26	0.05	0.05	<i>b</i>	0
	Zinc	0.9	1.6	1.48	2.0	<i>b</i>	0
Outfall 503 (Steam Plant Wastewater Treatment Facility)	Cyanide	0.4	0.72	0.65	1.20	<i>b</i>	0
	PCB				0.001	<i>b</i>	0
	pH, standard units			<i>a</i>	9.0	<i>b</i>	0
	Total suspended solids	125	417	30.0	40.0	<i>b</i>	0
	Oil and grease	63	83.4	10	15	<i>b</i>	0
	Iron	20.8	20.8	5.0	5.0	<i>b</i>	0
	Cadmium	0.16		0.075	0.15	<i>b</i>	0
	Chromium	0.8	0.8	0.20	0.20	<i>b</i>	0
	Copper	4.17	4.17	0.20	0.40	<i>b</i>	0
	Lead			0.10	0.20	<i>b</i>	0
	Zinc	4.17	4.17	1.0	1.0	<i>b</i>	0
Outfall 512 (Groundwater Treatment Facility)	pH			<i>a</i>	9.0	100	8
	PCB				0.001	100	4
Outfall 520	pH, standard units				9.0	100	14
Outfall 200 (North/ South pipes)	pH, standard units				9.0	100	36
	Hexane extractables						
	Material			10	15	100	36
	Cadmium			0.001	0.025	100	9
	Lead			0.041	1.190	100	9
	PCB			0.002	0.002	100	10
Outfall 550	pH, standard units			<i>a</i>	9.0	100	34
	Mercury			0.002	0.004	100	34
Outfall 551	pH, standard units				9.0	100	35
	Mercury			0.002	0.004	100	35
Outfall 051	pH, standard units			<i>a</i>	9.0	100	8
Outfall 135	pH, standard units			<i>a</i>	9.0	100	16
	Lead				0.5	100	8
	PCB			0.002	0.002	100	3
	pH, standard units			<i>a</i>	9.0	100	8
Outfall 125	Cadmium			0.001	0.025	100	8
	Lead			0.04	1.190	100	8
	PCB			0.002	0.002	100	3

Table 6.8 (continued)

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily av (lb/d)	Daily max (lb/d)	Daily av (mg/L)	Daily max (mg/L)		
Outfall 055	pH, standard units			^a	9.0	100	13
	Mercury				0.004	100	35
Outfall 109	Total residual chlorine				0.5	100	2
	pH, standard units			^a	9.0	100	4
Outfall 021	Total residual chlorine				0.5	100	3
	pH, standard units			^a	9.0	100	4
Outfall 077	Total residual chlorine				0.188	100	3
	pH, standard units			^a	9.0	100	8
Outfall EFP ^b	pH, standard units			^a	9.0	100	172 ^c
Outfall C11	pH, standard units			^a	9.0	100	18
	Total residual chlorine				0.019	100	16
Outfall S06	Temperature (°C)				30.5	100	18
	pH, standard units			^a	9.0	100	1
Outfall S19	pH, standard units			^a	9.0	100	3
Outfall S24	pH, standard units			^a	9.0	100	3
Category I outfalls	pH, standard units			^a	9.0	100	19
Category II outfalls	pH, standard units			^a	9.0	100	28
	Total residual chlorine				0.5	100	28
Category III outfalls	pH, standard units			^a	9.0	100	10
	Total residual chlorine				0.5	100	10

^aNot applicable.^bNo discharge.^cAlso known as Station 17.

Commercial Users Wastewater Permit for discharge of sanitary wastewater to the city of Oak Ridge publicly owned treatment works. Table 6.9 lists the Industrial and Commercial Users Wastewater Permit compliance monitoring requirements and the 2006 compliance record.

In general, the analytical results from 2006 storm water monitoring activities compared very favorably to the cut-off concentrations prescribed in the Multi-Sector General Permit. A few parameters exceeded the cut-off concentrations. They are the point of focus in the next series of inspections and protection measures designed to improving the quality of storm water exiting the Y-12 Complex. A summary of storm water data above the prescribed cut-off concentrations is contained in Table 6.10.

Detailed storm water data summary tables are given in *Environmental Monitoring on the Oak Ridge Reservation: 2006 Results* (DOE 2007b). (See <http://www.ornl.gov/aser/>.)

Late in CY 2005, numerous violations of the NPDES permit occurred for mercury at the Central Mercury Treatment System (CMTS). These mercury violations were the result of a brine leak that occurred in October 2005 in Building 9201-5. Brine is a mixture of methanol and water (21% and 79%, respectively) and is used in the chiller facilities to provide equipment cooling at the Y-12 Complex. The brine leaked into the basement sumps of 9201-5 which are hard piped to CMTS for mercury removal. The presence of methanol is believed to adversely affect the carbon filters at CMTS resulting in poor mercury removal. The CMTS was successfully brought back on line in April 2006; however, pumping of sump water from 9201-5 to CMTS has been halted.

In response to the initial leak, approximately 1 million gallons (MG) of waste water was collected from the basement sumps in Building 9201-5 and stored in tanks at the West

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Table 6.9. Y-12 Complex Discharge Point SS6, Sanitary Sewer Station 6
January through December 2006

Effluent parameter	Number of samples	Daily average value ^a (effluent limit)	Daily maximum value ^a (effluent limit)	Percentage of compliance
Flow, mgd	365	^b	1.4	100
pH, standard units	13	^b	9/6 ^c	100
Silver	16	0.05	0.1	100
Arsenic	16	0.01	0.015	100
Benzene	4	0.01	0.015	100
Biochemical oxygen demand	14	200	300	100
Cadmium	16	0.0033	0.005	100
Chromium	16	0.05	0.075	100
Copper	12	0.14	0.21	100
Cyanide	14	0.041	0.062	100
Iron	4	10	15	100
Mercury	14	0.023	0.035	100
Kjeldahl nitrogen	14	45	90	100
Methylene chloride	4	0.027	0.041	100
Nickel	16	0.021	0.032	100
Oil and grease	14	25	50	100
Lead	16	0.049	0.074	100
Phenols—total recoverable	14	0.3	0.5	100
Suspended solids	17	200	300	100
Toluene	4	0.01	0.02	100
Trichloroethene	4	0.018	0.027	100
Zinc	8	0.35	0.75	100

^aIndustrial and Commercial Users Wastewater Permit limits. Units in milligrams per liter unless otherwise indicated.

^bNot applicable.

^cMaximum value/minimum value.

Table 6.10. Summary of storm water data above cut-off concentration at the Y-12 Complex (mg/L)

Location	Date	Parameter	Result	Cut-off concentration	Sector mean value
Outfall 008	Oct. 11, 2006	Nitrogen (nitrate + nitrite)	0.834	0.68	N/A
Outfall 010	Oct. 11, 2006	Nitrogen (nitrate + nitrite)	0.709	0.68	N/A
Outfall S30	Sept. 28, 2006	Aluminum	9.98	0.75	2.08
Outfall S30	Sept. 28, 2006	Iron	5.39	5.0	3.7
Outfall S06	Sept. 18, 2006	Magnesium	17.9	0.0636	1.41

End Tank Farm. In April 2006, a special wastewater discharge to the sanitary sewer system was initiated for that wastewater. The water was characterized, aerated, and filtered before being placed into 5,000 gal tankers. It was discharged from tanker truck into the main Y-12 Complex sewer interceptor line at a control rate of 50 gallons per minute. Usually no more than two tanker loads or total of 10,000 gallons was discharged per day. Approximately

700,000 gal was discharged from April to end of 2006 with remaining wastewater to be discharged in 2007.

Sump water from 9201-5 continues to collect in the basement. The building has degraded significantly in recent years, prompting the relocation of all facility occupants and restricting access to only essential functions. The recommendation is to leave the accumulated water in the basement area until the brine system

is isolated from Building 9210-5 or other actions taken to significantly reduce the risk of a brine leakage into the basement area. This issue was reviewed with representatives from DOE-EM, EPA, and TDEC in the August 2006 CERCLA Core Team meeting and prompted the need to "change" the Phase 1 Record of Decision (ROD) for Upper East Fork Poplar Creek to reflect the changed flow being treated by the CMTS. The change was determined to be a Non-Significant Change to the ROD requiring approval of EPA and TDEC. Documentation providing technical and practical justification for not sending sump water from Building 9201-5 to the CMTS, and allowing the water to accumulate in the Alpha 5 basement at the present time, has been prepared and is being processed through the approval cycle.

6.5.4 Flow Management (or Raw Water)

Because of concern about maintaining water quality and stable flow in the upper reaches of East Fork Poplar Creek, the NPDES permit requires addition of Clinch River water to the headwaters of East Fork Poplar Creek (North/South Pipe-outfall 200 area) so that a minimum flow of 7 million gal/day is maintained at the point where East Fork Poplar Creek leaves the reservation (Station 17). The permit required that the project be implemented by March 1997, but the work was completed ahead of schedule (August 1996). With the completion of the project, instream water temperatures decreased by approximately 5°C (from approximately 26°C at the headwaters).

During CY 2006 the flow of Upper East Fork Poplar Creek was maintained in accordance with the permit conditions. The average daily flow during CY 2006 was 8.44 million gal/day.

6.5.5 Mercury Removal from Storm Drain Catch Basins

In May 2003, metallic mercury was observed in two storm drain catch basins located in the west end of the Y-12 Complex. The storm drain line on which the catch basins are located flows into East Fork Poplar Creek at outfall 200. Mercury tends to collect at those low spots in the drain system following heavy rains. During

2006, Y-12 spill response and waste services personnel conducted three removals and recovered an estimated 2.3 lb of mercury. Approximately 55 lb have been recovered since 2003; recovery of mercury is expected to continue in 2007.

6.6 Biomonitoring Program

In accordance with the 1995 NPDES permit (Part III-C, p. 39), a biomonitoring program was required that evaluated an East Fork Poplar Creek instream monitoring location (outfall 201), wastewater treatment system discharges, and locations in the storm drain system. A new NPDES permit (Part III-E, p. 29, implemented in spring 2006) requires a revised biomonitoring program that evaluates three outfalls to East Fork Poplar Creek (outfalls 200, 135, and 125).

Table 6.11 summarizes the results of biomonitoring tests conducted during the first quarter of 2006 on effluent samples from wastewater treatment systems and locations in the storm drain system. The results of the biomonitoring tests are expressed as the concentration of effluent that is lethal to 50% of the test organisms (LC₅₀) during a 48-h period. Thus, the lower the value, the more toxic an effluent. The LC₅₀ is compared with the effluent's calculated instream waste concentration to determine the likelihood that the discharged effluent would be harmful to aquatic life in the receiving stream. If the LC₅₀ is much greater than the instream waste concentration, it is less likely that there is an instream impact.

Effluent samples from two wastewater treatment system discharges were tested on *Ceriodaphnia dubia* once during 2006. With LC₅₀ concentrations of 92.4 and 83.1, respectively, effluents from the Groundwater Treatment Facility and the Central Mercury Treatment System were moderately toxic. In each case, the calculated instream waste concentrations of the effluent were less than the LC₅₀ concentrations, suggesting that effluents from the individual treatment facilities would not be acutely toxic to the aquatic life of East Fork Poplar Creek.

Various locations in the storm drainage system upstream of outfalls 200 and 201 were also monitored once during the year. When chlorine

Table 6.11. Y-12 Complex Biomonitoring Program summary information for wastewater treatment systems and storm sewer effluents for 2006^a

Site/building	Test date	Species	48-h LC ₅₀ ^b (%)	IWC ^c (%)
Groundwater Treatment Facility (512)	2/14/06	<i>Ceriodaphnia</i>	92.4	0.17
Storm sewer D4010	2/15/06	<i>Ceriodaphnia</i>	17.3	^d
Storm sewer D4010 (dechlorinated)	2/15/06	<i>Ceriodaphnia</i>	>100	^d
Storm sewer D4004	2/15/06	<i>Ceriodaphnia</i>	73.0	^d
Storm sewer D3311	2/17/06	<i>Ceriodaphnia</i>	>100	^d
Storm sewer D3311 (dechlorinated)	2/17/06	<i>Ceriodaphnia</i>	>100	^d
Storm sewer E3411	2/17/06	<i>Ceriodaphnia</i>	79.4	^d
Storm sewer E3411 (dechlorinated)	2/17/06	<i>Ceriodaphnia</i>	>100	^d
Central Mercury Treatment System (551)	2/18/06	<i>Ceriodaphnia</i>	83.1	0.11

^aSummarized are the effluents and their corresponding 48-h LC₅₀ and instream waste concentrations. Note: Discharges from treatment facilities are intermittent because of batch operations.

^bThe concentration of effluent (as a percentage of full-strength effluent diluted with laboratory control water) that is lethal to 50% of the test organisms in 48 h.

^cIWC = instream waste concentration based on actual flows at Station 17 in East Fork Poplar Creek.

^dThis point is in the storm sewer system; therefore, an IWC is not applicable.

or similar chemicals (e.g., bromine) were detected in a sample, side-by-side tests were conducted with a sample that was treated (dechlorinated) to remove the chlorine or chlorine-like chemical. In all cases where toxicity was detected in the nontreated sample (LC₅₀ less than 100%), survival was higher in the dechlorinated sample than in the nontreated sample. In some cases, the full-strength dechlorinated sample did not continue to reduce *Ceriodaphnia* survival, indicating that toxicity was due solely to chlorine or similar chemicals. Because flow is not measured at these storm-drain points, it is not possible to know the contribution of each to the total flow at outfall 201 (i.e., the instream waste concentration). It is notable, however, that the results of the biomonitoring tests at outfall 201 (Table 6.12) demonstrated that when all discharges were combined (treated effluent, storm sewer contribution, plus flow management water) the result was an absence of toxicity at outfall 201.

Table 6.12 summarizes the no-observed-effect concentrations (NOECs) and 96-hour LC₅₀ concentrations, for the instream monitoring location outfall 201. The NOEC is the concentration of effluent that does not reduce survival, growth, or reproduction of the biomonitoring test organisms during a 6- or 7-day test. Thus, like the LC₅₀, the lower the

Table 6.12. Y-12 Complex Biomonitoring Program summary information for outfall 201 for 2006^a

Test date	Species	NOEC ^b (%)	96-h LC ₅₀ ^c (%)
2/14	<i>Ceriodaphnia</i>	100	>100
	Fathead minnow	100	>100

^aSummarized are the no-observed effect concentrations (NOECs) and the 96-h LC₅₀ concentrations, for the instream monitoring location, outfall 201.

^bNOEC as a percentage of full-strength effluent from outfall 201 diluted with laboratory control water. The NOEC must equal one of the test concentrations and is the concentration that does not reduce *Ceriodaphnia* survival or reproduction or fathead minnow survival or growth.

^cThe concentration of effluent (as a percentage of full-strength effluent diluted with laboratory control water) that is lethal to 50% of the test organisms in 96 h.

value, the more toxic the effluent. Water from the instream monitoring point, out, fall 201, was tested once in 2006 using fathead minnow larvae (*Pimephales promelas*) and *Ceriodaphnia dubia*. The NOECs were 100% and the 96-h LC₅₀ concentrations were greater than 100% for both *Ceriodaphnia* and fathead minnow tests.

Table 6.13 summarizes the inhibition concentrations (IC_{25} s) for the monitoring locations outfalls 200, 135, and 125. The IC_{25} is the concentration of effluent that causes a 25% reduction in *Ceriodaphnia* survival or reproduction or fathead minnow survival or growth. Thus, like the LC_{50} and the NOEC, the lower the value, the more toxic the effluent. Water from each outfall was tested three times in 2006 using fathead

Table 6.13. Y-12 Complex Biomonitoring Program summary information for outfalls 200, 135, and 125 for 2006^a

Site	Test date	Species	IC_{25} ^b (%)
Outfall 200	6/20/06	<i>Ceriodaphnia</i>	>100
Outfall 200	6/20/06	Fathead minnow	>100
Outfall 135	6/20/06	<i>Ceriodaphnia</i>	>20
Outfall 135	6/20/06	Fathead minnow	>20
Outfall 125	6/20/06	<i>Ceriodaphnia</i>	>36
Outfall 125	6/20/06	Fathead minnow	>36
Outfall 200	8/22/06	<i>Ceriodaphnia</i>	>100
Outfall 200	8/22/06	Fathead minnow	>100
Outfall 135	8/22/06	<i>Ceriodaphnia</i>	>20
Outfall 135	8/22/06	Fathead minnow	>20
Outfall 125	9/7/06	<i>Ceriodaphnia</i>	>36
Outfall 125	9/7/06	Fathead minnow	>36
Outfall 200	12/12/06	<i>Ceriodaphnia</i>	>100
Outfall 200	12/12/06	Fathead minnow	>100
Outfall 135	12/12/06	<i>Ceriodaphnia</i>	>20
Outfall 135	12/12/06	Fathead minnow	>20
Outfall 125	11/28/06	<i>Ceriodaphnia</i>	>36
Outfall 125	11/28/06	Fathead minnow	>36

^aSummarized are the inhibition concentrations (IC_{25}) for the discharge monitoring locations, outfalls 200, 135, and 125.

^b IC_{25} as a percentage of full-strength effluent from outfall 200, 135 and 125 diluted with laboratory control water. The IC_{25} is the concentration that causes a 25% reduction in *Ceriodaphnia* survival or reproduction or fathead minnow survival or growth.

minnow larvae and *Ceriodaphnia dubia*. The IC_{25} was greater than the highest tested concentration of each effluent (100% for outfall 200, 20% for outfall 135, and 36% for outfall 125) for each test conducted during 2006.

6.7 Biological Monitoring and Abatement Programs

The NPDES permit issued to the Y-12 Complex in 2006 mandates a biological monitoring and abatement program (BMAP) with the

objective of demonstrating that the effluent limitations established for the facility protect the classified uses of the receiving stream, East Fork Poplar Creek. The current BMAP consists of three major tasks that reflect complementary approaches to evaluating the effects of the Y-12 Complex discharges on the aquatic integrity of East Fork Poplar Creek. These tasks include (1) bioaccumulation monitoring, (2) benthic macroinvertebrate community monitoring, and (3) fish community monitoring.

Monitoring is currently being conducted at five primary East Fork Poplar Creek sites, IC_{25} although sites may be excluded or added, depending upon the specific objectives of the various tasks. The primary sampling sites include upper East Fork Poplar Creek at East Fork Poplar Creek kilometer (EFK) 24.4 and 23.4 (upstream and downstream of Lake Reality, respectively); EFK 18.7 (also EFK 18.2), located off the ORR and below an area of intensive commercial and light industrial development; EFK 13.8, located upstream from the Oak Ridge Wastewater Treatment Facility; and EFK 6.3, located approximately 1.4 km below the ORR boundary (Fig. 6.8). Brushy Fork at Brushy Fork kilometer (BFK) 7.6 is used as a reference stream in two tasks of the BMAP. Additional sites off the ORR are also occasionally used for reference, including Beaver Creek, Bull Run, Cox Creek, Hinds Creek, Paint Rock Creek, and the Emory River in Watts Bar Reservoir (Fig. 6.9).

Trends of increases in species richness and diversity at upstream locations over the last decade demonstrate that the overall ecological health of East Fork Poplar Creek continues to improve. However, the pace of improvement in the health of East Fork Poplar Creek has slowed in recent years, and fish and invertebrate communities continue to be degraded in comparison with similar communities in reference streams.

6.7.1 Bioaccumulation Studies

Mercury and PCBs have been historically elevated in East Fork Poplar Creek fish relative to fish in uncontaminated reference streams. Fish are monitored regularly in East Fork Poplar Creek for mercury and PCBs to assess spatial

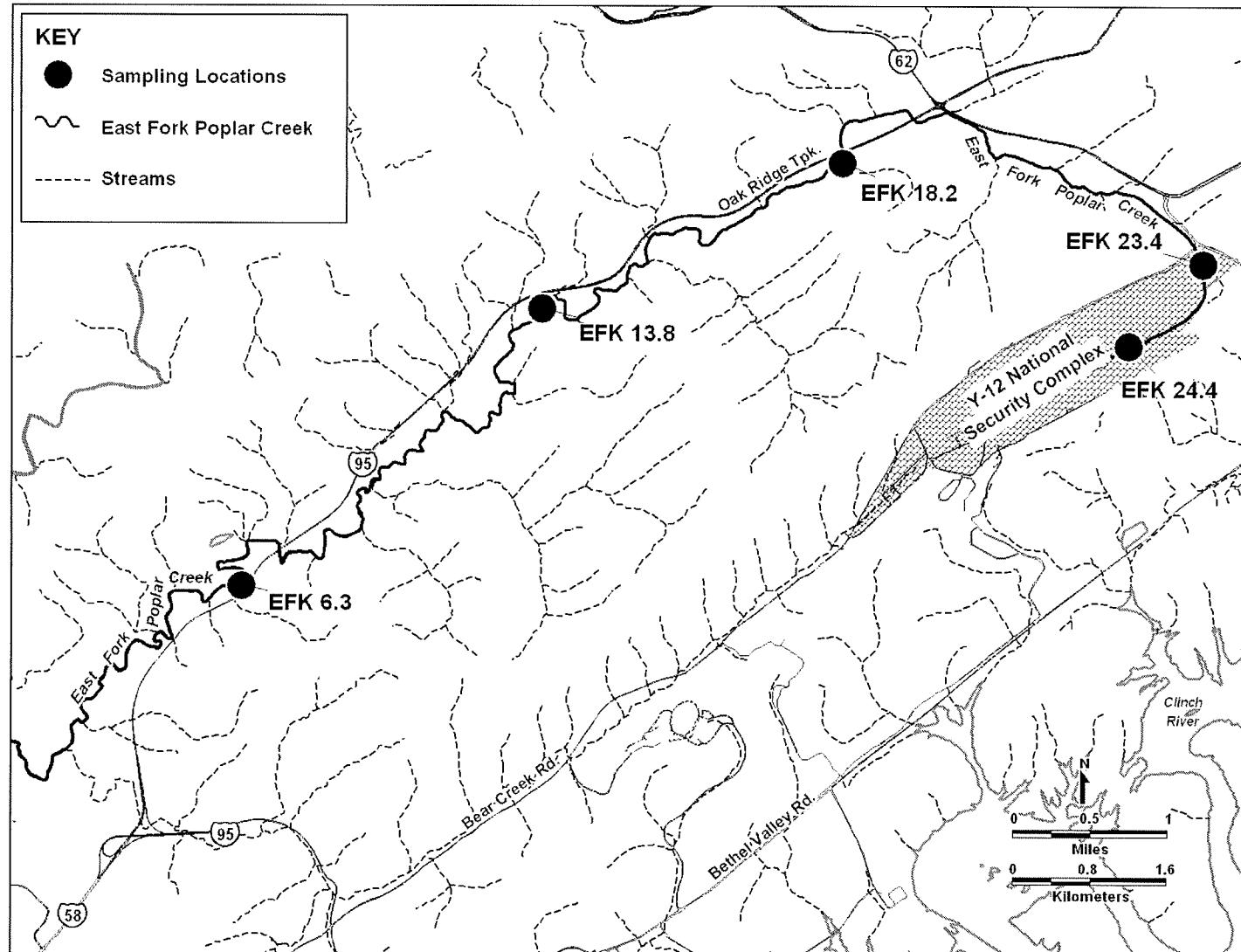


Fig. 6.8. Locations of biological monitoring sites on East Fork Poplar Creek in relation to the Oak Ridge Y-12 National Security Complex.

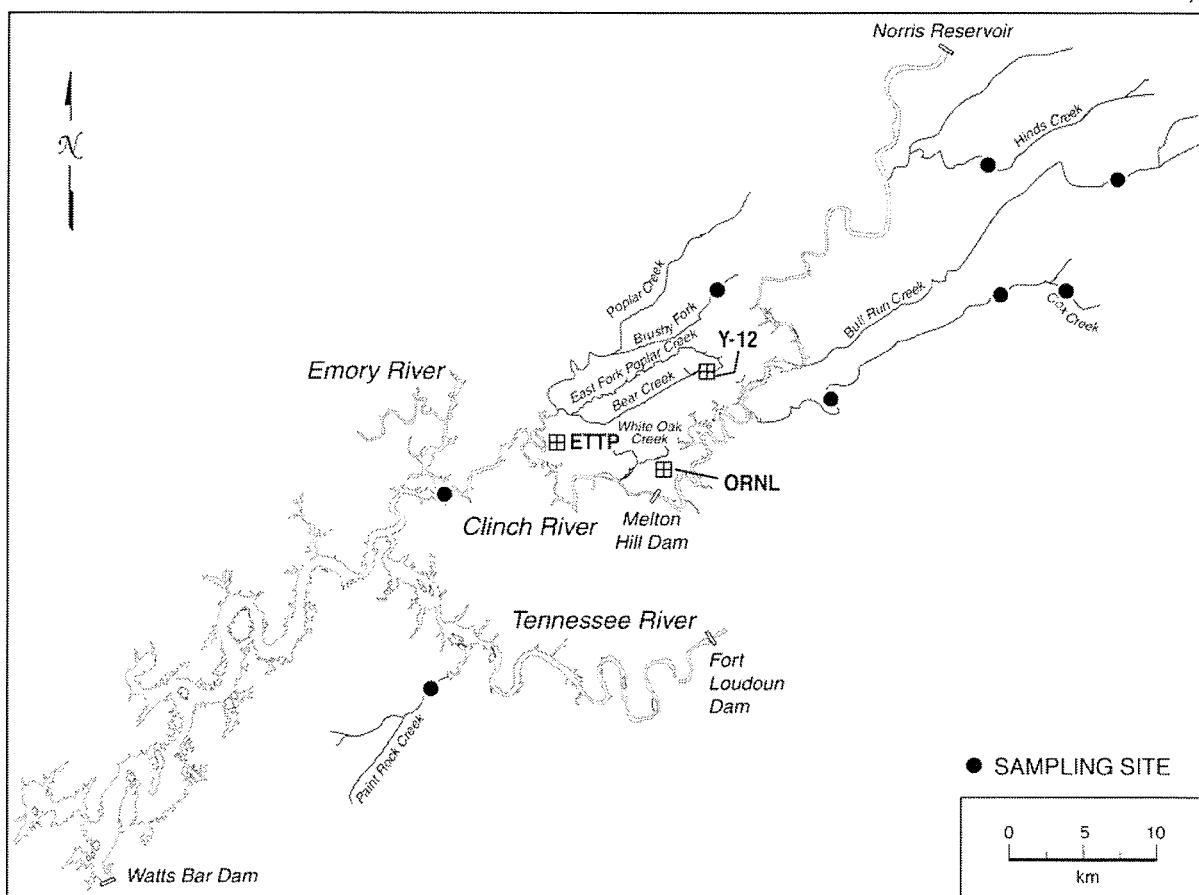


Fig. 6.9. Locations of biological monitoring reference sites in relation to the Oak Ridge Y-12 National Security Complex.

and temporal trends in bioaccumulation associated with ongoing remedial activities and plant operations.

As part of this monitoring effort, redbreast sunfish (*Lepomis auritus*) and rock bass (*Ambloplites rupestris*) are collected twice yearly from five sites throughout the length of East Fork Poplar Creek and are analyzed for tissue concentrations of mercury (twice yearly) and PCBs (annually). Largemouth bass (*Micropterus salmoides*) were collected once in 2006 from a site in Upper East Fork Poplar Creek (EFK 23.4) to monitor maximum bioaccumulation in larger piscivorous fish of the system.

Mercury concentrations remained much higher during 2006 in fish from East Fork Poplar Creek than in fish from reference streams. Elevated mercury concentrations in fish from the upper reaches of East Fork Poplar Creek indicate that the Y-12 Complex remains a continuing

source of mercury to fish in the stream. Although concentrations had leveled off in recent years, waterborne mercury concentrations in the upper reaches of East Fork Poplar Creek decreased substantially in 2006 following the start-up of a treatment system on a mercury-contaminated spring (Fig. 6.10). To date, mercury concentrations in fish have not responded to this recent decrease in waterborne mercury, but a substantial lag time in response (1–2 years) would be expected. Mean concentrations of PCBs in fish at EFK 23.4 (the site where PCBs in fish are highest) continued to trend downward over time in 2006 (Fig. 6.11) while downstream PCBs remained within ranges typical of past monitoring efforts at these sites.

6.7.2 Benthic Invertebrate Surveys

Benthic macroinvertebrate communities were monitored at three sites in East Fork Poplar

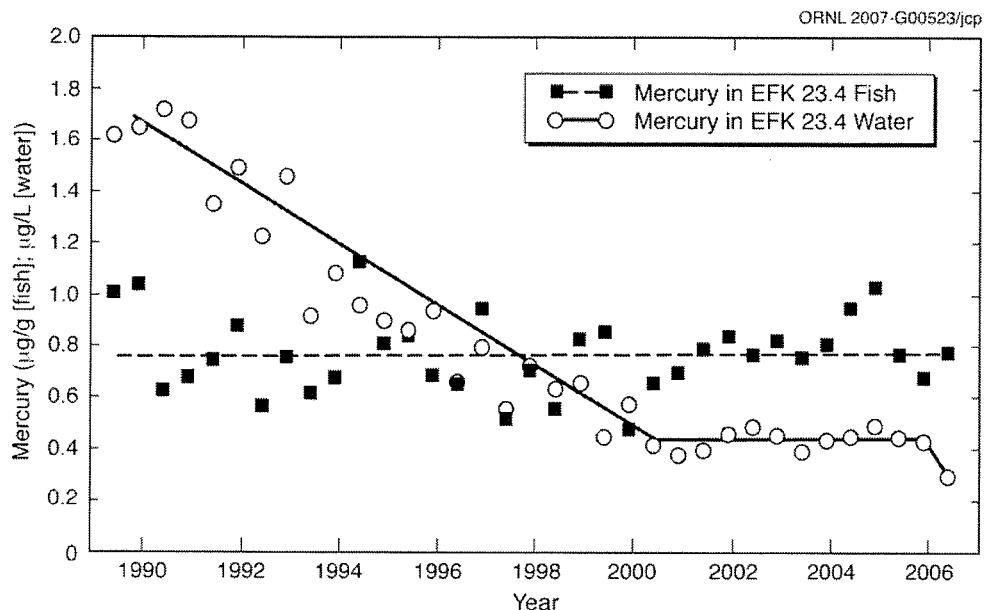


Fig. 6.10. Semiannual average mercury concentration in muscle fillets of fish and water in East Fork Poplar Creek at Station 17 through spring 2006. (EFK = East Fork Poplar Creek kilometer.)

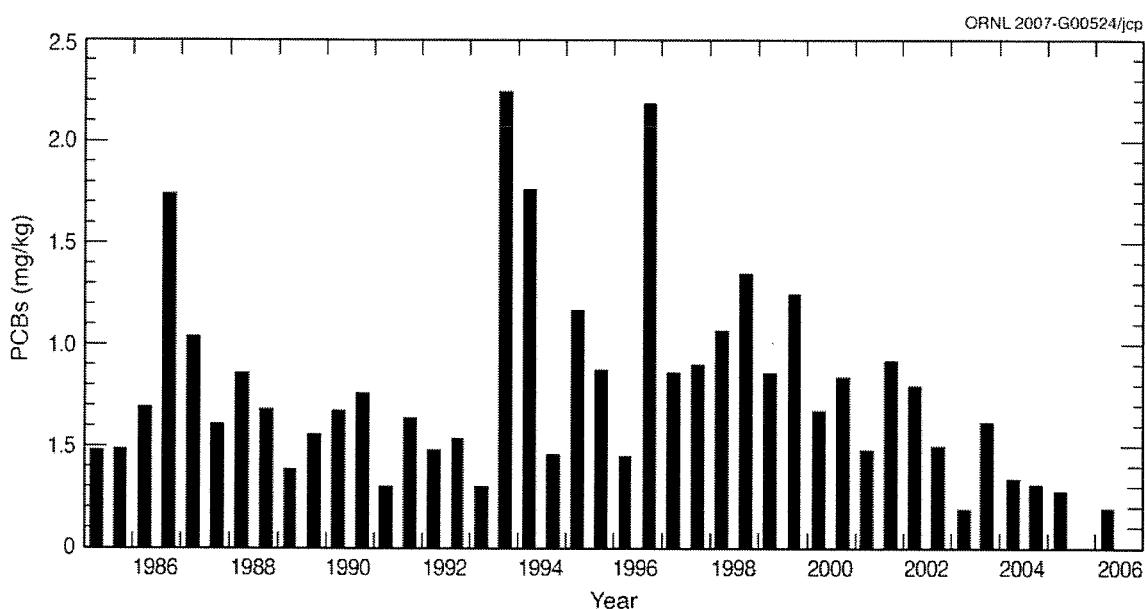


Fig. 6.11. Mean concentrations of PCBs in redbreast sunfish and rock bass muscle fillets in East Fork Poplar Creek at Station 17 through spring 2006.

Creek and at two reference streams in the spring of 2006. The macroinvertebrate communities at EFK 23.4 and EFK 24.4 remained significantly degraded as compared with reference communities, especially in the richness of pollution-sensitive taxa (Fig. 6.12). The pace of improvement in benthic macroinvertebrate communities has slowed in recent years at these sites in the upper reaches of East Fork Poplar Creek.

6.7.3 Fish Community Monitoring

Fish communities were monitored in the spring and fall of 2006 at five sites along East

Fork Poplar Creek and at a reference stream. Over the past two decades, overall species richness, density, and the number of pollution-sensitive fish species (Fig. 6.13) have increased at all sampling locations below Lake Reality. However, improvement in the fish community of East Fork Poplar Creek has slowed in recent years, particularly at sites closest to the Y-12 Complex. Despite improvements, the fish community continues to lag behind reference stream communities in most important metrics of fish diversity and community structure.

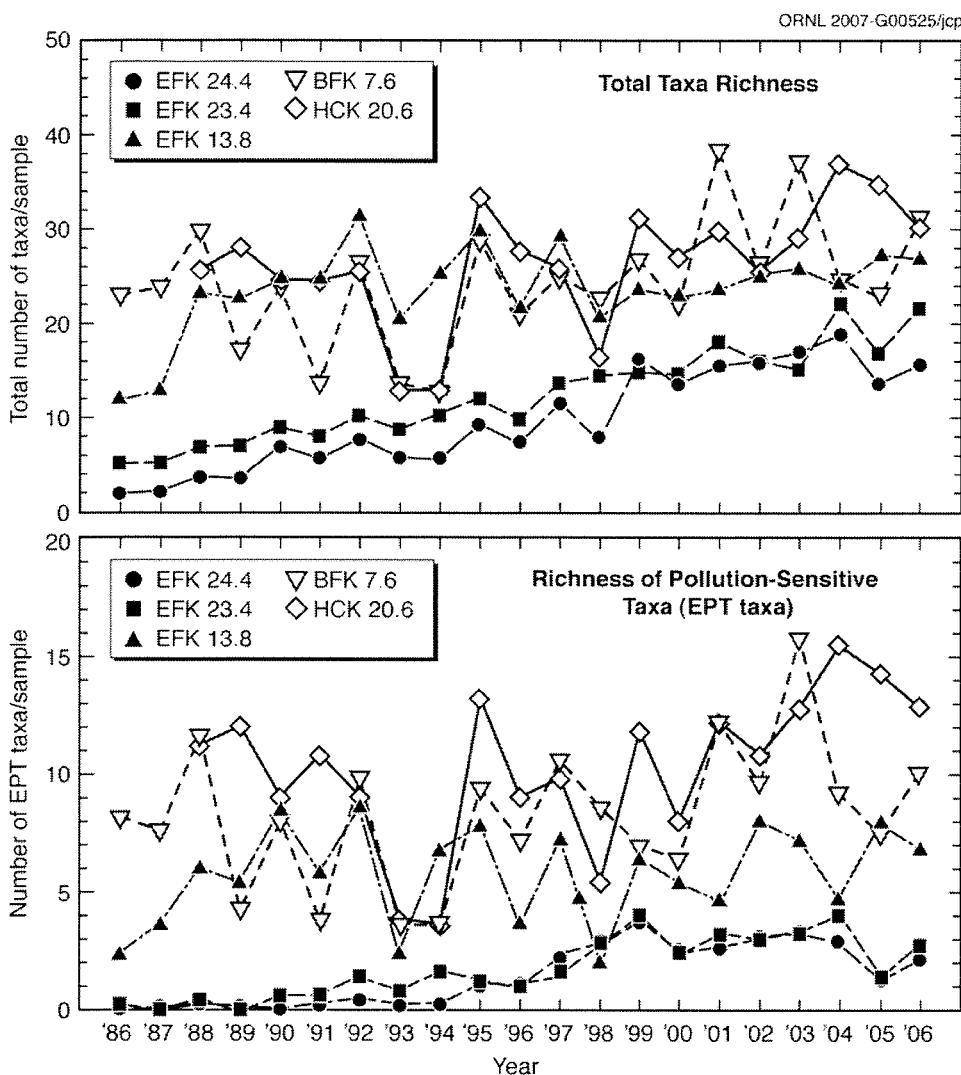


Fig. 6.12. Total taxonomic richness (mean number of taxa/sample) and total taxonomic richness of the Ephemeroptera, Plecoptera, and Trichoptera (EPT) (mean number of EPT taxa/sample) of the benthic macroinvertebrate communities in East Fork Poplar Creek and two reference sites, one on Brushy Fork and one on Hinds Creek (BFK 7.6 and HCK 20.6). (BFK = Brushy Fork kilometer; EFK = East Fork Poplar Creek kilometer; HCK = Hinds Creek kilometer).

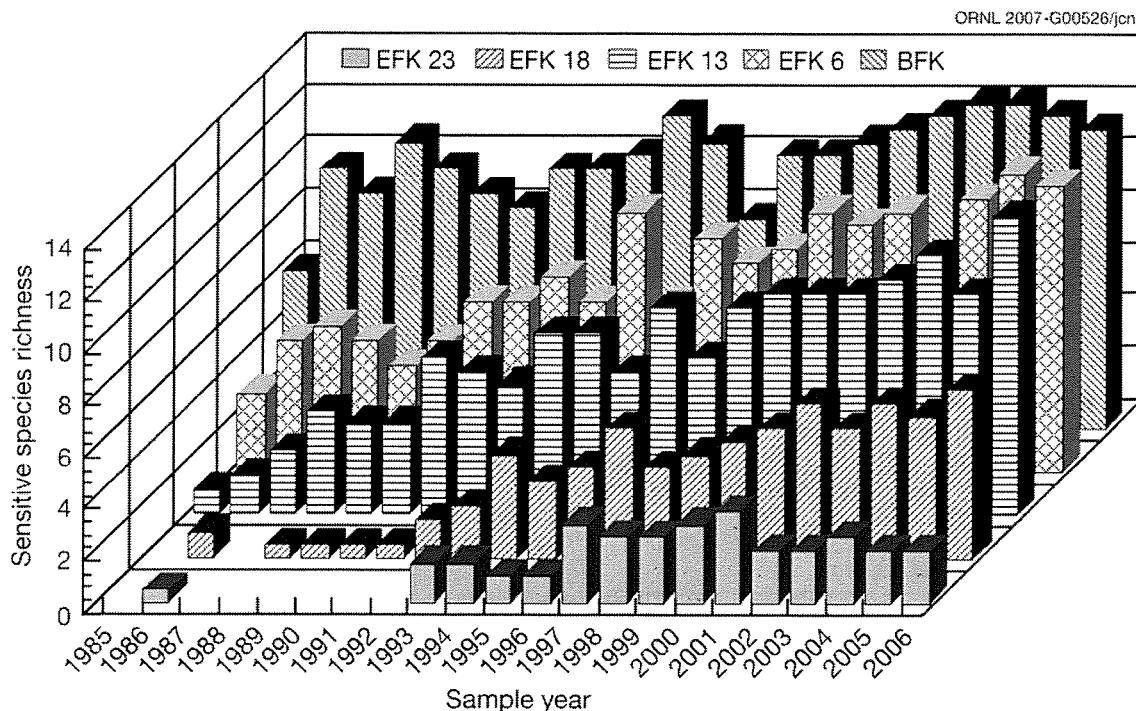


Fig. 6.13. Comparison of mean sensitive species richness (number of species) collected each year from 1985 through 2006 from four sites in East Fork Poplar Creek and a reference site (Brushy Fork). (EFK = East Fork Poplar Creek kilometer; BFK = Brushy Fork kilometer.)

6.8 Y-12 Complex Ambient Surface Water Monitoring

Routine surface water surveillance monitoring, above and beyond that required by the NPDES permit, is performed as a best management practice. The Y-12 Environmental Compliance Department staff monitor the surface water as it exits from each of the three hydrogeologic regimes that serve as exit pathways for surface water (Fig. 6.14).

Monitoring is conducted in East Fork Poplar Creek at Station 17 (9422-1), near the junction of Scarboro and Bear Creek roads. During the first quarter of 2006 the best management practices sampling program consisted of one 7-day composite each week. These samples are analyzed for mercury, ammonia-N, inductively coupled plasma (ICP) metals, and total suspended solids. The NPDES permit which became effective on May 1, 2006, includes most of these parameters plus dissolved oxygen, temperature, nitrate/nitrite and phosphorus as a requirement for monitoring and sets limits at Station 17 for

pH within range of 6.0 to 9.0 units. Monitoring at Station 17 continued for the remainder of the year by a 7-day composite sampling conducted weekly to satisfy the NPDES permit conditions. For years monitoring has been conducted in Bear Creek at BCK 4.55 (former NPDES Station 304), which is at the western boundary of the Y-12 Complex area of responsibility. Surveillance sampling at this location was suspended in June 2006, and instream sampling is conducted upstream at S24 or BCK 9.4. in accordance with the permit issue in 2006. This sampling is quarterly and includes pH, total suspended solids, PCBs, phosphorus, nitrate-nitrite, total nitrogen and metals.

The exit pathway from the Chestnut Ridge Hydrogeologic Regime is monitored via NPDES location S19 (the former NPDES Station 302) at Rogers Quarry. S19 is an instream location of McCoy Branch and is sampled annually for suspended and dissolved solids, metals, and pH.

In addition to those exit pathway locations, a network of real-time monitors is located at instream locations along Upper East Fork Poplar

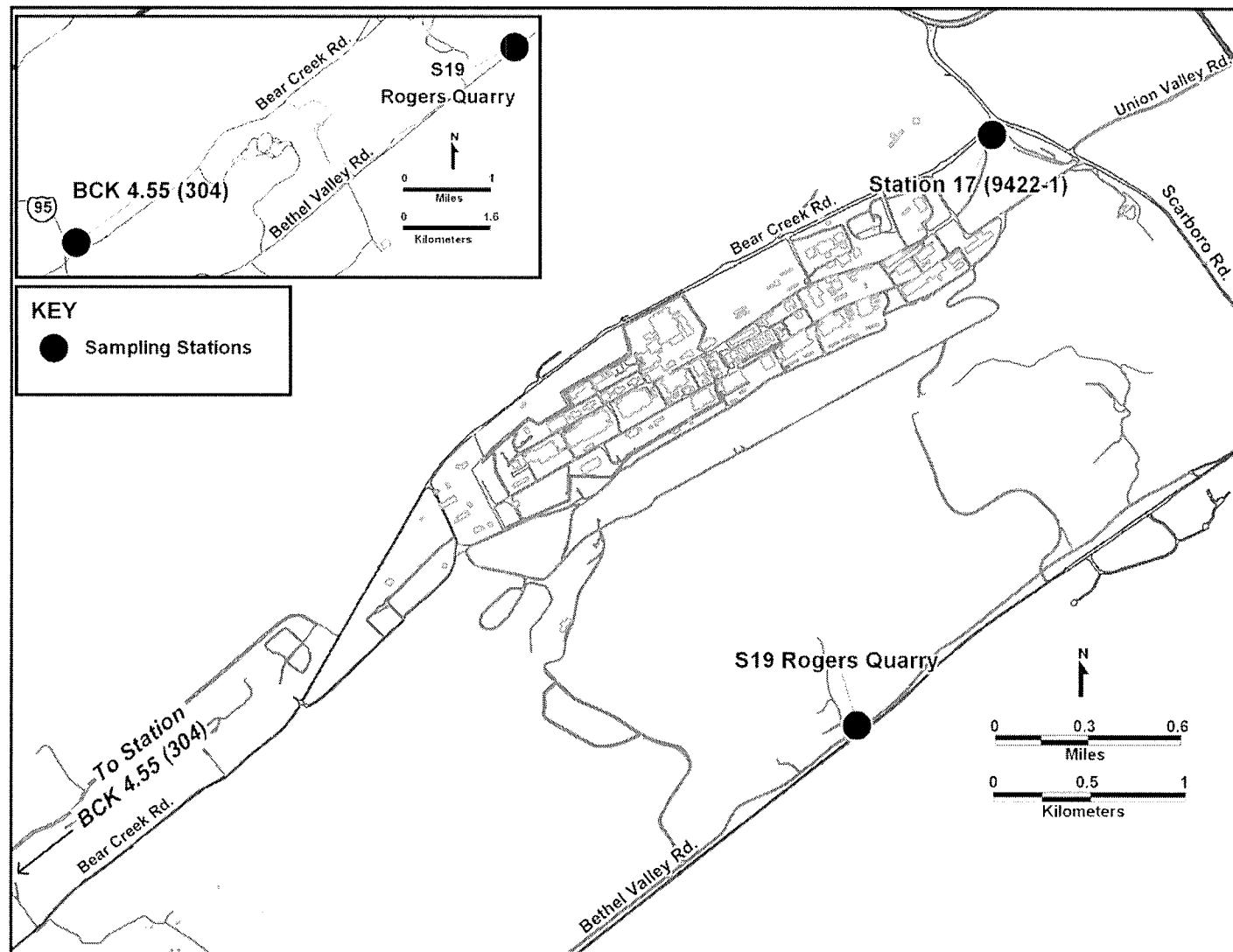


Fig. 6.14. Locations of Y-12 Complex surface water surveillance sampling stations.

