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ANNUAL SITE ENVIRONMENTAL REPORT 2008

THE OAK RIDGE RESERVATION

Annual Site ENVIRONMENTAL 2008 Report

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the Oak Ridge Reservation

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Acronyms and Abbreviations

AAS	ambient air station
ACGIH	American Conference of Governmental Industrial Hygienists
ALARA	as low as reasonably achievable
AM	action memorandum
AMO	Atlantic Multidecadal Oscillation
AMSE	American Museum of Science and Energy
ANSI	American National Standards Institute, Inc.
AOC	area of concern
ARAP	aquatic resource alteration permit
ASER	annual site environmental report
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
ASTM	American Society for Testing and Materials
B&W Y-12	B&W Technical Services Y-12
BCG	biota concentration guide
BCK	Bear Creek kilometer
BESC	BioEnergy Science Center
BFK	Brushy Fork kilometer
BJC	Bechtel Jacobs Company LLC
BMAP	Biological Monitoring and Abatement Program, Plan
BSTS	Big Spring Treatment System
CAA	Clean Air Act
CAP-88	Clean Air Assessment software
CBMH	catch basin manhole
CCC	Complex Command Center
CEMS	continuous emission monitoring system
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CH	contact-handled
CMTS	Central Mercury Treatment System
CNF	Central Neutralization Facility
CNMS	Center for Nanophase Materials Sciences
CRK	Clinch River kilometer
CROET	Community Reuse Organization of East Tennessee
CRT	cathode ray tube
CWA	Clean Water Act
CX	categorical exclusion
CY	calendar year
CYRTF	Coal Yard Runoff Treatment Facility
D&D	decontamination and decommissioning
DAC	derived air concentration
DCG	derived concentration guide
DES	detailed energy survey
DOE	U.S. Department of Energy

DOE-EM	DOE Office of Environmental Management
DOE-ORO	DOE Oak Ridge Operations Office
dps	disintegrations per second
DWI	David Witherspoon, Inc.
EC&P	Environmental Compliance and Protection
ECD	Environmental Compliance Department
ECM	energy conservation measures
ECR	environmental compliance representative
ED	effective dose
EDE	effective dose equivalent
EFD	east foundation drain
EFK	East Fork Poplar Creek kilometer
EM	(DOE Office of) Environmental Management
EMC	event mean concentration
EMEF	Environmental Management and Enrichment Facilities
EMMIS	Environmental Monitoring Management Information System
EMS	environmental management system
EMWMF	Environmental Monitoring Waste Management Facility
ENSO	El Niño Southern Oscillation
EO	environmental officer
EP&WSD	Environmental Protection and Waste Services Division
EPA	U.S. Environmental Protection Agency
EPACT	Energy Policy Act
EPCRA	Emergency Planning and Community Right-to-Know Act
EPO	environmental protection officer
EPT	Ephemeroptera, Plectoptera, and Trichoptera (taxa)
ER	Environmental Restoration
ES&H	Environment, Safety, and Health
ESCO	energy savings contractor
ESPC	energy savings performance contract
ESS	Environmental Surveillance System
ETCFC	East Tennessee Clean Fuel Coalition
ETTP	East Tennessee Technology Park
FCK	First Creek kilometer
FEC	Federal Electronics Challenge
FFA	Federal Facility Agreement
FFK	Fifth Creek kilometer
FGR	federal guidance report
FONSI	finding of no significant impact
FS	feasibility study
FY	fiscal year
GCK	Grass Creek kilometer
GET	General Employee Training
gsf	gross square feet
GWQAR	Groundwater Quality Assurance Report
HCK	Hinds Creek kilometer
HEPA	high-efficiency particulate air

HEUMF	Highly Enriched Uranium Materials Facility
HFIR	High Flux Isotope Reactor
HQ	hazard quotient
HSWA	Hazardous Solid Waste Amendment
IC_{25}	inhibition concentration (percentage that caused 25% reduction in survival, reproduction, or growth of the test organisms)
ICK	Ish Creek kilometer
ICP	inductively coupled plasma
ICP-MS	inductively coupled plasma mass spectrometry
ID	identification (number)
IDMS	Integrated Document Management System
IFDP	Integrated Facility Disposition Project
IP	initial proposal
ISM	Integrated Safety Management
ISMS	Integrated Safety Management System
ISO	International Organization for Standardization
ITER	International Thermonuclear Experimental Reactor
JIBS	Joint Institute for Biological Sciences
JTU	Jackson turbidity unit
LANL	Los Alamos National Laboratory
LC_{50}	concentration of aqueous sample lethal to 50% of test organisms in a given time span
LCD	liquid crystal display
LEED®	Leadership in Energy and Environmental Design
LIMS	Laboratory Information Management System
LLW	low-level radioactive waste
LOC	Local Oversight Committee
MACT	Maximum Achievable Control Technology
MBK	Mill Branch kilometer
MCCBK	McCoy Branch kilometer
MCL	maximum contaminant level
MDA	minimum detectable activity
MEK	Melton Branch kilometer
MIK	Mitchell Branch kilometer
MLF	Modernization of Laboratory Facilities
MOA	memorandum of agreement
MRF	Multiprogram Research Facility
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
NIOSH	National Institute for Occupational Safety and Health
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
NPL	National Priorities List
NSF-ISR	NSF International Registrations, Inc.
NSPS	New Source Performance Standard
NTRC	National Transportation Research Center
NTS	Nevada Test Site
NTU	nephelometric turbidity unit
NWTK	Northwest Tributary kilometer
ODS	ozone-depleting substance
OHS	Occupational Health Services
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
ORO	DOE Oak Ridge Operations Office
ORR PCB FFCA	Oak Ridge Reservation Polychlorinated Biphenyl Federal Facilities Compliance Agreement
ORR	Oak Ridge Reservation
ORSSAB	Oak Ridge Site Specific Advisory Board
ORSTP	Oak Ridge Science and Technology Park
OS	DOE Office of Science
OST	Office of Secure Transportation
OSTI	Office of Scientific and Technical Information
P2	pollution prevention
PAM	perimeter air monitoring
PCB	polychlorinated biphenyl
PCCR	phased construction completion report
PCPA	postclosure permit application
PDO	Pacific Decadal Oscillation
PIDAS	Perimeter Intrusion Detection Assessment System
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
PPE	personal protection equipment
PWD	process waste drain
PWTC	Process Waste Treatment Complex
QA	quality assurance
QC	quality control
QE	quality evaluation
R&D	research and development
RAC	Radiological Assessment Corporation
Rad NESHAP	National Emission Standards for Hazardous Air Pollutants for Radionuclides
RATA	Relative Accuracy Test Audit
RCK	Raccoon Creek kilometer
RCRA	Resource Conservation and Recovery Act
RfC	reference concentration
RfD	reference dose