Creek and at key points on the storm drain system that flows to the creek. The Surface Water Hydrological Information Support System is available for real-time water quality measurements, such as pH, temperature, dissolved oxygen, conductivity, and chlorine. The locations are noted in Fig. 6.15. Not all locations or parameters are operated on a routine basis.

For nonradiological parameters that are sampled and detected above the analytical method reporting detection limit, the data are compared with Tennessee water quality criteria (TDEC 2004). The most restrictive of either the “freshwater fish and aquatic life criterion maximum concentration” or the “recreation concentration for organisms only” standard is used. This comparison serves as a record of water quality, and the comparison to state water quality criteria limits is for informational purposes only; as such, no attempt is made to achieve the lowest possible detection limit for all parameters.

More than 900 surface water (surveillance and NPDES permit) samples were collected in 2006. Comparisons with Tennessee water quality criteria indicate that only mercury and zinc from samples collected at Station 17 were detected at values exceeding a criteria maximum. Results are shown in Table 6.14. Of all the parameters measured mercury is the only demonstrated contaminant of concern.

Additional sampling of springs and tributaries is conducted in accordance with the Y-12 Groundwater Protection Program to monitor trends throughout the three hydrogeologic regimes (see Sect. 6.10).

6.9 Y-12 Sediment Sampling

Historical data have shown that mercury, PCBs, and isotopes of uranium are present at detectable levels in sediment. Therefore, as a best management practice, the Y-12 Complex maintains an annual sampling program to determine whether these constituents are accumulating in the sediments of East Fork Poplar Creek and Bear Creek as a result of Y-12 Complex discharges. Results of the most recent monitoring activity are given in Table 6.15. The monitoring results indicate that the radiological levels, including isotopes of uranium and thorium, have not significantly changed.

This activity is also used to comply with DOE Order 5400.5, which states in Chapter II.3.a.2 that measures be taken to prevent the buildup of radionuclides in sediments caused by releases of waste streams to natural waterways. The order limits the amount of activity that may be present in released settleable solids. Because waste streams from the Y-12 Complex have very low settleable-solid contents, this sampling program to measure activity in the sediments of East Fork Poplar Creek and Bear Creek is used to determine whether a buildup of radionuclide concentrations is occurring.

6.10 Groundwater Monitoring at the Y-12 Complex

More than 200 sites have been identified at the Y-12 Complex that represent known or potential sources of contamination to the environment as a result of past waste management practices. Figure 6.16 depicts the major facilities considered as known and/or potential contaminant source areas for which groundwater monitoring was performed during CY 2006. Because of that contamination, extensive groundwater monitoring is performed to comply with regulations and DOE orders.

During CY 2006, routine groundwater monitoring at Y-12 was conducted primarily by two programs, the Y-12 Groundwater Protection Program, managed by BWXT Y-12 LLC, and the Water Resources Restoration Program, managed by BJC. Each program is responsible for monitoring groundwater to meet specific compliance requirements. In CY 2006, the Groundwater Protection Program performed monitoring to comply with DOE orders, while the Water Resources Restoration Program performed groundwater monitoring in compliance with CERCLA and RCRA. In addition to the monitoring performed by the Water Resources Restoration Program, BJC monitors groundwater at the solid waste disposal landfills on Chestnut Ridge and the EMWMF, in Bear Creek Valley.

Although the Groundwater Protection Program, the Water Resources Restoration Program, and other projects have differing technical objectives and responsibilities, considerable efforts are made to maintain consistency in groundwater monitoring activities at the Y-12

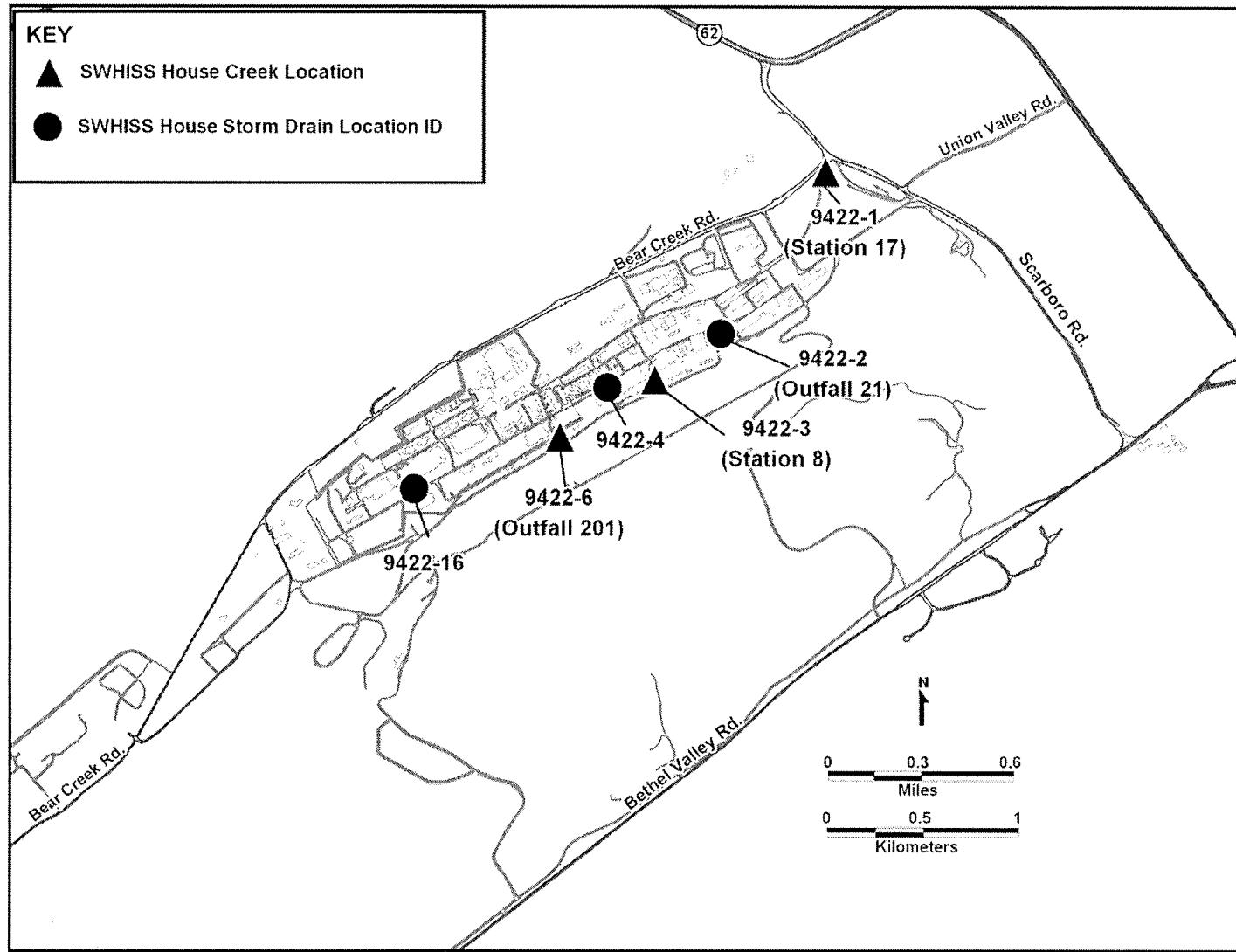


Fig. 6.15. Surface Water Hydrological Information Support System (SWHISS) monitoring locations.

Oak Ridge Reservation

Table 6.14. Surface water surveillance measurements exceeding Tennessee water quality criteria at the Y-12 Complex, 2006^a

Parameter detected	Location	Number of samples	Concentration (mg/L)			Water quality criteria (mg/L)	Number exceeding criteria
			Detection limit	Max	Avg		
Mercury	Station 17	99	0.0002	0.004	<0.0002	0.000051	75
Zinc	Station 17	17	0.05	0.344	<0.06	0.12	3

^aTDEC. 2004. *General Water Quality Criteria, Criteria of Water Uses—Toxic Substances*. TDEC 1200-4-03 (j). Tennessee Department of Environment and Conservation Tennessee Water Quality Control Board, Division of Water Pollution Control. Revised January 2004.

Table 6.15. Results of Y-12 Complex sediment monitoring^a

	2002	+/-	MDA	2003	+/-	MDA	2005	+/-	MDA	2006	+/-	MDA
Station 17												
²²⁶ Ra (pCi/g)	0.053	0.056	0.56	0.42	0.32	1.3	0.28	0.79	0.065	0.48	0.069	0.037
²²⁸ Th (pCi/g)	0.00063	0.0035	0.0058	0.46	0.24	0.19	0.44	0.13	0.067	0.65	0.26	0.43
²³⁰ Th (pCi/g)	-0.015	0.006	0.0057	0.77	0.4	0.15	0.26	0.11	0.092	-2.3	11	27
²³² Th (pCi/g)	0.0020	0.0029	0.0044	0.36	0.2	0.15	0.34	0.11	0.037	0.56	0.18	0.13
²³⁴ U (pCi/g)	0.25	0.039	0.0054	0.81	0.21	0.060	1.2	0.29	0.11	0.98	0.47	3.1
²³⁵ U (pCi/g)	0.012	0.0078	0.0072	0.047	0.057	0.062	0.1	0.071	0.070	0.061	0.077	4
²³⁸ U (pCi/g)	0.31	0.044	0.0054	1.2	0.26	0.050	1.2	0.26	0.050	1.5	0.32	3.5
Mercury (µg/g)	8.14			37.1			31.5			72.4		
Total PCBs (µg/kg)	1400			310			330			200		
BCK 9.4												
²²⁶ Ra (pCi/g)	0.26	0.096	0.31	-0.16	0.1	1.2	0.45	0.16	2	0.52	0.11	0.075
²²⁸ Th (pCi/g)	0.51	0.07	0.0075	0.52	0.17	0.10	0.51	0.15	0.071	0.92	0.37	0.51
²³⁰ Th (pCi/g)	0.21	0.038	0.0074	0.39	0.2	0.088	0.25	0.11	0.098	-2.5	12	28
²³² Th (pCi/g)	0.37	0.055	0.0043	0.25	0.11	0.069	0.37	0.12	0.040	0.5	0.22	0.17
²³⁴ U (pCi/g)	2.1	0.21	0.0043	3.9	0.53	0.056	0.19	0.077	0.058	3.5	0.71	1
²³⁵ U (pCi/g)	0.10	0.022	0.0051	0.25	0.11	0.047	0.063	0.037	0.013	0.29	0.15	0.13
²³⁸ U (pCi/g)	4.1	0.4	0.0045	8.2	0.96	0.050	9	0.96	0.052	6.8	0.9	0.099
Mercury (µg/g)	0.277			0.167			0.169			0.06		
Total PCBs (µg/kg)	590			490			640			240		

^aMDA = minimum detectable activity.

1 pCi = 3.7×10^{-2} Bq.

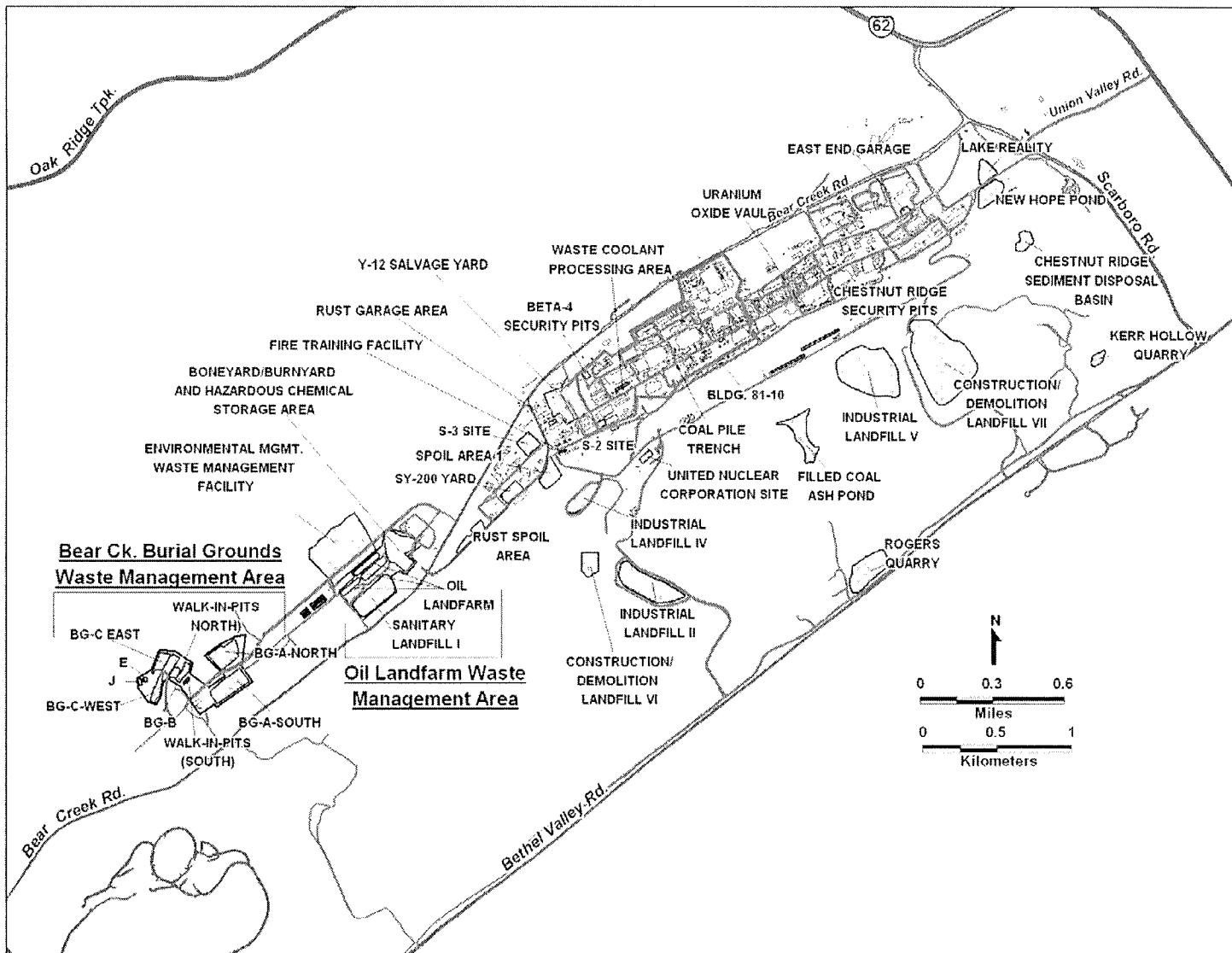


Fig. 6.16. Known or potential contaminant sources for which groundwater monitoring was performed on the Y-12 Complex during CY 2006.

Complex. Communication among the programs has been crucial in eliminating any redundancies in monitoring activities. In addition communication and cooperation provides for more consistent and efficient data collection, evaluation, and overall quality. All groundwater monitoring data obtained by all programs are evaluated to provide a comprehensive view of groundwater quality at the Y-12 Complex.

6.10.1 Hydrogeologic Setting

The Y-12 Complex is divided into three hydrogeologic regimes, which are 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, the Upper East Fork Poplar Creek Hydrogeologic Regime, and the Chestnut Ridge Hydrogeologic Regime (Fig. 6.17). Most of the Bear Creek and Upper East Fork Poplar Creek regimes are underlain by the ORR Aquitards. The 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 regime and the Upper East Fork regime is divergent from a topographic and groundwater divide located near the western end of the Y-12 Complex that defines the boundary between the two regimes (Fig. 6.17). In addition, flow converges on the primary surface streams (Bear Creek and Upper East Fork Poplar Creek) from Pine Ridge and Chestnut Ridge. In the Chestnut Ridge regime, a groundwater divide exists that approximately coincides with the crest of the ridge. Shallow groundwater flow 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 on and then 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 the valley and geologic strike. Groundwater flow rates in Bear Creek Valley vary widely; they are very slow within the deep interval of the ORR Aquitards (< 1 ft/year) but can be quite rapid within solution conduits in the Maynardville Limestone (tens to thousands of feet per day).

The rate of groundwater flow perpendicular to geologic strike from the ORR aquitards to the Maynardville Limestone has been estimated to be very slow below the water table interval. Most contaminant migration appears to be via surface tributaries to Bear Creek or along belowground utility traces and buried tributaries in the Upper East Fork regime. 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 known to extend east and west from the S-3 Site for thousands of feet. Volatile organic compounds at source units in the ORR Aquitards, however, tend to remain close to source areas because they tend to adsorb to the bedrock matrix, diffuse into pore spaces within the matrix, and degrade prior to migrating to exit pathways, where rapid transport occurs for long distances. Regardless, extensive volatile organic compound contamination occurs throughout the groundwater system in both the Bear Creek and Upper East Fork regimes.

Groundwater flow in the Chestnut Ridge regime is 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 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. Following the crest of the ridge, water table elevations decrease from west to east, demonstrating an overall easterly trend in groundwater flow.

6.10.2 Well Installation and Plugging and Abandonment Activities

A number of monitoring devices are routinely used for groundwater data collection at the Y-12 Complex. Monitoring wells are permanent devices used for the collection of groundwater samples; they are installed according to

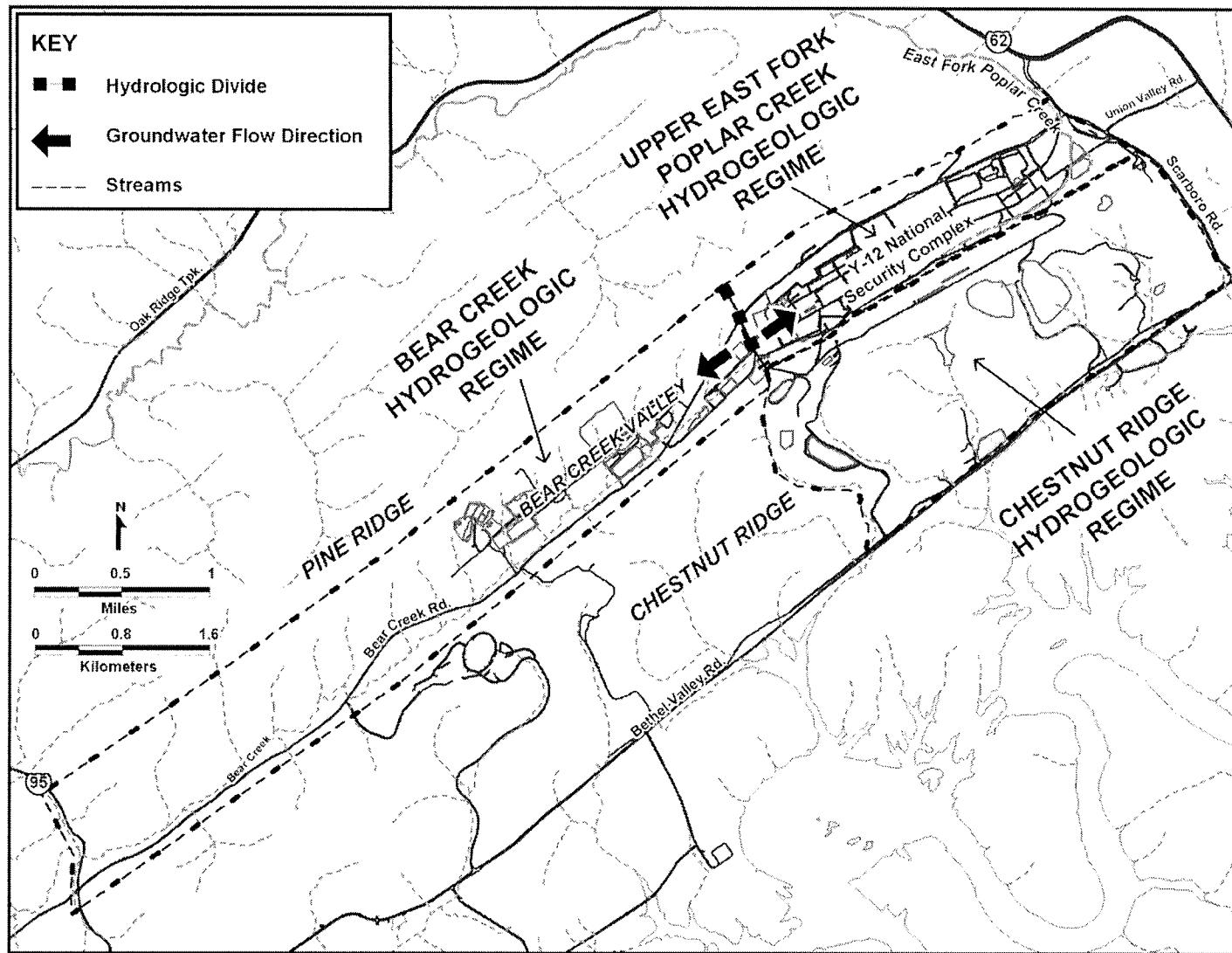


Fig. 6.17. Hydrogeologic regimes at the Y-12 Complex.

established regulatory and industry standards. Piezometers are primarily temporary devices used to measure groundwater table levels and are often constructed of polyvinyl chloride or other low-cost materials. Other devices or techniques are sometimes employed to gather data, including well points and push probes. In CY 2006, one surveillance monitoring well was installed to replace a plugged well impacted by construction activities. Also, 27 piezometers/wells were installed in support of activities by the Environmental Remediation Sciences Oak Ridge Field Research Center (formerly the Natural and Accelerated Bioremediation Research Field Research Center). The purpose of the field research center is to provide the fundamental science that will serve as the basis for development of cost-effective bioremediation of contaminant radionuclides and metals in the subsurface at DOE sites.

Well plugging and abandonment activities are conducted to protect human health and the environment, maintain the Y-12 monitoring well network, and meet operational needs. Wells that are damaged beyond rehabilitation, that interfere with planned construction activities, or from which no useful data can be obtained are selected for plugging and abandonment. In 2006, seven wells or piezometers were plugged and abandoned. All of these monitoring wells were impacted by construction and/or operations; thus requiring their removal.

6.10.3 CY 2006 Groundwater Monitoring Program

Groundwater monitoring in CY 2006 was performed to comply with DOE orders and regulations by the Groundwater Protection Program, the Water Resources Restoration Program, and other BJC projects. Compliance requirements were met by the monitoring of 211 wells and 50 surface water locations and springs (Table 6.16). Figure 6.18 shows the locations of ORR perimeter/exit pathway groundwater monitoring stations as specified in the *Environmental Monitoring Plan for the Oak Ridge Reservation* (DOE 2003).

Comprehensive water quality results of monitoring activities at Y-12 in CY 2006 are presented in the annual *Groundwater Monitoring Report* (BWXT Y-12 2007).

Details of monitoring efforts performed specifically for CERCLA baseline and remediation evaluation are published in the FY 2006 and FY 2007 Water Resources Restoration Program sampling and analysis plans (BJC 2005 and BJC 2006), and the 2006 *Remediation Effectiveness Report* (DOE 2007a).

Groundwater monitoring compliance reporting to meet RCRA postclosure permit requirements can be found in the RCRA annual reports (BJC 2007b).

6.10.4 Y-12 Groundwater Quality

Historical monitoring efforts have shown that four types of contaminants have affected groundwater quality at the Y-12 Complex: nitrate, volatile organic compounds, metals, and radionuclides. Of those, nitrate and volatile organic compounds are the most widespread. Some radionuclides, particularly uranium and ^{99}Tc , are significant, principally in the Bear Creek regime and the western and central portions of the Upper East Fork regime. Trace metals, the least extensive groundwater contaminants, generally occur in a small area of low-pH groundwater at the western end of the complex, near the S-2 and S-3 sites. Historical data have shown that plumes from multiple-source units have mixed with one another and that contaminants (other than nitrate and ^{99}Tc) are no longer easily associated with a single source.

6.10.4.1 Upper East Fork Poplar Creek Hydrogeologic Regime

The Upper East Fork regime contains contaminant source areas and surface water and groundwater components of the hydrogeologic system within the Y-12 Complex and Union Valley to the east and off the ORR. Among the three hydrogeologic regimes on the Y-12 Complex, the Upper East Fork regime encompasses most of the known and potential sources of surface water and groundwater contamination. A brief description of waste management sites is given in Table 6.17. Chemical constituents from the S-3 Site (primarily nitrate and ^{99}Tc) dominate groundwater contamination in the western portion of the Upper East Fork regime, while

Table 6.16. Summary of CY 2006 groundwater monitoring at the Y-12 Complex

	Purpose for which monitoring was performed				
	Restoration ^a	Waste management ^b	Surveillance ^c	Other ^d	Total
Number of active wells	58	34	119	40	251
Number of other monitoring stations (e.g., springs, seeps, surface water)	29	6	15	8	58
Number of samples taken ^e	176	116	176	191	659
Number of analyses performed	9,707	13,170	16,613	2,020	41,510
Percentage of analyses that are non-detects	70.7	79.9	77.6	51.5	75.5
Ranges of results for positive detections, VOCs (µg/L)^f					
Chloroethenes	1–5,300	0.2–6.6	1–72,000	NA	
Chloroethanes	1–690	0.28–24	1–5,600	NA	
Chloromethanes	1–1,300	0.1–4.8	1–1,100	NA	
Petroleum hydrocarbons	1–9,500	0.1–4	1–2,800	NA	
Uranium (mg/L)	0.00435–0.509	0.004–0.0116	0.000515–1.42	0.03–66.96	
Nitrates (mg/L)	0.021–7,980	0.043–2.2	0.0294–11,300	0.47–49326	
Ranges of results for positive detections, radiological parameters (pCi/L)^g					
Gross alpha activity	1.31–529	1.31–17.6	2.8–550	NA	
Gross beta activity	2.67–16,500	1.9–161	4.3–18,000	NA	

^aMonitoring to comply with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements and with Resource Conservation and Recovery Act postclosure detection and corrective action monitoring.

^bSolid waste landfill detection monitoring and CERCLA landfill detection monitoring.

^cDOE Order 450.1 surveillance monitoring.

^dResearch related groundwater monitoring associated with activities of the DOE Environmental Remediation Sciences Oak Ridge Field Research Center.

^eFor the Restoration, Waste Management, and Surveillance programs, this reflects the number of unfiltered samples, excluding duplicates. For the Other program, this reflects the number of filtered and unfiltered samples, excluding duplicates.

^fThese ranges reflect concentrations of individual contaminants (not summed VOC concentrations):

Chloroethenes—includes tetrachloroethene, trichloroethene, 1,2-dichloroethene (*cis* and *trans*), 1,1-dichloroethene, and vinyl chloride.

Chloroethanes—includes 1,1,1-trichloroethane, 1,2-dichloroethane, and 1,1-dichloroethane.

Chloromethanes—includes carbon tetrachloride, chloroform, and methylene chloride.

Petroleum hydrocarbon—includes benzene, toluene, ethylbenzene, and xylene.

^g1 pCi = 3.7×10^{-2} Bq.

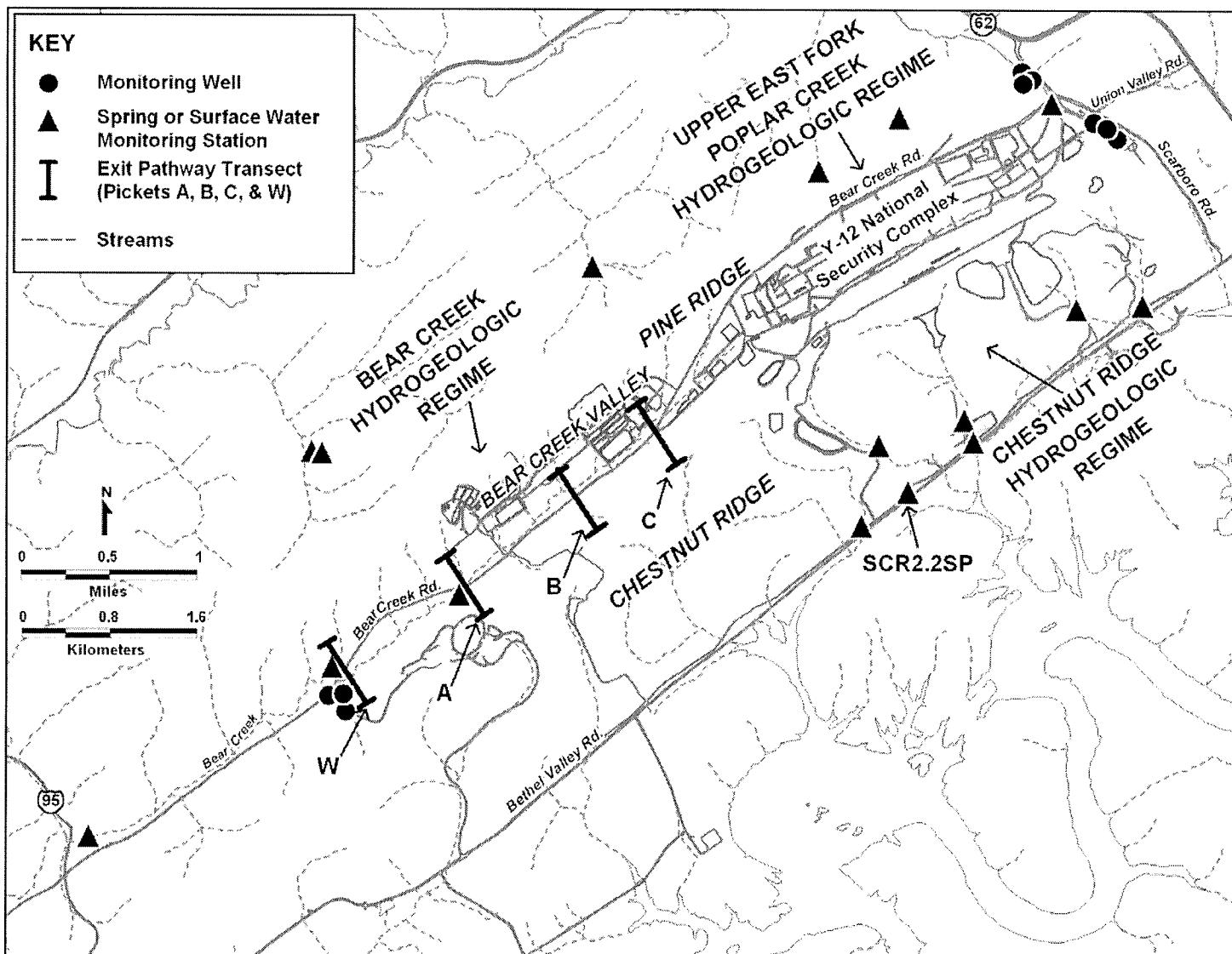


Fig. 6.18. Locations of ORR perimeter/exit pathway well, spring, and surface water monitoring stations in the Environmental Monitoring Plan for the Oak Ridge Reservation.

Table 6.17. History of waste management units and underground storage tanks included in CY 2006 groundwater monitoring activities, Upper East Fork Poplar Creek Hydrogeologic Regime^a

Site	Historical data
New Hope Pond	Built in 1963. Regulated flow of water in Upper East Fork Poplar Creek before exiting the Y-12 Complex grounds. Sediments include PCBs, mercury, and uranium but not hazardous according to toxicity characteristic leaching procedure. An Oil Skimmer basin was built as part of the pond when constructed. This basin collected oil and floating debris from Upper East Fork Poplar Creek prior to discharge into the pond. Closed under RCRA in 1990.
Salvage Yard Scrap Metal Storage Area	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	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	Used from 1978 to 1986. Two tanks used to store PCB-contaminated oils, both within a diked area.
Salvage Yard Drum Deheader	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.
Building 81-10 Area	Mercury recovery facility operated from 1957 to 1962. Potential historical releases to groundwater from leaks and spills of liquid wastes or mercury. The building structure was demolished in 1995.
Rust Garage Area	Former vehicle and equipment maintenance area, including four former petroleum USTs. Petroleum product releases to groundwater are documented.
9418-3 Uranium Oxide Vault	Originally contained an oil storage tank. Used from 1960 to 1964 to dispose of nonenriched uranium oxide. Leakage from the vault to groundwater is the likely release mechanism.
Fire Training Facility	Used for hands-on fire-fighting training. Sources of contamination to soil include flammable liquids and chlorinated solvents. Infiltration is the primary release mechanism to groundwater.
Beta-4 Security Pits	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.
S-2 Site	Used from 1945 to 1951. An unlined reservoir received liquid wastes. Infiltration is the primary release mechanism to groundwater.
Waste Coolant Processing Area	Used from 1977 to 1985. Former biodegradation facility used to treat waste coolants from various machining processes. Closed under RCRA in 1988.
East End Garage	Used from 1945 to 1989 as a vehicle fueling station. Five USTs used for petroleum fuel storage were excavated, 1989 to 1993. Petroleum releases to the groundwater are documented.
Coal Pile Trench	Located beneath the current steam plant coal pile. Disposals included solid materials (primarily alloys). Trench leachate is a potential release mechanism to groundwater.

^aAbbreviations

PCB = polychlorinated biphenyl

RCRA = Resource Conservation and Recovery Act

UST = underground storage tank

groundwater in the eastern portion, including Union Valley, is predominantly contaminated with volatile organic compounds.

Plume Delineation

Sources of groundwater contaminants monitored during CY 2006 include the S-2 Site, the Fire Training Facility, the S-3 Site, the Waste Coolant Processing Facility, petroleum USTs, New Hope Pond, the Beta-4 Security Pits, the Salvage Yard, and process/production buildings throughout the Y-12 Complex. Although the S-3 Site, now closed under RCRA, is located west of the current hydrologic divide that separates the Upper East Fork regime from the Bear Creek regime, it has contributed to groundwater contamination in the western part of this regime.

Nitrate

Nitrate concentrations in groundwater at the Y-12 Complex exceed the 10 mg/L drinking water standard in a large part of the western portion of the Upper East Fork regime (a complete list of national drinking water standards is presented in Appendix D). The two primary sources of nitrate contamination are the S-2 and S-3 sites. The extent of the nitrate plume is essentially defined in the unconsolidated and shallow bedrock zones. In CY 2006, groundwater containing nitrate concentrations as high as 9100 mg/L (Well GW-109) occurred in the shallow bedrock just east of the S-3 Site (Fig. 6.19). These results are consistent with results in previous years. An increasing trend in nitrate concentrations at monitoring wells in the eastern portion of Y-12 has been observed. These concentrations are low but periodically exceed the drinking water standard. This increase indicates that the nitrate plume in the Maynardville Limestone is slowly migrating into the eastern area of the Y-12 Complex from the S-2 and/or the S-3 sites. Historical results from monitoring wells in near source areas indicate generally decreasing trends.

Trace Metals

Concentrations of barium, beryllium, cadmium, chromium, lead, mercury, nickel, and uranium exceeded drinking water standards during CY 2006 in samples collected from vari-

ous monitoring wells and surface water locations downgradient of the S-2 Site, the S-3 Site, the Salvage Yard, and throughout the complex. Elevated concentrations of those metals in groundwater were most commonly observed from monitoring wells in the unconsolidated zone. Trace metal concentrations above standards tend to occur only adjacent to the source areas due to their low solubility in natural water systems. However, some metals, such as mercury and uranium, are being transported through the surface water and groundwater systems and have been observed in concentrations above the drinking water standards. Concentrations of uranium exceed the standard (0.03 mg/L) in a number of source areas (e.g., production areas and the Former Oil Skimmer Basin) and contribute to the uranium concentration in Upper East Fork Poplar Creek.

Volatile Organic Compounds

Because of the many legacy source areas, volatile organic compounds are the most widespread groundwater contaminants in the East Fork regime. Dissolved volatile organic compounds in the regime primarily consist of chlorinated solvents and petroleum hydrocarbons. In CY 2006, the highest summed concentration of dissolved chlorinated solvents (77,545 µg/L) was found in groundwater at Well 55-3B in the western portion of the Y-12 Complex adjacent to manufacturing facilities. The highest dissolved concentration of petroleum hydrocarbons (19,600 µg/L) was obtained from Well GW-658 at the closed East End Garage.

The CY 2006 monitoring results generally confirm findings from the previous years of monitoring. A continuous dissolved plume of volatile organic compounds in groundwater in the bedrock zone extends eastward from the S-3 Site over the entire length of the regime (Fig. 6.20). The primary sources are the Waste Coolant Processing Facility, fuel facilities (Rust Garage and East End), Y-12 Salvage Yard, and other waste-disposal and production areas throughout the Y-12 Complex. Chloroethene compounds (tetrachloroethene, trichloroethene, dichloroethene, and vinyl chloride) tend to dominate the volatile organic plume composition in the western and central portions of the Y-12 Complex. However, tetrachloroethene and isomers of dichloroethene are almost ubiquitous

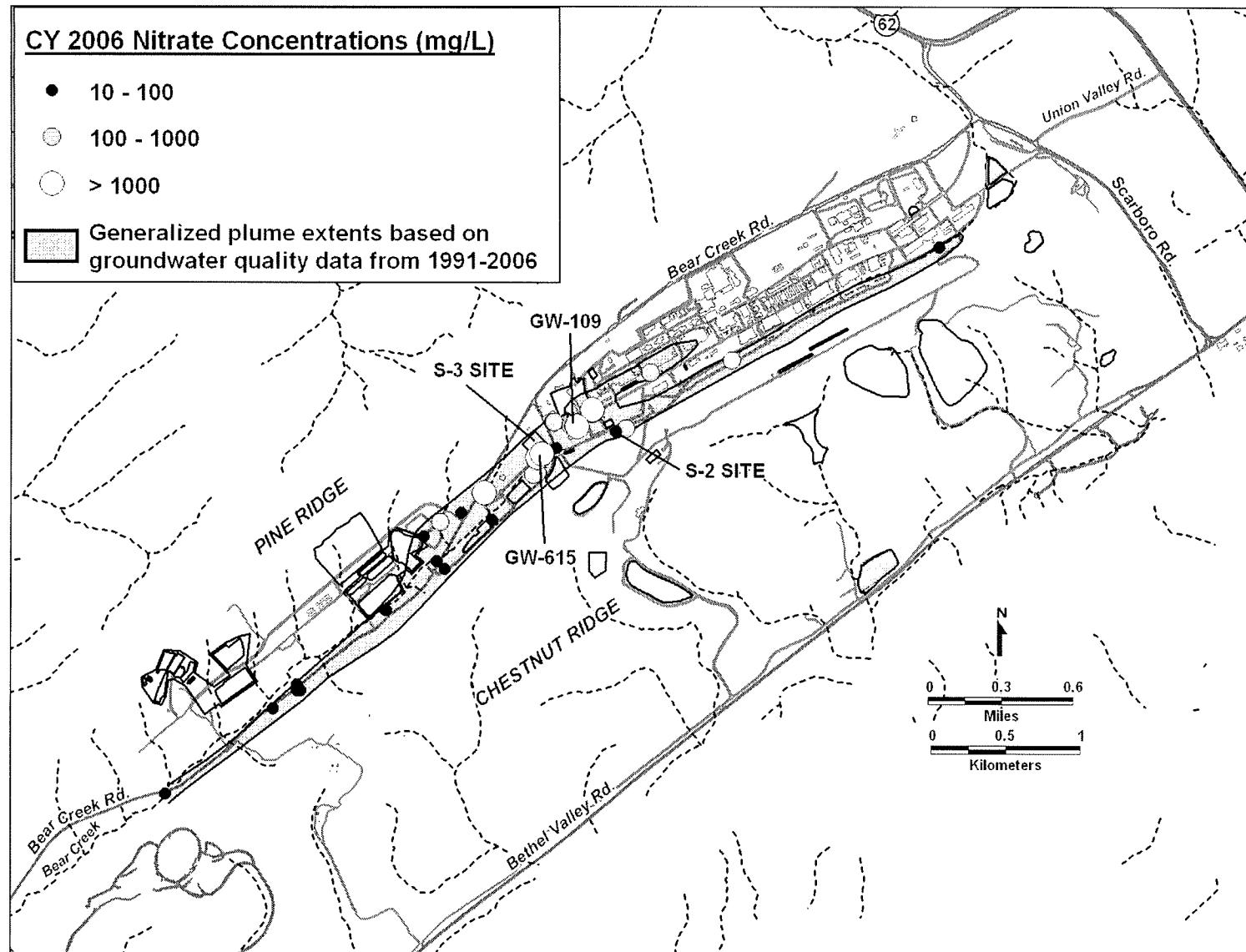


Fig. 6.19. Nitrate (as nitrogen) observed in groundwater at the Y-12 Complex, 2006.

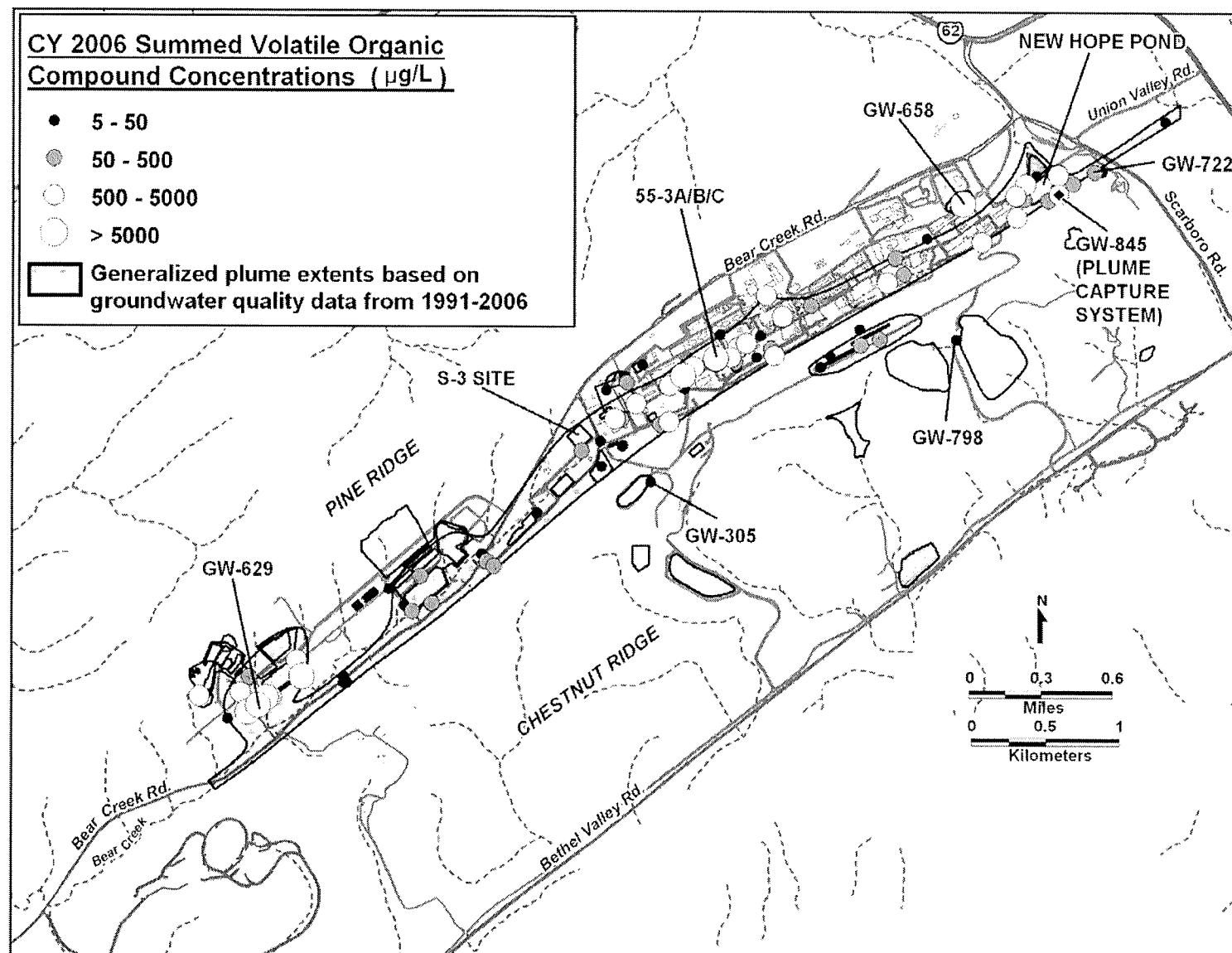


Fig. 6.20. Summed volatile organic compounds observed in groundwater at the Y-12 Complex, 2006.

throughout the extent of the plume, indicating many source areas. Chloromethane compounds (carbon tetrachloride, chloroform, and methylene chloride) are the predominant volatile organic compounds in the eastern portion of the complex.

Variability in concentration trends of chlorinated volatile organic compounds near source areas is seen within the Upper East Fork regime. As seen in previous years, data from most of the monitoring wells have remained relatively constant (i.e., stable) or have decreased since 1988. Increasing trends are observed in monitoring wells associated with the Waste Coolant Processing Facility, some production/process facilities, and the East End volatile organic compound plume, indicating that some portions of the plume are still mobile. Within the exit pathway the general trends are also stable or decreasing. These trends west of New Hope Pond are indicators that the contaminants from source areas are attenuating due to factors such as (1) dilution by surrounding uncontaminated groundwater, (2) dispersion through a complex network of fractures and conduits, (3) degradation by chemical or biological means, or (4) adsorption by surrounding bedrock and soil media. Wells to the southeast of New Hope Pond are displaying the effects of the pumping well (GW-845) operated to capture the plume prior to migration off of the ORR into Union Valley. Wells east of the New Hope Pond and north of Well GW-845 exhibit an increasing trend in volatile organic compound concentrations, indicating that little impact or attenuation from the plume capture system is apparent across lithologic units (perpendicular to strike). However, no subsequent downgradient detection of these compounds is apparent, so migration seems to be limited.

Monitoring wells at two former petroleum hydrocarbon contaminant sources (the Rust Garage Area and the East End Garage) were sampled to evaluate the present condition of groundwater. A well at the Rust Garage has shown a significant increase in concentration since the early 1990s. A well at the East End Garage shows petroleum hydrocarbon concentrations consistent with those observed during the early 1990s. These observations indicate that there is still an accumulation of hydrocarbon contaminants within and surrounding each well.

Radionuclides

The primary alpha-emitting radionuclides found in the East Fork regime during CY 2006 are isotopes of uranium. Groundwater with gross alpha activity greater than 15 pCi/L (the drinking water standard) occurs in scattered areas throughout the Upper East Fork regime (Fig. 6.21). Historical data show that gross alpha activity consistently exceeds the drinking water standard and that it is most extensive in groundwater in the unconsolidated zone in the western portion of the Y-12 Complex near source areas such as the S-3 Site, the S-2 Site, and the Y-12 Salvage Yard. However, the highest gross alpha activity (529 pCi/L) in groundwater continues to be observed on the east end of the Y-12 Complex in Well GW-154, east of the Former Oil Skimmer Basin.

The primary beta-emitting radionuclides observed in the Upper East Fork regime during CY 2006 are ⁹⁹Tc and uranium. Elevated gross beta activity in groundwater in the Upper East Fork regime shows a pattern similar to that observed for gross alpha activity, where ⁹⁹Tc is the primary contaminant exceeding the screening level of 50 pCi/L in groundwater in the western portion of the regime, with the primary source being the S-3 Site (Fig. 6.22). The highest gross beta activity in groundwater was observed during CY 2006 from well GW-108 (16,500 pCi/L), east of the S-3 site.

Exit Pathway and Perimeter Monitoring

Data collected to date indicate that volatile organic compounds are the primary class of contaminants that are migrating through the exit pathways in the Upper East Fork regime. The compounds are migrating at depths of almost 500 ft in the Maynardville Limestone, the primary intermediate to the deep groundwater exit pathway on the east end of the Y-12 Complex. The deep fractures and solution channels that constitute flow paths within the Maynardville Limestone appear to be well connected, resulting in contaminant migration for substantial distances off the ORR into Union Valley to the east of the complex.

In addition to the intermediate to deep pathways within the Maynardville Limestone, shallow groundwater within the water table interval

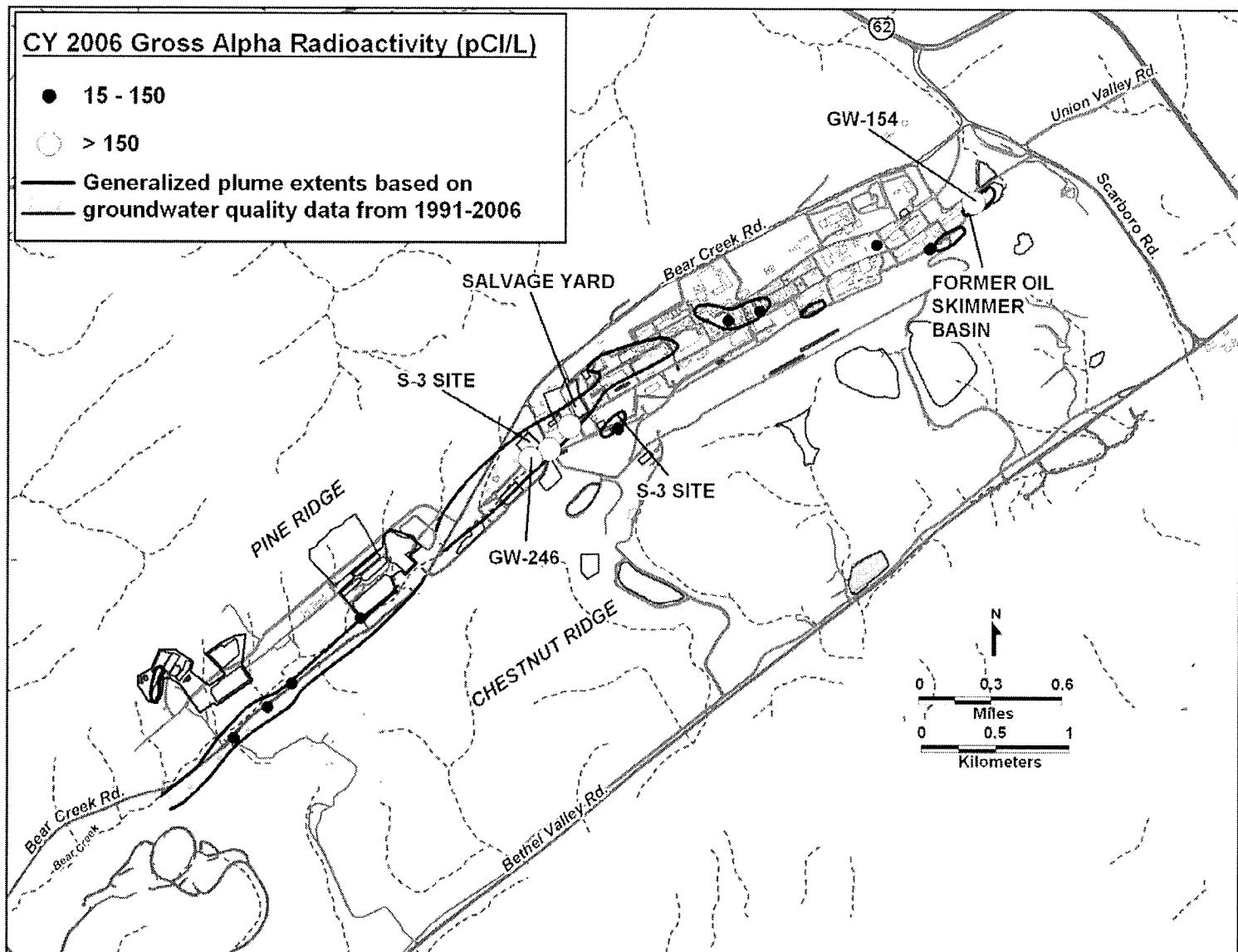


Fig. 6.21. Gross alpha radioactivity observed in groundwater at the Y-12 Complex, 2006.

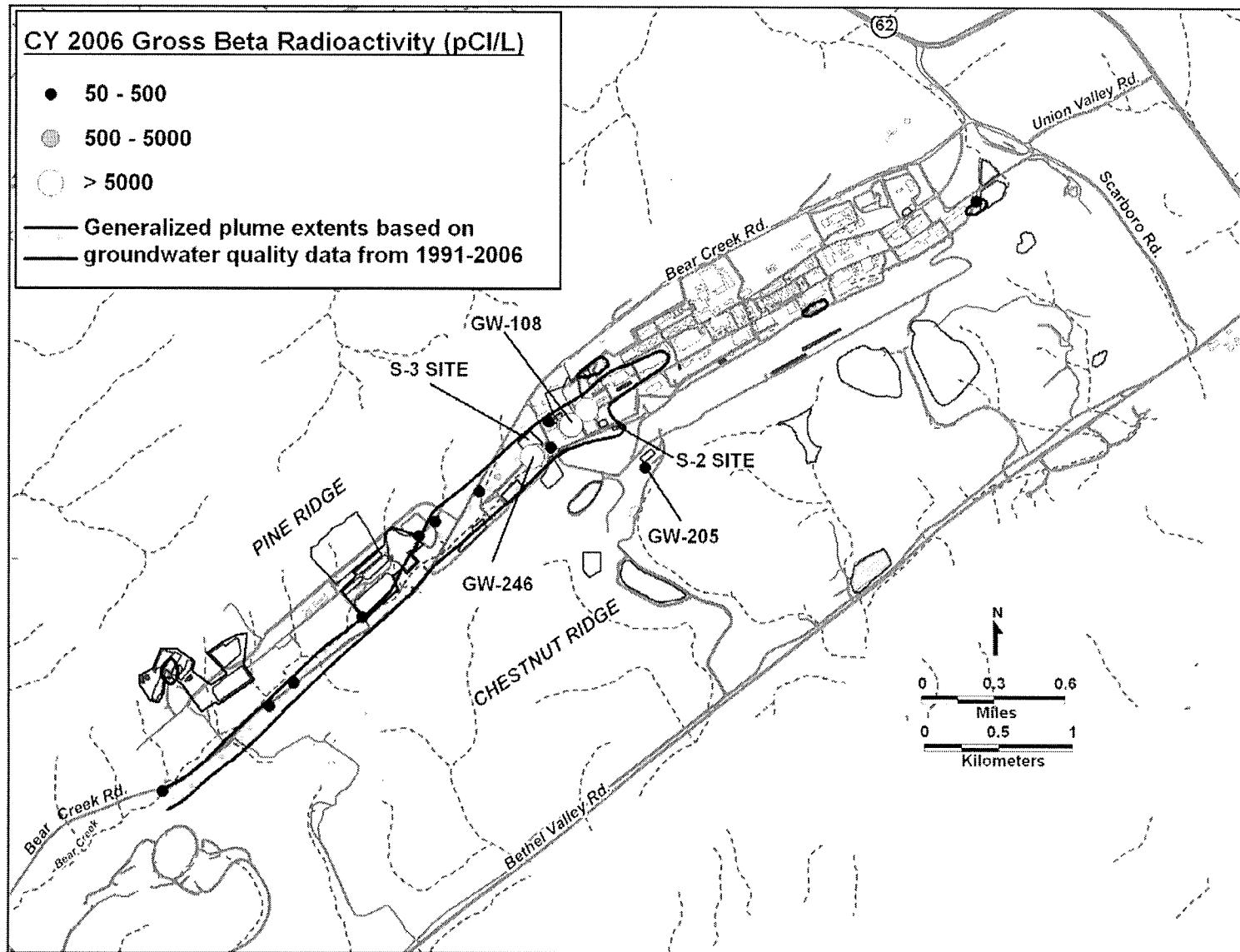


Fig. 6.22. Gross beta radioactivity observed in groundwater at the Y-12 Complex, 2006.

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of that geologic unit near New Hope Pond, Lake Reality, and Upper East Fork Poplar Creek is also monitored. Historically, volatile organic compounds have been observed near Lake Reality from wells, a dewatering sump, and the New Hope Pond distribution channel underdrain. In that area, shallow groundwater flows north-northeast through the water table interval east of New Hope Pond and Lake Reality, following the path of the distribution channel for Upper East Fork Poplar Creek.

During CY 2006, the observed concentrations of volatile organic compounds at the New Hope Pond distribution channel underdrain continue to remain low. This may be because the continued operation of the groundwater plume-capture system in Well GW-845 southeast of the New Hope Pond is effectively reducing the levels of volatile organic compounds in the area. The installation of the plume capture system was completed in June 2000. This system pumps groundwater from the intermediate bedrock depth to mitigate off-site migration of volatile organic compounds. Groundwater is continuously pumped from the Maynardville Limestone at about 25 gal/min, passes through a treatment system to remove the volatile organic compounds, and then discharges to Upper East Fork Poplar Creek.

Monitoring wells near Well GW-845 have shown some encouraging response to the pumping activities. The multiport system installed in Well GW-722, approximately 500 ft east and downgradient of Well GW-845, permits sampling of ten discrete zones within the Maynardville Limestone between 87 and 560 ft below ground surface. This well has been instrumental in characterizing the vertical extent of the east-end plume of volatile organic compounds and is critical in the evaluation of the effectiveness of the plume capture system. Monitoring results from the sampled zones in Well GW-722 indicate reductions in volatile organic compounds due to groundwater pumping upgradient at Well GW-845. Other wells also show decreases that may be attributable to the plume capture system operation. These indicators show that operation of the plume capture system is decreasing volatile organic compounds upgradient and downgradient of Well GW-845.

Historically, three wells, located in the large gap in Pine Ridge through which Upper East

Fork Poplar Creek exits the Y-12 Complex, were used to monitor shallow, intermediate, and deep groundwater intervals (Fig. 6.18). Shallow groundwater moves through this exit pathway, and very strong upward vertical flow gradients exist; two of the three wells located in this area are artesian (water flows from the well casing due to unusually high naturally occurring water pressure). Continued monitoring of the wells since about 1990 has not shown that any contaminants are moving via this exit pathway. Only the shallow well was monitored in CY 2006, and no groundwater contaminants were observed.

Four sampling locations continue to be monitored north and northwest of the Y-12 Complex to evaluate possible contaminant transport from the ORR. These locations are considered unlikely groundwater or surface water contaminant exit pathways; however, monitoring was performed due to previous public concerns regarding potential health impacts from Y-12 operations to nearby residences. Two of the stations monitored tributaries that drain the north slope of Pine Ridge on the ORR and that discharge into the adjacent Scarborough Community. One location monitors an upper reach of Mill Branch, which discharges into the residential areas along Wiltshire Drive. The remaining location monitors Gum Hollow Branch as it discharges from the ORR and flows adjacent to the Country Club Estates community. Samples were obtained and analyzed for metals, inorganic parameters, volatile organic compounds, and gross alpha and gross beta activities. No results exceeded a drinking water standard, nor were there any indications that contaminants were being discharged from the ORR into those communities.

6.10.4.2 Union Valley Monitoring

Groundwater monitoring data obtained in 1993 provided the first strong indication that volatile organic compounds were being transported off the ORR through the deep Maynardville Limestone exit pathway. The Upper East Fork Poplar Creek remedial investigation (DOE 1998) provided a discussion of the nature and extent of the volatile organic compounds.

In CY 2006, monitoring of locations in Union Valley continued, showing an overall decreasing trend in the concentrations of con-

taminants forming the groundwater contaminant plume in Union Valley.

Under the terms of an interim record of decision, administrative controls, such as restrictions on potential future groundwater use, have been established. Additionally, the previously discussed plume capture system (Well GW-845) was installed and initiated to mitigate the migration of groundwater contaminated with volatile organic compounds into Union Valley (DOE 2007a).

In July 2006, the Agency for Toxic Substances and Diseases Registry, the principal federal public health agency charged with evaluating the human health effects of exposure to hazardous substances in the environment, published a report in which they evaluated groundwater contamination across the ORR (ATSDR 2006). In the report, it was acknowledged that extensive groundwater contamination exists throughout the ORR, but the authors concluded that there is no public health hazard from exposure to contaminated groundwater originating from the ORR. This conclusion category is used for sites that, because of the absence of exposure, do not pose a public health hazard. The Y-12 Complex east end volatile organic compound groundwater contaminant plume is the only confirmed off-site contaminant plume migrating across the ORR boundary. The report recognized that the institutional and administrative controls established in the record of decision do not provide for reduction in toxicity, mobility, or volume of contaminants of concern, but they conclude that these controls are protective of public health to the extent that they limit or prevent community exposure to contaminated groundwater in Union Valley.

6.10.4.3 Bear Creek Hydrogeologic Regime

Located west of the Y-12 Complex 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 Complex to State Highway 95. Table 6.18 describes each of the waste management sites within the Bear Creek regime.

Plume Delineation

The primary groundwater contaminants in the Bear Creek regime are nitrate, trace metals, volatile organic compounds, and radionuclides. The S-3 Site is a source of all four of these contaminants. The Oil Landfarm waste management area, consisting of the Oil Landfarm, the Boneyard/Burnyard, the Hazardous Chemical Disposal Area, and Landfill I, is a significant source of uranium, other trace metals, and volatile organic compounds. Other sources of volatile organic compounds include the Rust Spoil Area, and the Bear Creek Burial Grounds waste management area. Volatile organic compounds such as tetrachloroethene, trichloroethene, 1,1-dichloroethene, 1,2-dichloroethene, and high concentrations of PCBs have been observed as deep as 270 ft below the Bear Creek Burial Grounds.

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. This aquitard unit is positioned north of and adjacent to the exit pathway unit, the Maynardville Limestone. 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.

Nitrate

Unlike many groundwater contaminants, nitrate is highly soluble and moves easily with groundwater. The limits of the nitrate plume probably define the maximum extent of subsurface contamination in the Bear Creek regime. The horizontal extent of the nitrate plume is essentially defined in groundwater in the upper to intermediate part of the aquitard and aquifer (less than 300 ft below the ground surface).

Data obtained during CY 2006 indicate that nitrate concentrations in groundwater exceed the drinking water standard in an area that extends west from the S-3 Site for approximately 8,000 to 11,000 ft down Bear Creek Valley, which is consistent with historical nitrate observations. Some fluctuation in plume extents has been observed over the last several years in the Maynardville Limestone. Nitrate concentrations greater than 100 mg/L persist out to about 1,500

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Table 6.18. History of waste management units included in CY 2006 groundwater monitoring activities, Bear Creek Hydrogeologic Regime^a

Site	Historical data
S-3 Site	Four unlined surface impoundments constructed in 1951. Received liquid nitric acid/uranium-bearing wastes via the Nitric Acid Pipeline until 1983. Closed and capped under RCRA in 1988. Infiltration was the primary release mechanism to groundwater.
Oil Landfarm	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	Used from 1943 to 1970. Unlined shallow trenches used to dispose of construction debris and to burn magnesium chips and wood. Excavated and restored in 2002–2003 as part of Boneyard/Burnyard remedial activities.
Burnyard	Used from 1943 to 1968. Wastes, metal shavings, solvents, oils, and laboratory chemicals were burned in two unlined trenches. Excavated and restored in 2002–2003.
Hazardous Chemical Disposal Area	Used from 1975 to 1981. Built over the burnyard. Handled compressed gas cylinders and reactive chemicals. Residues placed in a small, unlined pit. The northwest portion was excavated and restored in 2002–2003 as part of Boneyard/Burnyard remedial activities.
Sanitary Landfill I	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 1985.
Bear Creek Burial Grounds: A, C, and Walk-in Pits	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 (1993), and the Walk-in Pits (1995). Infiltration is the primary release mechanism to groundwater.
Bear Creek Burial Grounds: B, D, E, J, and Oil Retention Ponds 1 and 2	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 February 1995.
Rust Spoil Area	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 volatile organic compounds to shallow groundwater according to CERCLA remedial investigation.
Spoil Area I	Used from 1980 to 1988 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. CERCLA record of decision issued in 1996.
SY-200 Yard	Used from 1950 to 1986 for equipment and materials storage. No documented waste disposal at the site occurred. Leaks, spills, and soil contamination are concerns. CERCLA record of decision issued in 1996.
Above-Grade LLW Storage Facility	Constructed in 1993. Consists of six above-grade storage pads used to store inert, low-level radioactive debris and solid wastes packaged in steel containers.

^aAbbreviations

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act

LLW = low-level radioactive waste

PCB = polychlorinated biphenyl

RCRA = Resource Conservation and Recovery Act

TDEC = Tennessee Department of Environment and Conservation

to 2,500 ft west of the S-3 Site in the Nolichucky Shale. Historically, the highest nitrate concentrations are observed adjacent to the S-3 Site in groundwater in the unconsolidated zone and at shallow depths (less than 100 ft below ground surface) in the aquitard. However, in CY 2006 the highest nitrate concentration (11,300 mg/L) was observed at Well GW-615 adjacent to the S-3 Site at a depth of 223 ft below ground surface (Fig. 6.19), indicating that high concentrations persist deeper in the subsurface groundwater system. In previous years, elevated concentrations of nitrate have been observed as deep as 740 ft below ground surface.

During 2006, surface water nitrate results exceeding the drinking water standard were observed as far as 15,000 ft west of the S-3 Site.

Trace Metals

During CY 2006, uranium, barium, cadmium, lead, beryllium, nickel, arsenic, mercury, and selenium were identified from groundwater monitoring as the trace metal contaminants in the Bear Creek regime that exceeded drinking water standards. Historically, elevated concentrations of many of the trace metals were observed at shallow depths near the S-3 Site. Disposal of acidic liquid wastes at the S-3 Site reduced the pH of the groundwater, which allows the metals to remain in solution longer and migrate further from the source area. Elsewhere in the Bear Creek regime, where natural geochemical conditions prevail, the trace metals may occur sporadically and in close association with source areas because conditions are typically not favorable for dissolution and migration. In CY 2006, the listed trace metals were evident at elevated concentrations within the surface

water and groundwater downgradient of the S-3 Site, the Bear Creek Burial Ground, and the Oil Landfarm waste management areas.

The most prevalent trace metal contaminant observed within the Bear Creek regime is uranium, indicating that geochemical conditions are favorable for its migration. The Boneyard/Burnyard site was identified as the primary source of uranium contamination of surface water and groundwater. Historically, uranium is observed at concentrations exceeding the drinking water standard of 0.03 mg/L in shallow monitoring wells, springs, and surface water locations downgradient from all of the waste areas. In 2003, BJC performed the final remedial actions at the Boneyard/Burnyard with the objective of removing materials contributing to surface water and groundwater contamination to meet existing record-of-decision goals. Approximately 86,000 yd³ of waste materials were excavated and placed in the EMWMF (DOE 2007a). There has been a significant decrease in uranium in the surface water tributary immediately downstream of the Boneyard/Burnyard, which indicates that the remedial actions performed from 2002 to 2003 were successful in removing much of the primary source of uranium in Bear Creek Valley. In CY 2006, a corresponding decrease in uranium concentrations was observed downstream in Bear Creek (Table 6.19). Other trace metal contaminants that have been observed in the Bear Creek regime are antimony, boron, chromium, cobalt, lithium, manganese, strontium, and thallium. Concentrations have commonly exceeded background values in groundwater near contaminant source areas.

Table 6.19. Nitrate and uranium concentrations in Bear Creek

Bear Creek Monitoring Station (distance from S-3 site)	Contaminant	Average concentration (mg/L)					
		1990– 1993	1994– 1997	1998– 2001	2002– 2004	2005	2006
BCK-11.84 to 11.97 (~0.5 miles downstream)	Nitrate	119	80	80	84	63.3	35.8
	Uranium	0.196	0.134	0.139	0.119	0.088	0.102
BCK-09.20 to 09.47 (~2 miles downstream)	Nitrate	16.4	9.6	10.6	11.9	6.6	10.2
	Uranium	0.091	0.094	0.171	0.099	0.038	0.063
BCK-04.55 (~5 miles downstream)	Nitrate	4.6	3.6	2.6	3.5	1.1	0.312
	Uranium	0.034	0.031	0.036	0.029	0.017	0.00112 ^a

^aInconsistently low when compared to historical data for BCK-04.55.

Volatile Organic Compounds

Volatile organic compounds are widespread in groundwater in the Bear Creek regime. The primary compounds are tetrachloroethene, trichloroethene, 1,2-dichloroethene, 1,1-dichloroethane, and vinyl chloride. In most areas, they are dissolved in the groundwater and can occur in bedrock at depths greater than 270 ft below the Bear Creek Burial Ground waste management area. Groundwater in the aquitards that contains detectable levels of volatile organic compounds occurs primarily within about 1000 ft of the source areas. The highest concentrations observed in CY 2006 in the Bear Creek regime occurred in the intermediate bedrock zone at the Bear Creek Burial Ground waste management area, with a maximum summed volatile organic compound concentration of 21,968 $\mu\text{g/L}$ in Well GW-629 (Fig. 6.20). This result is much higher than concentrations seen previously. This, coupled with increasing trends observed downgradient of the Bear Creek Burial Ground waste management area in the aquitards, indicates that some migration of volatile organic compounds is occurring. This migration through the aquitards parallel to the valley axis and toward the exit pathway (Maynardville Limestone) is occurring in both the unconsolidated and bedrock intervals.

Significant transport of volatile organic compounds has occurred in the Maynardville Limestone. Data obtained from exit pathway monitoring locations show that in the vicinity of the water table, an apparently continuous dissolved plume extends at least 7400 ft westward from the S-3 Site to just southeast of the Bear Creek Burial Ground waste management area.

Radionuclides

The primary radionuclides identified in the Bear Creek regime are isotopes of uranium and ^{99}Tc . Neptunium-237, ^{241}Am , radium, strontium, thorium, plutonium, and tritium are secondary and less widespread radionuclides, primarily present in groundwater near the S-3 Site. Evaluations of their extent in groundwater in the Bear Creek regime during CY 2006 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 drinking

water standard for gross alpha activity), then one (or more) of the alpha-emitting radionuclides (e.g., uranium) was 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. Technetium-99, a more volatile radionuclide, is qualitatively screened by gross beta activity analysis and, at certain monitoring locations, is evaluated isotopically.

Groundwater with elevated levels of gross alpha activity occurs near the S-3 Site and the Oil Landfarm and Bear Creek Burial Grounds waste management areas. In the bedrock interval, gross alpha activity exceeds 15 pCi/L in groundwater in the aquitards only near source areas (Fig. 6.21). Data obtained from exit pathway monitoring stations show that gross alpha activity in groundwater in the Maynardville Limestone and in the surface waters of Bear Creek exceeds the drinking water standard for over 9,000 ft west of the S-3 Site. The highest gross alpha activity observed in CY 2006 was 550 pCi/L in Well GW-246 located adjacent to the S-3 Site.

The distribution of gross beta radioactivity in groundwater is similar to that of gross alpha radioactivity. During CY 2006, it appears that the lateral extent of gross beta activity within the exit pathway groundwater interval and surface water above the drinking water standard has not changed from those observed in recent years. Gross beta activities exceeded 50 pCi/L within the Maynardville Limestone exit pathway for 8,000 to 10,000 ft from the S-3 Site (Fig. 6.22). The highest gross beta activity in groundwater in the Bear Creek Regime this year was 18,000 pCi/L at Well GW-246 located adjacent to the S-3 Site.

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, the springs along the valley floor, and groundwater

in the Maynardville Limestone are hydraulically connected. The western exit pathway well transect (Picket W) serves as the perimeter well location for the Bear Creek regime (Fig. 6.18).

Exit pathway monitoring consists of continued monitoring at four well transects (pickets) and selected springs and surface water stations. Groundwater quality data obtained during CY 2006 from the exit pathway monitoring wells indicate that groundwater is contaminated above drinking water standards in the Maynardville Limestone as far west as Picket A.

Surface water samples collected during CY 2006 indicate that water in Bear Creek contains many of the compounds found in the groundwater. Additionally, nitrate and uranium concentrations and gross beta activities exceeding their respective drinking water standards have been observed in surface water west of the burial grounds as far as Picket W (BWXT 2007). The concentrations in the creek decrease with distance downstream of the waste disposal sites (Table 6.19). Individual monitoring locations along Bear Creek also show a decrease in concentration with respect to time, reflecting the positive steps toward remediation of legacy wastes and active mitigating practices of pollution prevention.

6.10.4.4 Chestnut Ridge Hydrogeologic Regime

The Chestnut Ridge Hydrogeologic Regime is flanked to the north by Bear Creek Valley and to the south by Bethel Valley Road (Fig. 6.17). The regime encompasses the portion of Chestnut Ridge extending from Scarboro Road, east of the complex, to Dunaway Branch, located just west of Industrial Landfill II.

The Chestnut Ridge Security Pits area is the only documented source of groundwater contamination in the regime. Contamination from the Security Pits is distinct and does not mingle with plumes from other sources. Table 6.20 summarizes the operational history of waste management units in the regime.

Plume Delineation

The horizontal extent of the volatile organic compound plume at the Chestnut Ridge Security Pits is reasonably well defined in the water table and shallow bedrock zones. With one exception,

historical monitoring indicates that the volatile organic compound plume from the Chestnut Ridge Security Pits has not migrated very far in any direction (< 1,000 ft). Groundwater quality data obtained during CY 2006 indicate that the western lateral extent of the plume of volatile organic compounds at the site has not changed significantly from previous years. An increase in volatile organic compound contaminants over the past several years at a well approximately 1,500 ft southeast of the Chestnut Ridge Security Pits shows that some migration of the eastern plume is occurring.

Nitrate

Nitrate concentrations were below the drinking water standard at all monitoring stations in the Chestnut Ridge Hydrogeologic Regime.

Trace Metals

Groundwater concentrations of trace metals exceeded regulatory standards during CY 2006 at four locations. Concentrations above the drinking water standard for nickel were observed in samples from one monitoring well. Two surface water monitoring stations showed elevated concentrations of arsenic. Elevated levels of lead and arsenic were observed in one natural spring.

Nickel concentrations above the drinking water standard (0.1 mg/L) were observed from one well at the Industrial Landfill IV (Fig. 6.16). The presence of nickel in groundwater samples from monitoring wells at the Y-12 Complex, with the exception of the S-3 Site, is not due to historical waste disposal, but is probably due to corrosion of well casings. Nickel is a primary component of stainless steel, and its presence indicates the occurrence of corrosion and subsequent dissolution of stainless steel well casing and screen materials due to chemical or biochemical processes (LMES 1999).

Elevated concentrations of arsenic above the drinking water standard (0.01 mg/L) were observed in two surface water monitoring location downstream from the Filled Coal Ash Pond, which is monitored under a CERCLA record of decision (DOE 2007a). A constructed wetland area is being utilized to prevent surface water contamination by effluent from the Filled Coal

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Table 6.20. History of waste management units included in CY 2006 groundwater monitoring activities, Chestnut Ridge Hydrogeologic Regime^a

Site	Historical data
Chestnut Ridge Sediment Disposal Basin	Operated from 1973 to 1989. Received soil and sediment from New Hope Pond and mercury-contaminated soils from the Y-12 Complex. Site was closed under RCRA in 1989. Not a documented source of groundwater contamination.
Kerr Hollow Quarry	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 February 1995.
Chestnut Ridge Security Pits	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.
United Nuclear Corporation Site	Received about 29,000 drums of cement-fixed sludges and soils demolition materials, and low-level radioactive contaminated soils. Closed in 1992; CERCLA record of decision has been issued.
Industrial Landfill II	Operated from 1983–1995. Central sanitary landfill for the Oak Ridge Reservation. Detection monitoring under postclosure plan has been ongoing since 1996.
Industrial Landfill IV	Opened for operations in 1989. Permitted to receive only nonhazardous industrial solid wastes. Detection monitoring under TDEC solid-waste-management regulations has been ongoing since 1988.
Industrial Landfill V	Facility completed and initiated operations April 1994. Baseline groundwater monitoring began May 1993 and was completed January 1995. Currently under TDEC solid-waste-management detection monitoring.
Construction/Demolition Landfill VI	Facility operated from December 1993 to November 2003. Baseline groundwater quality monitoring began May 1993 and was completed December 1993. Currently under post-closure care and detection monitoring per TDEC regulations. Post-Closure period ended and the permit was terminated March 2007.
Construction/Demolition Landfill VII	Facility construction completed in December 1994. TDEC granted approval to operate January 1995. Baseline groundwater quality monitoring began in May 1993 and was completed in January 1995. Permit-required detection monitoring per TDEC was temporarily suspended October 1997 pending closure of construction/demolition Landfill VI. Reopened and began waste disposal operations in April 2001.
Filled Coal Ash Pond	Site received Y-12 Steam Plant coal ash slurries. A CERCLA record of decision has been issued. Remedial action complete.
East Chestnut Ridge Waste Pile	Operated from 1987 to 1989 to store contaminated soil and spoil material generated from environmental restoration activities at Y-12. Closed under RCRA in 2005 and incorporated into RCRA Postclosure Plan issued by TDEC in 2006.

^aAbbreviations

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act.

RCRA = Resource Conservation and Recovery Act.

TDEC = Tennessee Department of Environment and Conservation.

Ash Pond. During CY 2006, the locations where elevated arsenic levels were detected are both upgradient and downgradient of this wetland area. Downgradient of the wetlands, concentrations are noticeably lower and surface water samples obtained approximately 2000 ft downstream (Rogers Quarry) exhibit no detectable arsenic.

Elevated concentrations of lead and arsenic were observed at natural spring SCR2.2SP (Fig. 6.18). This is the first time lead and arsenic have been observed at this spring, with lead levels above the federal and state water supply action level (0.015 mg/L). Arsenic was also observed, however the concentration did not exceed the drinking water standard. The source of these contaminants is unknown and continued monitoring at this location will be performed to evaluate these results.

Volatile Organic Compounds

Monitoring of volatile organic compounds in groundwater attributable to the Chestnut Ridge Security Pits has been in progress since 1987. A review of historical data indicates that concentrations of volatile organic compounds in groundwater at the site have generally decreased since 1988. However, a general increasing trend in volatile organic compounds in groundwater samples from monitoring well GW-798 to the southeast and downgradient of the Chestnut Ridge Security Pits has been developing since CY 2000 (Fig. 6.20). This trend seems to have peaked at the beginning of CY 2003 and has stabilized between 15 and 20 µg/L. The volatile organic compounds detected in CY 2006 are characteristic of the Chestnut Ridge Security Pits plume; none of the detected compounds were observed to exceed their respective drinking water standards. These results indicate that there is some migration occurring through the developed fracture and conduit system of the karst dolostone to the southeast of the Chestnut Ridge Security Pits.

At Industrial Landfill IV, a number of volatile organic compounds have been observed since 1992. Monitoring well GW-305, located immediately to the southeast of the facility, has historically displayed concentrations of compounds below applicable drinking water standards, but the concentrations have been on a shallow increase. In CY 2005, the fourth-quarter

result for one of the compounds, 1,1-dichloroethene, was 7.6 µg/L, which is the only time a drinking water standard (7 µg/L) has been exceeded at this location. Results from monitoring well GW-305 continue to show trace levels of volatile organic compounds; however, none of the detected compounds exceeded their respective drinking water standard during CY 2006.

Radionuclides

In CY 2006, there was no gross alpha activity above the drinking water standard of 15 pCi/L. Gross beta activities were below the screening level of 50 pCi/L at all monitoring stations except at monitoring well GW-205 (Fig. 6.22) at the United Nuclear Corporation site (the maximum detected activity was 143 pCi/L). This location has consistently exceeded the screening level since August 1999. Isotopic analyses show a correlative increase in the beta-emitting radionuclide ^{40}K , which is not a known contaminant of concern at the United Nuclear Corporation Site. The source of the radioisotope is not known.

Exit Pathway and Perimeter Monitoring

Contaminant and groundwater flow paths in the karst bedrock underlying the Chestnut Ridge regime have not been well characterized by conventional monitoring techniques. Tracer studies have been used in the past to attempt to identify exit pathways. Based on the results of tracer studies to date, no springs or surface streams that represent discharge points for groundwater have been conclusively correlated to a waste management unit that is a known or potential groundwater contaminant source.

Monitoring of natural groundwater exit pathways is a basic monitoring strategy in a karst regime such as that of Chestnut Ridge. Perimeter springs and surface water tributaries were monitored to determine whether contaminants are exiting the downgradient (southern) side of the regime. Five springs and three surface water monitoring locations were sampled during CY 2006. Contaminants were detected in only one of the natural discharge points (lead and arsenic at SCR2.2.SP).

6.11 Modernization Activities at the Y-12 National Security Complex

NNSA has embarked on a significant facility and infrastructure modernization program at the Y-12 Complex. The objectives of the program are to

- consolidate operations to improve productivity and reduce operating and maintenance cost through footprint reduction,
- modernize existing facilities and site infrastructure systems to sustain operations into the future,
- replace obsolete, ineffective facilities with new modernized structures designed for their intended use, and
- demolish or disposition surplus facilities and materials no longer required to perform missions.

Key considerations of the modernization strategy include incorporation of sustainable environmental stewardship in planning, design, and construction; maintaining compliance with regulatory requirements; and coordinating NNSA's modernization activities with CERCLA requirements.

Overall implementation of the modernization program is consistent with NNSA's Complex 2030 vision for the Nuclear Weapons Complex and with the current site-wide environmental impact statement for the Y-12 Complex and its associated record of decision. NNSA is presently updating the site-wide environmental impact statement.

6.11.1 Infrastructure Reduction

The Y-12 Complex's infrastructure reduction effort focuses on removing excess buildings and infrastructure to support reduction in maintenance and operating cost and to provide real estate for future modernization needs. In addition, Y-12's infrastructure reduction efforts are an important component of NNSA's 2030 Complex vision. The efforts help support the strategic goal of reducing the active footprint at the complex by 50% in the next decade.

Infrastructure activities have already significantly changed the face of the Y-12 Complex. In FY 2006, an additional 109,959 ft² of floor space

was demolished, bringing Y-12's total to over 1 million ft² demolished since the program was initiated in 2001. Infrastructure reduction also supports Y-12's waste reduction goals and recycling initiatives. Since 2002, infrastructure reduction tasks completed 33 pollution prevention projects, including ongoing recycling projects that have eliminated more than 7.35 million lb of waste (that's more than \$989,000 in cost avoidance).

To stay in step with modernization, over the next three years an additional 20 buildings equaling approximately 375,000 ft² are planned for demolition. These buildings include the maintenance shop, engineering buildings and the cafeteria.

6.11.2 New Construction

Y-12 is implementing a number of projects to replace several key facilities and upgrade site infrastructure systems. In some cases new facilities will be constructed to maximize protection of sensitive materials and operations, and in other cases the new facilities will replace worn-out obsolete buildings and systems. Examples include the following.

- New Garage Building—Construction of garage office was completed in 2004, and the service bays were completed in FY 2006. The new garage replaced the existing garage, which was demolished in FY 2006.
- New East End Records Storage Facility—Construction is complete and the building was occupied in 2006.
- Highly Enriched Uranium Materials Facility—This new, state-of-the-art storage facility will consolidate special nuclear material that is housed in multiple aging facilities. Construction is under way and completion is scheduled in 2008 with operation expected in 2010.
- Uranium Processing Facility—The Uranium Processing Facility, a key component of NNSA's Complex 2030 vision will consolidate the remaining enriched-uranium and other processing operations. NNSA published a notice of intent in the *Federal Register* (70 FR 71270) on November 28, 2005, announcing its intent to prepare a site-wide environmental impact statement to analyze

alternatives. Completion of the Uranium Processing Facility is projected for 2015.

- Beryllium Capability Project—This project will provide new equipment within existing facilities to support ongoing beryllium operations at the Y-12 Complex. The project will address modern technologies and engineered controls for beryllium operations. Construction is expected to be completed by FY 2008.
- Potable Water System Upgrade: The line item project will provide water flow and pressure to support current and future Y-12 needs, as well as replace obsolete and aging water system which limits system reliability. Site characterization was completed in 2006 and construction is planned to begin in 2007.

6.11.3 Operating Lease Project

Staff at the Y-12 Complex are working with a private-sector entity to provide for the construction of two new technical and administrative support facilities: the Jack Case Center and the New Hope Building (Fig. 6.23).

The Jack Case Center, to be built north of the recently demolished Y-12 Administration Building, will house administrative, technical, and engineering functions now scattered across the site. The Jack Case Center is named in honor of Jack M. Case, a former Y-12 Plant Manager who rose through the ranks to become plant manager and had the longest tenure—15 years.

The New Hope Building will be located where the small community of New Hope once stood at the east end of the complex. The structure will house a visitor's center and other functions requiring frequent interaction with the public.

Together, these new facilities will replace about 1 million ft² of obsolete workspace with about 550,000 ft² of modern office and laboratory space for about 1,400 employees. Construction is over 80% complete for both buildings, and occupancy is scheduled for late 2007.

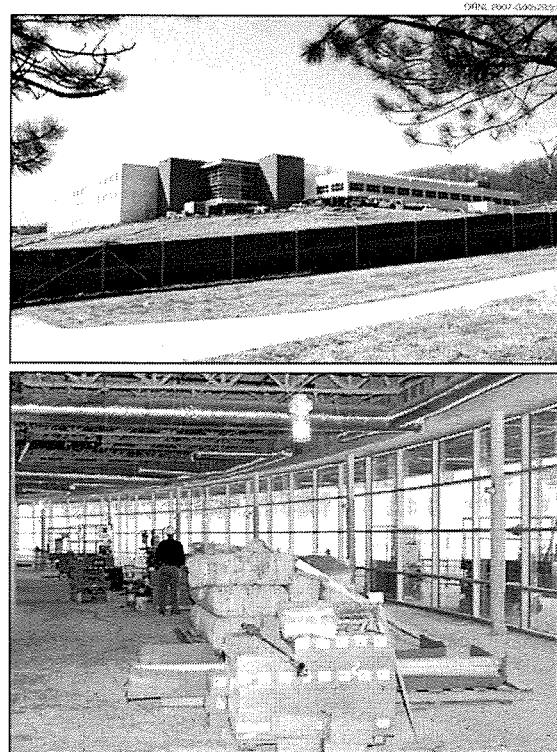


Fig. 6.23. Construction on the Jack Case Center.

Both Jack Case and New Hope centers have incorporated many Leadership in Energy and Environmental Design (LEED®) guided sustainable building practices and techniques, with New Hope pursuing LEED certification. The LEED program falls under the U.S. Green Building Council and is used to guide building design toward a holistic approach to sustainability. Our country's need to construct smarter, more environmentally friendly buildings is the focus of the program, and Y-12 is following it in new construction projects. From establishing parking spaces for alternative-fuel vehicles to installing low-flow water fixtures in the restrooms to New Hope's four aboveground 12,000-gal rainwater-harvesting tanks, LEED has inspired an impressive list of "green" features throughout both facilities.

7. ORR Environmental Monitoring Program

In addition to environmental monitoring conducted at the three major Oak Ridge DOE installations, reservation-wide surveillance monitoring is performed to measure radiological and nonradiological parameters directly in environmental media adjacent to the facilities. Data from the ORR surveillance programs are analyzed to assess the environmental impact of DOE operations on the entire reservation and the surrounding area. Dose assessment information based on data from ORR surveillance programs is given in Chap. 8.

7.1 Meteorological Monitoring

Eight 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, which would be used in the event of accidental releases from a facility. Data from the towers are also used to support various research and engineering projects.

7.1.1 Description

The eight meteorological towers (Table 7.1) are depicted in Fig. 7.1.