RH	remote-handled
RI	species of regional importance
ROD	record of decision
RQ	reportable quantity
RRD	Research Reactors Division
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SBMS	Standards-Based Management System
SDWA	Safe Drinking Water Act
SE	standard error
SF	slope factor
SHPO	state historic preservation officer
SIP	State Implementation Plan
SMS	Safety Management System
SNS	Spallation Neutron Source
SPCC	Spill Prevention, Control, and Countermeasures Plan
SPEIS	Supplemental Programmatic Environmental Impact Statement
SPWTF	Steam Plant Wastewater Treatment Facility
STP	Sewage Treatment Plant
SWEIS	sitewide environmental impact statement
SWHISS	Surface Water Hydrological Information Support System
SWMU	solid waste management unit
SWP3	Storm Water Pollution Prevention Program
SWSA	solid waste storage area
TCE	trichloroethene
TDEC	Tennessee Department of Environment and Conservation
TEAM	Transformational Energy Action Management
TOA	Tennessee Oversight Agreement
TRC	total residual chlorine
TRU	transuranic
TSCA	Toxic Substances Control Act
TSS	total suspended solids
TVA	Tennessee Valley Authority
TWA	time-weighted average
TWPC	Transuranic Waste-Processing Center
TWRA	Tennessee Wildlife Resources Agency
USDA	U.S. Department of Agriculture
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
WOC	White Oak Creek
WOD	White Oak Dam
WOL	White Oak Lake

WQC	Water quality criteria
WQPP	water quality protection plan
WRRP	Water Resources Restoration Program
WSR	Waste Services Representative
WWTS	Waste Water Treatment System
Y-12 Complex	Y-12 National Security Complex
YSO	Y-12 Site Office

Units of Measure and Conversion Factors

Units of measure and their abbreviations

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

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

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1. Introduction to the Oak Ridge Reservation

The Oak Ridge Reservation (ORR) consists of three major government-owned, contractor-operated facilities: 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/sci/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 450.1A, *Environmental Protection Program*. The results summarized in this report are based on data collected prior to and through 2008. 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. Appendix B contains a glossary of technical terms that may be useful for clarifying some of the language used in this document.

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 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 Tennessee Valley Authority (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 and was the fifth-largest city in Tennessee; however; it was not shown on any map. At the Y-12 National Security Complex (Y-12 Complex or Y-12), south of the city, an electromagnetic method was used to separate uranium-235 (^{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. At that time, 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 ORR contains three major DOE installations: the Y-12 Complex, formerly the Y-12 Plant; Oak Ridge National Laboratory (ORNL), formerly the X-10 site; and the East Tennessee Technology Park (ETTP), formerly the K-25 Site. DOE also operates a number of facilities in addition to the major installation sites (see Sect. 1.4).

1.3 Site Description

1.3.1 Location and Population

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 13,619 ha (approximately 33,653 acres) 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; some of the area west of ETTP lies outside the city limits. The residential section of Oak Ridge forms the northern boundary of the reservation. The TVA's Melton Hill and Watts Bar reservoirs on the Clinch and Tennessee rivers form the southern and western boundaries (Fig. 1.2). The population of the 10-county region surrounding the ORR is about 927,200 with about 1.5% of its labor force employed on the reservation (Fig. 1.3). Other towns close to the reservation include Oliver Springs, Clinton, Lake City, 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 183,550. 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.

1.3.2 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 30 year mean temperature for the period of 1978 to 2007 is 14.6°C. The average temperature for the Oak Ridge area during 2008 was 14.8°C. The coldest month is usually January, with temperatures averaging about 2.8°C. During 2008, January temperatures averaged near normal at 2.8°C. July tends to be the warmest month, with average temperatures of 25.5°C. July 2008 temperatures averaged 25.2°C, slightly below the 30 year mean for July.

Average annual precipitation in the Oak Ridge area for the 30 year period from 1978 to 2007 was 1,340.3 mm, including about 27.9 cm of snowfall annually (NOAA 2009). Total rainfall during 2008, (measured at the Oak Ridge National Weather Service meteorological tower), was 1,184.3 mm, and total

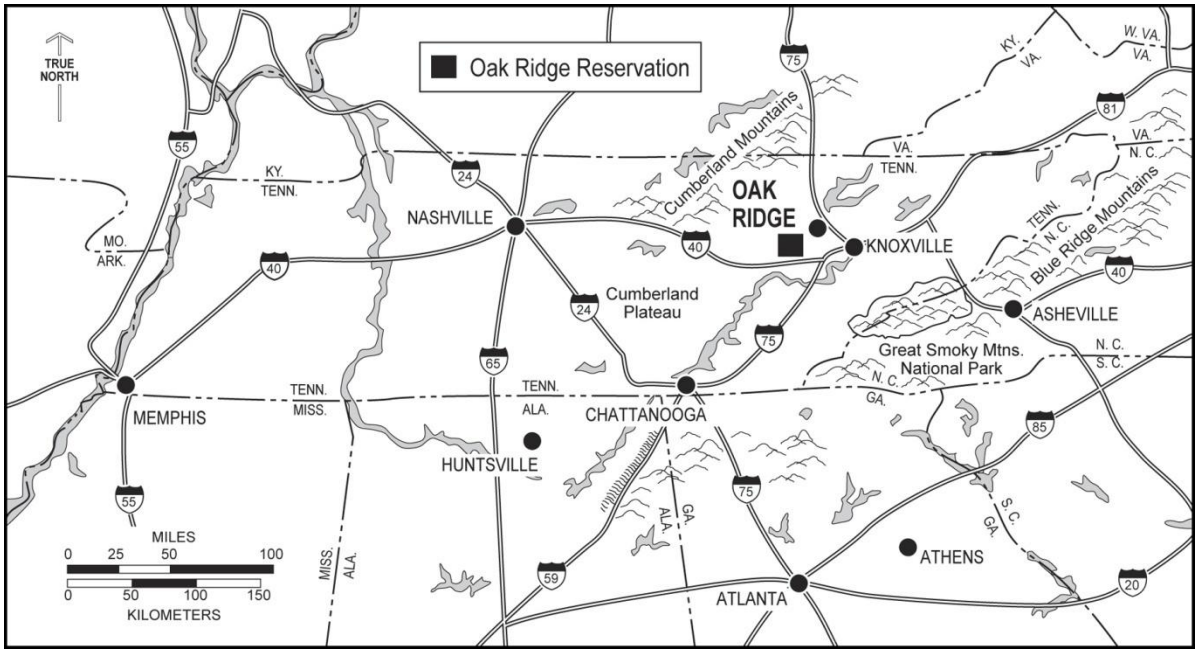


Fig. 1.1. Location of the city of Oak Ridge.

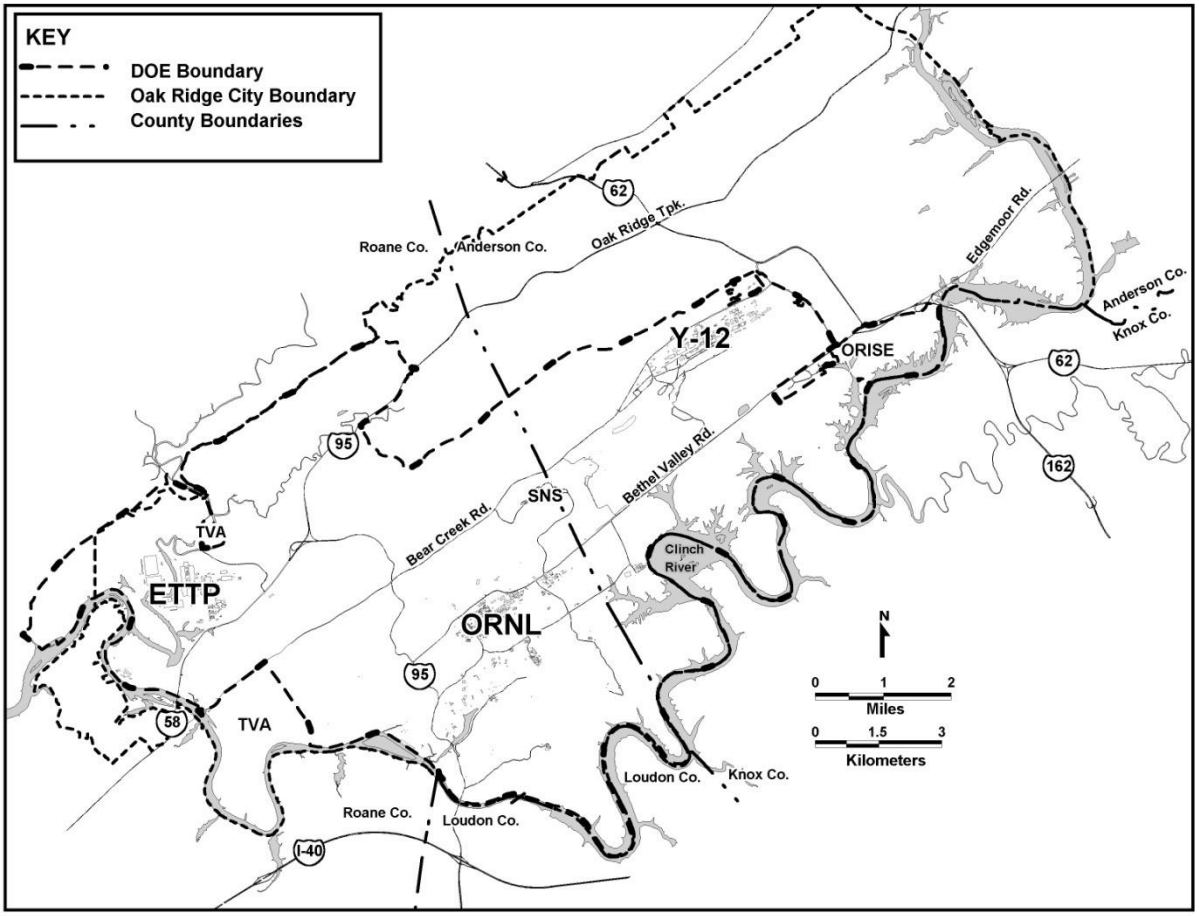


Fig. 1.2. The Oak Ridge Reservation.