Table 7.1. ORR meteorological towers

Tower	Height (m)
Y-12 Complex	
Tower Y (Plant Shift Superintendent Office)	30
MT6/West	60
ORNL	
MT2/C	100
MT3/B	30
MT4/A	30
ETTP	
MT1/K (1208)	60
MT7/L (1209)	30
ORNL/ETTP	
M (208A)	10

Meteorological data are collected at different altitudes (2, 10, 15, 30, 60, and 100 m above the ground) to assess the vertical structure of the atmosphere, particularly with respect to wind

shear and stability. Stable boundary layers and significant wind shear zones (related to local ridge-and-valley terrain as well as the Great Valley; see Sect. 1.3) can significantly affect the movement of a plume after a facility release (Bowen et al. 2000). All of the towers collect data at the 10 m level (except Tower Y, which collects data at 2, 15 and 30 m). Additionally, selected towers collect data at the 30, 60, and 100 m levels. At each measurement level, temperature, wind speed, and wind direction are measured. Data needed to determine atmospheric stability (a measure of vertical mixing properties of the atmosphere) are measured at most towers. Barometric pressure is measured at one or more of the towers at each facility (MT1, MT2, MT7, and Tower Y (Y-12 PSS). Precipitation is measured at MT6 and Tower Y (Y-12 PSS) at the Y-12 Complex, Towers MT1 and MT7 at the ETTP, and at Tower MT2 at ORNL. Solar radiation is measured at Towers MT6 at the Y-12 Complex, Towers MT1 and MT7 at the ETTP, and Tower MT2 at ORNL.

Data from the towers at each site are collected by a dedicated control computer (DASMET). The towers are polled, and data are archived on both hard disk and DVD-R disks. Values collected at 1 min, 15 min, and hourly intervals are stored at two locations (Y-12 for Y-12 sites, ORNL for ORNL and ETTP sites). Long-term archives are kept of 1 min data for ORNL and ETTP and of 15 min and hourly data for all sites. The meteorological monitoring data from the ORR are summarized monthly as wind roses and daily as data tables. General quarterly calibrations of the instruments are managed by ORNL and the Y-12 Complex.

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

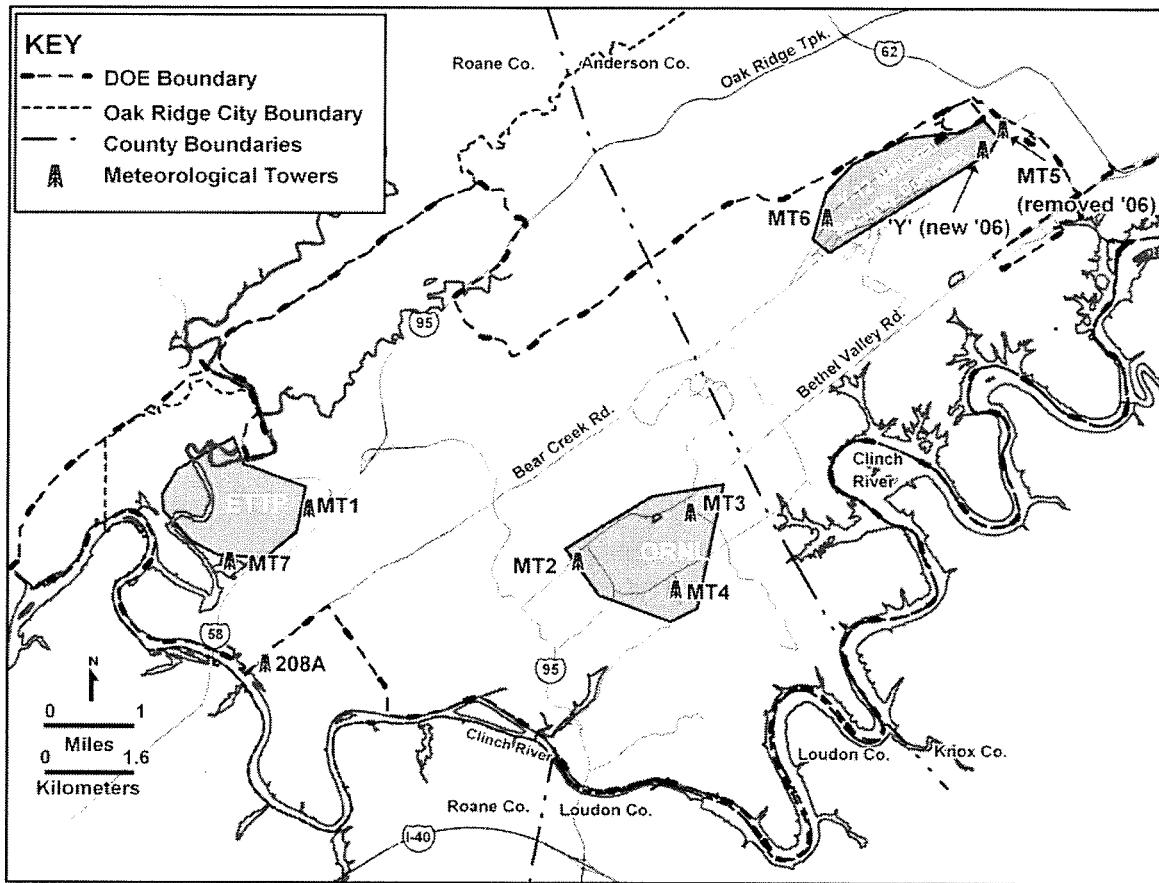


Fig. 7.1. The ORR meteorological monitoring network.

Annual dose estimates are calculated from archived data (hourly values). Data quality is checked continuously against predetermined data constraints, and out-of-range parameters are marked invalid and are excluded from compliance modeling. Records of data problems and errors are routinely kept for all eight tower sites.

7.1.2 Meteorological Impacts on Modeling Results

Pervailing 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 ORR sites. Winds in the valleys tend to follow the ridge axes, with limited cross-ridge flow within local valley bottoms. These conditions are dominant over most of the ORR, with the exception of the ETTP, which is located in a

relatively open valley bottom (which results in more varied flow).

On the reservation, low-speed winds dominate near the surface level. This characteristic is typical of most near-surface measurements but is amplified by the nearby ridges. Winds sometimes accelerate near ridge top level (see Sect. 1.3).

The atmosphere over the reservation is dominated by stable conditions on most nights and for a few hours just after sunrise. These conditions, when coupled with the low wind speeds and channeling effects of the valleys, result in poor dilution of material emitted from the facilities. However, high roughness values (caused by terrain and obstructions such as trees and buildings) may partially mitigate these factors through the increased turbulence (mixing) that results. These features are captured in the data input to the dispersion models and are re-

flected in the modeling studies conducted for each facility.

Precipitation data from Tower MT2/C are used in stream-flow modeling and in certain research efforts. The data indicate the variability of regional precipitation: the high winter rainfall resulting from frontal systems and the uneven, but occasionally intense, summer rainfall associated with thunderstorms. The year 2006 yielded precipitation totals (1252.4 mm or 51.10 in) that were slightly below the long-term average (1323 mm or 54 in).

The average data recovery rate (a measure of acceptable data) across locations used for modeling during 2006 was 97.0% for ORNL sites (Towers MT2, MT3, and MT4), 89.2% for ETTP sites (Towers MT1 and MT7), and 98.8% for Y-12 sites (Tower West). ETTP Tower MT1 (K1208) experienced a major system failure due to lightning activity during late July 2006. As a result, about 20% of the data from this site is missing. Replacement data were largely provided by Site MT7 (L1209), located less than 1 km south of MT1. Site MT1's data recovery was better than 96.8% during 2006.

7.2 External Gamma Radiation Monitoring

External gamma radiation monitoring is conducted to determine whether radioactive effluents from the ORR are increasing external radiation levels significantly above normal background levels. The data also provide a means for comparing results from year to year and for establishing trends.

7.2.1 Data Collection and Analysis

External gamma measurements (exposure rates) are recorded weekly at six ambient air stations from resident external gross gamma monitors (Fig. 7.2). Each consists of a dual-range, high-pressure ion chamber sensor and digital electronic count-rate meter and a totalizer. Totalizing consists of multiplying the count rate by the time of exposure to obtain total exposure.

7.2.2 Results

Table 7.2 summarizes the data collected at each station during the year. The mean observed

exposure rate for the reservation network for 2006 was 5.5 $\mu\text{R}/\text{h}$, and the average at the reference location was 4.6 $\mu\text{R}/\text{h}$. Exposure rates from background sources in Tennessee range from 2.9 to 11 $\mu\text{R}/\text{h}$. The measured ORR exposure rate was within the range of normal background levels in Tennessee, indicating that activities on the ORR do not increase external gamma levels in the area above normal background levels.

7.3 Ambient Air Monitoring

In addition to exhaust stack monitoring conducted at the DOE Oak Ridge installations, ambient air monitoring is performed to measure radiological parameters directly in the ambient air adjacent to the facilities. Ambient air monitoring also provides a means to verify that contributions of fugitive and diffuse sources are insignificant, serves as a check on dose-modeling calculations, and would allow determination of contaminant levels at monitoring locations in the event of an emergency.

The following sections discuss the ambient air monitoring networks for the ORR. Other air monitoring programs are discussed in the site-specific chapters.

7.3.1 ORR Ambient Air Monitoring

The objectives of the ORR ambient air monitoring program are to perform surveillance of airborne radionuclides at the reservation perimeter and to collect reference data from a location not affected by activities on the ORR. The ORR perimeter air monitoring network includes stations 35, 37, 38, 39, 40, 42, 46, and 48 (Fig. 7.3). Reference samples are collected from Station 52 (Fort Loudoun Dam). Sampling was conducted at each ORR station during 2006 to quantify levels of alpha-, beta-, and gamma-emitting radionuclides and ^{3}H .

Atmospheric dispersion modeling was used to select appropriate sampling locations. The locations selected are those likely to be affected most by releases from the Oak Ridge facilities. Therefore, in the event of a release, no residence or business in the vicinity of the ORR should receive a radiation dose greater than doses calculated at the sampled locations.

Oak Ridge Reservation

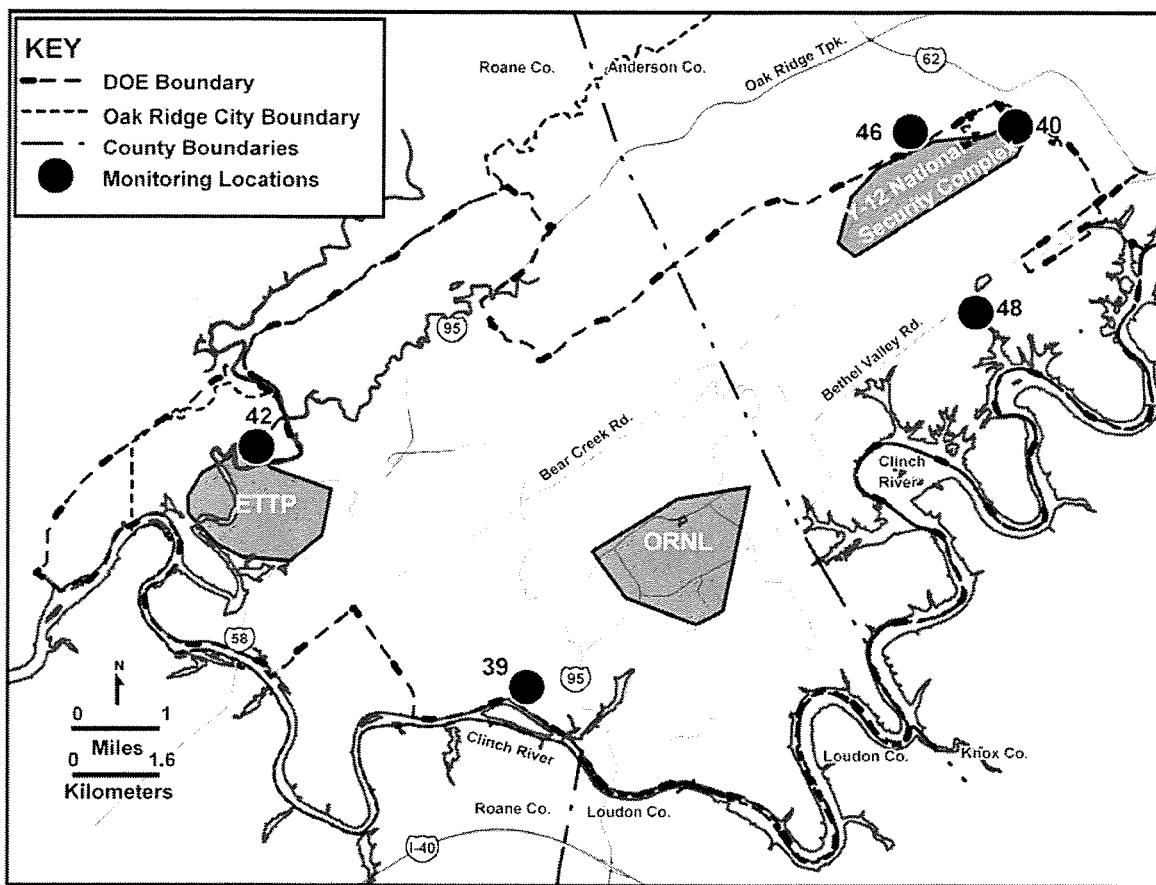


Fig. 7.2. External gamma radiation monitoring locations on the ORR.

Table 7.2. External gamma averages for the ORR, 2006

Monitoring location	Number of data values collected	Measurement ($\mu\text{R/h}$) ^a			Standard error of mean
		Min	Max	Mean	
39	52	5.5	6.5	6.3	0.00003
40	52	4.9	5.8	5.5	0.00002
42	52	4.2	5.1	4.8	0.00003
46	52	5.8	6.3	6.3	0.00001
48	51	4.4	4.8	4.6	0.00001
52	8	4.5	4.8	4.6	0.00003

^aTo convert microroentgens per hour ($\mu\text{R}/\text{h}$) to milliroentgens per year, multiply by 8,760.

The sampling system consists of two separate instruments. Particulates are captured on glass-fiber filters in a high-volume air sampler. The filters are collected weekly, composited quarterly, and then submitted to the laboratory for isotopic analysis. The second system is designed to collect tritiated water vapor. The sam-

pler consists of a prefilter followed by an adsorbent trap consisting of indicating silica gel. The samples are collected weekly or biweekly, composited quarterly, then submitted to the laboratory for ^3H analysis.

The ORR ambient air network (Fig. 7.3) provides appropriate monitoring for all facilities

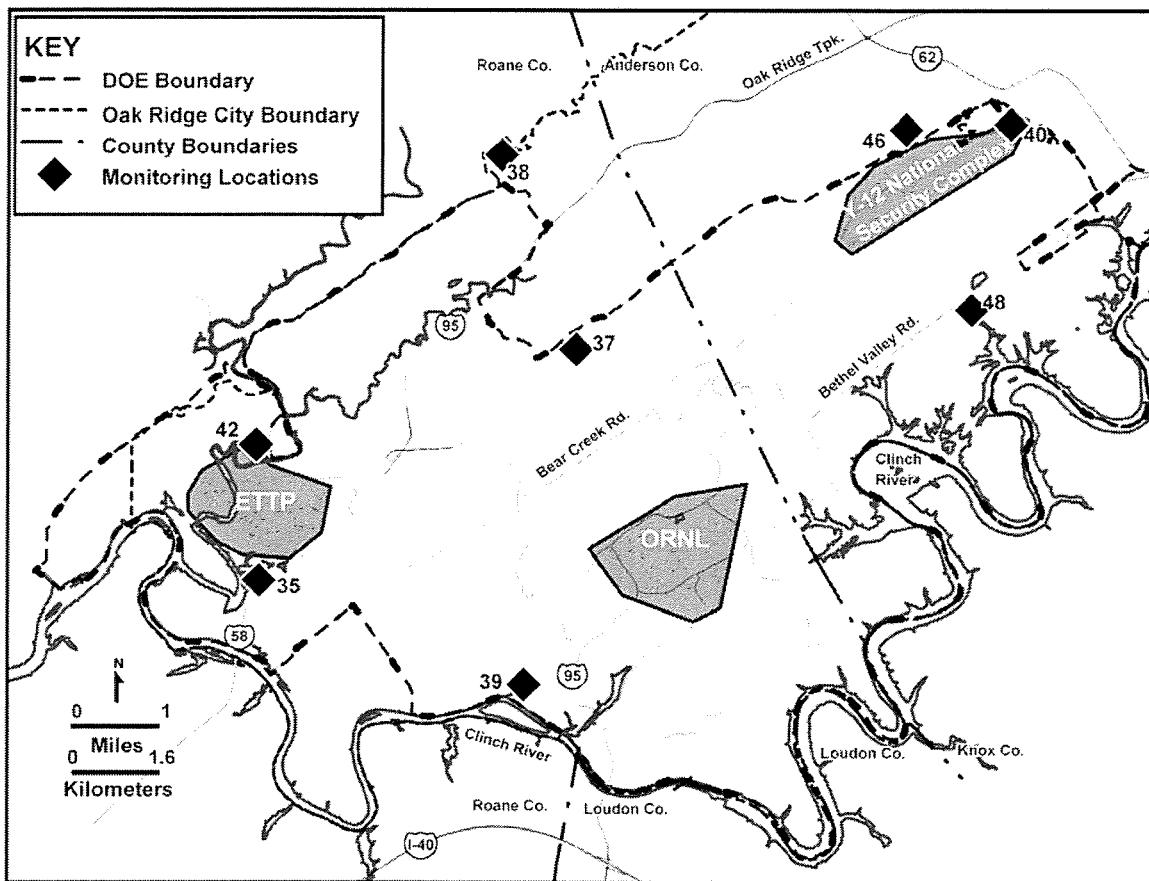


Fig. 7.3. Locations of ORR perimeter air monitoring stations.

within the reservation and thus eliminates the necessity for site-specific ambient air programs. 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 the Y-12 Complex operation. Station 40 monitors the east end of the Y-12 Complex, and Station 37 monitors the overlap of the Y-12 Complex, ORNL, and ETTP emissions.

7.3.2 Results

Data from the ORR ambient air stations are analyzed to assess the impact of DOE operations on the local air quality. Each measured radionuclide concentration is compared with appropriate DCGs, which serve as references for conducting environmental protection programs at DOE sites. All radionuclide concentrations measured at the ORR ambient air stations were less than

1% of applicable DCGs. Statistical significance testing is also performed to compare average radionuclide concentrations measured at ORR ambient air stations with concentrations measured at the reference location. This test reflects the mathematical probability of certain outcomes but is not an indication of environmental significance. There were no calculated statistical differences in average concentrations of, ^{7}Be , ^{238}U , or ^{40}K . The concentrations of ^{3}H , ^{234}U , and ^{235}U at the ORR ambient air stations were slightly higher than those observed at the background location at the 95% confidence level. A summary of radionuclide concentrations measured at the ambient air stations is presented in Table 7.3. Table 7.4 represents the average concentration of three isotopes of uranium at each station for sampling years 2003, 2004, 2005, and 2006.

Table 7.3. Average radionuclide concentrations at ORR perimeter air monitoring stations, 2006

Parameter	No. detected/ no. total	Concentration (pCi/mL) ^a		
		Average	Min	Max
Station 35				
⁷ Be	4/4	3.77E-08	2.36E-08	4.35E-08
⁴⁰ K	0/4	1.28E-10	-3.34E-10	3.70E-10
Tritium	1/4	2.51E-06	-3.66E-06	9.06E-06
²³⁴ U	4/4	1.43E-11	6.10E-12	3.45E-11
²³⁵ U	3/4	1.09E-12	1.20E-13	2.54E-12
²³⁸ U	4/4	1.94E-11	7.14E-12	4.81E-11
Station 37				
⁷ Be	4/4	3.87E-08	2.90E-08	4.80E-08
⁴⁰ K	0/4	2.07E-10	-1.96E-10	9.11E-10
Tritium	0/4	-5.55E-07	-3.90E-06	8.24E-07
²³⁴ U	4/4	4.52E-12	2.97E-12	6.11E-12
²³⁵ U	2/4	5.83E-13	1.66E-13	9.64E-13
²³⁸ U	4/4	6.84E-12	4.09E-12	1.03E-11
Station 38				
⁷ Be	4/4	4.32E-08	3.07E-08	4.95E-08
⁴⁰ K	0/4	3.31E-10	1.21E-10	5.62E-10
Tritium	0/4	1.36E-06	1.78E-07	3.89E-06
²³⁴ U	4/4	5.69E-12	3.80E-12	1.03E-11
²³⁵ U	1/4	4.72E-13	1.99E-13	7.33E-13
²³⁸ U	4/4	8.28E-12	5.20E-12	1.58E-11
Station 39				
⁷ Be	4/4	3.25E-08	2.03E-08	4.59E-08
⁴⁰ K	0/4	1.12E-10	-5.81E-10	6.80E-10
Tritium	0/4	1.55E-06	3.28E-07	3.46E-06
²³⁴ U	4/4	4.46E-12	2.11E-12	1.00E-11
²³⁵ U	1/4	4.08E-13	1.36E-13	9.87E-13
²³⁸ U	4/4	4.51E-12	1.06E-12	1.04E-11
Station 40				
⁷ Be	4/4	4.07E-08	1.58E-08	7.01E-08
⁴⁰ K	0/4	-9.66E-13	-2.87E-10	4.34E-10
Tritium	0/4	1.12E-06	-3.77E-07	3.24E-06
²³⁴ U	4/4	2.07E-11	6.30E-12	2.83E-11
²³⁵ U	3/4	1.22E-12	3.44E-13	2.09E-12
²³⁸ U	4/4	6.65E-12	2.49E-12	1.15E-11
Station 42				
⁷ Be	4/4	3.21E-08	1.86E-08	4.32E-08
⁴⁰ K	0/4	3.71E-11	-3.44E-10	6.57E-10
Tritium	0/4	-7.05E-07	-2.79E-06	1.42E-06
²³⁴ U	4/4	1.01E-11	2.80E-12	1.84E-11
²³⁵ U	0/4	3.55E-13	-5.22E-14	8.85E-13
²³⁸ U	4/4	9.68E-12	2.24E-12	2.09E-11

Table 7.3 (continued)

Parameter	No. detected/ no. total	Concentration (pCi/mL) ^a		
		Average	Min	Max
Station 46				
⁷ Be	4/4	4.33E-08	2.60E-08	6.83E-08
⁴⁰ K	0/4	-1.35E-10	-7.49E-10	3.68E-10
Tritium	0/4	-8.57E-08	-2.41E-06	2.80E-06
²³⁴ U	4/4	1.07E-11	5.25E-12	1.71E-11
²³⁵ U	1/4	4.14E-13	2.22E-13	5.56E-13
²³⁸ U	4/4	7.01E-12	3.61E-12	9.79E-12
Station 48				
⁷ Be	4/4	3.68E-08	2.59E-08	5.39E-08
⁴⁰ K	0/4	-1.08E-10	-7.19E-10	1.50E-10
Tritium	0/4	9.19E-07	-4.39E-07	2.17E-06
²³⁴ U	4/4	5.50E-12	2.85E-12	1.02E-11
²³⁵ U	1/4	2.49E-13	5.80E-14	5.87E-13
²³⁸ U	4/4	4.15E-12	2.31E-12	5.12E-12
Station 52				
⁷ Be	4/4	4.07E-08	2.25E-08	5.36E-08
⁴⁰ K	0/4	1.63E-10	-3.03E-11	4.84E-10
Tritium	0/4	-6.73E-07	-2.89E-06	5.81E-07
²³⁴ U	4/4	3.52E-12	1.87E-12	5.62E-12
²³⁵ U	0/4	-6.54E-14	-1.79E-13	0.00E+00
²³⁸ U	4/4	3.69E-12	2.53E-12	5.84E-12

^a1 pCi = 3.7×10^{-2} Bq.

7.4 Surface Water Monitoring

7.4.1 ORR Surface Water Monitoring

The ORR surface water monitoring program consists of sample collection and analysis from three locations on the Clinch River (see Fig. 7.4 and Table 7.5). This program is conducted in conjunction with site-specific surface water monitoring activities to enable an assessment of the impacts of past and current DOE operations on the quality of local surface water.

Sampling frequency and parameters vary by site. Grab samples are collected at all locations and are analyzed for general water quality parameters, screened for radioactivity, and analyzed for metals and specific radionuclides when appropriate. Samples from two sites are also checked for volatile organic compounds, and one sample is checked for PCBs. Table 7.5 lists the specific locations and associated sampling frequencies and parameters.

The sampling locations are classified by the state of Tennessee for recreation and domestic use. Tennessee water quality criteria associated with these classifications are used as references where they are applicable (TDEC 2004). The Tennessee water quality criteria do not include criteria for radionuclides. Four percent of the DOE DCG is used for radionuclide comparison because this value is roughly equivalent to the 4-mrem dose limit from ingestion of drinking water on which the EPA radionuclide drinking water standards are based.

7.4.2 Results

Comparison of 2006 surface water sample results from locations upstream of DOE inputs with results from surface water samples obtained downstream of DOE inputs shows that there were no statistically significant differences in any of the parameters of interest. Radionuclides were not detected above 4% of the respective

Table 7.4. Uranium concentrations in ambient air on the ORR^a

Isotope	Concentration (10^{-15} $\mu\text{Ci}/\text{mL}$)			
	2003	2004	2005	2006
Station 35				
^{234}U	6.9E-02	2.38E-02	1.24E-02	1.43E-02
^{235}U	3.6E-03	1.36E-03	1.10E-03	1.09E-03
^{238}U	2.3E-02	1.56E-02	2.16E-02	1.94E-02
Station 37				
^{234}U	9.1E-03	1.24E-02	8.01E-03	4.52E-03
^{235}U	4.6E-04	5.40E-04	9.22E-04	5.83E-04
^{238}U	5.6E-03	7.90E-03	1.01E-02	6.84E-03
Station 38				
^{234}U	1.3E-02	9.47E-03	6.21E-03	5.69E-03
^{235}U	8.1E-04	6.17E-04	5.72E-04	4.72E-04
^{238}U	8.3E-03	8.50E-03	7.50E-03	8.28E-03
Station 39				
^{234}U	5.1E-03	4.84E-03	4.58E-03	4.46E-03
^{235}U	2.8E-04	4.36E-04	5.74E-04	4.08E-04
^{238}U	3.9E-03	4.03E-03	4.40E-03	4.51E-03
Station 40				
^{234}U	3.1E-02	3.83E-02	2.85E-02	2.07E-02
^{235}U	1.4E-03	1.43E-03	1.43E-03	1.22E-03
^{238}U	7.8E-03	7.74E-03	8.73E-03	6.65E-03
Station 42				
^{234}U	7.0E-02	2.00E-02	7.51E-03	1.01E-02
^{235}U	3.9E-03	1.06E-03	4.58E-04	3.55E-04
^{238}U	2.8E-02	1.31E-02	1.03E-02	9.68E-03
Station 46				
^{234}U	1.6E-02	2.09E-02	1.82E-02	1.07E-02
^{235}U	8.4E-04	1.47E-03	1.10E-03	4.14E-04
^{238}U	7.8E-03	9.88E-03	1.04E-02	7.01E-03
Station 48				
^{234}U	8.0E-03	7.31E-03	7.63E-03	5.50E-03
^{235}U	4.9E-04	6.15E-04	5.01E-04	2.49E-04
^{238}U	5.9E-03	5.93E-03	6.60E-03	4.15E-03
Station 52				
^{234}U	3.9E-03	5.00E-03	5.03E-03	3.52E-03
^{235}U	3.2E-04	3.72E-04	5.31E-03	-6.54E-05
^{238}U	3.4E-03	4.26E-03	3.95E-03	3.69E-03

^a1 $\mu\text{Ci} = 3.7 \times 10^4$ Bq.

DCG at any location. Acetone and methylene chloride, both common laboratory contaminants, were detected in a few samples at estimated levels in 2006. Tetrachloroethene, a volatile organic compound was detected in the May sample at CRK 70 at low, estimated levels.

7.5 Food

Analysis of vegetation samples collected from areas that could potentially be affected by activities on the reservation enables the evaluation of potential radiation doses received by people consuming food crops, to predict possible concentrations in meat and milk from animals consuming hay, and to monitor trends in environmental contamination and possible long-term accumulation of radionuclides.

7.5.1 Hay

Hay is sampled annually from five areas on the ORR and from one area immediately adjacent to the reservation (Fig. 7.5) that have the potential for deposition of airborne materials from ORR sources. Areas 1, 2, and 3 are within the predicted air plume for an ORNL source and could be affected by ETTP sources. Areas 4, 5, and 6 are within the predicted air plumes for ETTP, ORNL, and Y-12 sources. Individual samples are collected from all six sites; a composite sample from Areas 1, 2, and 3 and a composite sample from Areas 2, 4, and 5 are submitted for laboratory analyses. In addition, a sample from Area 6 is submitted separately because it best represents the combined plumes from all three sites. A reference sample is collected from a site near Norris Dam (Area 7, not shown on Fig. 7.5), which is outside the influence of ORR sources.

7.5.1.1 Results

Hay samples collected during June 2006 were analyzed for gross alpha, gross beta, gamma emitters, and uranium isotopes. No gamma-emitting radionuclides were detected above minimum detectable activity (MDA), with the exception of the naturally occurring radionuclides ^{7}Be and ^{40}K . Information on detected radionuclides in hay is shown in Table 7.6.

7.5.2 Vegetables

Tomatoes, lettuce, and turnips were purchased from farmers near the ORR. The locations were chosen based on availability and on the likelihood of being affected by routine releases from the Oak Ridge facilities.

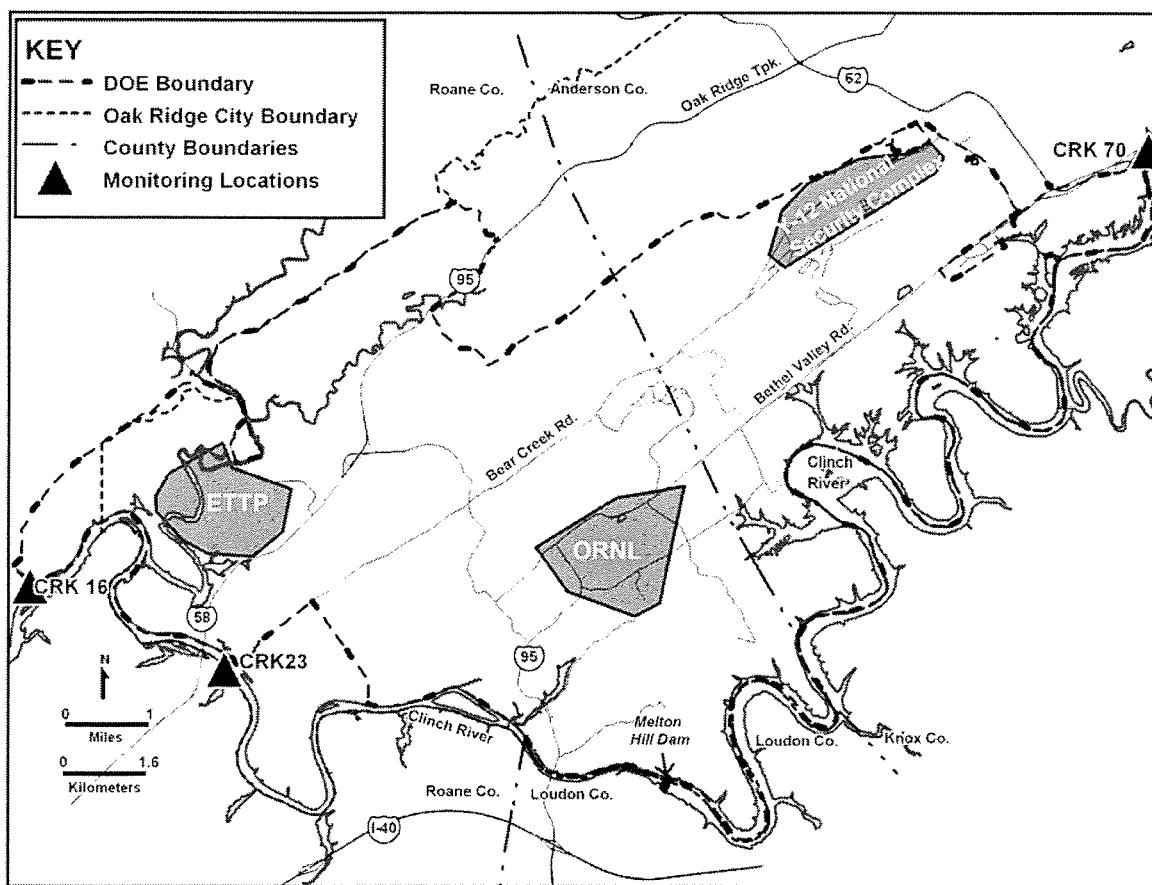


Fig. 7.4. Locations of ORR surface water surveillance sampling stations.

Table 7.5. ORR surface water sampling locations, frequencies, and parameters, 2006

Location ^a	Description	Frequency	Parameters
CRK 16	Clinch River downstream from all DOE ORR inputs	Monthly	Volatiles, metals, gross alpha, gross beta, gamma scan, field measurements ^b
CRK 23	Water supply intake for the ETTP	Monthly	Gross alpha, gross beta, total radioactive strontium, gamma scan, ³ H, field measurements ^b
CRK 70	Solway Bridge	Monthly	Volatiles, metals, gross alpha, gross beta, total radioactive strontium, gamma scan, ³ H, field measurements ^b

^aLocations indicate bodies of water and distances (e.g., CRK 16 = 16 km upstream from the confluence of the Clinch and the Tennessee rivers).

^bField measurements consist of dissolved oxygen, pH, and temperature.

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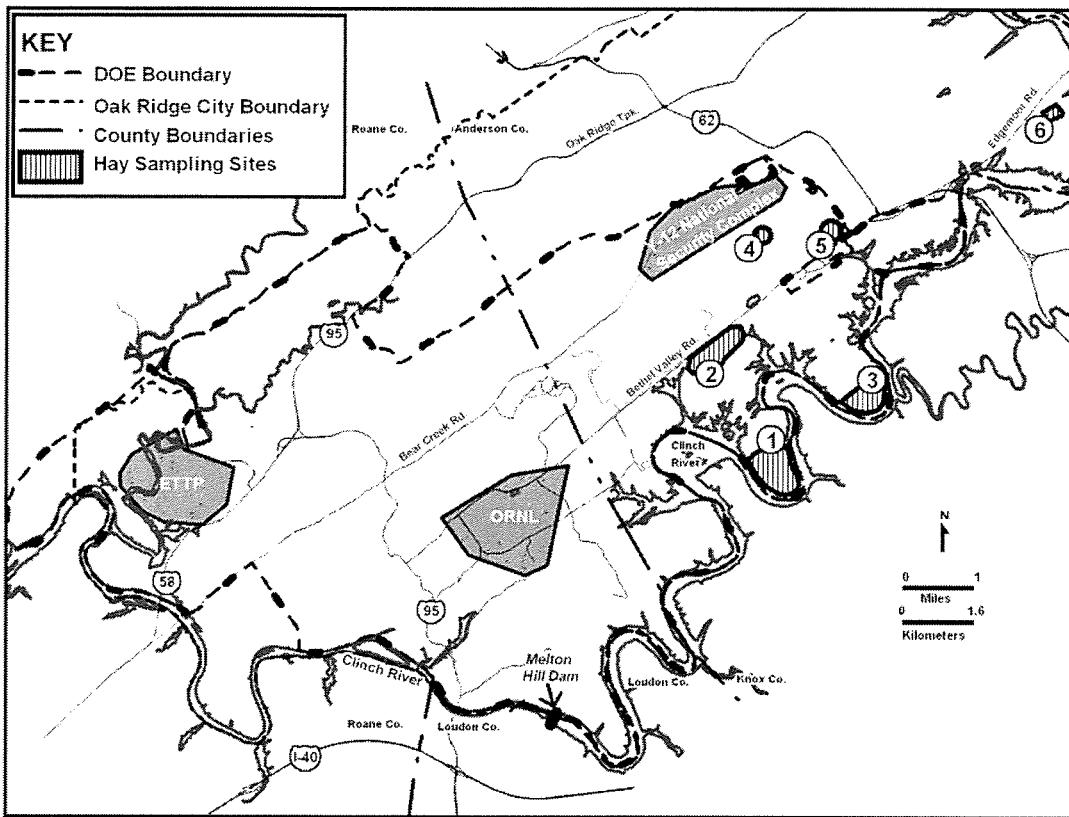


Fig. 7.5. Hay sampling locations on the ORR, indicated by numbered areas.

Table 7.6. Concentrations of radionuclides detected in hay, 2006 (pCi/kg)^a

Gross alpha	Gross beta	⁷ Be	⁴⁰ K	²³⁴ U	²³⁵ U	²³⁸ U
Area 1-2-3 composite						
0.00015	0.011	0.0062	0.015	0.000012	<i>b</i>	0.0000093
Area 2-4-5 composite						
0.00032	0.014	<i>b</i>	0.015	0.000035	0.0000029	0.000040
Area 6						
<i>b</i>	0.011	<i>b</i>	0.017	0.000010	<i>b</i>	0.0000073
Area 7—Norris reference location						
0.00011	0.012	0.010	0.015	<i>b</i>	<i>b</i>	<i>b</i>

^aDetected radionuclides are detected above the minimum detectable activity.

1 pCi = 3.7×10^{-2} Bq.

^bValue was not detected above the minimum detectable activity.

7.5.2.1 Results

Samples were analyzed for gross alpha, gross beta, gamma emitters, and uranium isotopes. No gamma-emitting radionuclides were detected above MDA, with the exception of the naturally occurring radionuclide ^{40}K . Concentrations of radionuclides detected above MDA are shown in Table 7.7.

7.5.3 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 2006 milk-sampling program consisted of grab samples collected every other month from three locations (Fig. 7.6). One is a commercial dairy in Powell that processes milk from various locations in east Tennessee; the second dairy is in Claxton, and the third is in Maryville (a reference location). Milk samples are analyzed for gamma emitters and for total radioactive strontium ($^{89}\text{Sr} + ^{90}\text{Sr}$) by chemical separation and low-background beta counting. Liquid scintillation is used to analyze for ^3H .

7.5.3.1 Results

Concentrations of radionuclides detected above MDA in milk are presented in Table 7.8. Total radioactive strontium ($^{89}\text{Sr} + ^{90}\text{Sr}$) was detected at least twice at each of the locations, including the reference location.

7.6 Fish

Members of the public could be exposed to contaminants originating from DOE-ORO activities through consumption of fish caught in area waters. This exposure pathway is monitored by collecting fish from three locations on the Clinch River annually and analyzing edible fish flesh. The locations are as follows (see Fig. 7.7):

- Clinch River upstream from all DOE ORR inputs (CRK 70),
- Clinch River downstream from ORNL (CRK 32), and
- Clinch River downstream from all DOE ORR inputs (CRK 16).

Sunfish (*Lepomis macrochirus*, *L. auritus*, and *Ambloplites rupestris*) and catfish (*Ictalurus punctatus*) are collected from each of the three locations, filleted, and frozen. In 2006, two composite samples of flesh from each species at each location were analyzed for selected metals, pesticides, PCBs, ^3H , gross alpha, gross beta, and gamma-emitting radionuclides and for total radioactive strontium.

7.6.1 Results

TDEC has adopted the EPA method for establishing fish consumption advisories for carcinogenic contaminants found in fish collected in waters designated for recreation and domestic water supply. There is a “do not consume” fish advisory (applicable to typical fishermen consumers) for catfish in Melton Hill Reservoir in its entirety because of PCB contamination, and a precautionary fish advisory for catfish in the Clinch River arm of Watts Bar Reservoir because of PCB contamination (TDEC 2002). This advisory is applicable to atypical consumers, those persons who, because of physiological factors or previous exposures, are more sensitive to specific pollutants; this may include pregnant or nursing women, children, and subsistence fishermen.

In 2006, mercury and radionuclides were detected in both sunfish and catfish at all locations. The 2006 results also show pesticides and PCBs detected in both species of fish at all locations. The pesticide delta-BHC was detected in the sunfish composite samples from CRK 70 and CRK 16; no delta-BHC was detected in sunfish at CRK 32. Pesticides were not detected in either catfish composite sample from CRK 16. Pesticides alpha-Chlordane, dieldrin, gamma-Chlordane, and heptachlor epoxide were detected in the catfish composite samples from CRK 70. Pesticides alpha-Chlordane and gamma-Chlordane were detected in the catfish composite samples from CRK 32. PCB-1260 was found in all of the sunfish and catfish composite samples from all of the locations. TDEC has issued a fish advisory for the Melton Hill Reservoir in its entirety because of PCB

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Table 7.7. Concentrations of radionuclides detected in vegetables, 2006 (pCi/kg)^a

Location	Gross alpha	Gross beta	⁷ Be	⁴⁰ K	²³⁴ U	²³⁵ U	²³⁸ U
Lettuce							
East of ORR (Claxton vicinity)	b	0.0034	b	0.0051	b	b	0.0000041
North of ETTP	0.000032	0.0021	b	0.0037	b	b	0.000012
North of ORR (Wartburg vicinity)	b	0.0025	b	0.0038	0.0000084	0.000002	0.0000057
Northeast of Y-12, Scarboro #1	0.00006	0.0025	b	0.0043	b	b	0.0000088
Northeast of Y-12, Scarboro #2	b	0.0039	b	0.0071	b	b	b
South of ORR (Eton Crossroad/ Lenoir City vicinity)	0.00013	0.0042	b	0.0061	0.0000093	b	0.000011
Southeast of ORNL	b	0.0028	0.00096	0.0032	b	0.0000019	b
Southwest of ORR (Kingston vicinity)	0.00016	0.0044	b	0.0058	0.000013	0.0000018	0.000014
Tomato							
East of ORR (Claxton vicinity)	b	0.0011	b	b	b	b	b
North of ETTP	0.000073	0.0018	b	0.0035	b	b	b
North of ORR (Wartburg vicinity)	0.00011	0.0015	b	0.0019	b	b	b
Northeast of Y-12, Scarboro #1	b	0.001	b	0.0029	0.000009	b	b
Northeast of Y-12, Scarboro #2	b	0.0015	b	0.0023	b	b	b
South of ORR (Eton Crossroad/ Lenoir City vicinity)	b	0.0018	b	0.0024	b	b	b
Southeast of ORNL	0.000055	0.0015	b	0.0018	b	b	b
Southwest of ORR (Kingston vicinity)	b	0.0015	b	0.0028	b	b	b
Turnip Roots							
East of ORR (Claxton vicinity)	b	0.0018	b	0.0042	b	b	b
North of ETTP	0.000019	0.0016	b	0.0031	b	b	b
North of ORR (Wartburg vicinity)	b	0.002	b	0.005	0.0000038	b	b
Northeast of Y-12, Scarboro #1	b	0.0012	b	0.0018	b	b	b
Northeast of Y-12, Scarboro #2	0.000025	0.0018	b	0.0037	0.0000085	b	b
South of ORR (Eton Crossroad/ Lenoir City vicinity)	0.000032	0.0021	b	0.0026	b	b	b
Southeast of ORNL	0.000023	0.0022	b	0.0037	b	b	b
Southwest of ORR (Kingston vicinity)	0.000024	0.0021	b	0.0034	b	0.0000033	b

^aDetected radionuclides are those detected at or above minimum detectable activity. 1 pCi = 3.7×10^{-2} Bq.

^bValue was not detected above minimum detectable activity.

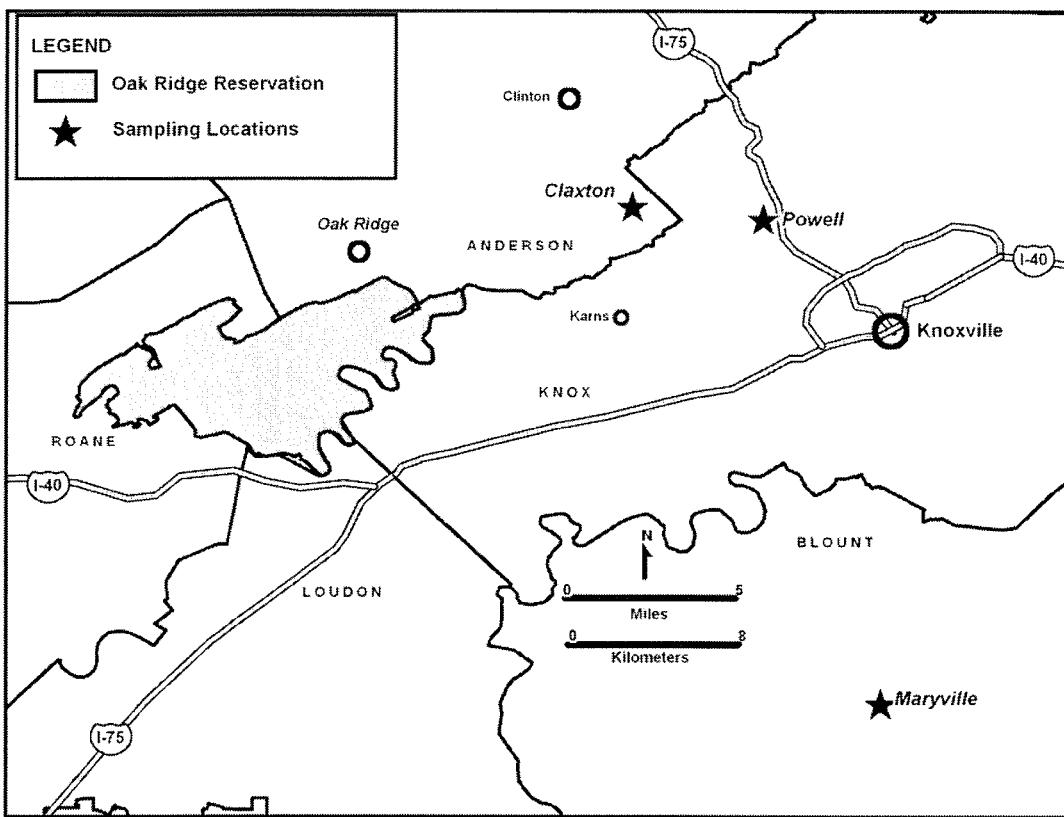


Fig. 7.6. Milk sampling locations in the vicinity of the ORR.