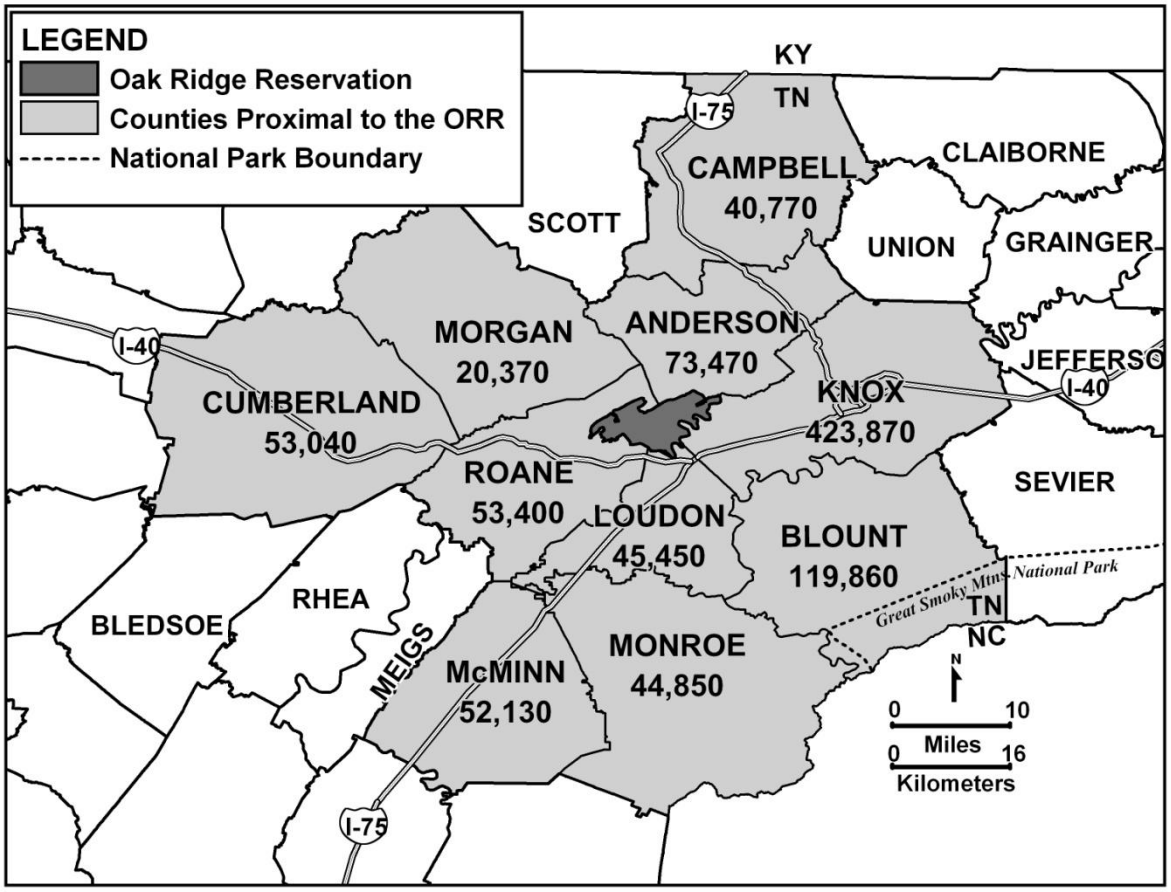


Fig. 1.3. Population by county in the ten-county region surrounding the Oak Ridge Reservation.

2008 snowfall was 2.0 cm. Although precipitation during 2008 was much higher than 2007, it still ranks over 12% below average. Monthly summaries of precipitation averages, extremes, and 2008 values are provided in Appendix C, Table C.1.

In 2008, wind speeds at ORNL Tower C (MT2) measured at 10 m above ground level averaged 1.2 m/s. This value increases to about 3.0 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 ORR towers during 2008 can be found in Appendix C (Figs. C.1–C.17). Wind direction and speed frequencies during precipitation events over the previous 10 years can be found in Appendix C (Figs. C.18–C.21). In Appendix C, Figs. C.22–C.28 provide information on wind direction and speed with respect to stability class during 2008.

More 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).

1.3.3 Regional Air Quality

The Environmental Protection Agency (EPA) Office of Air Quality Planning and Standards has set National Ambient Air Quality Standards (NAAQS) for key principal pollutants, 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); particles with an aerodynamic diameter less than or equal to 10 µm (PM_{10}); and the new, stricter federal standard, fine particulate matter with an aerodynamic

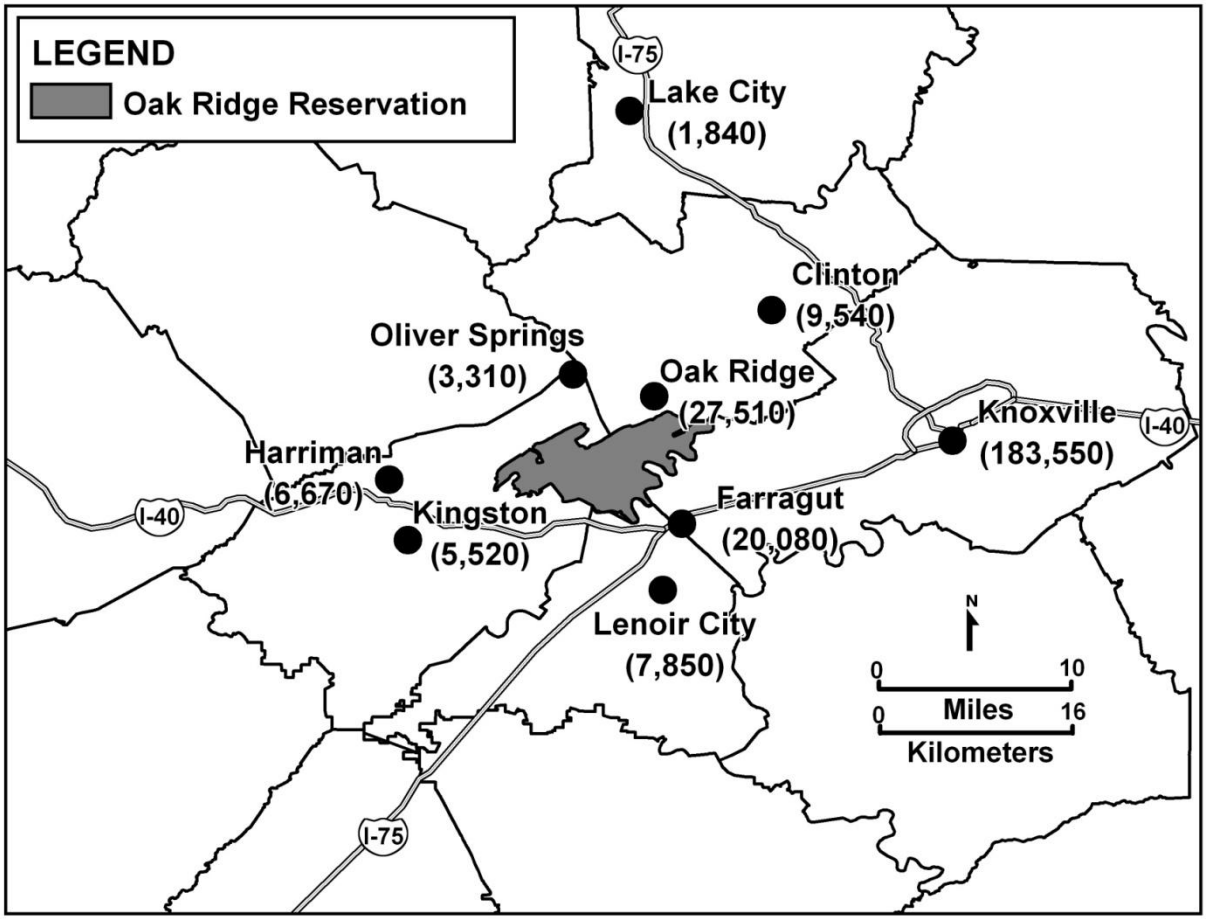


Fig. 1.4. Locations and populations of towns nearest to the Oak Ridge Reservation.

diameter less than or equal to 2.5 µm ($PM_{2.5}$). EPA evaluates NAAQS based on ambient (outdoor) levels of the criteria pollutants. Areas that satisfy NAAQS are classified as attainment areas whereas 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 a nonattainment area for the $PM_{2.5}$ air quality standard. EPA designated the portion of Roane County surrounding the Kingston Steam Plant as a nonattainment area as well. Air quality in the greater Knoxville and Oak Ridge area is in attainment with the NAAQS for all other criteria pollutants for which EPA has made attainment designations.

1.3.4 Surface Water

Waters that drain 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 km^2 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 Complex near the former S-3 Ponds and flows northeast along the south side of the Y-12 Complex. 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 storm water 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 km^2. 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.

1.3.5 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 Upper Conasauga Group, consisting of dolostone and limestone, respectively, comprise the most significant water-bearing hydrostratigraphic unit in the Valley and Ridge Province (Zurawski 1978) as well as on the ORR. Being composed of the fairly soluble minerals, these bedrock formations are prone to dissolution as slightly acidic rainwater and percolating recharge water come in contact with mineral surfaces. This dissolution increases fracture apertures and can form caverns and extensive solution conduit networks under some circumstances. This hydrostratigraphic unit is referred to locally as 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 high productivity of the Knox Aquifer is attributed to the combination of its abundant and sometimes large solution conduit systems and frequently thick overburden soils that promote recharge and storage of groundwater.

The remaining geologic units on the ORR (the Rome Formation, the Conasauga Group below the Maynardville Limestone, and the Chickamauga Group) are composed predominantly of shales, siltstones, and sandstones with a subordinate and locally variable amount of carbonate bedrock. These formations are predominantly composed of insoluble minerals such as clays and quartz that were derived from ancient continental erosion. Groundwater occurs and moves through fractures in those bedrock units. Groundwater availability in such settings is dependent on the abundance and interconnectedness of fractures as well as connection of fractures to sources of recharge, such as alluvial soils along streams that can provide some sustained infiltration. The shale and sandstone formations are the poorest aquifers in the Valley and Ridge Province (Zurawski 1978). Well yields are generally low in the Rome, Conasauga, and Chickamauga bedrock formations except in very localized areas, where carbonate beds may provide greater groundwater storage than adjacent clastic bedrock (Fig. 1.5). Detailed information on ORR groundwater hydrology and flow is available in *Oak Ridge Reservation Physical Characteristics and Natural Resources* (Parr and Hughes 2006).

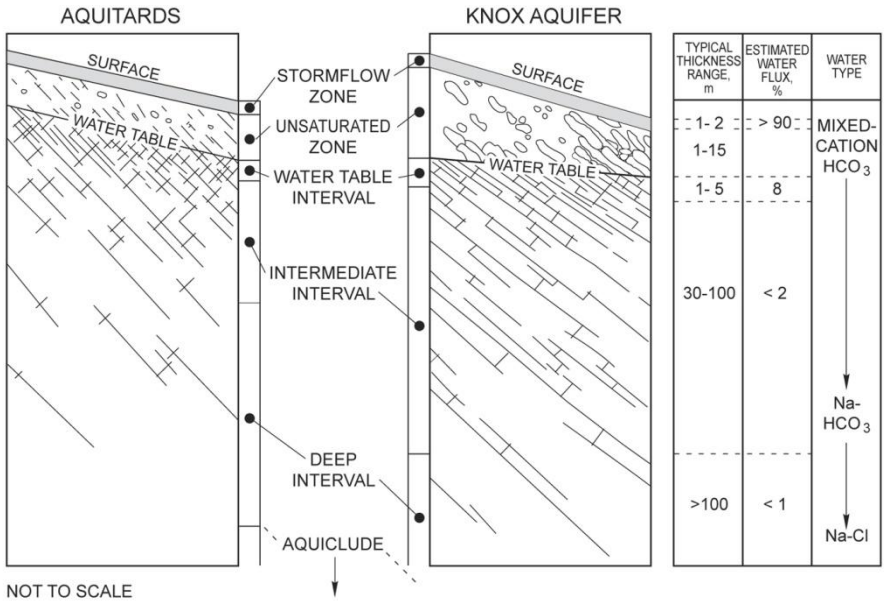


Fig. 1.5. Vertical relationships of flow zones of the ORR: estimated thicknesses, water flux, and water types.

1.3.6 Natural, Cultural, and Historic Resources

The ORR contains a unique variety of natural, cultural, and historic resources. Ongoing efforts continue to focus on preserving the rich diversity of resources found on the reservation.

1.3.6.1 Wetlands

About 243 ha (600 acres) of wetlands have been identified on the ORR, 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 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 ha 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. A detailed wetland map of the ETTP area of responsibility has also been developed and is periodically revised and updated as needed.

1.3.6.2 Wildlife/Endangered Species

Animals listed as species of concern known to be present on the reservation (excluding the Clinch River bordering the reservation) are given along with their status in Table 1.1. 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. Some of these (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. Other 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).

Table 1.1. Animal species of concern reported from and sensitive wildlife species recently found on the Oak Ridge Reservation[a]

Scientific name	Common name	Status[b]		
		Federal	State	PIF[c]
	MAMMALS			
Myotis grisescens	Gray bat	E	E	
Sorex longirostris	Southeastern shrew		NM	
	FISH			
Phoxinus tennesseensis	Tennessee dace		NM	
	AMPHIBIANS AND REPTILES			
Crytobranchus alleganiensis	Hellbender	MC	NM	
Hemidactylium scutatum	Four-toed salamander		NM	
	BIRDS			
	Darters			
Anhinga anhinga	Anhinga		NM	
	Bitterns and Herons			
Ardea alba	Great egret		NM	
Egretta caerulea	Little blue heron		NM	
Egretta thula	Snowy egret		NM	
	Kites, Hawks, Eagles, and Allies			
Haliaeetus leucocephalus	Bald eagle[d]		NM	
Circus cyaneus	Northern harrier		NM	
Accipiter striatus	Sharp-shinned hawk		NM	
Buteo platypterus	Broad-winged hawk			RI
	Falcons			
Falco peregrinus	Peregrine falcon[e]		E	RI
	Grouse, Turkey, and Quail			
Bonasa umbellus	Ruffed grouse			RI
Colinus virginianus	Northern bobwhite			RI
	Rails, Gallinules, and Coots			
Gallinula chloropus	Common moorhen		NM	
	Owls			
Aegolius acadicus	Northern saw-whet owl	MC	T	RI
Tyto alba	Barn owl		NM	