Table 7.8. Concentration of radionuclides detected in raw milk, 2006

Analysis	No. detected/ no. total	Detected concentration (pCi/L) ^{a,b}			Standard error of mean
		Max	Min	Avg	
Claxton					
Potassium-40	6/6	1200*	1100*	1200*	17
Total rad Sr	2/6	1.9*	0.51*	1.2*	0.21
Maryville					
Potassium-40	6/6	1400*	1100*	1300*	45
Total rad Sr	2/6	1.2*	0.12	0.76	0.16
Powell					
Potassium-40	6/6	1300*	1100*	1200*	28
Total rad Sr	3/6	2.1*	1.1*	1.6*	0.17

^aDetected radionuclides are those detected above minimum detectable activity.
1 pCi = 3.7×10^{-2} Bq.

^bIndividual and average concentrations significantly greater than zero at the 95% confidence level are identified by an asterisk (*).

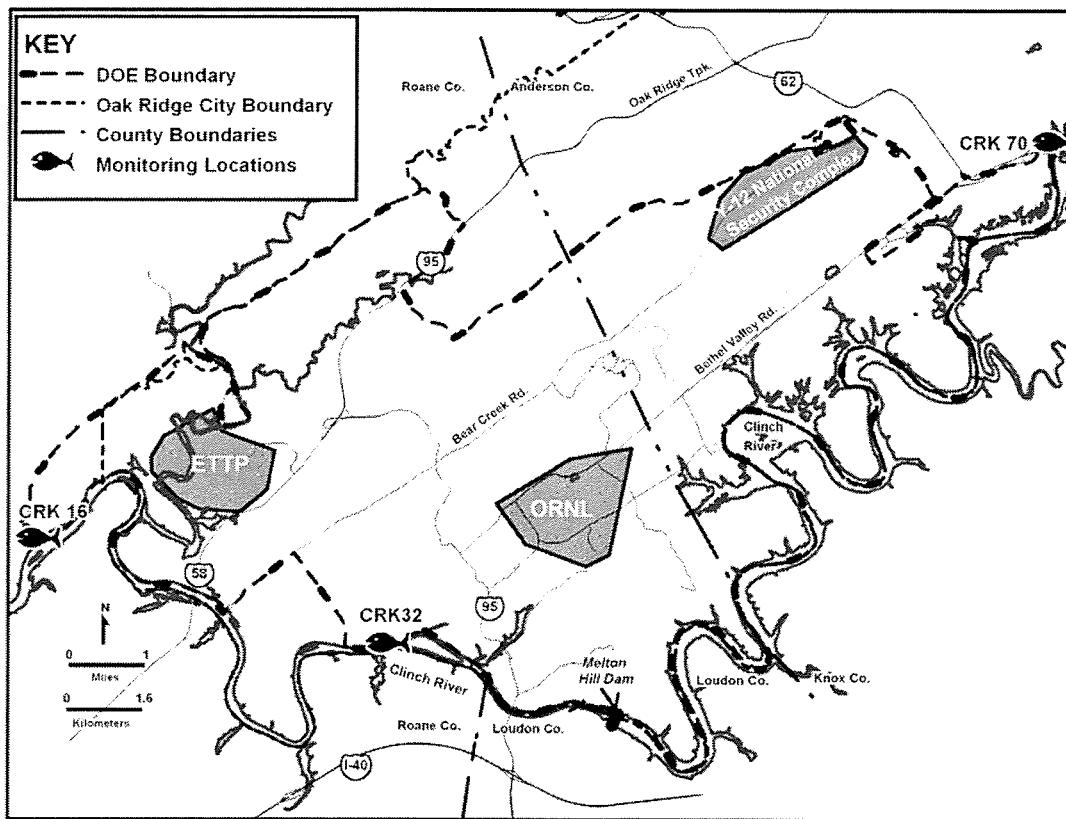


Fig. 7.7. Fish sampling locations for the ORR.

contamination, and the 2006 ORR fish data at upstream and downstream locations are consistent with the advisory.

7.7 White-Tailed Deer

The twenty-first annual deer hunts managed by DOE and the Tennessee Wildlife Resources Agency (TWRA) were held on the ORR during the final quarter of 2006. ORNL staff, TWRA personnel, and student members of the Wildlife Society (University of Tennessee chapter) performed most of the necessary operations at the checking station.

The 2006 hunts were held on three weekends. Shotgun/muzzleloader and archery hunts were held November 11–12, December 2–3, and December 16–17. In 2006, there were about 500 shotgun/muzzleloader-permitted hunters and 525 archery-permitted hunters. The Tower Shielding area, Park City Road/Chestnut Ridge area, and Poplar Creek Road area were opened for an archery-only hunt on all three weekends. There was a two-deer limit for the November

and December hunts. Two deer could be harvested. One could be an antlered buck; however, only bucks with a rack that had either a spread of at least 15 in. or at least four 1-in. antler points on one side could be harvested.

The year's total harvest was 286 deer. From the total harvest of 286 animals, 128 (44.8%) were bucks and 158 (55.2%) were does. The heaviest buck had twelve antler points and weighed 186 lb. The greatest number of antler points found on one buck was 15. The heaviest doe weighed 118 lb.

Since 1985, 9501 deer have been harvested. Of these only 185 (1.95%) have been retained as a result of potential radiological contamination. The heaviest buck was 218 lb (harvested in 1998), and the average weight is 85.7 lb. The eldest deer harvested was 12 years old; the average age is 1.9 years. For more information, see the ORNL wildlife webpage: <http://www.ornl.gov/sci/rmal/huntinfo.htm>.

7.7.1 Results

In the 2006 hunts, 286 deer were harvested. Of the deer harvested, two (0.7%) were retained for exceeding the administrative release limits (1.5 times the background for beta activity in bone (~20 pCi/g) or 5 pCi/g of ^{137}Cs in edible tissue). The two retained deer exceeded the limit for beta-particle activity in bone. The average weight of the released deer was 91.3 lb; the maximum weight was 186 lb. The average ^{137}Cs concentration in the released deer was 0.7 pCi/g, and the maximum ^{137}Cs concentration in the released deer was 2 pCi/g.

It is assumed that 55% of the field weight is edible meat; therefore, the average deer would yield 50.2 lb of meat. Based on the average weight, the total harvest of edible meat (286 released deer) is estimated to be 14,255 lb.

7.8 Fowl

7.8.1 Waterfowl Surveys—Canada Geese

The consumption of Canada geese is a potential pathway for exposure of members of the public to radionuclides released from Oak Ridge operations because open hunts for Canada geese are held in counties adjacent to the ORR each year. To determine concentrations of gamma-emitting radionuclides accumulated by waterfowl that feed and live on the ORR, Canada geese are rounded up each summer and are subjected to noninvasive gross radiological surveys.

From the roundup, 203 geese were subjected to live whole-body gamma scans. The geese were collected from ETTP (102), ORNL (42), and Clark Center Park (59). None exceeded the administrative release limits.

A Canada goose hunt was initiated on Solway and Freels Bend in the fall of 2006. The hunt was initiated as part of the overall Canada goose management program on the reservation. The hunts were conducted from one-half hour before sunrise until noon on two Saturdays in September. Hunters were also allowed to take wood duck and teal on the second Saturday, in conjunction with the statewide season for these species. Two Canada geese and six wood ducks were screened at the check station; none exceeded the limits for release. The low number of birds brought to the check station for screening

was attributed to the fact the most hunters entered and exited the site by boat, and were not inclined to travel back to the reservation from off-site boat ramps after the hunt.

7.8.1.1 Results

The average ^{137}Cs concentration in the released geese was 0.17 pCi/g. The maximum ^{137}Cs concentration in the released geese was 0.49 pCi/g. The average weight of the geese screened during the roundup was 8.4 lb (3.8 kg), and the maximum goose weight was 12.6 lb (5.7 kg). Three adult geese were sacrificed for radiological analyses. Laboratory analyses of the sacrificed geese are used to verify that the field screening approach is an appropriate method for quantifying radionuclide concentrations.

7.8.2 Turkey Monitoring

Two wild turkey hunts managed by DOE and TWRA were held on the reservation (April 1–2 and April 8–9, 2006). Hunting was open for both shotguns and archery. Thirty-nine turkeys were harvested, of which 3 (7.7%) were juveniles and 36 (92.3%) were adults. The average turkey weight was about 19.5 lb (8.85 kg). The largest tom weighed 23.5 lb (10.7 kg) and had 1.08-in. spurs and a 9.0-in. beard. The longest beard (12 in.) was measured on a tom weighing 21.8 lb (9.9 kg).

Since 1997, 458 turkeys have been harvested. Of these, only three (0.7%) have been retained because of potential radiological contamination. The heaviest turkey was 24.6 lb (11.2 kg); the average weight is 18.6 lb (8.4 kg). The longest spur on turkey harvested on the ORR was 1.5 in. (average 0.8 in.) and the longest beard was 13.5 in. (average 9.2 in.). ORNL wildlife (<http://www.ornl.gov/rmal/huntinfo.htm>). For additional information, see the webpage

7.8.2.1 Results

In 2006, none of the 39 birds harvested exceeded the administrative release limits established for radiological contamination. The average ^{137}Cs concentration in the released turkeys was 0.09 pCi/g, and the maximum ^{137}Cs concentration in the released birds was 0.15 pCi/g. It is assumed that about 50% of the field weight is edible meat; therefore, the aver-

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age turkey would yield about 9.8 lb (4.4 kg) of meat. Based on the average weight, the total

harvest of edible meat (39 released birds) is estimated to be about 380.6 lb (172.7 kg).

8. Dose

Activities on the ORR have the potential to release small quantities of radionuclides and hazardous chemicals to the environment. These releases could result in exposures of members of the public to low concentrations of radionuclides or chemicals. Monitoring of materials released from the reservation and environmental monitoring and surveillance on and around the reservation provide data used to show that doses from released radionuclides and chemicals are in compliance with the law; the calculated doses are compared with existing state and federal criteria.

A hypothetical maximally exposed individual could have received a total effective dose equivalent (EDE) of about 0.8 mrem from radionuclides emitted to the atmosphere from all of the sources on the ORR in 2006; this is well below the National Emission Standards for Hazardous Air Pollutants standard of 10 mrem for protection of the public.

A worst-case analysis of exposures to waterborne radionuclides for all pathways combined gives a maximum possible individual EDE of about 0.7 mrem. This dose is based on a person eating 21 kg/year of the most contaminated accessible fish, drinking 730 L/year of the most contaminated drinking water, and using the shoreline near the most contaminated stretch of water for 60 h/year.

Calculations to determine possible doses from consumption of deer, geese, and turkey harvested on or near the ORR resulted in the following: an individual who consumed an average-weight deer containing the average ^{137}Cs concentration could have received an EDE of about 0.8 mrem, an individual who consumed an average-weight goose containing the average ^{137}Cs concentration could have received 0.02 mrem, and an individual who consumed an average-weight turkey containing the average ^{137}Cs concentration could have received 0.02 mrem. In worst-case analyses, if a hypothetical person consumed one deer (maximum actual deer) and two geese and two turkeys (each containing the maximum concentration of measured radionuclides and maximum weights), that person could have received an EDE of approximately 3 mrem. This calculation is conducted to provide an estimated upper-bound EDE from consuming wildlife harvested from the ORR.

8.1 Radiation Dose

Small quantities of radionuclides were released to the environment from operations at the ORR facilities during 2006. Those releases are described, characterized, and quantified in previous chapters of this report. This chapter presents estimates of potential radiation doses to the public from the releases. The dose estimates are performed using monitored and estimated release data, environmental monitoring and surveillance data, estimated exposure conditions that tend to maximize the calculated dose equivalents, and environmental transport and dosimetry codes that also tend to overestimate the calculated dose equivalents. Thus, the presented dose estimates do not necessarily reflect doses received by typical people in the vicinity of the ORR; these estimates likely are overestimates.

8.1.1 Terminology

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, whereas internal exposures continue as long as the radionuclides remain inside the person. Also, external exposures may result in uniform irradiation of the entire body, including all organs, while internal exposures usually result in nonuniform irradiation of the body and organs. 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 G. An important term to understand is “effective dose equivalent” (EDE). EDE is a risk-based dose equivalent that can be used to estimate health effects or risks to exposed persons. It is a weighted sum of dose equivalents to specified organs and is expressed in rems or sieverts (1 rem = 0.01 Sv).

One rem of effective dose equivalence, regardless of radiation type or method of delivery, has the same total radiological (in this case, also biological) risk effect. Because the doses being considered here are very small, EDEs are usually expressed in millirem (mrem), which is one one-thousandth of a rem. (See Appendix G, Table G.2, for a comparison and description of various dose levels.)

8.1.2 Methods of Evaluation

8.1.2.1 Airborne Radionuclides

The radiological consequences of radionuclides released to the atmosphere from ORR operations during 2006 were characterized by calculating, for each major facility and for the entire ORR, EDEs to maximally exposed off-site individuals, to on-site members of the public where no physical access controls are managed by DOE, and to the entire population residing within 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 40 CFR 61, Subpart H, which governs the emissions of radionuclides other than radon from DOE facilities. This package implements a steady-state Gaussian plume atmospheric dispersion model to calculate concentrations of radionuclides in the air and on the ground and 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.

A total of 41 emission points on the ORR, each of which includes one or more individual sources, was modeled during 2006. The total includes 8 points at the Y-12 Complex, 25 points at ORNL, and 8 points at ETTP. Table 8.1 is a list of the emission-point parameter values and receptor locations used in the dose calculations.

Meteorological data used in the calculations for 2006 were in the form of joint frequency distributions of wind direction, wind speed class, and atmospheric stability category. (See Table 8.2 for a summary of tower locations used to model the various sources.) During 2006, rainfall, as averaged over the four rain gauges

located on the ORR, was 1,267.9 mm. The average air temperature was 14.8°C, and the average mixing-layer height was 564.5 m. The mixing height is the depth of the atmosphere adjacent to the surface within which air is mixed.

For occupants of residences, the dose calculations assume that the occupant remained at home (actually, unprotected outside the house) during the entire year and obtained food according to the rural pattern defined in the National Emission Standards for Hazardous Air Pollutants (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 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 of the ORR. The same assumptions are used for occupants of businesses, but the resulting doses are divided by 2 to compensate for the fact that businesses are occupied for less than one-half a year and that less than one-half of a worker's food intake occurs at work. For collective EDE estimates, production of beef, milk, and crops within 80 km of the ORR was calculated using production rates provided with CAP-88.

Results

Calculated EDEs from radionuclides emitted to the atmosphere from the ORR are listed in Table 8.3 (maximum individual) and Table 8.4 (collective). The hypothetical maximally exposed individual for the ORR was located about 2,170 m east-northeast of the main Y-12 National Security Complex release point, about 10,429 m northeast of the 7911 stack at ORNL, and about 14,488 m east-northeast of the Toxic Substances Control Act (TSCA) Incinerator (stack K-1435) at the ETTP. This individual could have received an EDE of about 0.8 mrem, which is well below the NESHAP standard of 10 mrem and is 0.3% of the 300 mrem that the average individual receives from natural sources of radiation. The calculated collective EDE to the entire population within 80 km of the ORR (about 1,040,041 persons) was about 18.4 person-rem, which is approximately 0.006% of the 312,012 person-rem that this population received from natural sources of radiation (based on an individual dose of 300 mrem/year).

Table 8.1. Emission point parameters and receptor locations used in the dose calculations

Source ID	Stack height (m)	Stack diameter (m)	Effective exit gas velocity (m/s)	Exit gas temperature (°C)	Distance (m) and direction to the maximally exposed individual		
					Plant maximum	ORR maximum	
X-Lab Hoods							
X-1000 Lab Hoods	15		0	Ambient	5613	ENE	11010 NE
X-3000 Lab Hoods	15		0	Ambient	5064	E	10358 NE
X-4000 Lab Hoods	15		0	Ambient	4633	E	10006 NE
X-6000 Lab Hoods	15		0	Ambient	4164	E	9402 NE
X-7000 Lab Hoods	15		0	Ambient	3212	NE	10133 NNE
X- 8920 Lab Hoods	15		0	Ambient	4273	ESE	7424 NE
X-2026	22.9	1.05	10.21	Ambient	5296	E	10526 NE
X-2099	3.66	0.178	22.1	Ambient	5296	E	10526 NE
X-2523	7	0.3	8.16	Ambient	5339	E	10721 NE
X-3018	61	4.11	0.23	Ambient	5125	E	10309 NE
X-3020	61	1.22	15.21	Ambient	5125	E	10309 NE
X-3039	76.2	2.44	13.5	Ambient	5060	E	10337 NE
X-3074 Group	4	0.25	0	Ambient	5125	E	10309 NE
X-3544	9.53	0.279	21.69	Ambient	5081	ENE	10563 NE
X-3608 Air Stripper	10.97	2.44	0.57	Ambient	4966	ENE	10485 NE
X-3608 Filter Press	8.99	0.36	9.27	Ambient	4966	ENE	10485 NE
X-5505							
X-5505M	11	0.305	3.05	Ambient	4361	E	9813 NE
X-5505NS	11	0.96	0	Ambient	4361	E	9813 NE
X-7025	4	0.3	13.36	Ambient	3143	E	8398 NE
X-7503	30.5	0.91	12.1	Ambient	4289	ENE	10201 NE
X-7830 Group	4.6	0.248	8.15	Ambient	5342	ENE	11632 NE
X-7856-CIP	18.29	0.483	12.91	Ambient	5342	ENE	11632 NE
X-7877	13.9	0.406	13.56	Ambient	5342	ENE	11632 NE
X-7880	27.43	1.52	13.99	Ambient	5342	ENE	11632 NE
X-7911	76.2	1.52	13.34	Ambient	4259	ENE	10429 NE
X-7966	6.096	0.292	10.11	Ambient	4259	ENE	10429 NE
X-8915	24.38	4.0	0.53	Ambient	4273	ESE	7424 ENE
X-Decon Areas	15	0	0	Ambient	5060	E	10337 NE
X-Soil & Sediment	0.38	0.2	0	Ambient	4289	ENE	10201 NE
X-STP	7.6	0.203	12.73	Ambient	5219	ENE	10729 NE
X-SWSA-5 TRU	.305	.87	0	Ambient	5151	ENE	11081 NE
K-1004-L Lab D&D	1.83	0.3	0	Ambient	2919	NE	15356 ENE
K-1066	3	2.54	0	Ambient	4073	ENE	16821 ENE
K-1407-U CNF	7.16	1.22	0.625	Ambient	2814	NE	14869 ENE
K-1420 Repack	0.456	0.31	0	Ambient	2051	NE	14703 ENE
K-1423 SWR	7.62	0.71	12.8	Ambient	2637	ENE	15359 ENE
K-1435 Incinerator	30.5	1.37	5.64	79.76	1940	NE	14488 ENE
K-1435-C Tanks	18.29	0.2	0	Ambient	1997	NE	14516 ENE
K-25 Seg Shop 18A	18.3	1.37	2.56	Ambient	2956	ENE	15691 ENE

Oak Ridge Reservation

Table 8.1 (continued)

Source ID	Stack height (m)	Stack diameter (m)	Effective exit gas velocity (m/s)	Exit gas temperature (°C)	Distance (m) and direction to the maximally exposed individual			
					Plant maximum	ORR maximum		
Y-9422-22 Air Stripper	3.96	0.153	0	Ambient	478	NW	478	NW
Y-9616-7 Degas	12.2	0.2	4.36	Ambient	4037	ENE	4037	ENE
Y-9616-7 Lab Hood	12.2	0.25	0.69	Ambient	4037	ENE	4037	ENE
Y-9623 Lab Hood	8.5	0.254	0.64	Ambient	2350	ENE	2350	ENE
Y-Monitored	20	0	0	Ambient	2168	ENE	2168	ENE
Y-Union Valley Lab	4.27	0.762	13.08	Ambient	904	SW	904	SW
Y-Unmonitored Processes	20	0	0	Ambient	2168	ENE	2168	ENE
Y-Unmonitored Lab Hoods	20	0	0	Ambient	2168	ENE	2168	ENE

Table 8.2. Summary of ORR meteorological towers, sampling heights, and sources

Tower	Height (m)	Source
Y-12 Complex		
MT6	60 ^a	All Y-12 sources and SNS and 8920 Hoods (ORNL)
ETTP		
MT1	10	K-1435 Tanks
MT1	60	K-1435 Incinerator
MT7	10	K-1004L, K-1066, K-1407-U, K-1420, K-1423-SWR, K-1435C
MT7	30	K-25 Segmentation Shop 18A
ORNL		
MT4	10	X-7830, X-7966, X-SWSA-5 TRU, and X-Soils and Sediment
MT4	30	X-7503, X-7856-CIP, X-7877, X-7880, X-7911, and X-7000 Lab Hoods
MT3	10	X-7025
MT3	30	X-6000 Lab Hoods
MT2	10	X-2099, X-2523, X-3074, X-3544, X-3597, X-3608FP, and X-STP
MT2	30	X-2026, X-3608AS, X-5505(NS & M), X-Decon Areas, and X-1000, 3000, & 4000 Lab Hoods
MT2	100	X-3018, X-3020, and X-3039

^aWind speeds adjusted to match conditions at a height of 20 m.

The maximally exposed individual for the Y-12 National Security Complex was located at 2,170 m east-northeast of the main Y-12 National Security Complex release point. This individual could have received an EDE of about 0.8 mrem from Y-12 National Security Complex emissions. Inhalation and ingestion of uranium

radioisotopes (i.e., ^{232}U , ^{233}U , ^{234}U , ^{235}U , ^{236}U , and ^{238}U) accounted for essentially all (more than 99%) of the dose. The contribution of Y-12 Complex emissions to the 50-year committed collective EDE to the population residing within 80 km of the ORR was calculated to be about

Table 8.3. Calculated radiation doses to maximally exposed off-site individuals from airborne releases during 2006

Plant	Total effective dose equivalents [mrem (mSv)]	
	At plant max	At ORR max
ORNL	0.06 (0.0006) ^a	0.008 (0.00008)
ETTP	0.09 (0.0009) ^b	0.01 (0.0001)
Y-12	0.8 (0.008) ^c	0.8 (0.008)
Entire ORR	^d	0.8 (0.008) ^c

^aThe maximally exposed individual was located 5,060 m E of X-3039 and 4,259 m ENE of X-7911.

^bThe maximally exposed individual was located 1,940 m NE of K-1435.

^cThe maximally exposed individual is located 2,168 m ENE of the Y-12 National Security Complex release point.

^dNot applicable.

^cThe maximally exposed individual for the entire ORR is the Y-12 maximally exposed individual.

Table 8.4. Calculated collective effective dose equivalents from airborne releases during 2006

Plant	Effective dose equivalents ^a	
	(Person-rem)	(Person-Sv)
ORNL	1.3	0.013
ETTP	4.9	0.049
Y-12	12.3	0.123
Entire ORR	18.4	0.184

^aCollective effective dose equivalents to the 1,040,041 persons residing within 80 km of the ORR.

12.3 person-rem, which is approximately 67% of the collective EDE for the ORR.

The maximally exposed individual for ORNL was located at a residence about 5,060 m east of the 3039 stack and 4,260 m east-northeast of the 7911 stack. This individual could have received an EDE of about 0.06 mrem from ORNL emissions. Radionuclides contributing 1% or more to the dose include ¹³⁸Cs (57.6%), ²¹²Pb (9.0%), ⁴¹Ar (5.4%), uranium radioisotopes (5.3%), ²⁴⁴Cm (7.7%), ¹³¹I (2.4%), ⁸⁸Kr (2.1%), ¹³⁸Xe (1.8%), ³H (1.5%), ⁹⁰Sr (1.4%), and ¹³⁷Cs (1.2%). The contribution of ORNL emissions to the collective EDE to the population residing within 80 km of the ORR was calculated to be about 1.3 person-rem, ap-

proximately 6.8% of the collective EDE for the ORR.

The maximally exposed individual for the ETTP was located at a business about 1,940 m northeast of the TSCA Incinerator stack (K-1435). The EDE received by this individual was calculated to be about 0.09 mrem. About 84% of the dose is from ingestion and inhalation of uranium radioisotopes, about 10% is from ³H, and about 5% is from thorium radioisotopes. The contribution of ETTP emissions to the collective EDE to the population residing within 80 km of the ORR was calculated to be about 4.9 person-rem, approximately 26.7% of the collective EDE for the reservation.

The reasonableness of the estimated radiation doses can be inferred by comparing EDEs estimated from measured radionuclide air concentrations with EDEs estimated from calculated (using CAP-88 and emission data) radionuclide air concentrations at the ORR perimeter air monitoring stations (PAMs) (Table 7.2). Based on measured radionuclide air concentrations that could have been released from operations on the ORR (i.e., excluding naturally occurring ⁷Be and ⁴⁰K), hypothetical individuals assumed to reside at the PAMs could have received EDEs between 0.01 and 0.06 mrem/year. Based on calculated radionuclide air concentrations released from operations on the ORR, hypothetical individuals assumed to reside at the PAMs could have received EDEs between 0.08 and 0.9 mrem/year. EDEs calculated using CAP-88 tended to be higher than EDEs calculated using measured air concentrations (Table 8.5).

An indication of doses from sources other than those on the ORR can be obtained from the EDE calculated at the background air monitoring station (Station 52), which was 0.01 mrem/year. (The isotopes ⁷Be and ⁴⁰K also were not included at the background air monitoring station calculation). It should be noted that measured air concentrations of ⁷Be and ⁴⁰K were similar at the PAM stations and at the background air monitoring station.

Of particular interest is a comparison of doses calculated using measured air concentrations of radionuclides at PAMs located near the maximally exposed individuals for each plant and doses calculated for those individuals using CAP-88 and measured emissions. PAM 40 is

Table 8.5. Hypothetical effective dose equivalents from living at ORR and ETTP ambient-air monitoring stations during 2006

Station	Calculated effective dose equivalent			
	Using air monitor data		Using CAP-88 and emission data	
	mrem/year	mSv/year	mrem/year	mSv/year
35	0.06	0.0006	0.2	0.002
37	0.01	0.0001	0.2	0.002
38	0.01	0.0001	0.08	0.0008
39	0.01	0.0001	0.2	0.002
40	0.03	0.0002	0.9	0.009
42	0.02	0.0002	0.07	0.0007
46	0.02	0.0002	0.2	0.002
48	0.02	0.0002	0.4	0.004
52	0.01	0.0001	<i>a</i>	<i>a</i>
K2	0.1	0.001	<i>a</i>	<i>a</i>
K6	0.02	0.0002	<i>a</i>	<i>a</i>
K9	0.1	0.001	<i>a</i>	<i>a</i>
K11	0.08	0.0008	<i>a</i>	<i>a</i>

^aEffective dose equivalents were not calculated using CAP-88 and emission data to the given ambient air monitor location.

located near the maximally exposed individual for the Y-12 Complex. The EDE calculated using measured air concentrations, assuming a business location, was 0.01 mrem/year, much less than the EDE of 0.9 mrem/year calculated at the PAM 40 air monitor station using CAP-88. PAM 39 is located near the second highest dose location for ORNL (in same wind direction but closer); the EDE calculated using measured air concentrations was 0.01 mrem/year, less than the 0.2 mrem/year calculated using CAP-88. The K-2 Air Monitoring Station is located closer to ETTP than the maximally exposed individual (at a business) for ETTP; the EDE calculated using measured air concentrations was 0.06 mrem/year, less than the ETTP maximally exposed individual annual dose of 0.1 mrem, estimated using CAP-88.

Several air monitors also were located on the ETTP site (see Fig. 4.9). EDEs calculated from air concentrations of radionuclides at these monitors were between 0.02 and 0.1 mrem/year.

8.1.2.2 Waterborne Radionuclides

Radionuclides discharged to surface waters from the ORR enter the Tennessee River system by way of the Clinch River (see Sect. 1.5 for the surface water setting of the ORR). Discharges from the Y-12 Complex enter the Clinch River via Bear Creek and East Fork Poplar Creek, both

of which enter Poplar Creek before it enters the Clinch River, and by discharges from Rogers Quarry into McCoy Branch and then into Melton Hill Lake. Discharges from ORNL enter the Clinch River via White Oak Creek and enter Melton Hill Lake via some small drainage creeks. Discharges from the ETTP enter the Clinch River either directly or via Poplar Creek. This section discusses the potential radiological impacts of these discharges to persons who drink water; eat fish; and swim, boat, and use the shoreline at various locations along the Clinch and Tennessee rivers.

For assessment purposes, surface waters potentially affected by the ORR are divided into seven segments: (1) Melton Hill Lake above all possible ORR inputs, (2) Melton Hill Lake, (3) Upper Clinch River (from Melton Hill Dam to confluence with Poplar Creek), (4) Lower Clinch River (from confluence with Poplar Creek to confluence with the Tennessee River), (5) Upper Watts Bar Lake (from near confluence of the Clinch and Tennessee Rivers to below Kingston), (6) Lower System (the remainder of Watts Bar Lake and Chickamauga Lake to Chattanooga), and (7) Poplar Creek (including the confluence of East Fork Poplar Creek).

Two methods are used to estimate potential radiation doses to the public. The first method

Table 8.6. Summary of annual maximum individual (mrem) and collective (person-rem) effective dose equivalents (EDEs) from waterborne radionuclides^{a,b}

	Drinking water	Eating fish	Other uses	Total ^c
Upstream of All ORR Discharge Locations (CRK 70 and CRK 66, City of Oak Ridge Water Plant)				
Individual EDE	0.003	0.03	0.000004	0.03
Collective EDE	0.04	0.002	0.000001	0.04
Melton Hill Lake (CRK 58, Knox Count Water Plant)				
Individual EDE	0.003	0.00007	0.00005	0.03
Collective EDE	0.04	0.002	0.00001	0.04
Upper Clinch River (CRK 23, Gallaher Water Plant, CRK 32)				
Individual EDE	0.01	0.7	0.00005	0.7
Collective EDE	0.009	0.1	0.00001	0.1
Lower Clinch River (CRK 16)				
Individual EDE	NA ^d	0.08	0.004	0.08
Collective EDE	NA ^d	0.03	0.01	0.04
Upper Watts Bar Lake, Kingston Municipal Water Plant				
Individual EDE	0.02	0.01	0.0006	0.03
Collective EDE	0.2	0.02	0.004	0.3
Lower System (Lower Watts Bar Lake and Chickamauga Lake)				
Individual EDE	0.02	0.01	0.0005	0.03
Collective EDE	2	0.1	0.04	2
Poplar Creek				
Individual EDE	NA ^d	0.3	0.006	0.3
Collective EDE	NA ^d	0.009	2E-7	0.009

^a1 mrem = 0.01 mSv.

^bDoses based on measured radionuclide concentrations in water or estimated from measured discharges and known or estimated stream flows.

^cRounded difference between individual pathway doses and total.

^dNot at drinking water supply locations.

uses radionuclide concentrations in the medium of interest (i.e., in water and fish) determined by laboratory analyses of water and fish samples (see Sects. 7.4 and 7.6). The second method calculates possible radionuclide concentrations in water and fish from measured radionuclide discharges and known or estimated stream flows. The advantage of the first method is the use of radionuclide concentrations measured in water and fish; disadvantages are the inclusion of naturally occurring radionuclides (e.g., ^{40}K , uranium and its progeny, thorium and its progeny, and unidentified alpha and beta activities), the possible inclusion of radionuclides discharged from sources not part of the ORR, the possibility that some radionuclides of ORR origin might be present in quantities too low to be measured, and the possibility that the presence of some ra-

dionuclides might be misstated (e.g., present in a quantity below the detectable limit). Estimated doses from measured radionuclide concentrations are presented without and with contributions of naturally occurring radionuclides. The advantages of the second method are that most radionuclides discharged from the ORR will be quantified and that naturally occurring radionuclides will not be considered or will be accounted for separately; the disadvantage is the use of models to estimate the concentrations of the radionuclides in water and fish. Both methods use the same models (Hamby 1991) to estimate radionuclide concentrations in media and at locations other than those that are sampled (e.g., downstream). However, combining the two methods should allow the potential radiation doses to be bounded.

In the following drinking water and fish subsections, the estimated maximum EDE is based on either the first method, which uses radionuclide concentrations measured in the medium of interest (i.e., in water and fish), or by the second method, which calculates possible radionuclide concentrations in water and fish from measured radionuclide discharges and known or estimated stream flows. The EDEs estimated by both methods, in each of the surface water segments, are provided in Appendix G.

Drinking Water

Several water treatment plants that draw water from the Clinch and Tennessee River systems could be affected by discharges from the ORR. No in-plant radionuclide concentration data are available for any of these plants; all of the dose estimates given below likely are high because they are based on radionuclide concentrations in water before it enters a processing plant. For purposes of assessment, it was assumed that the drinking water consumption rate for the maximally exposed individual is 730 L/year and the drinking water consumption rate for the average person is 370 L/year. The average drinking water consumption rate is used to estimate the collective EDE. As explained in Appendix G, EDEs were calculated from measured concentrations of radionuclides in water and from radionuclide concentrations in water that were calculated using measured radionuclide discharges and streamflow data. At all locations in 2006, estimated maximum EDEs to a person drinking water were calculated using measured radionuclide concentrations in off-site surface water and exclude naturally occurring radionuclides, such as ^{40}K .

Melton Hill Lake above all possible ORR inputs. For reference purposes, the EDE to a hypothetical highly exposed person drinking water at CRK 66, which is located upstream of all ORR inputs, was estimated to be about 0.003 mrem. The collective EDE to the 29,981 persons who drink water from the city of Oak Ridge water plant could have been 0.04 person-rem. If naturally occurring radionuclides are included, the EDEs could have been 2 mrem and 31 person-rem.

Melton Hill Lake. The only water treatment plant located on Melton Hill Lake that could be

affected by discharges from the ORR is a Knox County plant. This plant is located near surface water sampling location CRK 58. A highly exposed individual could have received an EDE of about 0.003 mrem; the collective dose to the 48,316 persons who drink water from this plant could have been 0.06 person-rem. If naturally occurring radionuclides are included, the EDEs could have been 2 mrem and 50 person-rem.

Upper Clinch River. The ETTP (Gallaher) water plant draws water from the Clinch River near CRK 23. For assessment purposes, it is assumed that workers obtain half their annual water (370 L) intake at work. Such a worker could have received an EDE of about 0.01 mrem; the collective dose to the 1750 workers who drink water from this plant could have been about 0.009 person-rem. If naturally occurring radionuclides are included, the EDEs could have been about 4 mrem and 4 person-rem.

Lower Clinch River. There are no drinking water intake locations in this river segment (from the confluence with Poplar Creek to the confluence with the Tennessee River).

Upper Watts Bar Lake. The Kingston and Rockwood municipal water plants draw water from the Tennessee River not very far from its confluence with the Clinch River. A highly exposed individual could have received an EDE of about 0.02 mrem; the collective dose to the 23,551 persons who drink water from these plants could have been about 0.2 person-rem. If naturally occurring radionuclides are included, the EDEs could have been 0.7 mrem and 9 person-rem.

Lower System. Several water treatment plants are located on tributaries of Watts Bar Lake and Chickamauga Lake. Based on discharge and Clinch River water data, persons drinking water from these plants could not have received EDEs greater than about 0.02 mrem calculated for drinking Kingston and Rockwood water. The collective dose to the 263,174 persons who drink water within the lower system could be about 3 person-rem. If naturally occurring radionuclides are included, the EDEs could have been 0.7 mrem and 73 person-rem.

Poplar Creek. There are no drinking water intake locations on Poplar Creek.

Eating Fish

Fishing is quite common on the Clinch and Tennessee River systems. For assessment purposes, it was assumed that avid fish consumers would have eaten 21 kg of fish during 2006 and that the average person, who is used for collective dose calculations, would have consumed 6.9 kg of fish. As mentioned above, the estimated maximum EDE will be based on either the first method, measured radionuclide concentrations in fish, or by the second method, which calculates possible radionuclide concentrations in fish from measured radionuclide discharges and known or estimated stream flows and excludes naturally occurring radionuclides (e.g., ^{238}U , ^{232}Th , ^{40}K). The EDEs estimated by both methods, in each of the surface water segment, are provided in Appendix G.

Melton Hill Lake above all possible ORR inputs. For reference purposes, a hypothetical avid fish consumer who ate fish caught at CRK 70, which is above all possible ORR inputs, could have received an EDE of about 0.03 mrem. If naturally occurring radionuclides are included, the EDE could have been 17 mrem.

Melton Hill Lake. An avid fish consumer who ate fish from Melton Hill Lake could have received an EDE of about 0.00007 mrem. The collective EDE to the 266 persons who could have eaten such fish could be about 0.000006 person-rem. If naturally occurring radionuclides are included, the EDEs could have been 9 mrem and 0.8 person-rem. (The EDEs including naturally occurring radionuclides ignore an elevated ^{40}K measurement in water at CRK 58. If this measurement is included, the EDEs could have been 47 mrem and 4 person-rem. This exclusion affects calculated maximum doses in all the downstream water bodies.)

Upper Clinch River. An avid fish consumer who ate fish from the Upper Clinch River could have received an EDE of about 0.7 mrem. The collective EDE to the 516 persons who could have eaten such fish could have been about 0.1 person-rem. If naturally occurring radionuclides are included, the EDEs could have been 18 mrem and 3 person-rem.

Lower Clinch River. An avid fish consumer who ate fish from the Lower Clinch River (CRK 16) could have received an EDE of about 0.08 mrem. The collective EDE to the 1,204 persons who could have eaten such fish could have

been about 0.03 person-rem. If naturally occurring radionuclides are included, the EDEs could have been 18 mrem and 7 person-rem.

Upper Watts Bar Lake. An avid fish consumer who ate fish from Upper Watts Bar Lake could have received an EDE about 0.01 mrem. The collective EDE to the 3,439 persons who could have eaten such fish could be about 0.02 person-rem. If naturally occurring radionuclides are included, the EDEs could have been 3 mrem and 4 person-rem.

Lower System. An avid fish consumer who ate fish from Lower System could have received an EDE of about 0.01 mrem. The collective EDE to the 34,276 persons who could have eaten such fish could have been about 0.1 person-rem. If naturally occurring radionuclides are included, the EDEs could have been 3 mrem and 30 person-rem.

Poplar Creek. An avid fish consumer who ate fish from Poplar Creek could have received an EDE of about 0.3 mrem. Assuming 100 people could have eaten fish from Poplar Creek, the collective EDE is estimated to be about 0.009 person-rem. If naturally occurring radionuclides are included, the EDEs could have been 7 mrem and 0.2 person-rem.

Other Uses

Other uses of the ORR area waterways include swimming or wading, boating, and use of the shoreline. A highly exposed "other user" was assumed to swim or wade for 30 h/year, boat for 63 h/year, and use the shoreline for 60 h/year. The average individual, who is used for collective dose estimates, was assumed to swim or wade for 10 h/year, boat 21 h/year, and use the shoreline for 20 h/year. Measured and calculated concentrations of radionuclides in water and the LADTAP XL code (Hamby 1991) were used to estimate potential EDEs from these activities. At all locations in 2006, the estimated highly exposed individual EDEs were based on measured off-site surface water radionuclide concentrations and exclude naturally occurring radionuclides, such as ^{40}K . When compared with EDEs from eating fish from the same waters, the EDEs from these other uses are relatively insignificant.

Melton Hill Lake above all possible ORR inputs. For reference purposes, an individual other user of Melton Hill Lake above ORR inputs could have received an EDE of about

0.000004 mrem. If naturally occurring radionuclides are included, the EDE could have been 0.1 mrem.

Melton Hill Lake. An individual other user of Melton Hill Lake could have received an EDE of about 0.00007 mrem. The collective EDE to the 34,706 other users could have been about 0.0004 person-rem. If naturally occurring radionuclides are included, the EDEs could have been 0.5 mrem and 3 person-rem.

Upper Clinch River. An other user of the Upper Clinch River could have received an EDE of about 0.00005 mrem. The collective EDE to the 516 other users could have been about 0.00001 person-rem. If naturally occurring radionuclides are included, the EDEs could have been 0.5 mrem and 0.09 person-rem.

Lower Clinch River. An other user of the Lower Clinch River could have received an EDE of about 0.004 mrem. The collective EDE to the 7,880 other users could have been about 0.01 person-rem. If naturally occurring radionuclides are included, the EDEs could have been 0.5 mrem and 1 person-rem.

Upper Watts Bar Lake. An other user of Upper Watts Bar Lake could have received an EDE of about 0.0006 mrem. The collective EDE to the 22,514 other users could have been about 0.004 person-rem. If naturally occurring radionuclides are included, the EDEs could have been 0.2 mrem and 1 person-rem.

Lower System. An other user of the Lower System could have received an EDE of about 0.0005 mrem. The collective EDE to the 224,392 other users could have been about 0.04 person-rem. If naturally occurring radionuclides are included, the EDEs could have been 0.1 mrem and 9 person-rem.

Poplar Creek. An other user of Poplar Creek could have received an EDE of about 0.006 mrem. The collective EDE to the 100 other users could have been about 2E-7 person-rem. If naturally occurring radionuclides are included, the EDEs could have been 0.06 mrem and 0.000001 person-rem.

Summary

Table 8.6 is a summary of potential EDEs from identified waterborne radionuclides around the ORR. Adding worst-case EDEs for all pathways in a water-body segment gives a maximum individual EDE of about 0.7 mrem to a person

obtaining his or her full annual complement of fish, drinking water, and participation in other water uses from the Upper Clinch River. The maximum collective EDE to the 50-mile population could be as high as 2.5 person-rem. These are small percentages of individual and collective doses attributable to natural background radiation, about 0.2% and 0.0008%, respectively.

8.1.2.3 Radionuclides in Other Environmental Media

The CAP-88 computer codes are used to calculate radiation doses from ingestion of meat, milk, and vegetables that contain radionuclides released to the atmosphere. These doses are included in the dose calculations for airborne radionuclides. However, some environmental media, including the three mentioned, are sampled as part of the surveillance program. The following dose estimates are based on environmental sampling results and may include contributions from radionuclides occurring in the natural environment, released from the ORR, or both.

Milk

Milk collected at two locations at a distance from the ORR and at a remote location was found to contain low concentrations of ⁹⁰Sr (Sect. 7.5.3). At one location, tritium was detected in one sample. The sample data were used to calculate potential EDEs to hypothetical persons who drank 310 L (NRC 1977) of sampled milk during the year.

These hypothetical persons could have received an EDE of between 0.05 and 0.08 mrem from drinking milk from the near locations and about 0.04 mrem from the remote location, excluding the contribution from ⁴⁰K, a naturally occurring radionuclide.

Food Crops

The food-crop sampling program is described in Sect. 7.5. Samples of tomatoes, lettuce, and turnips were obtained from six local gardens. These vegetables represent fruit-bearing, leafy, and root vegetables. All radionuclides found in the food crops are found in the natural environment and in commercial fertilizers, and all but ⁷Be and ⁴⁰K also are emitted

from the ORR. Dose estimates are based on hypothetical consumption rates of vegetables that contain statistically significant amounts of detected radionuclides that could have come from the ORR. Based on a nationwide food consumption survey (EPA 1997), a hypothetical home gardener was assumed to have eaten 32 kg of homegrown tomatoes, 10 kg of homegrown lettuce, and 37 kg of homegrown turnips. The hypothetical gardener could have received a 50-year committed EDE of between 0.06 and 0.2 mrem, depending on garden location. Of this total, between 0.03 and 0.09 mrem could have come from eating tomatoes, between 0.01 and 0.08 mrem from eating lettuce, and between 0.03 and 0.1 mrem from eating turnips. The highest dose to a gardener could have been about 0.2 mrem from consuming all three types of homegrown vegetables.

An example of a naturally occurring and fertilizer-introduced radionuclide is ^{40}K , which is specifically identified in the samples and accounts for most of the beta activity found in them. The presence of ^{40}K in the samples adds, on average, between 4 and 6 mrem to the hypothetical home gardener's EDE.

Many of the samples contained detected activities of unidentified beta- and alpha-emitting radionuclides. By subtracting identified activities of beta- and alpha-emitting radionuclides from the unidentified beta and alpha activities, excess beta and alpha activities were estimated. If the excess unidentified beta and alpha activities were from ^{90}Sr and ^{210}Po , a hypothetical home gardener could have received an additional EDE of between 0.1 and 7 mrem. Of this total, between 0.005 and 7 mrem could have come from eating tomatoes, between 0.1 and 3 mrem from eating lettuce, and between 0.6 and 2 mrem from eating turnips. It is believed that most of the excess unidentified beta and alpha activities are due to naturally occurring or fertilizer-introduced radionuclides, not radionuclides discharged from the ORR.

Hay

Another environmental pathway that was evaluated using sampling data is eating beef and drinking milk obtained from hypothetical cows that ate hay harvested from the ORR. Statistically significant concentrations of ^7Be , ^{40}K , and uranium (^{234}U and ^{238}U) were detected at all

sampling locations. Statistically significant concentrations were also found for ^7Be , ^{40}K , and ^{234}U at the background location. Excluding the doses from ^7Be and ^{40}K (both naturally occurring), the average EDE from drinking milk and eating beef from Areas 1, 2, and 3; 2, 4, and 5; and 6 (see Sect. 7.5.1 and Fig. 7.5) was estimated to be between 0.3 and 2 mrem. Also, excluding the doses from ^7Be , ^{40}K , resulted in a maximum EDE of about 0.5 mrem for the hay samples collected from Area 7 (the background location). The samples also contained small amounts of detected activities of primarily unidentified alpha-emitting radionuclides. By further subtracting unidentified activities of alpha- and beta-; the estimated EDE from drinking milk and eating beef from Areas 1, 2, and 3; 2, 4, and 5; and 6 was estimated to be about 0.04 mrem. Excluding the unidentified activity of alpha-emitting radionuclides, the estimated EDE from drinking milk and eating beef from the background location (Area 7) was estimated to be about 0.002 mrem.

White-Tailed Deer

The Tennessee Wildlife Resources Agency (TWRA) conducted three 2-day deer hunts during 2006 on the Oak Ridge Wildlife Management Area, which is part of the ORR (see Sect. 7.7). During the hunts, 286 deer were harvested and were brought to the TWRA checking station. At the station, a bone sample and a tissue sample were taken from each deer and were field-counted for radioactivity to ensure that the deer met wildlife release criteria (less than 20 pCi/g of beta-particle activity in bone or 5 pCi/g of ^{137}Cs in edible tissue). Two deer exceeded the limit for beta-particle activity in bone and were confiscated. The remaining 284 deer were released to the hunters.

The average ^{137}Cs concentration in tissue of the 284 released deer, as determined by field counting, was 0.68 pCi/g; the maximum ^{137}Cs concentration in a released deer was 2.04 pCi/g. Many of the ^{137}Cs concentrations were less than minimum detectable levels. The average weight was 91.26 lb, and the maximum weight of the released deer was 186 lb. The EDEs attributed to field-measured ^{137}Cs concentrations and actual field weights of the released deer ranged from 0.04 to 1.7 mrem. An individual who consumed one average-weight deer (91.3 lb), assuming

55% field weight is edible meat, containing the 2006 average concentration of ^{137}Cs (0.68 pCi/g) could have received an EDE of about 0.8 mrem.

In 2006, the maximum field-measured ^{137}Cs concentration was 2.04 pCi/g, and the maximum deer weight was 186 lb. A hypothetical hunter who consumed a deer of maximum weight and ^{137}Cs content could have received an EDE of about 4.7 mrem.

Tissue samples collected in 2006 from 12 deer (10 released and 2 retained) were subjected to laboratory analysis. Requested radioisotopic analyses included ^{137}Cs , ^{90}Sr , and ^{40}K radionuclides. Comparison of the field to analytical ^{137}Cs concentrations results found that the field concentrations were greater than the analytical results. All were less than the administrative limit of 5 pCi/g. The ^{90}Sr concentrations analyzed in these tissue samples were all less than the minimum detectable levels. Using ^{137}Cs and ^{90}Sr (at the minimum detectable levels) analytical tissue data and actual deer weights, the estimated doses for these 12 deer ranged between 0.4 to 1.4 mrem.

The maximum estimated EDE from consuming venison from an actual released deer (based on field ^{137}Cs concentrations and weights) and including the maximum 2006 analytical ^{90}Sr result (0.18 pCi/g, which was at the minimum detectable level) is estimated to be about 3 mrem. This estimate is considered a more realistic evaluation of a maximum EDE from consuming venison from deer harvested on the ORR in 2006 than estimating an EDE from consumption of venison with maximum ^{137}Cs concentrations, maximum weight, and maximum ^{90}Sr concentration found in historical data, as conducted in the previous evaluations.

The maximum EDE to an individual consuming venison from two or three deer was also evaluated. There were about 26 hunters who harvested two deer or more from the ORR. Based on ^{137}Cs concentrations determined by field counting and actual field weight, the EDE range to a hunter who consumed two or more harvested deer was estimated to range between 0.7 to 3 mrem.

The collective EDE from eating all the harvested venison from ORR with a 2006 average field-derived ^{137}Cs concentration of 0.68 pCi/g and average weight of 91.3 lb is estimated to be about 0.2 person-rem.

Canada Geese

During the 2006 goose roundup, 203 geese were weighed and subjected to whole-body gamma scans. The geese were field-counted for radioactivity to ensure that they met wildlife release criteria (less than 5 pCi/g of ^{137}Cs in tissue). The average ^{137}Cs concentration was 0.17 pCi/g, with maximum ^{137}Cs concentration in the released geese of 0.49 pCi/g. Most of the ^{137}Cs concentrations were less than minimum detectable activity levels. The average weight of the geese screened during the roundup was about 8.4 lb (3.82 kg). The maximum goose weight was about 12.6 lb (5.7 kg). The EDEs attributed to field-measured ^{137}Cs concentrations and actual field weights of the geese ranged from 0 to 0.02 mrem. If a person consumed a released goose with an average weight of 8.4 lb and an average ^{137}Cs concentration of 0.17 pCi/g, the estimated EDE would be about 0.02 mrem. It is assumed that approximately half the weight of a Canada goose is edible. The maximum estimated EDE to an individual who consumed a hypothetical released goose with the maximum ^{137}Cs concentration of 0.49 pCi/g and the maximum weight of 12.6 lb was about 0.07 mrem.

It is possible that one person could eat more than one goose that spent time on the ORR. Most hunters harvest on average one to two geese per hunting season (USFWS 1995). If one person consumed two geese of maximum weight with the highest measured concentration of ^{137}Cs , that person could have received an EDE of about 0.2 mrem.

The two geese screened during the 2006 goose hunt had ^{137}Cs concentrations less than 0.2 pCi/g. Assuming maximum weight obtained during the roundup, the estimated EDE from consuming both geese would be about 0.06 mrem. In 2006, a muscle sample was analyzed for ^{40}K , ^{137}Cs , and ^{90}Sr from a seriously injured goose that had to be euthanized. The analytical results for ^{137}Cs and ^{90}Sr were less than MDA levels. Assuming MDA levels, excluding ^{40}K concentrations (naturally occurring radionuclide), and maximum weight from the goose roundup, the estimated dose from consuming this goose was about 0.08 mrem.

Eastern Wild Turkey

Two wild turkey hunts were held on the reservation in 2006, one on April 1 and 2 and the other on April 8 and 9. Thirty-nine birds were harvested, and none were retained. The average ^{137}Cs concentration measured in the released turkeys was 0.09 pCi/g, and the maximum ^{137}Cs concentration was 0.15 pCi/g. The average weight of the turkeys released was about 19.5 lb. The maximum turkey weight was about 23.5 lb.

If a person consumed a wild turkey with an average weight of 19.5 lb and an average ^{137}Cs concentration of 0.09 pCi/g, the estimated EDE would be about 0.02 mrem. The maximum estimated EDE to an individual who consumed a hypothetical released turkey with the maximum ^{137}Cs concentration of 0.15 pCi/g and the maximum weight of 23.5 lb was about 0.04 mrem. It is assumed that approximately half the weight of a wild turkey is edible. In 2006, one hunter harvested two turkeys during the turkey hunt. The EDE from one person consuming both turkeys was estimated to be about 0.04 mrem. No tissue samples were analyzed in 2006.

The collective EDE from consuming all the harvested wild turkey meat (39 birds) with an average field-derived ^{137}Cs concentration of 0.09 pCi/g and average weight of 19.5 lb is estimated to be about 0.0008 person-rem.

Direct Radiation

External exposure rates from background sources in the state of Tennessee average about 6.4 $\mu\text{R}/\text{h}$ and range from 2.9 to 11 $\mu\text{R}/\text{h}$. These exposure rates translate into annual EDE rates that average 42 mrem/year and range between 19 and 72 mrem/year (Myrick et al. 1981). External radiation exposure rates are measured at numerous locations on and off the ORR. The average exposure rate at PAMs around the ORR during 2006 was about 5.5 $\mu\text{R}/\text{h}$. This rate corresponds to an EDE rate of about 36 mrem/year. All measured exposure rates at or near the ORR boundaries are near background levels.

External exposure rate measurements taken during 1997 along a 1.7-km length of Clinch River shoreline averaged 8.4 $\mu\text{R}/\text{h}$ and ranged between 6.9 and 9.3 $\mu\text{R}/\text{h}$. This corresponds to an average exposure rate of about 2.0 $\mu\text{R}/\text{h}$ (0.0015 mrem/h) above background. A potential maximally exposed individual would be a hypo-

thetical fisherman assumed to have spent 5 h/week (250 h/year) near the point of average exposure on the Clinch River shoreline. This hypothetical maximally exposed individual could have received an EDE of about 0.4 mrem above background during 2006.

As described in Sect. 4.10, the UF_6 cylinder storage yards and K-770 Scrap Yard at ETTP are potential sources of direct gamma and neutron radiation exposure to the public. Measured exposure rates and a hypothetical model of a maximally exposed individual were used to calculate theoretical doses. The calculated EDEs were based on gamma and neutron dose rates measured at the K-1066-J and K-1066-E Cylinder Yards along the near bank of Poplar Creek, the parking lot adjacent to the K-1066-K Cylinder Yard, and the near bank of the Clinch River in the vicinity of the K-770 Scrap Yard.

The potential maximally exposed individual model used for exposure from the K-1066-J or K-1066-E Cylinder Yard is a hypothetical fisherman assumed to have spent 250 h/year near the point of average exposure. This hypothetical individual could have received an EDE above background of about 0.25 mrem from gamma radiation and 0.50 mrem from neutron radiation (0.75 mrem gamma and neutron) along the bank of Poplar Creek near the K-1066-E Cylinder Yard during 2006. This section of the creek runs through the ETTP plant and is used at times by fishermen; however, it is very unlikely that anyone would fish this stretch of Poplar Creek for 250 h/year. At the time of the January surveys, no cylinders were being stored in the K-1066-J Cylinder Yard, and consequently there was no potential dose above background levels at this location.

General area dose rates were recorded in the vicinity of the K-770 Scrap Yard, along the near bank of the Clinch River. A hypothetical fisherman assumed to have spent 250 h/year near the point of average exposure along the bank of the Clinch River near the K-770 Scrap Yard could have received an EDE above background of about 0.50 mrem from gamma radiation and no dose from neutron radiation during 2006.

The parking lot adjacent to the K-1066-K Cylinder Yard is used by workers and the public. This parking lot is intended for employees and has no public facilities. A potential maximally exposed individual is someone assumed to have

spent 30 min per work day (125 h/year) waiting in the parking lot at the point of average exposure along the edge closest to the K-1066-K Cylinder Yard. This hypothetical individual could have received an EDE above background of no dose from gamma radiation and 0.13 mrem from neutron radiation during 2006. At the time of the survey, no cylinders were being stored in the K-1066-K Cylinder Yard.

8.1.3 Doses to Aquatic and Terrestrial Biota

8.1.3.1 Aquatic Biota

DOE Order 5400.5, Chap. II, sets an absorbed dose rate limit of 1 rad/day to native aquatic organisms from exposure to radioactive material in liquid wastes discharged to natural waterways (see Appendix G for definitions of absorbed dose and the rad). To demonstrate compliance with this limit, the aquatic organism assessment was conducted using the RESRAD-Biota code (Version 1.21), a companion tool for implementing the DOE technical standard, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2002). The code serves as DOE's "next-generation" biota dose evaluation tool and uses the screening [i.e., biota concentration guides (BCGs)] and analysis methods in the technical standard.

The intent of the graded approach is to protect populations of aquatic organisms from the effects of exposure to anthropogenic ionizing radiation. Certain organisms are more sensitive to ionizing radiation than others. Therefore, it is generally assumed that protecting the more-sensitive organisms will adequately protect other, less-sensitive organisms. Depending on the radionuclide, either aquatic organisms (e.g., crustaceans) or riparian organisms (e.g., raccoons) may be considered to be the more sensitive and are the limiting organisms for the general screening phase of the graded approach for aquatic organisms. The graded approach for evaluating radiation doses to aquatic biota consists of a three-step process that involves (1) data assembly, (2) general screening of media-specific radionuclide concentrations to media-specific BCGs, and (3) site-specific screening and analysis. In the general screening

phase, surface water radionuclide concentrations and sediment radionuclide concentrations can be compared to the media-specific BCGs using default parameters. This aquatic dose assessment was based primarily on surface water sampling data.

At ORNL, doses to aquatic organisms are based on surface water concentrations at 10 different sampling locations:

- Melton Branch (MEK 0.2),
- White Oak Creek (WCK 1.0 and 2.6),
- First Creek,
- Fifth Creek,
- Raccoon Creek,
- Northwest Tributary, and
- Clinch River (CRK 32, 58, and 66).

Two additional surface water sampling locations on the ORR were also evaluated: Bear Creek (BCK 0.6) and East Fork Poplar Creek (EFK 5.4) All but two of these locations, WCK 1.0 (White Oak Creek at the dam) and White Oak Creek (WCK 2.6), passed the screening phase (maximum concentrations and using default parameters for BCGs). At WCK 1.0 and WCK 2.6, the default bioaccumulation factors for both ^{137}Cs and ^{90}Sr were adjusted to reflect on-site bioaccumulation of these radionuclides in fish. Riparian organisms are the limiting receptor for both ^{137}Cs and ^{90}Sr in surface water; however, the best available bioaccumulation data for White Oak Creek are for fish. Because fish are consumed by riparian organisms (e.g., raccoons), adjustment of the fish bioaccumulation factor modified the bioaccumulation of both ^{90}Sr and ^{137}Cs in riparian organisms. This resulted in absorbed dose rates to aquatic organisms below the DOE aquatic dose limit of 1 rad/day at all 12 sampling locations.

At the Y-12 Complex, doses to aquatic organisms were estimated from surface water concentrations at nine different sampling locations:

- SWHISS Station 9422-1 (Station 17),
- Discharge Point S24, Bear Creek at BCK 9.4
- Station 304, Bear Creek at Hwy. 95
- Discharge Point S17 (unnamed tributary to the Clinch River),
- Rogers Quarry Discharge Point S19
- outfall 512
- outfall 520,

- outfall 550, and
- Central Mercury Treatment Unit (outfall 551).

All but four locations passed the general screening phase (maximum water concentrations and default parameters for BCGs). These four locations: S24 Bear Creek, outfall 512, Station 304 Bear Creek, and SWHISS Station 9422-1, passed using average water concentrations. This resulted in absorbed dose rates to aquatic organisms below the DOE aquatic dose limit of 1 rad/day at all nine Y-12 locations.

At ETTP, doses to aquatic organisms were estimated from surface water concentrations at eight different sampling locations:

- Mitchell Branch at K1700 and at MIK 1.4 (upstream location),
- Poplar Creek at K-716 (downstream),
- K1007-B and K-1710 (upstream location),
- K901-A (downstream of ETTP operations), and
- Clinch River (CRK 16 and CRK 23).

All of these locations passed the initial general screening (using maximum concentrations and default parameters for BCGs). This resulted in absorbed dose rates to aquatic organisms below the DOE aquatic dose limit of 1 rad/day at all eight sampling locations.

8.1.3.2 Terrestrial Biota

In 2006, a terrestrial biota sampling strategy that considers guidance provided in *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2002) and existing radiological information on the concentrations and distribution of radiological contaminants on the ORR was developed. Sampling for terrestrial dose assessment was initiated in 2007.

As a result of CERCLA and the programs initiated to remediate the effects of hazardous waste disposal on the ORR, a substantial amount of radiological data in various media (e.g., soils, sediment, and surface water) have been collected and reported in Remedial Investigation (RI) reports and numerous other documents. In addition, baseline ecological risk assessments (BERAs) were conducted between 1997 and 2000 for all major disposal sites at the three DOE facilities on the ORR, including Bethel Valley and Melton Valley at the Oak Ridge Na-

tional Laboratory, Bear Creek Valley, and upper East Fork Poplar Creek at the Y-12 National Security Complex, and the ETTP. In some cases, additional BERAs were conducted for specific waste sites (e.g., selected disposal ponds and burial grounds at ETTP in 1995, sitewide residual contamination in soils and Mitchell Branch at ETTP in 2006, and Melton Valley Watershed in 2004). The results of these BERAs serve as a basis for identifying ORR sampling locations. The ORR sampling program focuses initially on unremediated areas, such as floodplains and selected upland areas. Floodplains are often downstream of contaminant source areas and are dynamic systems where soils are eroding in some area and being deposited in others.

The sampling strategy consists of two phases: (1) initial sampling to estimate doses based on the radionuclide concentrations in soil, and (2) follow-up, which involves site-specific sampling of biota if the benchmark of 0.1 rad per day is exceeded. Doses in the initial sampling will be estimated for soil invertebrates and small mammals, such as shrews and mice. Doses to wide-ranging, terrestrial wildlife species are unlikely to exceed 0.1 rad per day. Where there are recent data in areas of interest (e.g., ETTP BERA 2006 data) these data will be used.

The soil sampling is initially focusing on unremediated areas, such as floodplains and some upland areas. Floodplains are often downstream of contaminant source areas and are dynamic systems where soils are eroding in some places and being deposited in others. Suggested soil sampling locations and soil radionuclide analytes are identified below:

1. *White Oak Creek floodplain between the lower boundary of the Intermediate Pond and White Oak Creek.* Hazard quotients greater than 1 have been estimated for soil invertebrates and shrews and mice in this floodplain area. Suggested soil radionuclide analytes include ^{137}Cs , ^{60}Co , ^{90}Sr , ^{239}Pu , ^{240}Pu , ^{241}Am , and ^{244}Cm .
2. *Bear Creek Valley floodplain.* Although data indicate that radionuclide concentrations in the soils are low, the results are based on a relatively small number of samples. Suggested soil radionuclide analytes include ^{234}U , ^{238}U , ^{241}Am , and ^{238}Pu .

3. *West Bethel Valley in the vicinity of the Contractor's Landfill and station SWSA 3-3.* Potential ecological risks to terrestrial biota were identified. Suggested soil radionuclide analyte is ^{137}Cs .
4. *Select areas near the ETTP Powerhouse, North Trash Slope, and the Mitchell Branch Habitat Area.* Suggested soil radionuclide analytes include ^{234}U , ^{238}U and ^{239}Pu .

8.1.4 Current-Year Summary

A summary of the maximum EDEs to individuals by pathway of exposure is given in Table 8.7. In the very unlikely event that any person were irradiated by all of those sources and pathways for the duration of 2006, that person could have received a total EDE of about 9 mrem. Of that total, 0.8 mrem would have come from airborne emissions, 0.7 mrem from waterborne emissions, (0.02 mrem from drinking water from the Watts Bar Lake, 0.7 mrem from consuming fish from the Clinch River, and 0.004 mrem from other water uses), and 0.8 mrem from direct radiation while fishing on Poplar Creek inside the ETTP. This dose is about 3% of the annual dose (300 mrem) from background radiation. The EDE of 6 mrem includes the person who received the highest EDEs from eating wildlife harvested on the ORR. If the maximally exposed individual did not consume wildlife harvested from the ORR, the estimated dose would be about 3 mrem.

DOE Order 5400.5 limits the EDE that an individual may receive from all exposure pathways from all radionuclides released from the ORR during 1 year to no more than 100 mrem. The 2006 maximum EDE should not have exceeded about 6 mrem, or about 6% of the limit given in DOE Order 5400.5. (For further information, see Table G.2 in Appendix G, which summarizes dose levels associated with a wide range of activities.)

The total collective EDE to the population living within a 80-km radius of the ORR was estimated to be about 21 person-rem. This dose is about 0.007% of the 312,012 person-rem that this population received from natural sources during 2006.

8.1.5 Five-Year Trends

Dose equivalents associated with selected exposure pathways for the years from 2001 to 2006 are given in Table 8.8. The variations in values over the 5-year period likely are not statistically significant. The dose estimates for direct irradiation along the Clinch River have been corrected for background.

8.1.6 Potential Contributions from Non-DOE Sources

There are several non-DOE facilities on or near the ORR that could contribute radiation doses to the public. These facilities submit annual reports to demonstrate compliance with NESHAP regulations and the terms of their operating licenses. DOE requested information pertaining to potential radiation doses to members of the public who also could have been affected by releases from these facilities. Eight facilities responded to the DOE request. Based on these responses, no member of the public should have received an EDE greater than 3.7 mrem due to airborne releases from these facilities. The maximally exposed individual dose of 15.3 mrem/year was estimated at the boundary of one of the facilities. Four facilities responded stating that there had been no air or water releases.

8.2 Chemical Dose

8.2.1 Drinking Water Consumption

To evaluate the drinking water pathway, hazard quotients (HQs) were estimated upstream and downstream of the ORR discharge points (Table 8.9). (See Appendix H for a detailed description of the chemical dose methodology). Chemical analytes were measured in surface water samples collected at CRK 70 and CRK 16. CRK 70 is located upstream of all DOE discharge points, and CRK 16 is located downstream of all DOE discharge points. As shown in Table 8.9, HQs were less than 1 for detected chemical analytes for which there are reference doses or maximum contaminant levels.

Table 8.7. Summary of maximum potential radiation dose equivalents to an adult during 2006 and locations of the maximum exposures

Pathway	Dose to maximally exposed individual		Percentage of DOE mrem/year limit (%)	Estimated population dose		Population within 80 km	Estimated background radiation population dose (person-rem) ^a
	mrem	mSv		person-rem	person-Sv		
Airborne effluents:							
All pathways	0.8	0.008	0.8	18.4	0.184	1,040,041 ^b	
Liquid effluents:							
Drinking water	0.02	0.0002	0.02	2	0.02	369,153 ^c	
Eating fish	0.7	0.007	0.7	0.4	0.004	39,931 ^d	
Other activities	0.004	0.0004	0.004	0.04	0.0004	290,107 ^d	
Eating deer	3	0.03 ^e	3.0	0.2	0.002	284	
Eating geese	0.2	0.002 ^f	0.2	<i>g</i>	<i>g</i>		
Eating turkey	0.04	0.0004 ^h	0.04	0.0008	8E-6	39	
Direct radiation	0.8	0.008 ⁱ	0.8	0.08	0.0008	100	
All pathways	6	0.06	6	21	0.21	1,040,041	312,012

^aEstimated background population dose is based on 300 mrem/year individual dose and the population within 80 km of the ORR.

^bPopulation based on 2000 census data.

^cPopulation estimates based on community and non-community drinking water supply data from the Tennessee Department of Environment and Conservation, Division of Water.

^dPopulation estimates based population within 80 km and fraction of fish harvested in Melton Hill, Watts Bar, and Chickamauga reservoirs. Melton Hill recreational information obtained from TVA (TVA 2006).

^eThe maximum EDE from consumption of a deer harvested on the ORR in 2006 and the population dose is based on number of hunters that harvested deer.

^fFrom consuming two hypothetical worst-case geese, each a combination of the heaviest goose harvested and the highest measured concentrations of ¹³⁷Cs in released geese.

^gPopulation doses were not estimated for the consumption of geese since few geese (2) were brought to checking station during the goose hunt.

^hFrom consuming two hypothetical worst-case turkey, each a combination of the heaviest turkey harvested and the highest measured concentrations of ¹³⁷Cs in released turkey. The population dose is based on the number of released turkeys.

ⁱDirect radiation dose estimate based on exposure to a fisherman on Poplar Creek.

Acceptable risk levels for carcinogens typically range from 10^{-4} to 10^{-6} . Risk values greater than 10^{-5} were calculated for the intake of arsenic in water collected at both upstream and downstream locations.

8.2.2 Fish Consumption

Chemicals in water can be accumulated by aquatic organisms that may be consumed by humans. To evaluate the potential health effects from the fish consumption pathway, HQs were estimated for the consumption of noncarcinogens, and risk values were estimated for the consumption of carcinogens detected in sunfish and

catfish collected both upstream and downstream of the ORR discharge points. In the current assessment, a fish consumption rate of 60 g/day (21 kg/year) is assumed for both the noncarcinogenic and carcinogenic pollutants. This is the same fish consumption rate used in the estimation of the maximum exposed radiological dose from consumption of fish. (See Appendix H for a detailed description of the chemical dose methodology.)

As shown in Table 8.10, for consumption of sunfish and catfish, HQ values of less than 1 were calculated for the all detected analytes

Table 8.8. Trends in total effective dose equivalent (mrem)^a for selected pathways

Pathway	2002	2003	2004	2005	2006
All air	0.3	0.2	0.4	0.9	0.8
Fish consumption (Clinch River)	0.3	1	0.2	0.3	0.7
Drinking water (Kingston)	0.04 ^b	0.1	0.04	0.03	0.02
Direct radiation (Clinch River)	0.4 ^c	0.4	0.4	0.4	0.5 ^{d,e}
Direct radiation (Poplar Creek)	2 ^c	2 ^d	3 ^d	1 ^d	0.8 ^d

^a1 mrem = 0.01 mSv.^bBased on water samples from the Clinch River System.^cThese 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.^dIncluded gamma and neutron radiation measurement data. In 2006, the Poplar Creek location was near the K-1066E Cylinder Yard.^eThis location is along the bank of the Clinch River near the K-770 Scrap Yard, in previous years (e.g., 2002 to 2005), the direct radiation measurements were from an area near Jones Island.**Table 8.9. Chemical hazard quotients and estimated risks for drinking water, 2006^a**

Chemical	Hazard quotient	
	CRK 70 ^b	CRK 16 ^c
Antimony		~0.03
Arsenic	~0.1	~0.2
Acetone	~0.0001	~0.0001
Barium	~0.005	0.005
Boron	0.002	0.002
Chromium	~0.01	~0.01
Lead	0.1	
Manganese	0.01	0.009
Molybdenum	0.005	0.004
Nickel	0.002	0.002
Strontium	0.005	0.005
Thallium	~0.2	~0.2
Tetrachloroethene	~0.002	~0.0001
Uranium	0.002	0.003
Vanadium	~0.01	~0.008
Zinc	0.0006	0.0004
Risk for carcinogens		
Arsenic	~7E-5	~3E-5

^aA tilde (~) indicates that estimated values were used in the calculation.^bMelton Hill Reservoir above city of Oak Ridge input.^cClinch River downstream of all DOE inputs.

except for arsenic and Aroclor-1260. For arsenic, HQ values greater than one were estimated at all three locations for both sunfish and catfish. An HQ greater than one for Aroclor-1260 was estimated in sunfish in two locations (CRK 32 and 16) and in catfish at all three locations.

For carcinogens, risk values greater than 10^{-5} were calculated for the intake of arsenic found in sunfish and catfish collected at all three locations. For catfish, risk values greater than 10^{-5} were also calculated for the intake of Aroclor-1260 collected at all three locations. At CRK 70, the risk value for dieldrin in catfish was greater than 10^{-5} ; however, dieldrin was not detected at the other locations. The Tennessee Department of Environment and Conservation (TDEC) has issued a fish advisory that states that catfish should not be consumed from Melton Hill Reservoir (in its entirety) because of PCB contamination and has issued a precautionary fish consumption advisory for catfish in the Clinch River arm of Watts Bar Reservoir (TDEC 2002).

Table 8.10. Chemical hazard quotients and estimated risks for carcinogens in fish, 2006^a

Carcinogen	Sunfish			Catfish		
	CRK 70 ^b	CRK 32 ^c	CRK 16 ^d	CRK 70 ^b	CRK 32 ^c	CRK 16 ^d
Hazard quotient for metals						
Arsenic	1.6	1.6	1.6	1.2	1.3	1.3
Barium	0.0006	0.0009	0.0004	0.0002	0.00009	0.00008
Cadmium		0.01	~0.01	~0.01	0.01	~0.01
Chromium	0.02	0.02	0.01	0.02	0.02	0.01
Lead	0.6	~0.5	0.4	0.6	0.5	0.3
Manganese	0.006	0.004	0.004	0.001	0.001	0.002
Mercury	0.1	0.2	0.5	0.3	0.3	0.6
Molybdenum	~0.003	0.006	~0.004	0.01	~0.003	~0.003
Selenium	0.3	0.2	0.2	0.1	0.1	0.1
Strontium	0.002	0.003	0.001	0.0001	0.00006	0.0002
Thallium	0.07	0.09	0.06	0.03	0.04	0.05
Uranium	0.0003	0.0002	0.0002	0.0006	0.0002	0.0003
Zinc	0.05	0.04	0.04	0.02	0.02	0.02
Hazard quotient for pesticides and Aroclors						
Aroclor-1260	~0.5	~0.95	0.98	7.4	18.5	2.8
BHC, delta	~0.2		~0.07			
Chlordane, alpha				0.01	0.004	
Chlordane, gamma				0.01	~0.002	
Dieldrin				~0.08		
Heptachlor epoxide				~0.1		
Risks for carcinogens						
Arsenic	3E-4	3E-4	3E-4	2E-4	3E-4	3E-4
Aroclor-1260	~8E-6	~2E-5	2E-5	1E-4	3E-4	5E-5
Chlordane, alpha				1E-6	3E-7	
Chlordane, gamma				8E-7	2E-7	
Dieldrin				~3E-5		
PCBs (mixed) ^e	~8E-6	~2E-5	2E-5	1E-4	3E-4	5E-5

^aA tilde (~) indicates that estimated values were used in the calculation, and a blank space indicates that the parameter was undetected.

^bMelton Hill Reservoir, above Oak Ridge city input.

^cClinch River, downstream of ORNL.

^dClinch River, downstream of all DOE inputs.

^eMixed PCBs consists of the summation of Aroclors detected or estimated.

9. Quality Assurance

Environmental decisions on the ORR are made on the assumption that analytical results are representative of site conditions. Many factors can potentially affect the results of environmental data collection activities, including sampling personnel, methods, and procedures; field conditions; sample handling, preservation, and transport; personnel training; analytical methods; data reporting; and record keeping. Quality assurance programs are designed to minimize these sources of variability and to control all phases of the monitoring process.

9.1 Introduction

The application of quality assurance/quality control (QA/QC) programs for environmental monitoring activities on the ORR is essential for generating data of known and defensible quality. Each aspect of an environmental monitoring program, from sample collection to data management, must address and meet applicable quality standards.

9.2 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 work control processes and standard operating procedures for sample collection and analysis;
- use of chain-of-custody and sample-identification procedures;
- instrument standardization, calibration, and verification;
- sample technician and laboratory analyst training;
- sample preservation, handling, and decontamination; and
- use of QC samples, such as field and trip blanks, duplicates, and equipment rinses.

9.3 Analytical Quality Assurance

The contract analytical laboratories that perform the analyses of environmental samples from the ORR environmental monitoring programs are required to have documented QA/QC programs, well-trained and qualified staff, appropriately maintained equipment and facilities,

and applicable certifications. The analytical laboratories conduct extensive internal QC programs, participate in external QA programs, and use statistics to evaluate and continuously improve performance.

9.3.1 Internal Quality Assurance/Quality Control

Analytical results may be affected by a large number of factors inherent to the measurement process. Laboratories that support ORR environmental monitoring programs employ internal QA/QC programs to ensure the early detection of problems that may arise from contamination, inadequate calibrations, calculation errors, or improper procedure performance. Internal laboratory QA/QC programs include routine calibrations of counting instruments, yield determinations, frequent use of check sources and background counts, replicate and spiked sample analyses, matrix and reagent blanks, and maintenance of control charts to indicate analytical deficiencies. These 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 traceable to the National Institute of Standards and Technology (NIST), DOE sources, or EPA are used (when available) for such work.

Other internal practices employed to ensure that laboratory results are representative of actual conditions include staff training and management, adequacy of the laboratory environment, safety, the storage, integrity and identity of samples, record keeping, the maintenance and calibration of instruments, and the use of technically validated and properly documented methods.

9.3.2 External Quality Assurance/ Quality Control

Contract analytical laboratories also participate in external QA/QC programs to ensure reported results are within required levels of precision and accuracy. External QA/QC programs typically involve laboratories analyzing samples of unknown composition supplied by customers or by DOE- or EPA-approved proficiency-testing supplier organizations. These samples may be single-blind control samples that are identified to the laboratory as performance evaluation samples or double-blind control samples that have the characteristics of routine samples and are provided to the laboratory without being identified as control samples. The supplying organizations know the true composition of the samples and provide the contract laboratories with data reports on their analytical performance. The following sections describe other external QA/QC programs in which analytical laboratories may participate.

9.3.2.1 EPA Water Pollution and Water Supply Performance Studies

Participation in the EPA Water Pollution Program and the EPA Water Supply Program studies is required by most states for laboratories performing analyses of water samples for regulatory programs. The EPA Water Supply Program 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. This program is also used by other states as part of their certification programs. Participation in the Water Pollution Program satisfies the EPA and NPDES program requirement that laboratories performing CWA analyses participate in a Discharge Monitoring Report Quality Assurance Program.

Since October 24, 1999, all water pollution and water supply studies except whole effluent toxicity testing have been performed by commercial vendors. NIST certifies non-EPA proficiency testing providers to prepare performance evaluation samples and to evaluate laboratory performance. EPA continues to issue standard

operating procedures for use in the water supply and water pollution programs.

9.3.2.2 DOE Mixed Analyte Performance Evaluation Program

The Mixed Analyte Performance Evaluation Program is set up by the DOE Radiological and Environmental Sciences Laboratory in conjunction with the Laboratory Management Division of the Office of Technology Development to evaluate analysis of mixed-waste samples. Participation is required by DOE for laboratories that perform environmental analytical measurements in support of environmental management activities. Various matrices, such as soil, water, air filters, and vegetation, are submitted semianually for analysis for a variety of radioactive isotopes as well as metals and organic parameters. A statistical report is issued for each study.

9.3.2.3 Proficiency Evaluation Testing Programs

Proficiency evaluation testing programs involve the analysis of “blind” samples supplied by approved vendors. Participating laboratories return analytical results to the sample providers, and the results are compared with results from other laboratories that use the same testing method. A “report card” is issued to the laboratory to provide a “snapshot” of a laboratory’s measurements and quality system at one point in time. Regular and frequent participation then builds up a picture over time that can help laboratory and quality managers, as well as clients, accrediting bodies, and regulators to assess a laboratory’s analytical quality. Participation in proficiency evaluation testing programs may satisfy requirements for participating in NPDES discharge monitoring report QA studies in some cases.

9.3.3 Y-12 Analytical Chemistry Organization Scores on FY 2006 Performance Evaluation Programs

The BWXT Y-12 Analytical Chemistry Organization subscribes to a number of independent, external QA/QC programs that submit blind samples and score the quality of the results. This

is necessary to retain numerous certifications required by customers and to ensure the quality of the analyses. The Analytical Chemistry labs achieved an overall FY 2006 score of 98.58% from 54 different studies. The results compare with a national average of 94.95% among programs for which data are available. On 44 of the studies, the Analytical Chemistry Organization labs received a score of 100%.

9.3.4 Quality Assessment Programs for Subcontracted Laboratories

Competitive award systems are used by UT-Battelle and by the Bechtel Jacobs Sample Management Office to select laboratories that are contracted under basic ordering agreements to perform analytical work. Commercial laboratories approved by the Sample Management Office are required to comply with the requirements set forth in the Integrated Contractor Procurement Team Basic Ordering Agreement terms and conditions. Oversight of subcontracted commercial laboratories is performed by the DOE Environmental Management Consolidated Audit Program, which is supported by the Sample Management Office, DOE, the Sample Management Office, and other subcontractors from across the DOE complex work together in the Environmental Management Consolidated Audit Program to conduct on-site laboratory reviews and to monitor the performance of all subcontracted laboratories. Awards are made to laboratories to provide analytical support to projects based on the best value added to the project. Best value is a graded approach that comprises price and performance history.

The Sample Management Office contractor manages the Integrated Performance Indicator Program to report quality indicators that will assess trends for commercial analytical laboratories used to support Sample Management Office projects (and their subcontractors) within DOE-ORO. The objective of the Integrated Performance Indicator Program is to evaluate all analytical laboratories based on a set of standardized performance criteria that can then be quantitatively tracked and trended. The Sample Management Office contractor uses these performance indicators to monitor the performance of the laboratories.

A limited basic order agreement with commercial laboratories has been established by UT-Battelle for the procurement of analytical services to characterize environmental and waste samples. Laboratories included in the agreement are required to comply with the terms and conditions of the Integrated Contractor Procurement Team Contract, Basic Order Agreement. A statement of work for each project specifies any additional QA/QC requirements and includes detailed information, data, deliverables, turn-around times, and required methods.

9.4 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. Some level of verification and validation of field and analytical data collected for environmental monitoring and restoration programs is 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 the intended use. The extent of project data verification and validation activities is based on project-specific requirements.

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. Typically, routine data verification actions alone are sufficient to document the validity and accuracy of environmental reports. For 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 require a more thorough technical validation of the data as mandated by the project's data quality objectives. Sampling and analyses conducted as part of a remedial investigation to support the CERCLA process may generate data that are needed to

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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 these cases, the data quality objectives of the project may mandate a thorough technical evaluation of the data against rigorous predetermined criteria. The validation process may result in the identification of data that do not meet predetermined QC criteria or in the ultimate rejection of data for their intended use. Typical criteria evaluated in the validation of Contract Laboratory Program 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.

Integration of compliance-monitoring data for the ORR with sampling and analysis results from remedial investigations is a function of the Oak Ridge Environmental Information System (OREIS). OREIS is necessary to fulfill requirements prescribed in both the Federal Facility Agreement and the Tennessee Oversight Agreement and to support data management

activities for DOE. The Federal Facility Agreement, a tripartite agreement among DOE, EPA Region 4, and the state of Tennessee, requires DOE to maintain one consolidated database for environmental data generated at DOE facilities on the ORR. According to the Federal Facility Agreement, the consolidated database is to include data generated pursuant to the agreement 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 database 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 restoration projects, 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 4 and the TDEC/DOE Oversight Division.

Appendix A. Errata

Appendix A. Errata

The following corrections are to *Oak Ridge Reservation Annual Site Environmental Report for 2005*, DOE/ORO/2218, U.S. Department of Energy, Oak Ridge Office, Oak Ridge, Tennessee, September 2006.

Chap. 2, Sect. 2.2.13.3, third paragraph, the DOE document reference citation should be DOE 2005. The corresponding reference is as follows.

DOE. 2005. *Compliance Plan, National Emission Standards for Hazardous Air Pollutants for Radionuclides on the Oak Ridge Reservation, Oak Ridge, Tennessee*. DOE/ORO/2196. U.S. Department of Energy, Washington, D.C.

Chap. 2, abstract, the fourth paragraph should read as follows.

On July 14, 2005, there was a reportable release of asbestos at the ETTP K-1400 building. Approximately 2 lb of asbestos insulation fell from utility steam lines.

Chap. 5, Sect. 5.11.4, p. 5-35, the following sentence should appear at the end of the last paragraph.

Well 4529 is a shallow well located up-gradient of the tritium release sites used to monitor the shallow portion of the aquifer for tritium originating north of the HFIR complex.

Chap. 5, Sect. 5.11.6.7, page 5-38, the following statement should appear between the first and second sentence in the first paragraph.

Consequently, trend analyses were performed on historical data for Wells 658, 892, and 661. The reference value for tritium (20,000 pCi/L) was used solely as a basis of comparison. Exceedance of the tritium reference value does not result in a regulatory compliance issue.

Chap. 5, Sect. 5.11.6.8, page 5-38, the second sentence should read as follows.

Statistically significant downward trends were observed in tritium concentrations at Wells 658 and 892 during 2005.

Chap. 7, Table 7.2, the data for Station 39 are as follows.

Table 7.2. Average radionuclide concentrations at ORR perimeter air monitoring stations, 2005 (pCi/mL)^a

Parameter	No. detected/		Minimum	Maximum
	no. total	Average		
Station 39				
⁷ Be	4/4	3.95E-08	3.60E-08	4.34E-08
⁴⁰ K	0/4	1.56E-10	-5.10E-11	4.06E-10
Tritium	1/4	3.80E-06	2.80E-07	5.76E-06
²³⁴ U	4/4	4.46E-12	3.28E-12	5.40E-12
²³⁵ U	1/4	5.60E-13	1.87E-13	1.19E-12
²³⁸ U	4/4	4.32E-12	3.42E-12	5.37E-12

1 pCi = 3.7×10^{-2} Bq.

Chap. 7, Sect. 7.8.2, the first sentence in the second paragraph should read as follows:

Since 1997, 419 turkeys have been harvested.

Chap. 8, Sect. 8.1.2.3, “the Food Crops” section should read as follows. (The passages in italics differ from those in the original).

Food Crops

The food-crop sampling program is described in Sect. 7.5. Samples of tomatoes, lettuce, and turnips were obtained from six local gardens. These vegetable types are representative of fruit-bearing, leafy, and root vegetables. All radionuclides found in the food crops are found in the natural environment and in commercial fertilizers, and all but ^{7}Be and ^{40}K also are emitted from the ORR.

Dose estimates are based on hypothetical consumption rates of vegetables that contain statistically significant amounts of certain radionuclides that could have come from the ORR. Based on a nationwide food consumption survey (EPA 1997), a hypothetical home gardener was assumed to have eaten 32 kg of homegrown tomatoes, 10 kg of homegrown lettuce, and 37 kg of homegrown turnips. The hypothetical gardener could have received a 50-year committed EDE of *between 0.09 and 0.3 mrem*, depending on garden location. Of this total, *between 0.05 and 0.2 mrem* could have come from eating tomatoes, between 0.04 and 0.06 mrem from eating lettuce, and between 5E-8 and 7E-8 mrem from eating turnips. The highest dose to a gardener could have been about *0.3 mrem* from consuming all three types of homegrown vegetables.

An example of a naturally occurring and fertilizer-introduced radionuclide is ^{40}K , which is specifically identified in the samples and accounts for most of the beta activity found in them. (Potassium-40 actually accounts for all the beta activity found in leafy-vegetable samples.) The presence of ^{40}K in the samples adds, on average, around *2 mrem* to the hypothetical home gardener’s EDE.

Many of the samples contained detected activities of unidentified beta- and alpha-emitting radionuclides. By subtracting identified activities of beta- and alpha-emitting radionuclides from the unidentified beta and alpha activities, excess beta and alpha activities were estimated. If the excess unidentified beta and alpha activities were ^{90}Sr and ^{210}Po , respectively, a hypothetical home gardener could have received an additional EDE of *between 0.5 and 4 mrem*. Of this total, *between 2 and 4 mrem* could have come from eating tomatoes, *between 0.5 and 2 mrem* from eating lettuce, and about *8E-7 mrem* from eating turnips. It is believed that most of the excess unidentified beta and alpha activities are due to naturally occurring or fertilizer-introduced radionuclides, not radionuclides discharged from the ORR.

The following correction is to *Oak Ridge Reservation Annual Site Environmental Report Summary, 2005*, DOE/ORO/2219, U.S. Department of Energy, Oak Ridge Office, Oak Ridge, Tennessee, February 2007

On page 10, in the “Maximum potential radiation dose equivalents” table, the conversion note should be corrected as follows:

“1 mrem = 100 mSv” should read “1 mSv = 100 mrem.”