Table 1.1 (continued)

Scientific name	Common name	Status[b]		
		Federal	State	PIF[c]
	Goatsuckers			
Caprimulgus carolinensis	Chuck-will's-widow			RI
Caprimulgus vociferus	Whip-poor-will			RI
	Swifts			
Chaetura pelagica	Chimney swift			RI
	Kingfishers			
Ceryle alcyon	Belted kingfisher			RI
	Woodpeckers			
Melanerpes erythrocephalus	Red-headed woodpecker			RI
Sphyrapicus varius	Yellow-bellied sapsucker	MC	NM	
Picoides pubescens	Downy woodpecker			RI
Colaptes auratus	Northern flicker			RI
	Tyrant Flycatchers			
Contopus cooperi	Olive-sided flycatcher		NM	RI
Contopus virens	Eastern wood-pewee			RI
Empidonax trailii	Willow flycatcher			RI
Empidonax virescens	Acadian flycatcher			RI
	Swallows			
Progne subis	Purple martin			RI
	Titmice and Chickadees			
Poecile carolinensis	Carolina chickadee			RI
	Nuthatches			
Sitta pusilla	Brown-headed nuthatch			RI
	Kinglets, Gnatcatchers, and Thrushes			
Hylocichla mustelina	Wood thrush			RI
	Thrashers and Mockingbirds			
Toxostoma rufum	Brown thrasher			RI
	Shrikes			
Lanius ludovicianus	Loggerhead shrike	MC	NM	RI
	Vireos			
Vireo flavifrons	Yellow-throated vireo			RI

Table 1.1 (continued)

Scientific name	Common name	Status[b]		
		Federal	State	PIF[c]
	Wood Warblers			
Vermivora chrysoptera	Golden-winged warbler	MC	NM	RI
Vermivora pinus	Blue-winged warbler			RI
Dendroica cerulea	Cerulean warbler		NM	RI
Dendroica discolor	Prairie warbler			RI
Dendroica fusca	Blackburnian warbler			RI
Mniotilta varia	Black-and-white warbler			RI
Helmitheros vermivorus	Worm-eating warbler			RI
Seiurus motacilla	Louisiana waterthrush			RI
Oporornis formosus	Kentucky warbler			RI
Wilsonia canadensis	Canada warbler			RI
Wilsonia citrina	Hooded warbler			RI
Icteria virens	Yellow-breasted chat			RI
	Tanagers			
Piranga olivacea	Scarlet tanager			RI
Piranga rubra	Summer tanager			RI
	Cardinals, Grosbeaks, and Allies			
Passerina cyanea	Indigo bunting			RI
	Towhees, Sparrows, and Allies			
Pipilo erythrophthalmus	Eastern towhee			RI
Spizella pusilla	Field sparrow			RI
Ammodramus savannarum	Grasshopper sparrow			RI
Pooecetes gramineus	Vesper sparrow		NM	
	Blackbirds and Allies			
Sturnella magna	Eastern meadowlark			RI

[a]Land and surface waters of the ORR exclusive of the Clinch River, which borders the ORR

[b]Status codes

E = endangered
T = threatened
MC = species of management concern
NM = in need of management
RI = regional importance

[c]Partners in Flight was launched in 1990 in response to growing concerns about declines in the populations of many land bird species, and to emphasize the conservation of birds not covered by existing conservation initiatives.

[d]The bald eagle was federally delisted effective August 8, 2007.

[e]The peregrine falcon was federally delisted effective August 25, 1999.

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. Three gray bats were mist-netted outside a cave on the ORR in 2006. The peregrine falcon, listed by the state of Tennessee as endangered, and the northern saw-whet owl, listed by the state as threatened, are only very rare transients on the site. 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. The bald eagle, also listed by the state as in need of management, is increasingly seen in winter and may well begin nesting here within a few years. Others, such as the northern harrier, great egret, and yellow-bellied sapsucker, are migrants or winter residents that do not nest on the reservation. The golden-winged warbler, listed by the state as in need of management, has been sighted once on the reservation. Barn owls have been known to nest on the reservation in the past. One species, the spotfin chub (*Cyprinella monnacha*), which is listed as threatened by both the state and the federal government, has been sighted and collected in the city of Oak Ridge and is possibly present on the ORR. The Tennessee dace, listed by the state as being in need of management, has been found in some sections of Grassy Creek.

1.3.6.3 Threatened and Endangered Plants

There are currently 22 state 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 1.2). 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 was recently found on the ORR but was removed from the state list at the January 2007 meeting of the Tennessee Heritage Program scientific advisory committee, which produces the state list. 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 plant species listed by the state are currently found on adjacent lands and may be present on the ORR as well, although they have not been located (Table 1.2).

Several changes have been made to the 2008 ORR rare plant list (Table 1.2). In 2008, the naked-stem sunflower was added to the ORR list of state-protected plants (Table 1.2). This plant, found during botanical surveys, is listed as special concern by the state. Also a new site for a plant, spreading false-foxglove, which is special concern, was found. This plant is known from several other sites on the ORR. In addition the ORR list (Table 1.2) has been changed from the 2008 list to make it agree with changes by the state in scientific names used for plants.

1.3.6.4 Historical and Cultural Resources

The DOE Oak Ridge Office (ORO) *Cultural Resource Management Plan* (DOE 2001) was developed to identify, assess, and document historic and cultural resources on the ORR. These resources include the New Bethel Baptist Church and Cemetery (the church and two gravehouses), George Jones Memorial Baptist Church, Freels Cabin (a dwelling and one outbuilding), Bear Creek Road Checking Station, Bethel Valley Road Checking Station, and the Oak Ridge Turnpike Checking Station.