Appendix B. Climate Overview for the Oak Ridge Area

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Winds

Five major terrain-related wind regimes regularly affect the Great Valley of Eastern Tennessee: pressure-driven channeling, downward-momentum transport or vertically coupled flow, forced channeling, along-valley thermal circulations, and mountain-valley circulations. Pressure-driven channeling and vertically coupled flow (unstably stratified conditions) affect wind flow on scales comparable to that of the Great Valley (hundreds of kilometers). Forced channeling occurs on similar scales but is also quite important at smaller spatial scales such as that of the local ridge-and-valley (Birdwell 1996). Along-valley and mountain-valley circulations are thermally-driven and occur within a large range of spatial scales. Thermal flows are more prevalent under conditions of clear skies and low humidity.

Pressure-driven channeling, in its simplest essence, is the redirection of synoptically induced wind flow through a valley channel. The direction of wind flow through the valley is determined by the pressure gradient superimposed on the valley's axis (Whiteman 2000). The process is affected by Coriolis forces, a leftward deflection of winds (in the Northern Hemisphere). Eckman (1998) suggested that pressure-driven channeling plays a significant role in the Great Valley. Winds driven purely by such a process shift from up-valley to down-valley flow or conversely as "weather"-induced flow shifts across the axis of the Great Valley. Since the processes involved in pressure-driven flow primarily affect the horizontal motion of air, the presence of a temperature inversion enhances flow significantly. Weak vertical air motion and momentum associated with such inversions allow different layers of air to slide over each other (Monti et al. 2002).

Forced channeling is defined as the direct deflection of wind by terrain. This form of channeling necessitates some degree of vertical motion transfer, implying that the mechanism is less pronounced during temperature-inversion conditions. Although forced channeling may result from interactions between large valleys and mountain ranges (such as the Great Valley and the surrounding mountains), the mechanism is especially important in narrow, small valleys such as those on the Oak Ridge Reservation (Kossman and Sturman 2002).

Large-scale forced channeling occurs regularly within the Great Valley when northwest to north winds (perpendicular to the axis of the central Great Valley) coincide with vertically coupled flow. The phenomenon sometimes results in a split flow pattern (winds southwest of Knoxville moving down-valley and those to the east of Knoxville moving up-valley). The causes of such a flow pattern may include the shape characteristics of the Great Valley (Kossman and Sturman 2002) but also may be related to the specific location of the Cumberland and Smoky Mountains relative to upper level wind flow (Eckman 1998). The convex shape of the Great Valley with respect to a northwest wind flow may lead to a divergent wind flow pattern in the Knoxville area. This results in downward air motion. Additionally, horizontal flow is reduced by the windward mountain range (Cumberland Mountains), which increases buoyancy and Coriolis effects (Froude and Rossby ratios in the meteorological field). Consequently, the leeward mountain range (Smoky Mountains) becomes more effective at blocking or redirecting the winds.

Vertically coupled winds occur when the atmosphere is unstable (characterized by cooler temperatures aloft). When a strong horizontal wind component is also present (as in conditions behind a winter cold front), winds "ignore" the terrain, flowing over it in roughly the same direction as the winds aloft. This phenomenon is a consequence of the horizontal transport and momentum aloft being transferred to the surface. However, Coriolis effects may turn the winds by up to 25° to the left (Birdwell 1996).

Thermally driven winds are common in areas of significantly complex terrain. These winds occur as a result of pressure and temperature differences caused by varied surface-air energy exchange at similar

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altitudes along a valley's axis, sidewalls, and/or slopes. Thermal flows operate most effectively when synoptic winds are light and when thermal differences are exacerbated by clear skies and low humidity (Whiteman 2000). Ridge-and-valley terrain may be responsible for enhancing or inhibiting such air flow, depending on the ambient weather conditions. Eckman (1998) suggested that the presence of daytime up-valley winds and night time down-valley (drainage) flows between the ridge-and-valley terrain of the Oak Ridge area tended to reverse at about 9:00 to 11:00 a.m. and at about 5:00 to 7:00 p.m. local time respectively. The terrain-following nature of drainage winds suggests that they would be more directly impacted by the presence of the ridge-and-valley than daytime flows, which tend to be accompanied by significant vertical motions.

Figures B.1, B.2, and B.3 are wind roses for data obtained during 2006 at ORNL Meteorological Tower C, at 10, 30, and 100 m above ground level, respectively. The wind roses represent typical trends and should be used with caution.

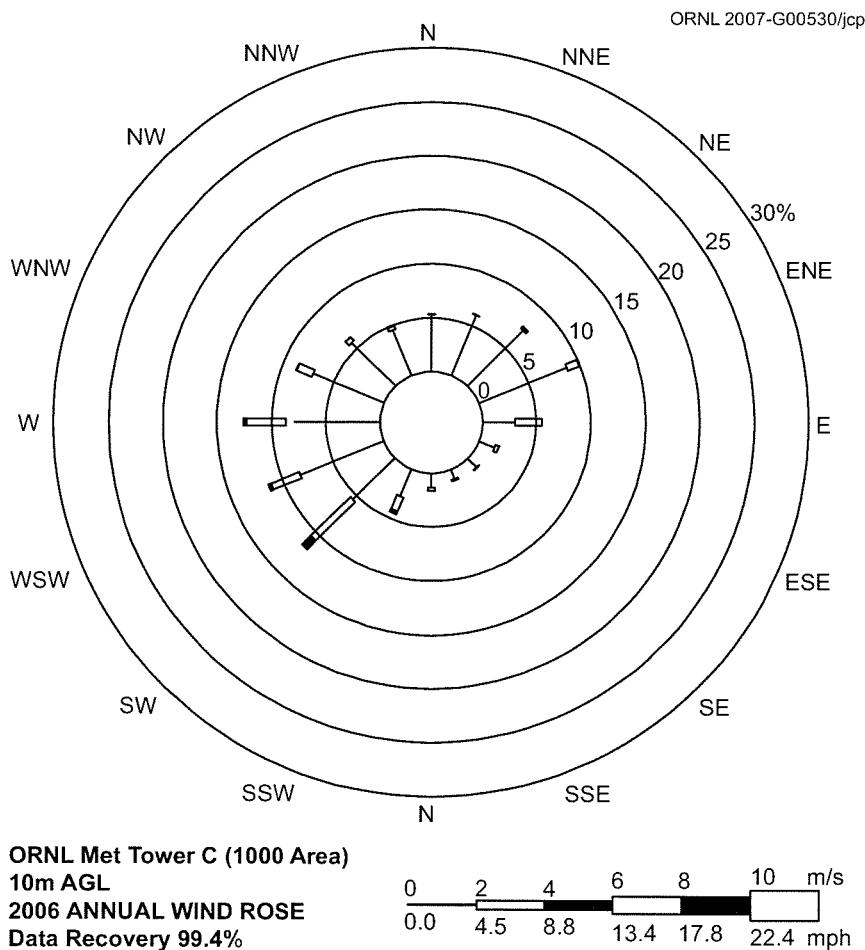


Fig. B.1. Wind rose for ORNL Meteorological Tower C for data taken at 10 m above ground level, 2006.

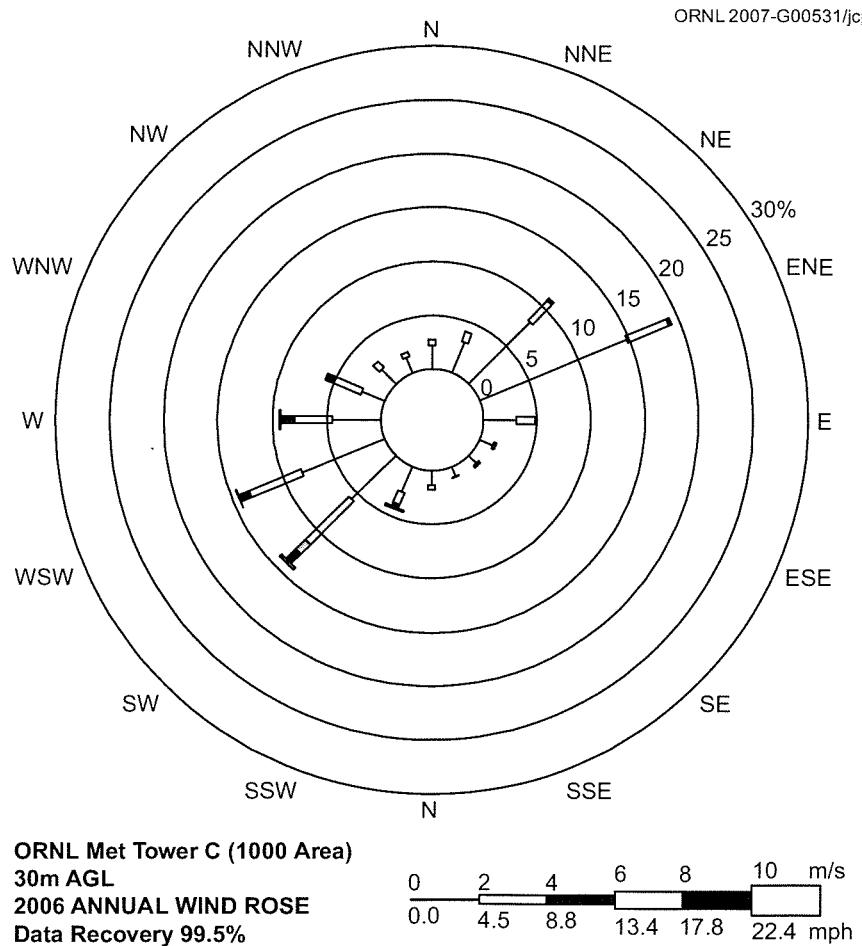


Fig. B.2. Wind rose for ORNL Meteorological Tower C for data taken at 30 m above ground level, 2006.

A wind rose depicts the typical distribution of wind speed and direction for a given location. The winds are represented in terms of the direction from which they originate. The rays emanating from the center correspond to points of the compass. The length of each ray is related to the frequency that winds blow from that direction. The concentric circles represent increasing frequencies from the center outward.

Temperature and Precipitation

Temperature and precipitation normals (1975–2005) and extremes (1948–2006), and their durations are summarized for the City of Oak Ridge in Table B.1. Hourly freeze data (1985–2006) are given in Table B.2.

Stability

The local ridge-and-valley terrain plays a role in the development of stable surface air under certain conditions and influences the dynamics of air flow. Although ridge-and-valley terrain creates identifiable patterns of association during unstable conditions as well, strong vertical mixing and momentum tend to significantly reduce these effects (see Table B.3). Stability describes the tendency of the atmosphere to

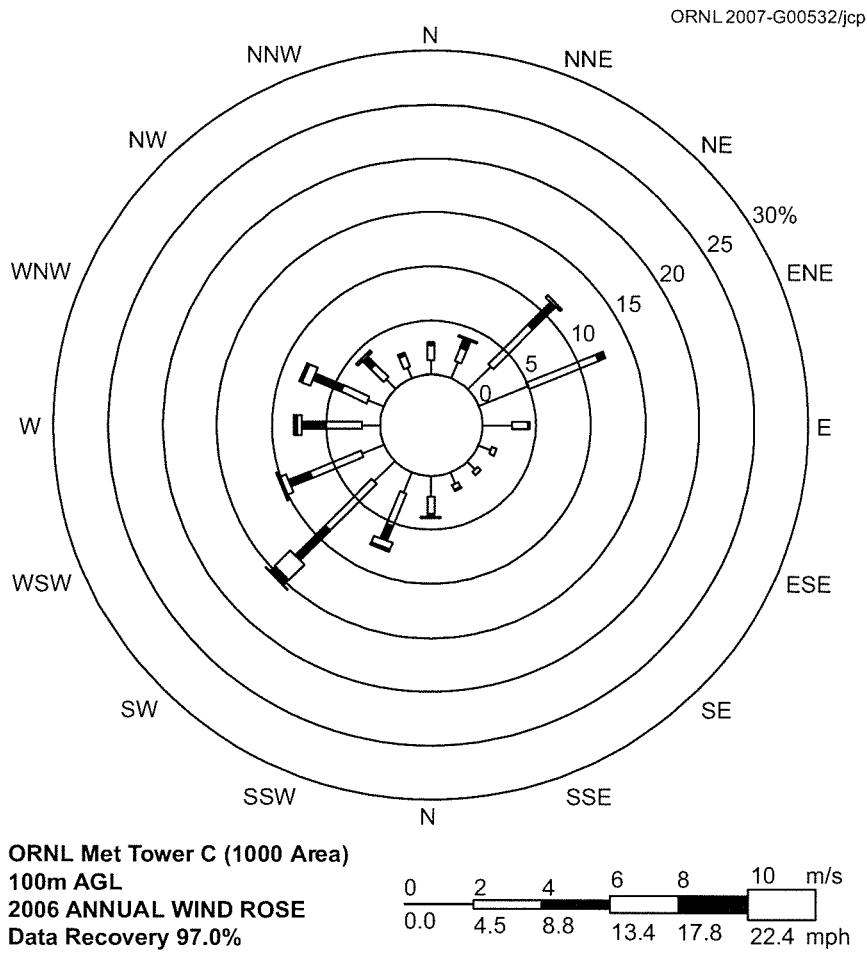


Fig. B.3. Wind rose for ORNL Meteorological Tower C for data taken at 100 m above ground level, 2006.

mix or overturn. Consequently, dispersion parameters are influenced by the stability characteristics of the atmosphere. Stability classes range from "A" (very unstable) to "G" (very stable). The "D" stability class represents a neutral state. (see Table B.4).

The suppression of vertical motions during stable conditions increases the frequency with which air motion is impacted by the local terrain. Conversely, stable conditions isolate wind flows within the ridge-and-valley terrain from the effects of more distant terrain features and from winds aloft. These effects are particularly true with respect to mountain waves. Deep stable layers of air tend to reduce the vertical space available for oscillating vertical air motions caused by local mountain ranges (Smith et al. 2002). This effect on mountain wave formation may be important with regard to the impact that the nearby Cumberland Mountains may have on local air flow.

A second factor that may decouple large-scale wind flow effects from local ones (and thus produce stable surface layers) occurs with overcast sky conditions. Clouds overlying the Great Valley may warm due to direct insolation on the cloud tops. Warming may also occur within the clouds as latent energy is released due to the condensation of moisture. Surface air underlying the clouds may remain relatively cool (as it is cut off from direct exposure to the sun). Consequently, the vertical temperature gradient associated with the air mass becomes more stable (Lewellen and Lewellen 2002). Long wave cooling of a fog deck has also been observed to help modify stability in the surface layer (Whiteman et al. 2001).

Stable boundary layers typically form as a result of radiational cooling processes near the ground (Van De Weil et al. 2002); however, they are also influenced by the mechanical energy supplied by horizontal wind motion (which is in turn influenced by the large-scale "weather"-related pressure

gradient). Ridge-and-valley terrain may have a significant ability to block such winds and their associated mechanical energy (Carlson and Stull 1986). Consequently, enhanced radiational cooling at the surface results since there is less wind energy available to remove chilled air.

Stable boundary layers also exhibit intermittent turbulence that has been associated with a number of the above factors. The process results from a “give-and-take” between the effects of friction and radiational cooling. As a stable surface layer intensifies via a radiation cooling process, it tends to decouple from air aloft, thereby reducing the effects of surface friction. The upper air layer responds with an acceleration in wind speed. Increased wind speed aloft results in an increase in mechanical turbulence and wind shear at the boundary with the stable surface layer. Eventually, the turbulence works into the surface layer and weakens it. As the inversion weakens, friction again increases, reducing winds aloft. The reduced wind speeds aloft allow enhanced radiation cooling at the surface, which re-intensifies the inversion and allows the process to start again. Van De Weil et al. (2002) have shown that cyclical temperature oscillations up to 4°C may result from these processes. Since these intermittent processes are driven primarily by large-scale horizontal wind flow and radiational cooling of the surface, ridge-and-valley terrain significantly affects these oscillations.

Table B.1. Climate normals (1976–2005) and extremes (1948–2006) for Oak Ridge, Tennessee (Town Site), with 2006 Comparisons

Monthly variables	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Temperature, °C (°F)													
30-year average max	7.5 (45.5)	11.0 (51.8)	16.3 (61.4)	21.7 (71.0)	25.7 (78.2)	29.5 (85.1)	31.3 (88.4)	30.9 (87.6)	27.5 (81.5)	22.7 (72.9)	15.4 (59.7)	9.3 (48.7)	20.7 (69.3)
2006 average max	12.5 (54.5)	10.3 (50.6)	16.2 (61.2)	24.1 (75.4)	24.6 (76.2)	29.9 (85.9)	32.1 (89.7)	31.9 (89.4)	25.1 (77.1)	19.8 (67.6)	15.4 (59.7)	12.9 (55.3)	21.2 (70.2)
59-year record max	24 (76)	26 (79)	30 (86)	33 (92)	34 (93)	38 (101)	41 (105)	39 (103)	39 (102)	32 (90)	28 (83)	26 (78)	41 (105)
30-year average Min	-2.9 (26.7)	-1.1 (30.1)	2.9 (37.2)	6.9 (44.5)	12.1 (53.8)	16.8 (62.3)	19.4 (66.9)	18.9 (66.0)	14.9 (58.9)	8.1 (46.5)	3.1 (37.6)	-1.4 (29.4)	8.1 (46.7)
2006 average min	1.9 (35.5)	-1.0 (30.2)	4.2 (39.5)	10.7 (51.3)	12.7 (54.8)	17.2 (63.0)	20.2 (68.3)	21.4 (70.5)	14.3 (57.8)	7.6 (46.5)	3.3 (37.9)	0.1 (32.1)	9.4 (48.9)
59-year record min	-27 (-17)	-25 (-13)	-17 (1)	-7 (20)	-1 (30)	4 (39)	9 (49)	10 (50)	1 (33)	-6 (21)	-18 (0)	-22 (-7)	-27 (-17)
30-year average	1.4 (34.6)	4.0 (39.2)	9.0 (48.2)	14.8 (58.6)	18.5 (65.3)	22.7 (72.8)	24.6 (76.2)	24.8 (76.6)	21.2 (70.2)	14.8 (58.7)	8.8 (47.9)	3.9 (39.0)	14.0 (57.3)
2006 average	7.2 (45.0)	4.7 (40.4)	10.2 (50.4)	17.4 (63.4)	18.6 (65.5)	23.6 (74.5)	26.1 (79.0)	26.7 (80.0)	19.7 (67.5)	13.7 (56.6)	9.3 (48.8)	6.5 (43.7)	15.3 (59.6)
2006 departure from average	5.8 (10.4)	0.7 (1.2)	1.2 (2.2)	2.7 (4.8)	0.1 (0.2)	0.9 (1.7)	1.6 (2.8)	1.9 (3.4)	-1.5 (-2.7)	-1.2 (-2.1)	0.5 (0.9)	2.6 (4.7)	1.3 (2.3)
30-year average heating degree days, °C (°F)^a													
	497 (895)	378 (681)	279 (502)	133 (239)	43 (77)	3 (5)	0	0	16 (28)	126 (226)	278 (500)	442 (796)	2194 (3949)
30-year average cooling degree days, °C (°F)^a													
	0	0	1 (2)	12 (22)	58 (105)	147 (264)	218 (393)	200 (360)	103 (185)	14 (26)	1 (2)	0	755 (1359)
Precipitation, mm (in.)													
30-year average	122.2 (4.81)	121.7 (4.79)	129.8 (5.11)	111.5 (4.39)	122.5 (4.82)	118.1 (4.65)	138.0 (5.43)	86.1 (3.39)	99.6 (3.92)	71.9 (2.83)	125.3 (4.93)	127.5 (5.02)	1374.3 (54.09)
2006	135.7 (5.34)	60.7 (2.39)	117.9 (4.64)	194.6 (7.66)	57.7 (2.27)	34.3 (1.35)	108.2 (4.26)	127.8 (5.03)	121.2 (4.77)	125.3 (4.93)	86.6 (3.41)	63.5 (2.50)	1233.6 (48.55)
2006 departure from average	13.5 (0.53)	-61.0 (-2.40)	-11.9 (-0.47)	83.1 (3.27)	-64.8 (-2.55)	-83.8 (-3.30)	-29.7 (-1.17)	41.7 (1.64)	21.6 (0.85)	53.4 (2.10)	-38.6 (-1.52)	-64.0 (-2.52)	-140.8 (-5.54)
59-year record max monthly	337.2 (13.27)	324.7 (12.78)	311.0 (12.24)	356.5 (14.03)	271.9 (10.70)	283.0 (11.14)	489.6 (19.27)	265.8 (10.46)	176.6 (6.95)	176.6 (6.95)	310.5 (12.22)	321.2 (12.64)	489.6 (19.27)
59-year record max 24-h	108.0 (4.25)	131.6 (5.18)	120.4 (4.74)	158.5 (6.24)	112.0 (4.41)	94.0 (3.70)	124.8 (4.91)	190.1 (7.48)	129.8 (5.11)	67.6 (2.66)	130.1 (5.12)	130.1 (5.12)	190.1 (7.48)
59-year record min monthly	23.6 (0.93)	21.3 (0.84)	54.1 (2.13)	22.4 (0.88)	20.3 (0.80)	13.5 (0.53)	31.3 (1.23)	13.7 (0.54)	Trace	Trace	34.8 (1.37)	17.0 (0.67)	13.5 (0.53)
Snowfall, mm (in.)													
30-year average	99.1 (3.9)	101.6 (4.0)	12.7 (0.5)	5.1 (0.2)	0	0	0	0	0	0	2.5 (0.1)	53.4 (2.1)	274.4 (10.8)
2006	Trace (Trace)	88.9 (3.5)	Trace (Trace)	0	0	0	0	0	0	0	Trace (Trace)	0	88.9 (3.5)
59-year record monthly	243.9 (9.6)	437.0 (17.2)	533.6 (21.0)	149.9 (5.9)	Trace	0	0	0	0	Trace	165.2 (6.5)	533.6 (21.0)	533.6 (21.0)
59-year record 24-h	210.9 (8.3)	287.1 (11.3)	304.9 (12.0)	137.2 (5.4)	Trace	0	0	0	0	Trace	165.2 (6.5)	304.9 (12.0)	304.9 (12.0)

Table B.1 (continued)

Monthly variables	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Days, average, maximum, and minimum temperature													
30-year average max $\geq 32^{\circ}\text{C}$	0	0	0	0.1	0.9	5.1	14.5	11.7	3.8	0	0	0	36.1
2006 days max $\geq 32^{\circ}\text{C}$	0	0	0	0	4	7	20	17	0	0	0	0	48
30-year average min $\leq 0^{\circ}\text{C}$	22.7	17.2	12.1	2.8	0.1	0	0	0	0	2.2	11.4	20.3	88.8
2006 days min $\leq 0^{\circ}\text{C}$	13	20	8	0	0	0	0	0	0	4	11	16	72
30-year average max $\leq 0^{\circ}\text{C}$	3.4	1.3	0.2	0	0	0	0	0	0	0	0.1	1.8	6.8
2006 days max $\leq 0^{\circ}\text{C}$	0	0	0	0	0	0	0	0	0	0	0	1	1
Days, average, maximum, and minimum precipitation													
30-year average $\geq 0.01 \text{ in.}$	11.6	10.6	12.0	10.2	11.6	11.6	12.3	9.7	9.3	8.1	10	11.1	128.1
2006 days $\geq 0.01 \text{ in.}$	13	10	9	13	13	7	14	13	10	10	8	8	128
30-year average $\geq 1.00 \text{ in.}$	1.3	1.2	1.5	0.8	1.5	1.4	1.5	0.8	1.3	0.8	1.4	1.4	14.9
2006 days $\geq 1.00 \text{ in.}$	1	0	1	1	0	0	0	0	1	1	2	1	8

^aUnit degrees, not absolute degrees.

Table B.2. Hourly freeze data for Oak Ridge, Tennessee, 1985–2006
Number of hours at or below a given temperature (°C)^a

Year	January				February				March				April		May		October				November				December				Annual		
	≤0	<-5	<-10	<-15	≤0	<-5	<-10	<-15	≤0	<-5	<-10	≤0	<-5	≤0	<-5	≤0	<-5	≤0	<-5	<-10	≤0	<-5	<-10	<-15	≤0	<-5	<-10	<-15	≤0	<-5	<-10
1985	467	195	103	39	331	127	26	0	105	6	0	43	3	0	0	0	0	22	0	0	431	201	66	2	1399	532	195	41			
1986	308	125	38	10	161	29	3	0	124	28	0	17	0	0	0	0	0	32	10	0	232	34	0	0	874	226	41	10			
1987	302	53	7	0	111	19	3	0	95	0	0	55	4	0	0	0	0	36	0	103	18	0	151	16	0	0	853	110	10	0	
1988	385	182	43	0	294	102	19	0	97	9	0	6	0	0	0	0	0	45	0	62	3	0	301	55	0	0	1190	351	62	0	
1989	163	27	0	0	190	66	10	0	35	0	0	18	0	3	0	7	0	125	14	0	421	188	71	30	962	295	81	30			
1990	142	13	0	0	115	5	0	0	35	0	0	35	0	0	0	0	0	19	0	62	1	0	172	43	5	0	580	62	5	0	
1991	186	44	0	0	158	47	15	0	49	0	0	0	0	0	0	0	0	4	0	148	16	0	192	38	0	0	737	145	15	0	
1992	230	65	8	0	116	22	0	0	116	4	0	27	2	0	0	0	0	7	0	100	0	0	0	166	9	0	0	762	102	8	0
1993	125	11	0	0	245	47	8	0	124	32	9	3	0	0	0	0	0	0	0	152	2	0	0	223	44	0	0	872	136	17	0
1994	337	191	85	26	196	46	3	0	66	0	0	18	0	0	0	0	0	0	0	53	1	0	0	142	0	0	0	812	238	88	26
1995	240	45	6	0	217	84	18	0	37	0	0	0	0	0	0	0	0	0	0	142	3	0	0	288	84	10	0	924	216	34	0
1996	301	91	0	0	225	110	62	27	182	49	6	23	0	0	0	0	3	0	101	0	0	0	194	40	4	0	1029	290	72	27	
1997	254	101	24	0	67	0	0	0	25	0	0	6	0	0	0	0	6	0	96	10	0	0	232	14	0	0	686	125	24	0	
1998	97	10	7	0	25	0	0	0	74	20	0	0	0	0	0	0	0	0	38	0	0	0	132	4	0	0	366	34	7	0	
1999	181	68	0	0	113	14	0	0	62	0	0	0	0	0	0	0	4	0	41	0	0	0	177	23	0	0	578	105	0	0	
2000	273	62	5	0	127	30	0	0	18	0	0	8	0	0	0	0	11	0	94	11	0	0	345	124	7	0	876	227	12	0	
2001	281	60	5	0	79	9	0	0	53	0	0	2	0	0	0	0	18	0	28	0	0	0	137	35	0	0	598	104	5	0	
2002	185	28	0	0	121	16	0	0	91	17	0	2	0	0	0	0	0	0	41	0	0	0	82	6	0	0	522	67	0	0	
2003	345	123	26	0	117	12	0	0	19	0	0	0	0	0	0	0	0	0	37	0	0	0	102	9	0	0	620	144	26	0	
2004	285	50	2	0	76	0	0	0	18	0	0	0	0	0	0	0	0	0	9	0	0	0	247	41	4	0	635	91	6	0	
2005	151	65	6	0	52	1	0	0	81	1	0	0	0	0	0	0	1	0	55	0	0	0	176	28	0	0	516	95	6	0	
2006	70	0	0	0	169	19	0	0	44	0	0	0	0	0	0	0	15	0	37	0	0	0	126	41	1	0	461	60	1	0	
Avg.	241	73	17	3	150	37	8	1	70	8	1	12	0	0	0	0	8	0	72	4	0	0	212	49	8	1	766	171	33	6	

^aSource: 1985–2006 National Oceanic and Atmospheric Administration Atmospheric Turbulence and Diffusion Division KOQT Station, Automated Surface Observing System.

Table B.3. Hourly mixing height statistics for the Oak Ridge Reservation during 2006 (eastern standard time)

Hour	Average height (m)				
	Annual	Dec–Feb	Mar–May	Jun–Aug	Sep–Nov
0100	262	301	288	226	238
0200	263	295	270	227	262
0300	261	306	288	233	218
0400	259	305	279	228	224
0500	259	319	270	230	220
0600	264	331	266	229	232
0700	270	325	283	241	233
0800	260	289	280	239	233
0900	294	302	339	264	270
1000	385	371	430	416	323
1100	609	459	611	896	464
1200	871	536	973	1420	693
1300	1034	646	1005	1635	837
1400	1153	702	1147	1756	996
1500	1237	734	1244	1846	1113
1600	1244	761	1275	1805	1123
1700	1192	667	1371	1768	950
1800	1030	627	1265	1518	695
1900	893	544	1176	1373	466
2000	464	350	625	592	285
2100	285	300	348	268	224
2200	250	301	266	203	230
2300	255	277	299	211	231
2400	255	302	285	211	223
All	565	429	615	748	461

**Table B.4. Stability distribution by hour of the day measured at ORNL Tower C, 2006
(local time)**

Hour	Stability class ^a						
	A	B	C	D	E	F	G
1	0	0	0	24	48	210	83
2	0	0	0	25	52	202	86
3	0	0	0	28	47	213	77
4	0	0	0	22	53	216	74
5	0	0	0	24	52	218	71
6	0	0	0	22	46	231	66
7	0	0	0	23	48	226	68
8	0	0	0	365	0	0	0
9	0	100	17	248	0	0	0
10	0	196	68	101	0	0	0
11	17	181	104	63	0	0	0
12	59	165	90	51	0	0	0
13	90	140	89	46	0	0	0
14	83	146	95	41	0	0	0
15	69	143	106	47	0	0	0
16	32	152	109	72	0	0	0
17	0	0	0	159	199	7	0
18	0	0	0	129	185	51	0
19	0	0	0	73	191	94	7
20	0	0	0	43	145	152	25
21	0	0	0	30	78	212	45
22	0	0	0	29	61	210	65
23	0	0	0	27	61	197	80
24	0	0	0	19	54	208	84

^aStability classes range from "A" (very unstable) to "G" (very stable). The "D" stability class represents a neutral state.

Appendix C. Glossary

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absorption, atomic — 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.

ACM — Asbestos-containing materials.

aliquot — The quantity of sample being used for analysis.

alkalinity — 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; it has 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.

analyte — A constituent or parameter that is being analyzed.

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.

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 — The 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 applications. It was abolished by the Energy Reorganization Act of 1974 and was succeeded by the Energy Research and Development Administration (now part of the Department of Energy and the 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 Environmental Protection Agency (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.

Oak Ridge Reservation

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 — A positively charged ion.

CERCLA-reportable release — A release to the environment that exceeds reportable quantities as defined by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

chain-of-custody — A form that documents sample collection, transport, analysis, and disposal.

chemical oxygen demand — Indicates the quantity of oxidizable materials present in 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, and tetrachloroethene. 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 — Specifically, closure of a hazardous waste management facility under Resource Conservation and Recovery Act (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 — A measure of the radiation from an object or device; the signal that announces an ionization event within a counter.

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 (μ Ci) — 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.

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 standard (DWS) — Federal primary drinking water standards, both proposed and final, as set forth by the EPA.

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.

duplicate samples — Two or more samples collected simultaneously into separate containers.

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 the 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. Testing 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; half-lives can range in duration from less than a second to many millions of years.

halogenated compound — An organic compound bonded with one of the five halogen elements (astatine, bromine, chlorine, fluorine, or 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.

hydrogeology — Hydrologic aspects of site geology.

hydrology — The science dealing with the properties, distribution, and circulation of natural water systems.

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 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.

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 (mrem) — 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 — A 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 billion (ppb) — A unit measure of concentration equivalent to the weight/volume ratio expressed as micrograms per liter or nanograms per milliliter.

parts per million (ppm) — A unit measure of concentration equivalent to the weight/volume ratio expressed as milligrams per liter.

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 an EPA list because they are toxic and relatively common in industrial discharges.

process sewer — Pipe or drain, generally located underground, used to carry off process water and/or waste matter.

process water — Water used within a system process.

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 \times the radiation quality factor). Dose equivalent is frequently reported in units of millirem (mrem), which is one 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 a methodology or an instrument 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.

statistical significance testing — A procedure for decision making and data evaluation based on mathematical probability that provides a consistent, scientific methodology for collecting, analyzing, and presenting data. Statistical significance testing reflects the mathematical likelihood of certain outcomes but says nothing about its environmental significance.

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 — 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 a sampling location, treated as a 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 whether 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 content analyses. Common examples include trichloroethane, tetrachloroethene, and trichloroethene.

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.

Appendix D. Reference Standards and Data for Water

Table D.1. Reference standards for radionuclides in water

Parameter ^a	National primary drinking water standard ^b	4% of DCG ^c	DCG ^d
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	40,000	1,000,000	
¹³⁷ Cs	120	3,000	
¹⁵⁵ Eu	4,000	100,000	
Gross alpha ^e	15		
Gross beta (mrem/year)	4 ^f		
³ H	20,000 ^g	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 ^h	4	100
²²⁸ Ra	5 ^h	4	100
¹⁰⁶ Ru		240	6,000
⁹⁰ Sr	8 ^g	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
²³⁶ U		20	500
²³⁸ U		24	600
Uranium, natural		24	600
Uranium, total ⁱ (μg/L ^j)	30	20	500

^aOnly the radionuclides included in the Oak Ridge Reservation monitoring programs are listed.
Unless labeled otherwise, units are pCi/L.

^b40 CFR Part 141 National Primary Drinking Water Regulations Subparts B and G. The drinking water standards are resented strictly for reference purposes and only have regulatory applicability for public water supplies.

^cFour percent of the derived concentration guide represents the DOE criterion of 4 mrem effective dose equivalent from ingestion of drinking water.

^dDOE Order 5400.5 Chapter III, "Derived Concentration Guides for Air and Water."

^eExcludes radon and uranium.

^fPer the discussion in 40 CFR 141.66(b), compliance with the 4-mrem/year standard can be assumed if the average annual gross beta particle activity is less than 50 pCi/L and if the average annual concentrations of ³H and ⁹⁰Sr are less than 20,000 pCi/L and 8 pCi/L, respectively, provided that, if both radionuclides are present, the sum of their annual dose equivalents to bone marrow is less than 4 mrem/year. In the text of this document, 50 pCi/L is referred to as the "screening level."

^gThese values are not maximum contaminant levels, but are concentrations that result in the effective dose equivalent of the maximum contaminant level for gross beta emissions, which is 4 mrem/year.

^hApplies to combined ²²⁶Ra and ²²⁸Ra.

ⁱMinimum of uranium isotopes.

^jEffective December 8, 2003.

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Table D.2. Reference standards for chemicals and metals in water

Parameter	National drinking water standards		Tennessee water quality criteria ^c				
	Primary ^a	Secondary ^b	Domestic water supply	Fish and aquatic life		Recreation	
				CMC	CCC	Organisms	Water and organisms ^d
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 (<i>ortho</i>)	600		600			17,000	2,700
1,2-Diphenylhydrazine					2.0	0.36	
1,2,4-Trichlorobenzene	70		70		940	260	
1,3-Dichlorobenzene (<i>meta</i>)					960	320	
1,4-Dichlorobenzene (<i>para</i>)	75		75		2,600	400	
2,4-Dichlorophenol					290	77	
2,4-Dimethylphenol					850	380	
2,4-Dinitrophenol					5,300	69	
2,4-Dinitrotoluene					34	1.1	
2,4,6-Trichlorophenol					24	14	
2-Chlorophenol					150	81	
2-Chloronaphthalene					1,600	1,000	
2-Methyl-4,6-Dinitrophenol					280	13	
3,3-Dichlorobenzidine					0.28	0.21	
3,4-Benzo(b)fluoranthene					0.18	0.038	
Benzo(k)fluoranthene					0.18	0.038	
Acenaphthene					990	670	
Anthracene					40,000	8,300	
Benzidine					0.0020	0.00086	
Benzo(a)anthracene					0.18	0.038	
Benzo(a)pyrene	0.2		0.2		0.18	0.038	
bis-(2-chloroethyl)ether					5.3	0.30	
bis-(2-Chloro-isopropyl)ether					65,000	1,400	
bis-(2-ethylhexyl)phthalate	6		6		22	12	
Butylbenzyl phthalate					1,900	1,500	
Chrysene					0.18	0.038	
Di-n-butyl phthalate					4,500	2,000	
Dibenz(a,h)anthracene					0.18	0.038	
Diethyl phthalate					44,000	17,000	
Dimethyl phthalate					1,100,000	270,000	
Fluoranthene					140	130	
Fluorene					5,300	1,100	
Hexachlorobenzene	1		1		0.0029	0.0028	
Hexachlorobutadiene					180	4.4	
Hexachlorocyclopentadiene	50		50		17,000	240	

Table D.2 (continued)

Parameter	National drinking water standards		Tennessee water quality criteria ^c				
	Primary ^a	Secondary ^b	Domestic water supply	Fish and aquatic life		Recreation	
				CMC	CCC	Organisms	Water and organisms ^d
Hexachloroethane						33	14
Indeno(1,2,3-cd)pyrene						0.18	0.038
Isophorone						9,600	350
N-Nitrosodimethylamine			19			30	0.0069
N-Nitrosodi-n-propylamine						5.1	0.05
N-Nitrosodiphenylamine						60	33
Nitrobenzene						690	17
Pentachlorophenol (pH 7.8)	1		1			30	2.7
Phenol						1,700,000	21,000
Pyrene						4,000	830
Field measurements							
Chlorine (TRC), µg/L				19			
Dissolved oxygen, mg/L				5 (min)			
Temperature, µC			30.5	30.5		30.5	30.5
Turbidity, JTU ^e	1						
pH, standard units		(6.5, 8.5)	(6.0, 9.0)	(6.0, 9.0)		(5.5, 9.0)	(5.5, 9.0)
Metals (mg/L)							
Aluminum		0.05–0.2					
Antimony	0.006		0.006			0.64	0.0056
Arsenic	0.01 ^f		0.010	0.340 (III)	0.15	0.010	0.010
Barium	2		2				
Beryllium	0.004		0.004				
Cadmium	0.005		0.005	0.002 ^g		0.00025	
Chromium, total	0.1		0.1				
Chromium (hexavalent)				0.016	0.011		
Copper	1.3 ^h	1		0.013 ^g	0.009		
Iron		0.3					
Lead	0.015 ^h		0.005	0.065 ^g	0.0025		
Manganese		0.05					
Mercury	0.002		0.002	0.0014	0.00077	0.000051	0.00005
Nickel			0.1	0.470 ^g	0.052	4.6	0.61
Selenium	0.05		0.050	0.02	0.005		
Silver		0.1		0.0032 ^g			
Thallium	0.002		0.002			0.0063	0.0017
Zinc		5		0.120 ^g	0.120		
Others							
Asbestos (fibers/L)	7,000,000						
Chlorine (TRC)				0.019			
Color (color units)		15					
Cyanide (mg/L)	0.2		0.2	0.022	0.0052	220	0.7
<i>E. coli</i> (no./100 mL, geometric mean)			630	630		126	126
<i>E. coli</i> (no./100 mL, individual sample)				2,880		941	941

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Table D.2 (continued)

Parameter	National drinking water standards		Tennessee water quality criteria ^c				
	Primary ^a	Secondary ^b	Domestic water supply	Fish and aquatic life		Recreation	
				CMC	CCC	Organisms	Water and organisms ^d
Odor (threshold odor number)	3						
Total dissolved solids (mg/L)	500	500					
Pesticides/herbicides/PCBs (µg/L)							
2,3,7,8-TCDD (Dioxin)	0.00003		0.00003			0.000001	0.000001
2,4-D	70		70				
2,4,5-TP (Silvex)	50		50				
4,4'-DDT				1.1		0.0022	0.0022
4,4'-DDE						0.0022	0.0022
4,4'-DDD						0.0031	0.0031
a-BHC						0.049	0.026
b-BHC						0.17	0.091
Alachlor	2		2				
Aldrin				3.0		0.00050	0.00049
Atrazine	3		3				
Carbofuran	40		40				
Chlordane	2		2	2.4	0.0043	0.0081	0.0080
Dalapon	200		200				
1,2-Dibromo-3-chloropropane	0.2		0.2				
Di(ethylhexyl)adipate	400		400				
Dieldrin				0.24	0.056	0.00054	0.00052
Di(ethylhexyl)phthalate ⁱ							
Dinoseb	7		7				
Diquat	20		20				
a-Endosulfan				0.22	0.056	89	62
b-Endosulfan				0.22	0.056	89	62
Endosulfan sulfate						89	62
Endothall	100		100				
Endrin	2		2	0.086	0.036	0.81	0.76
Endrin aldehyde						0.30	0.29
Ethylene dibromide	0.05		0.05				
Glyphosate	700		700				
Heptachlor	0.4		0.4	0.52	0.0038	0.00079	0.00079
Heptachlor epoxide	0.2		0.2	0.52	0.0038	0.00039	0.00039
g-BHC (Lindane)	0.2		0.2	2.0	0.08	0.63	0.19
Methoxychlor	40		40				
Oxamyl (Vydate)	200		200				
PCB Aroclors (EPA 119-125)						0.00064	0.00064

Table D.2 (continued)

Parameter	National drinking water standards		Tennessee water quality criteria ^c				
	Primary ^a	Secondary ^b	Domestic water supply	Fish and aquatic life		Recreation	
				CMC	CCC	Organisms	Water and organisms ^d
PCB, total	0.5		0.5			0.00064	0.00064
Picloram	500		500				
Simazine	4		4				
Toxaphene	3		3	0.73		0.0028	0.0028
1,1,1-Trichloroethane	200		200				
1,1-Dichloroethene	7		7			32	0.57
1,1,2-Trichloroethane	5		5			160	5.9
Volatile organics (µg/L)							
1,1,2,2-Tetrachloroethane						40	1.7
1,2-Dichloroethane	5		5			370	3.8
1,2-Dichloroethene ^j							
<i>cis</i> -1,2-Dichloroethene	70		70				
<i>trans</i> -1,2-Dichloroethene	100		100			140,000	700
1,2-Dichloropropane	5		5			150	5.0
<i>cis</i> -1,3-Dichloropropene						1,700	10
<i>trans</i> -1,3-Dichloropropene						1,700	10
Acrolein						290	190
Acrylonitrile						2.5	0.51
Benzene	5		5			510	22
Bromodichloromethane	80 ^k					170	5.5
Bromoform	80 ^k					1,400	43
Carbon tetrachloride	5		5			16	2.3
Chlorobenzene	100		100			21,000	680
Chloroform	80 ^k					4,700	57
Dibromochloromethane	80 ^k					130	4.0
Ethylbenzene	700		700			29,000	3,100
Methylbromide						1,500	47
Methylene chloride (Dichloromethane)	5		5			5,900	46
Styrene	100		100				
Tetrachloroethene	5		5			33	6.9
Toluene	1,000		1,000			200,000	6,800
Trichloroethene	5		5			300	25

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Table D.2 (continued)

Parameter	National drinking water standards		Domestic water supply	Tennessee water quality criteria ^c			
	Primary ^a	Secondary ^b		CMC	CCC	Fish and aquatic life	Recreation
					Organisms	Water and organisms ^d	
Trihalomethanes, total	80 ^k						
Vinyl chloride	2		2			5,300	20
Xylene, total	10,000		10,000				

^a40 CFR Part 141—National Primary Drinking Water Regulations, Subparts B and G, as amended. The drinking water standards are presented strictly for reference purposes and only have regulatory applicability for public water supplies.

^b40 CFR Part 143—National Secondary Drinking Water Regulations, as amended.

^cRules of Tennessee Department of Environment and Conservation, Division of Water Pollution Control, Chapter 1200-4-3, General Water Quality Criteria, as amended. CMC = criterion maximum concentration; CCC= continuous concentration criteria.

^dThese criteria, for the protection of public health, pertain to the consumption of water and organisms. They apply only to waters designated for both recreation and domestic water supply.

^eJackson turbidity unit (JTU) and nephelometric turbidity unit (NTU) are roughly equivalent in the range of 25 to 1000 JTU.

^fAs of January 23, 2006.

^gThe standard is a function of total hardness. The values in this table correspond to a total-hardness value of 100 mg/L.

^h“Action level” for initiation of corrosion-control studies and treatment techniques, applicable to community water systems and nontransient, noncommunity water systems.

ⁱSee bis(2-ethylhexyl)phthalate.

^jSee cis-1,2-Dichlorethene and trans-1,2-Dichloroethene.

^kLimit for total trihalomethanes (bromodichloromethane + bromoform + chloroform + dibromochloromethane).

**Appendix E. National Pollutant Discharge
Elimination System Noncompliance
Summaries for 2006**

Appendix E. National Pollutant Discharge Elimination System Noncompliance Summaries for 2006

E.1 Y-12 Complex

E.1.1. Total Residual Chlorine at Outfall 201

Description and Cause

Total residual chlorine (TRC) field analysis was performed on several grab samples taken at outfall 201 on February 7, 2006, with elevated readings of 0.0542 mg/l and 0.0691 mg/L. Average of these readings results in a daily maximum concentration on February 7, 2006, of 0.0616 mg/L which is above the daily maximum allowed by the permit. A reading taken on the next day, February 8, 2006, was less than 0.05 mg/L or below detection.

Outfall 201 receives flow from the Y-12 National Security Complex outfalls 200 and 135, as well as raw water from the Clinch River. The elevated reading was in part caused by potassium permanganate added to the Clinch River water supplied by the city of Oak Ridge. Chlorine is no longer fed to the raw water and was not in the raw water on that day. An elevated reading taken the same day of the raw water was not chlorine but actually potassium permanganate, since most of the Environmental Protection Agency methods for residual chlorine are also affected by other oxidizers. Several readings taken this day at outfall 200 indicated presence of chlorine. Flow from this outfall will also influence TRC readings made at outfall 201. The dechlorination system was checked and found to be properly operating. The exact cause of elevated TRC readings is not known. Chlorine levels were normal when readings were made the next day.

E.2 East Tennessee Technology Park

E.2.1 Sanitary Water Line Break

Description and Cause

On November 27, 2006, during routine weekly sampling required by the East Tennessee Technology Park (ETTP) National Pollutant Discharge Elimination System (NPDES) Permit No. TN0002950, a non-compliance with the NPDES Permit limit for total residual chlorine (TRC) concentration was identified at storm water outfall 100. The sample result was 0.20 mg/L. This result exceeded the NPDES Permit limit for TRC for this outfall, which is a daily maximum concentration of 0.140 mg/L.

On November 27, 2006, field investigations were initiated to identify the source of the TRC in the discharge from outfall 100. Dechlorination tablets were placed in the outfall 100 drainage network immediately after the discovery of the noncompliance. Field investigations indicated that the source of the TRC was an underground sanitary water line break. On December 15, 2006, repairs to the broken sanitary water line were completed.

On December 11, 2006, during routine NPDES Permit compliance sampling activities, several dead fish were observed in the rip-rap lined channel that transports discharges from the outfall 100 storm drain network to the K-1007-P1 Pond. It was estimated that the total mortality was in excess of 1000 fish. The vast majority of the dead fish were determined to be shad. The cause of the fish kill is believed to be related to the sanitary water line break that discharged chlorinated water into the outfall 100 piping network.

Corrective Actions

The section of water line was immediately valved off, and repairs were effected. Subsequent monitoring of the outfall and the receiving waters revealed no detectable impacts.

E.3 Oak Ridge National Laboratory

E.3.1 No Observed Effect Concentration

Description and Cause

Toxicity tests required by the ORNL NPDES Permit were conducted on the effluent from the ORNL Sewage Treatment Plant (STP) in May, 2006. Survival was 100% for both fathead minnow larvae and *Ceriodaphnia dubia*. However, *Ceriodaphnia dubia* reproduction was significantly different from the control at all test concentrations, resulting in a NOEC being less than 9.8%, which was the lowest concentration tested. Investigation into this toxicity has not revealed a cause. As in occasional previous toxicity tests from this STP effluent, the concentration-response relationship was atypical with an essentially flat concentration-response curve. It appears this occasional flat concentration-response curve is unique to the STP effluent over other effluents at ORNL. Scientists at ORNL believe the test dilution series is the most likely explanation for these anomalous results. The concentration range required to be tested for the STP (9.8% to 41.1%) is highly appropriate for regulatory purposes, but might not be sufficient to produce a typical concentration-response curve in the case of this particular effluent.

Corrective Action

A confirmatory toxicity test of the STP effluent was conducted as required by the terms of the ORNL Permit. The effluent was evaluated for toxicity with *Ceriodaphnia dubia*. In this test, *Ceriodaphnia dubia* survival was 100% in all concentrations tested, and reproduction was not significantly different from the control at any of the test concentrations. This resulted in the NOEC of 41.1%, which was the greatest concentration tested according to the terms of the Permit. Based on the results of the confirmatory test, the toxicity indicated in the initial test appears to have been a temporary condition of unknown cause.

E.3.2 Temperature Change

Description and Cause

During the dry summer season, the discharge from outfall 281 (which is made up primarily of cooling tower blowdown) nearly constitutes the headwaters of the small tributary to which it discharges. In four rounds NPDES required of temperature measurements, the temperature of the tributary downstream of outfall 281 was greater than the upstream temperature in all measurements by amounts varying between 4.8 and 5.1° C, resulting in four NPDES noncompliances. Under narrative permit conditions, the discharge must not cause the instream temperature to change by more than 3°C relative to an upstream control point.

Corrective Action

A number of actions have been implemented at ORNL in an effort to reduce the tower blowdown temperature. A blowdown heat exchanger was installed and is activated if the blowdown temperature approaches 30°C. The system will automatically stop discharging blowdown if the temperature exceeds 30°C. The cooling tower was replaced in 2001; at about the same time, the blowdown point in the secondary coolant system was moved from the “hot” leg (discharge of the primary heat exchangers) to the “cold” leg (discharge of the secondary coolant pumps following cooling of the water by the tower). In a separate corrective action, the effluent was rerouted so that it would flow through a longer, shallower

and wider flow path (shaded by tree canopy) before being discharged to the receiving stream. All of these corrective actions have made incremental improvements, but because the volume of tower blowdown overwhelms natural flow in the stream, they have not completely remedied the problem.

Since its installation, the blowdown heat exchanger has been operated primarily to ensure that the blowdown does not cause the instream temperature to exceed 30.5°C. It is believed that by lowering the set point on the system and perhaps modifying other operational parameters, the blowdown heat exchanger can improve compliance with the 3°C relative temperature change criteria during hot summer conditions. ORNL has initiated a study to test the capabilities of the heat exchanger system and to determine appropriate operational parameters.

With considerable effort, it may be possible to relocate the outfall 281 discharge to another receiving stream as a corrective action. However, because the flow rate in the existing receiving stream would be considerably diminished if the discharge were to be relocated, leaving it at its current location may be environmentally preferable. This option will continue to be evaluated.

Appendix F. Permits

Table F.1. Y-12 Complex environmental permits, 2006

Regulatory Driver	Permit Title/Description	Permit Number	Issue Date	Exp Date	Owner	Operator	Responsible Contractor
CAA	Chip Oxidizer Operating Permit	554594	10/21/2004	10/21/2009	DOE	DOE	BWXT
CAA	Operating Permit (Title V)	554701	10/21/2004	10/21/2009	DOE	DOE	BWXT
CAA	Purification Facility/Construction Permit (Expiration date pending TDEC conversion to Operating Permit)	956248P	06/17/2003		DOE	DOE	BWXT
CAA	Depleted Uranium Forming and Heat Transfer (Construction Permit)	950266P	11/4/1998	7/1/2007	DOE	DOE	BWXT
CWA	Industrial & Commercial User Wastewater Discharge (Sanitary Sewer Permit)	No. I-91	04/01/2005	03/31/2010	DOE	DOE	BWXT
CWA	Pump & Haul 9720-82	SOP 04018	11/30/2004	11/30/2009	BWXT	BWXT	BWXT
CWA	National Pollutant Discharge Elimination System Permit	TN0002968	03/13/2006	12/31/2008	DOE	DOE	BWXT
CWA	General Stormwater Permit (Expires on approval of NOT)	TNR130714	02/06/2004		BWXT	BWXT	BWXT
RCRA	Hazardous Waste Transporter Permit	TN3890090001	1/28/2007	1/31/2008	DOE	DOE	BWXT
RCRA	Hazardous Waste Corrective Action Permit	TNHW-121	09/28/2004	09/28/2014	DOE	DOE, NNSA, and all ORR co-operators of hazardous waste permits	BJC
RCRA	Container Storage Units	TNHW-122	08/31/2005	08/31/2015	DOE	DOE/BWXT Y-12	BWXT / Navarro-GEM JV, co-operator
RCRA	Hazardous Waste Container Storage and Treatment Units	TNHW-127	10/06/2005	10/06/2015	DOE	DOE/BWXT Y-12	BWXT Y-12 co-operator
RCRA	RCRA Post-Closure Permit for the Chestnut Ridge Hydrogeologic Regime	TNHW-128	9/29/2006	9/29/2016	DOE	DOE/BJC	BJC
RCRA	RCRA Post-Closure Permit for the Bear Creek Hydrogeologic Regime	TNHW-116	12/10/2003	12/10/2013	DOE	DOE/BJC	BJC

Table F.1 (continued)

Regulatory Driver	Permit Title/Description	Permit Number	Issue Date	Exp Date	Owner	Operator	Responsible Contractor
RCRA	RCRA Post-Closure Permit for The Upper East Fork Poplar Creek Hydrogeologic Regime	TNHW-113	9/23/2003	9/23/2013	DOE	DOE/BJC	BJC
RCRA	Industrial Landfill IV (Operating, Class II)	IDL-01-103-0075	Permitted in 1988—most recent modification approved 1/13/1994	NA	DOE	DOE/BJC	BJC
RCRA	Industrial Landfill V (Operating, Class II)	IDL-01-103-0083	Initial permit 4/26/1993	NA	DOE	DOE/BJC	BJC
RCRA	Construction and Demolition Landfill (Overfilled, Class IV Subject to CERCLA ROD)	DML-01-103-0012	Initial permit 1/15/1986	NA	DOE	DOE/BJC	BJC
RCRA	Construction and Demolition Landfill VI (Postclosure care and maintenance)	DML-01-103-0036	Permit terminated by TDEC 3/15/2007	NA	DOE	DOE/BJC	BJC
RCRA	Construction and Demolition Landfill VII (Operating, Class IV)	DML-01-103-0045	Initial permit 12/13/1993	NA	DOE	DOE/BJC	BJC
RCRA	Centralized Industrial Landfill II (Postclosure care and maintenance)	IDL-01-103-0189	Most recent modification approved 5/8/1992	NA	DOE	DOE/BJC	BJC

Table F.2. Oak Ridge National Laboratory air permits, 2006

Emission source reference number	Permit number	Source description
73-0112-01	556850	Radioactive Materials Analytical Laboratory
73-0112-02	556850	Radiochemical Development Facility
73-0112-03	556850	Steam Plant
73-0112-05	556850	Manipulator Boot Shop
73-0112-07	556850	Boilers
73-0112-09	556850	Surface Coating and Cleaning Operation
73-0112-11	956542P	Spallation Neutron Source and Central Exhaust Facility (construction permit)
73-0112-24	556850	Boilers
73-0112-25	556850	Boilers
73-0112-37	547563	Air Stripper (Bechtel Jacobs Company permit)
73-0112-82	556850	High Flux Isotope Reactor & Radiochemical Engineering Development Center
73-0112-93	547563	Off Gas & Hot Cell Ventilation (Bechtel Jacobs Company permit)
Not applicable	0904-12 ^a	National Transportation Research Center

^aPermit issued by Knox County Department of Air Quality Management.

Table F.3. East Tennessee Technology Park environmental permits, 2006

Regulatory Driver	Permit Title/Description	Permit Number	Issue Date	Exp Date	Owner	Operator	Responsible Contractor
CAA	K-1202-STI Storage Tank Operating Permit	033203P	3/09/92	10/01/94 ^a	DOE	DOE	BJC
CAA	K-1202-ST2 Storage Tank Operating Permit	034392P	7/27/92	0/01/96 ^a	DOE	DOE	BJC
CAA	K-1420-A1 Storage Tank Operating Permit	034619P	7/27/92	10/01/96 ^a	DOE	DOE	BJC
CAA	K-1423 Solid Waste Repackaging Construction Permit	958435P	10/10/05	10/10/06 ^b	DOE	DOE	BJC
CAA	K-1425 WOS A, B, C, and D Storage Tank Operating Permit	029895P	9/21/90	10/01/96 ^b	DOE	DOE	BJC
CAA	K-1435 TSCA Incinerator Construction	957808I	1/25/05 Amended 8/18/05	1/25/06 ^b	DOE	DOE	BJC
CAA	K-1435-C Tank Farm Operating Permit	037460P	3/03/94	10/01/98 ^b	DOE	DOE	BJC
CAA	K-1407-U CNF Air Stripper Operating Permit	045253P	6/20/96	10/01/00 ^b	DOE	DOE	BJC
CAA	Fugitive Emissions Operating Permit	043016P	1995	10/01/99 ^a	DOE	DOE	BJC
CWA	National Pollutant Discharge Elimination System Permit	TN0002950	03/01/04	03/31/08	DOE	DOE	BJC
CWA	National Pollutant Discharge Elimination System Permit	TN0074225	10/07/2003	09/30/08	DOE	DOE	BJC
CWA	Holding Tank & Haul System for Domestic Wastewater	SOP-99033	4/29/05	4/29/10	BJC	BJC	BJC
CWA	Pump & Haul System for Sanitary Waste	SOP-01042	11/30/06	5/31/10	WESKEM	WESKEM	WESKEM
CWA	Pump & Haul System for Sanitary Waste	SOP-05068	06	06	WSMS	WSMS	WSMS
RCRA	Hazardous Waste Corrective Action Permit	TNHW-121	9/28/04	9/28/14	DOE	DOE	BJC
RCRA	TSCAI Container Storage Units	TNHW-015	9/28/87	9/28/97	DOE	DOE	BJC and Shaw Environmental
RCRA	Hazardous Waste Container Storage and Treatment Units	TNHW-015A	9/30/92	9/30/02	DOE	DOE	BJC and Shaw Environmental
RCRA	Hazardous Waste Container Storage and Treatment Units	TNHW-117	9/30/04	9/30/14	DOE	DOE	BJC, WESKEM, and Shaw Environmental

^aRequest to rescind permit submitted with Title V Major Source Operating Permit Application Update (Update submitted 8/04).

^bExisting permit extended indefinitely until replaced with a Title V Major Source Operating Permit (application submitted 9/20/96), modification requiring an amendment to existing permit, or request to rescind submitted.

Table F.4. Periods of excess emissions and out-of-service conditions for Y-12 Steam Plant east and west opacity monitors, 2006

Date	Stack	Condition	Comments
January 27	East	Opacity monitoring system was inoperative	Realigning the optical head and adjusting the zero and span values
February 7	West	Opacity monitor malfunction	Realigning the optical head and adjusting the zero and span values
February 25	East	Opacity monitoring system was inoperative	Opacity monitor malfunction
February 26 & 27	East	Ninety-six, 6-min periods of excess emissions	The excess emissions resulted of a malfunction which occurred when a bag was blown off in Compartment 7 of Baghouse 4
March 2 & 8	East	Opacity monitoring system was inoperative	Opacity monitor malfunction
March 27	West	Opacity monitoring system was out of service	Performed routine maintenance on the monitor which included adjusting the zero and span values in preparation to conduct the Calibration Error Test
March 30 & 31	East	Opacity monitoring system was out of service	Performed routine maintenance on the monitor which included adjusting the zero and span values in preparation to conduct the Calibration Error Test
October 27	East	Four 6-min periods of excess emissions	Baghouse 4 Chart Recorder malfunction which caused the baghouse bypass dampers to open
November 7	East	Two 6-min periods of excess emissions	Baghouse 4 Chart Recorder malfunction which caused the baghouse bypass dampers to open

Appendix G. Radiation

Appendix G. 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

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” (Alter 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. G.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 (millions of years), depending on the isotope (Table G.1).

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 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.

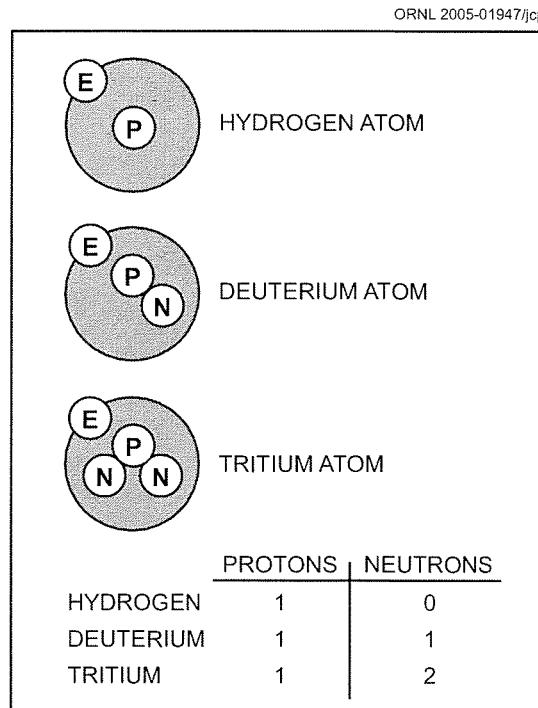


Fig. G.1. The hydrogen atom and its isotopes.

Table G.1. Radionuclide half-lives

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-234m	^{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 day
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 days	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: DOE 1989. *Radioactive Decay Data Tables: A Handbook of Decay Data for Application to Radioactive Dosimetry and Radiological Assessments*, DOE/TIC-11026.

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.

Non-ionizing Radiation

Non-ionizing radiation bounces off or passes through matter without displacing electrons. Examples include visible light and radio waves. At this time, it is unclear whether non-ionizing 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. For example, a person in Denver, Colorado, is exposed to more cosmic radiation than a person in New Orleans, Louisiana.

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 the radon isotope ^{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 ^{87}Rb and ^{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's 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 pa-

tients 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-weapons 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. G.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 could also inhale the 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.

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.

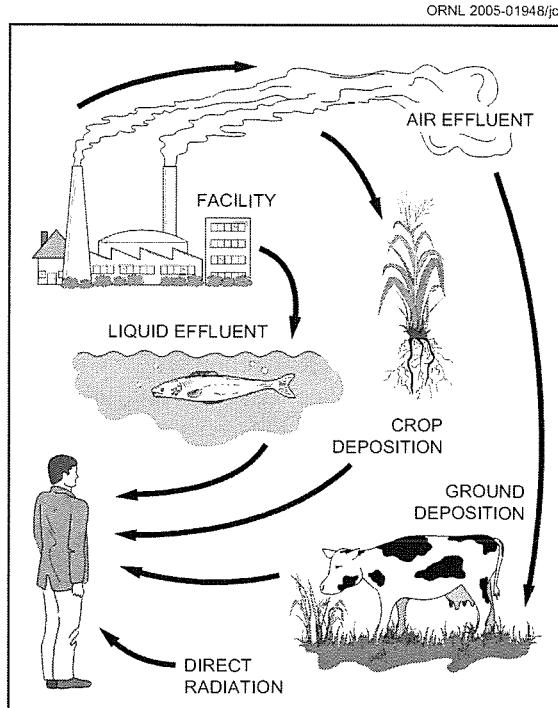


Fig. G.2. Examples of radiation pathways.

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, 1 g 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 usually expressed as 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 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 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 dose conversion factors exist. One type gives the committed dose equivalent (rem) resulting from intake (by inhalation and ingestion) of a unit activity (1.0 μ Ci) of a radionuclide. The second gives the dose equivalent rate (millirem per year) per unit activity (1.0 μ Ci) of a radionuclide in a unit (cubic or square centimeters) of an environmental compartment (air volume or ground surface). All dose conversion factors used in this report were approved by the Department of Energy or by the Environmental Protection Agency (DOE 1988a; DOE 1988b; EPA 1993).

Comparison of Dose Levels

Table G.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.

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

Oak Ridge Reservation

Table G.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 the Environmental Protection Agency (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, Kentucky, 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 Department of Energy (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 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 of 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 Westinghouse Savannah River Company 1994. *Savannah River Site Environmental Report for 1993, Summary Pamphlet*, WSRC-TR-94-076 (WSRC 1994).

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.

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).

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).

Doses 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).

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 an individual's average dose (NCRP 1987).

Water Pathway Dose Methodology

People can be exposed to radionuclides in the environment through a number of routes (Fig. G.2). Potential routes for internal and/or external exposure are referred to as exposure pathways. Several such pathways exist for exposures of humans to radionuclides in water. People may directly ingest (drink) the water. They may eat fish that were caught from the water and, thus, contain radionuclides taken in from the water. Also, people may swim in the water, may boat on the water, and may use shoreline that has absorbed radionuclides from the water. The following sections discuss the methodologies used to calculate potential radiological impacts to persons who drink water; eat fish; and swim, boat, and use the shoreline at various locations along the Clinch and Tennessee rivers. The results of these calculations are summarized in Sect. 8.1.2.2.

Radionuclides discharged to surface waters from the ORR enter the Tennessee River system by way of the Clinch River and various feeder streams (see Sect. 1.5 for the surface water setting of the ORR). Discharges from the Y-12 Complex enter the Clinch River via Bear Creek and East Fork Poplar Creek, both of which enter Poplar Creek before it enters the Clinch River, and by discharges from Rogers Quarry into McCoy Branch and then into Melton Hill Lake. Discharges from ORNL enter the Clinch River via White Oak Creek and Melton Hill Lake via some small drainage creeks. Discharges from the ETTP enter the Clinch River either directly or via Poplar Creek. For convenience, and to correspond to water sampling locations, surface waters around and below the ORR are divided into seven segments (which we call water bodies):

- Melton Hill Lake above all possible ORR inputs,
- Melton Hill Lake,
- Upper Clinch River from Melton Hill Dam to confluence with Poplar Creek,
- Lower Clinch River (from confluence with Poplar Creek to confluence with the Tennessee River),
- Upper Watts Bar Lake (from around the confluence with the Clinch River to below Kingston),
- Lower System (remainder of Watts Bar Lake and Chickamauga Lake), and
- Poplar Creek, including the confluence of East Fork Poplar Creek.

Since East Fork Poplar Creek is posted against water use, dose estimates for such uses are not reported.

The LADTAP XL methodology (Hamby 1991) is used to calculate individual and population doses via waterborne exposure pathways. All dose calculations require definition of radionuclide concentrations in the medium of interest (water, fish, and shoreline) in the water body of interest.

Two methods, determined by the type of data used, are used to estimate potential radiation doses to the public. The first method uses radionuclide concentrations in the medium of interest (i.e., in water and fish) that were determined by laboratory analyses of actual water and fish samples (see Sects. 7.4 and 7.6). The second method estimates radionuclide concentrations in water and fish that were calculated from measured radionuclide discharges and known or estimated stream flows.

The advantage of the first method is the use of radionuclide concentrations actually measured in water and fish; disadvantages are the inclusion of naturally occurring radionuclides especially in gross alpha- and beta-activity measurements, the possibility that some radionuclides of ORR origin might be present in quantities too low to be measured, and the possibility that the presence of some radionuclides might be misstated (e.g., present in a quantity below the detection limit). The advantages of the second method are that most radionuclides discharged from the ORR will be quantified and that naturally occurring radionuclides will not be considered or will be accounted for separately; the disadvantage is the lack of complete river, discharge, and stream flow data. Both methods use models to estimate the concentrations of the radionuclides in water and fish, except at locations (water bodies) where actual measurements are made. Using the two methods should allow the potential radiation doses to be bounded.

For some water bodies, radionuclide concentrations are measured directly. These concentrations are used to calculate concentrations in fish and shoreline, as described below. Concentrations in the water body downstream of the measured water body are obtained by multiplying the measured water body concentrations by the ratio of the measured water body flow (L/year) to the downstream water body flow (L/year); in essence, the concentrations in the upstream water body are diluted by any additional water input to the downstream water body. This dilution calculation continues for all other downstream water bodies.

For other water bodies, data are available on the activities of radionuclides discharged to a water body. These data may be in the form of (1) total activities discharged per year (Ci/year) or (2) activities per unit volume of water (Ci/L) plus the total volume of water discharged per year (L/year). Radionuclide concentrations in the receiving water body are calculated simply by dividing the measured discharge activities (Ci/year) by the total annual flow of the receiving water body (L/year). The process for calculating concentrations in downstream water bodies is the same as that described in the previous paragraph. It should be noted that the discharge flow rate is usually negligible with respect to the receiving water body flow rate.

Equations used to estimate water pathway doses from radionuclide concentrations in water are given in the following sections.

Drinking Water

Several water treatment plants along the Clinch and Tennessee River systems could be affected by discharges from the ORR. Since no in-plant radionuclide concentration data are available for any of these plants; all of the dose estimates given below likely are high because they are based on concentrations of radionuclides in water before it enters a processing plant. For purposes of assessment, it was assumed that maximally exposed individuals drink 730 L/year of water and that the average person drinks 370 L/year.

Table G.3 is a summary of potential EDEs from identified waterborne radionuclides around the ORR and shows the variation in dose based on method used to estimate dose. The EDE from ingestion of water is given by

$$H_{E,i,drink} = U_{drink} * C_{w,i} * DF_{i,ing} * \text{EXP}(-\lambda_{r,i} * t_{drink}) ,$$

where $H_{E,i,drink}$ = EDE due to drinking water containing nuclide i (mrem/year),
 U_{drink} = water consumption rate (L/year),

$C_{w,i}$	= concentration of nuclide i in water ($\mu\text{Ci/L}$),
$DF_{i,\text{ing}}$	= dose conversion factor for ingestion of nuclide i (mrem/ μCi),
$\lambda_{r,i}$	= radioactive decay constant for nuclide i (I/d),
t_{drink}	= time between entry of nuclide into plant and consumption (assumed one day).

Eating Fish

Fishing is quite common on the Clinch and Tennessee River systems. For purposes of assessment, it was assumed that avid fish consumers eat 21 kg/year of fish and that the average person consumes 6.9 kg/year of fish. EDEs were calculated from measured radionuclide contents in fish (see Sect. 7.6), measured concentrations of radionuclides in water, and calculated concentrations in water. The EDE from consumption of fish containing nuclide i is given by

$$H_{E,i,\text{fish}} = U_{\text{fish}} * C_{w,i} * DF_{i,\text{ing}} * B_{i,\text{fish}} * \text{EXP}(-\lambda_{r,i} * t_{\text{fish}}) ,$$

where	$H_{E,i,\text{fish}}$	= EDE due to eating fish containing nuclide i (mrem/year),
	U_{fish}	= fish consumption rate (kg/year),
	$C_{w,i}$	= concentration of nuclide i in water ($\mu\text{Ci/L}$),
	$DF_{i,\text{ing}}$	= dose conversion factor for ingestion of nuclide i (mrem/ μCi),
	$B_{i,\text{fish}}$	= bioaccumulation factor (L/kg),
	$\lambda_{r,i}$	= radioactive decay constant for nuclide i (I/d),
	t_{fish}	= time between harvest and consumption (assumed 10 days).

Fish samples are collected from Melton Hill Lake above all ORR inputs [Clinch River kilometer (CRK) 70], from the upper part of the Clinch River (CRK 32), and from the Clinch River below all ORR inputs (CRK 16). Unidentified beta and alpha activities are often detected in many of the fish samples. Excess beta and alpha activities are estimated by subtracting activities of identified beta- and alpha-particle-emitting radionuclides from the corresponding unidentified activities. The excess unidentified beta and alpha activities are assumed to be from the naturally occurring radionuclides ^{234}Th and ^{226}Ra .

Other Uses

Other uses of the ORR area waterways include swimming or wading, boating, and use of the shoreline. A highly exposed other user was assumed to swim or wade for 30 h/year, boat for 63 h/year, and use the shoreline for 60 h/year. Measured and calculated concentrations of radionuclides in water and the LADTAP XL methodology were used to estimate potential EDEs from these activities.

The EDE from swimming in water containing nuclide i (except tritium) is given by

$$H_{E,i,\text{swim}} = 0.142 * C_{w,i} * U_{\text{swim}} * DF_{i,\text{ws}} ,$$

where	$H_{E,i,\text{swim}}$	= EDE from swimming in water containing nuclide i (mrem/year),
	0.142	= unit conversion factor (1000 L/m^3 divided by 8760 h/year),
	U_{swim}	= time spent swimming (h/year),
	$C_{w,i}$	= concentration of nuclide i in water ($\mu\text{Ci/L}$),
	$DF_{i,\text{ws}}$	= dose conversion factor for submersion in water containing nuclide i (mrem- $\text{m}^3/\text{year-}\mu\text{Ci}$).

Complete submersion is assumed while swimming. For tritium, the swimming dose equation is

$$H_{E,T,\text{swim}} = C_{W,T} * U_{\text{swim}} * I_T * DF_{T,\text{ing}} ,$$

where	$H_{E,T,\text{swim}}$	= EDE from swimming in water containing tritium (mrem/year),
	U_{swim}	= time spent swimming (h/year),

$C_{w,T}$	= concentration of tritium in water ($\mu\text{Ci/L}$),
I_T	= absorption factor for tritium via whole body immersion in water ($= 0.035 \text{ L/h}$),
$DF_{T,\text{ing}}$	= dose conversion factor for ingestion of tritium (mrem/ μCi).

The EDE from boating on water containing nuclide i (except tritium) is given by

$$H_{E,i,\text{boat}} = 0.5 * (0.142 * C_{w,i} * U_{\text{boat}} * DF_{i,ws}) ,$$

where	$H_{E,i,\text{boat}}$	= EDE from boating on water containing nuclide i (mrem/year),
	0.5	= correction factor,
	0.142	= unit conversion factor (1000 L/m ³ divided by 8760 h/year),
	U_{boat}	= time spent boating (h/year),
	$C_{w,i}$	= concentration of nuclide i in water ($\mu\text{Ci/L}$),
	$DF_{i,ws}$	= dose conversion factor for submersion in water containing nuclide i [mrem-m ³ /year- μCi].

The 0.5 correction factor arises from the assumption used in LADTAP XL that doses per unit from boating equal one-half the doses from swimming. Any shielding by the boat's hull is ignored. The dose attributable to any tritium, which emits only very weak beta radiation, in the water is assumed to be 0.

The EDE from using a shoreline containing nuclide i is given by

$$H_{E,i,\text{shore}} = C_{i,\text{shore}} * U_{\text{shore}} * (G_{\text{shore}} / 8760) * DF_{i,\text{soil}} ,$$

where	$H_{E,i,\text{shore}}$	= EDE due to use of shoreline containing nuclide i (mrem/year),
	$C_{i,\text{shore}}$	= annual average concentration of nuclide i in shoreline soil ($\mu\text{Ci/m}^2$),
	U_{shore}	= duration of time spent on the shoreline (h/year),
	G_{shore}	= unitless shoreline width correction factor (0.2 for rivers),
	8760	= number of hours in a year (h/year), and
	$DF_{i,\text{soil}}$	= dose conversion factor for infinitely thick soil containing nuclide (mrem-m ² / $\mu\text{Ci-year}$).

The annual average concentration of nuclide i in shoreline soil is obtained by

$$C_{i,\text{shore}} = C_{w,i} * F_{i,w-s} * T_{1/2,i} * (1 - \text{EXP}[-\lambda_{r,i} * 365 * t_{s-w}]) ,$$

$C_{w,i}$	= annual average concentration of nuclide i in water ($\mu\text{Ci/L}$),
$F_{i,w-s}$	= water-to-sediment transfer coefficient nuclide i ($= 100 \text{ L/m}^2\text{-day}$),
$T_{1/2,i}$	= radioactive half-life of nuclide i (d),
$\lambda_{r,i}$	= radioactive decay constant for nuclide i (1/d),
t_{s-w}	= time over which shoreline soil is exposed to water containing nuclide i ($= 50$ years), and
365	= number of days in a year (d/year).

It is assumed that the buildup and decay of nuclides in shoreline soil has occurred at the current year's rates for the past 50 years.

When compared with EDEs from drinking water and eating fish from the same waters, the EDEs from these other uses are relatively small. Table G.3 is a summary of potential EDEs from identified waterborne radionuclides around the ORR and shows the variation in dose based on method used to estimate dose.

Table G.3. Summary of annual maximum individual effective dose equivalents from waterborne radionuclides (mrem)^a

Type of sample	Drinking water	Eating fish	Other uses	Total of highest
Melton Hill Lake above ORR inputs, CRK 70 and 66				
Fish ^b		0.03		0.03
Water ^c	0.003	0.00007	0.000004	0.003
Maximum	0.003	0.03	0.000004	0.03
Melton Hill Lake, CRK 58				
Water ^c	0.003	0.00007	0.00007	0.003
Discharge ^d	7E-7	1E-6	7E-8	2E-6
Maximum	0.003	0.00007	0.00007	0.003
Upper Clinch River, CRK 23, Gallaher Water Plant, CRK 32				
Fish ^b		0.7		0.7
Water ^c	0.01	0.002	0.00002	0.01
Discharge ^d	0.0001	0.0004	0.00005	0.0005
Maximum	0.01	0.7	0.00005	0.7
Lower Clinch River, CRK 16				
Fish ^b				
Water ^c	NA ^e	0.08	0.004	0.08
Discharge ^d	NA ^e	0.0004	2E-8	0.0004
Maximum	NA ^e	0.08	0.004	0.08
Upper Watts Bar Lake, Kingston Municipal Water Plant				
Water ^c	0.02	0.01	0.0006	0.03
Discharge ^d	2E-11	8E-12	2E-13	3E-11
Maximum	0.02	0.01	0.0006	0.03
Lower System (Lower Watts Bar Lake and Chickamauga Lake)				
Water ^c	0.02	0.01	0.0005	0.03
Discharge ^d	3E-10	1E-10	1E-12	4E-10
Maximum	0.02	0.01	0.0005	0.03
Poplar Creek				
Water ^c	NA ^e	0.3	0.006	0.3
Discharge ^d	NA ^e	0.0009	0.00001	0.0009
Maximum	NA ^e	0.3	0.006	0.3

^a1 mrem = 0.01 mSv.^bDoses based on measured radionuclide concentrations in fish tissue.^cDoses based on measured radionuclide concentrations in water.^dDoses based on measured discharges of radionuclides from on-site outfalls.^eNot at drinking water supply locations.

Appendix H. Chemicals

Appendix H. 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 possible 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. 1982).

Just as all humans are exposed to radiation in the normal daily routine, humans are also exposed to chemicals. Some potentially hazardous chemicals 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. Even some of the foods we eat contain natural toxins. Aflatoxin is a known toxin found in peanuts, and cyanide is found in apple seeds. 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 and gasoline). 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 rapidly 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 that live 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. Chemical health effects are divided into two broad categories: adverse or systemic effects (noncarcinogens) and cancer (carcinogens). Sometimes a chemical can have both a toxic and a carcinogenic effect. The toxic effect can be acute (short-term severe health effect) or chronic (longer-term persistent health effect). Toxicity is often evident in a shorter length of time than the carcinogenic effect. The potential health effects of noncarcinogens range from skin irritation to fatality. Carcinogens cause or increase the incidence of malignant neoplasms or cancers.

Toxicity refers to an adverse effect of a chemical on human health. Every day we ingest chemicals in the form of food, water, and sometimes medications. Even those chemicals 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 are 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

A reference dose is an estimate 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 of chemical per kilogram of an adult's body weight per day (mg/kg-day). These values are given in Table H.1.

Values for reference doses 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. Uncertainty factors are typically used in deriving reference doses. Uncertainty adjustments may be made if animal toxicity data are extrapolated to humans to account for human sensitivity, extrapolated from subchronic to chronic no-observed-adverse-effect-levels, extrapolated from lowest-observed-adverse-effect-levels to no-observed-adverse-effect-levels, and to account for database deficiencies. The use of uncertainty factors in deriving reference doses is thought to protect the sensitive human populations. The Environmental Protection Agency (EPA) maintains the Integrated Risk Information System data base, which contains verified reference doses and up-to-date health risk and EPA regulatory information for numerous chemicals.

Primary Maximum Contaminant Levels

For chemicals for which reference doses are not available in the Integrated Risk Information System, national primary drinking water maximum contaminant levels, expressed in milligrams of chemical per liter of drinking water, are converted to reference dose values by multiplying by 2 liters (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-day). These values are given in Table H.1.

Dose Term for Carcinogens

Slope Factor

A slope factor is a plausible upper-bound estimate of the probability of a response per unit intake of a chemical during 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-day). These values are given in Table G.1.

The slope factor converts the estimated daily intake averaged over a lifetime exposure to the incremental risk of an individual developing cancer. Because it is unknown for most chemicals whether a threshold (a dose below which no adverse effect occurs) exists for carcinogens, units for carcinogens are set in terms of risk factors. Acceptable risk levels for carcinogens range from 10^{-4} (risk of developing cancer over a human lifetime of 1 in 10,000) to 10^{-6} (risk of developing cancer over a human lifetime is 1 in 1,000,000). In other words, a certain chemical concentration in food or water could cause a risk of one additional cancer for every 10,000 (10^{-4}) to 1,000,000 (10^{-6}) exposed persons, respectively.

Table H.1. Chemical reference doses and slope factors used in drinking water and fish intake analysis

Elements			Compounds		
Chemical	Factor	Reference ^a	Chemical	Factor	Reference ^a
Antimony	4.0E-04	RfD	Acetone	9.0E-01	RfD
Arsenic	3.0E-04	RfD	Aroclor-1016	7.0E-05	RfD
	1.5E+00	SF	Aroclor-1260	2.0E-05	RfD ^b
Barium	2.0E-01	RfD	BHC-Delta	4.0E-06	c,d
Beryllium	2.0E-03	RfD	2-Butanone	6.0E-01	RfD
Boron	2.0E-01	RfD	Chlordane(alpha,gamma)	5.0E-04	RfD
Cadmium	5.0E-04	RfD		3.5E-01	SF
Chromium VI	3.0E-03	RfD	4,4'-DDE	3.4E-01	SF
Lead	1.4E-04	c,e	Dieldrin	5.0E-05	RfD
Manganese	1.4E-01	RfD		1.6E+01	SF
Mercury	3.0E-04	RfD ^f	Endrin	3.0E-04	RfD
Molybdenum	5.0E-03	RfD	Heptachlorepoxyde	1.3E-05	RfD
Nickel	2.0E-02	RfD		9.1E+00	SF
Selenium	5.0E-03	RfD	PCBs (mixed)	2.0E+00	SF ^g
Silver	5.0E-03	RfD	Toluene	8.0E-02	RfD
Strontium	6.0E-01	RfD	Tetrachloroethene	1.0E-02	RfD
Thallium	5.7E-05	c,h			
Uranium	3.0E-03	RfD			
Vanadium	7.0E-03	RfD			
Zinc	3.0E-01	RfD			

^aRfD: reference dose ($\text{mg kg}^{-1} \text{ day}^{-1}$); SF: slope factor (risk per mg/kg-day).

^bThe RfD for Aroclor-1254 is also used for Aroclor-1260.

^cThe water quality criteria (WQC) are given in units of micrograms per liter. To convert the concentration to an RfD ($\text{mg kg}^{-1} \text{ day}^{-1}$), divide by 1000 (to convert to milligrams per liter), multiply by the consumption rate (2 L/day), and divide by the mass of a reference man, 70 kg.

^dThis value is based on the 2004 Tennessee WQC for BHC- beta and applied to BHC-Delta for domestic water supplies.

^eThis value is based on the 2004 Tennessee WQC for lead for domestic water supplies.

^fAn EPA-approved oral chronic RfD, SF, or other guideline for elemental mercury in water or aquatic organisms is not available. Most guidelines refer to “recoverable” or inorganic mercury. RfD values exist for several inorganic mercury salts. The EPA oral RfD for soluble mercuric chloride (HgCl_2) is 3.0E-04 mg/kg/day.

^gThe cancer potency of PCB mixtures is determined using a three-tiered approach. This value is the upper bound slope factor for the High Risk and Persistence Tier.

^hThis value is based on the 2004 Tennessee WQC for thallium for domestic water supplies, which reflects the maximum contaminant level value (2 $\mu\text{g/L}$).

Measuring Chemicals

Environmental samples are collected in areas surrounding the ORR and are analyzed for those chemical constituents 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 sensitive; however, they have limits below which they cannot detect the chemicals of interest. Concentrations detected below the reported ana-

lytical detection limits of the instruments are recorded by the laboratory as estimated values, which have a greater uncertainty than those concentrations detected above the detection limits of the instruments. Health effect calculations using these estimated values are indicated with tildes (~) or “J.” The tilde indicates that estimated values were used in estimating the average concentration of a chemical. “J” indicates that the chemical concentration is detected below the reported analytical detection limits of the instruments and is recorded by the laboratory as an estimated value.

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. Clinch River surface water and fish samples are analyzed to estimate chemical contaminant concentrations. It is assumed that individuals 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 0.06 kg of fish per day from the river (21 kg per year). Estimated daily intakes or estimated doses to the public are calculated by multiplying measured (statistically significant) concentrations in water by 2 L or those in fish by 0.06 kg. This intake is first multiplied by the exposure duration (30 years) and exposure frequency (350 days/year), and then divided by an averaging time (30 years for noncarcinogens and 70 years for carcinogens). These assumptions are conservative, and in many cases they result in higher estimated intakes and doses than an actual individual would receive.

Dose Estimate

When the contaminant oral daily intake via exposure pathways has been estimated, the dose is determined. For chemicals, the dose to humans is measured as milligrams per kilogram-day (mg/ kg-day). In this case, the “kilogram” refers to the body weight of an adult individual. When a chemical dose is calculated, 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 30 years. Such exposures are called “chronic” in contrast to short-term exposures, which are called “acute.”

The daily intake or dose from ingestion of water is estimated by the following equation:

$$I = \frac{CW \times IR \times EF \times ED}{BW \times AT},$$

where

- I = intake (mg/kg-day)
- CW = Concentration in water (mg/L)
- IR = Ingestion rate (2 L/day)
- EF = Exposure frequency (350 days/year)
- ED = Exposure duration (30 years)
- BW = Body weight (70 kg)
- AT = Averaging time for noncarcinogens (365 days/year \times ED) or for carcinogens (365 days/year \times 70 years)

The daily intake rate or dose from consumption of fish obtained by recreational anglers is estimated by the following equation:

$$I = \frac{CW \times IR \times EF \times ED}{BW \times AT},$$

where

I = intake (mg/kg-day)
 CW = Concentration in fish tissue wet weight (mg/kg)
 IR = Ingestion rate (0.06 kg/day)
 EF = Exposure frequency (350 days/year)
 ED = Exposure duration (30 years)
 BW = Body weight (70 kg)
 AT = Averaging time for noncarcinogens (365 days/year \times ED) or for carcinogens (365 days/year \times 70 years)

Calculation Methodology

Current risk assessment methodologies use the term hazard quotient to evaluate noncarcinogenic health effects. Because intakes are calculated in milligrams per kilogram per day in the hazard quotient methodology, they are expressed in terms of dose. The hazard quotient is a ratio that compares the estimated exposure dose or intake (I) to the reference dose as follows:

$$HQ = \frac{I}{RfD},$$

where

HQ = hazard quotient (unitless),
 I = estimated intake or dose (mg/kg-day),
 RfD = reference dose (mg/kg-day).

Hazard quotient values of less than 1 indicate an unlikely potential for adverse health effects, whereas hazard quotient values greater than 1 indicate a concern for adverse health effects or the need for further study.

To evaluate carcinogenic risk, slope factors are used instead of reference doses. In previous reports, the estimated dose from ingesting water or fish from rivers and streams surrounding the ORR is compared to the chronic daily intake $I(10^{-5})$ derived from assuming a human lifetime risk of developing cancer of 10^{-5} (1 in 100,000). However, as in typical human health risk assessments, risk levels are derived as follows:

$$R = I \times SF,$$

where

R = risk
 I = estimated intake or (mg/kg-day),
 SF = slope factor, oral (risk per mg/kg-day).

To estimate the risk of inducing cancers from ingestion of water and fish, the estimated dose or intake (I) is multiplied by the slope factor (risk per mg/kg-day). As mentioned earlier, acceptable risk levels for carcinogens range from 10^{-4} (risk of developing cancer over a human lifetime of 1 in 10,000) to 10^{-6} (risk of developing cancer over a human lifetime is 1 in 1,000,000). The tilde (~) indicates that estimated values were used in estimating the average concentrations of a chemical.

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References

Note: In this report we refer to a number of documents (e.g., plans, reports) that are intended for internal use. For the most part, these documents function as a means of communication between governmental agencies and the tenant companies on the Oak Ridge Reservation or as the means by which analytical laboratories deliver results. As such, these documents are not readily available to the public and therefore are not cited in the list of references.

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