Table 1.2. Vascular plant species listed by state or federal agencies, 2008

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

[a]Status codes:
CE = Status due to commercial exploitation.
E =Endangered in Tennessee.
FSC =Federal Special of Concern; formerly designated as C2. See *Federal Register*, February 28, 1996.
S =Special concern in Tennessee.
T =Threatened in Tennessee.

[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.

[d]Ramps 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.

1.4 DOE Offices and Sites

1.4.1 The DOE Oak Ridge Office

The ORR is home to a world-leading research and manufacturing park, with major federal programs in the areas of science, environmental management, nuclear fuel supply, and national security. The ORO oversees and manages these programs at three primary sites: ORNL, ETTP, and the Oak Ridge Institute for Science and Education (ORISE).

The DOE presence in Oak Ridge has a major financial impact on the area as well; it serves as an economic engine, driving local, regional, and statewide development. DOE is credited with providing a $3.6 billion increase in the gross state product. It supports some 44,889 full-time jobs statewide, results in $76.9 million in state and local sales tax, and is the fourth largest employer in Tennessee.

With a federal and contractor workforce in Oak Ridge of more than 12,000 people, DOE is committed to continuing its strong ties to the communities in East Tennessee. The support of local communities has enabled the ORO to undertake some of the most complex work in DOE, and there is more to come as the ORO advances in public and private sector growth in the areas of science, manufacturing, national security, and reindustrialization.

1.4.2 The National Nuclear Security Administration Y-12 Site Office

Established by Congress in 2000, the National Nuclear Security Administration (NNSA) is a semiautonomous agency within DOE that works in partnership with the U. S. Department of Defense, national laboratories, and production plants to conduct routine maintenance and repair; dismantle retired weapons; refurbish warheads through the Life Extension Program; and maintain the capability to design, manufacture, and certify new warheads for the foreseeable future.

As one of NNSA's major production facilities, the Y-12 National Security Complex is a diverse site that supports NNSA through manufacturing and reworking nuclear weapon components, dismantling nuclear weapon components returned from the national arsenal, serving as the nation's storehouse of special nuclear materials, and providing special production support to other programs.

The NNSA Y-12 Site Office (YSO) is responsible for operation of the Y-12 facilities. YSO employees perform program oversight, contract and administrative management, and technical evaluation and assessment to meet its mission.

1.4.3 Oak Ridge National Laboratory

ORNL, DOE's largest science and energy laboratory (Fig 1.6), has been managed since April 2000 by UT-Battelle, LLC, a partnership of the University of Tennessee and Battelle Memorial Institute. ORNL was established in 1943 as a part of the secret Manhattan Project to pioneer a method for producing and separating plutonium. Today the laboratory supports the nation with a peacetime science and technology mission that is just as important as, but very different from, its role during the Manhattan Project. As an international leader in a range of scientific areas that support DOE's mission, ORNL has six major mission roles: neutron science, energy, high-performance computing, systems biology, materials science at the nanoscale, and national security. ORNL's leadership role in the nation's energy future includes hosting the U.S. project office for the ITER international fusion experiment and the Bioenergy Science Center, which is sponsored by the DOE Office of Science.

1.4.4 The Y-12 National Security Complex

The Y-12 National Security Complex (Fig. 1.7) is a premier manufacturing facility dedicated to making the United States and the world safer places. Operated by Babcock & Wilcox Technical Services Y-12, L.L.C. (B&W Y-12) for NNSA, Y-12 plays a vital role in the DOE's nuclear security enterprise.

Fig. 1.6. The Oak Ridge National Laboratory.

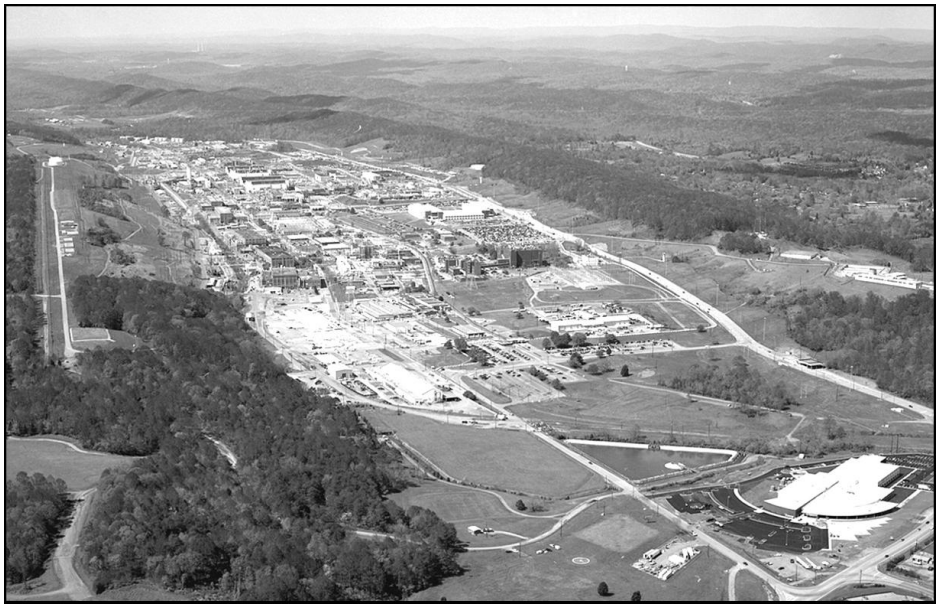


Fig. 1.7. Y-12 National Security Complex.

The complex was constructed as part of the World War II Manhattan Project. Construction for the Manhattan Project began with the first shovelful of dirt turned at Y-12 in February 1943, and operations began in November of that year. The first site mission was the separation of ^{235}U from natural uranium by the electromagnetic separation process. At its peak in 1945, more than 22,000 workers were employed at the site. Thirty months later the success of Y-12's mission was announced to the world when, after two atomic weapons (the uranium bomb, Little Boy, and the plutonium bomb, Fat Man) were detonated, the Empire of Japan surrendered, and World War II ended. Y-12 had separated the uranium used in Little Boy.

Since that time Y-12's missions have changed. Today, Y-12 is a unique national asset in the manufacture, processing and storage of special materials vital to our national security; contributes to the prevention of the spread of weapons of mass destruction; retrieves and stores nuclear materials; fuels the nation's naval reactors; and performs complementary work for other government and private-sector entities.

1.4.5 East Tennessee Technology Park

The ETTP was originally named the "Oak Ridge Gaseous Diffusion Plant" (Fig. 1.8) and began operations during World War II as part of the Manhattan Project. Its original mission was to produce enriched uranium for use in atomic weapons. After the war, the plant was renamed the "Oak Ridge K-25 Site" and produced enriched uranium for the commercial nuclear power industry. The plant was permanently shut down in 1987. DOE renamed the site the "East Tennessee Technology Park" in 1996 and began undergoing cleanup for ultimate conversion to a private sector industrial park called the "Heritage Center." Restoration of the environment, decontamination and decommissioning of facilities, and disposition of wastes are currently the major activities at the site.

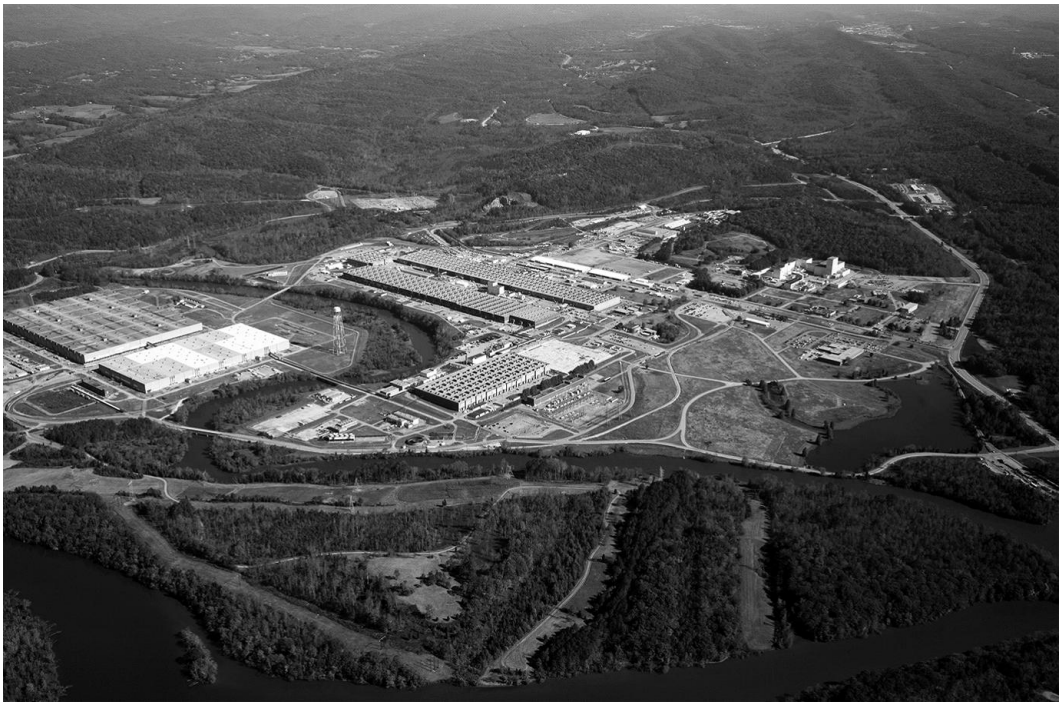


Fig. 1.8. East Tennessee Technology Park.

1.4.6 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 ha, 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 disturbed, 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. 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 almost 60 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 ecological 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.

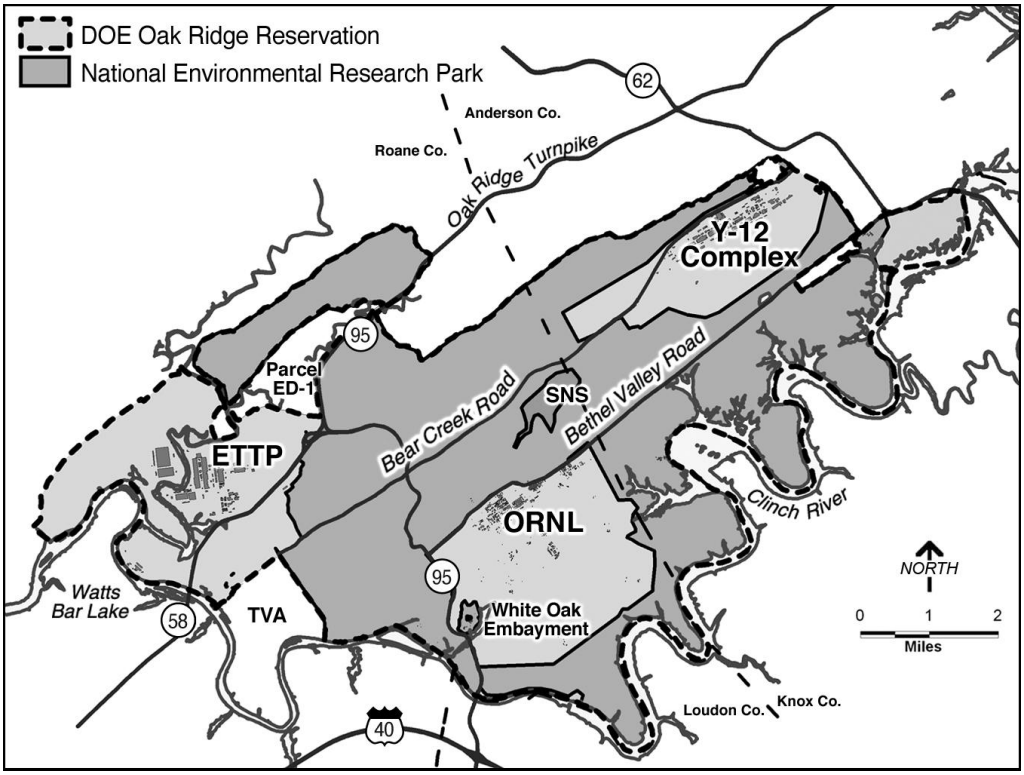


Fig. 1.9. The Oak Ridge National Environmental Research Park covers about 8,094 hectares on the reservation.

The Research Park has attracted more than 1,200 users from ORNL as well as from 150 colleges, universities, industries, and other state and federal agencies over the past 5 years. There were 335 users during 2008, representing 48 organizations, including educational institutions, state and federal agencies, and others.

1.4.7 Oak Ridge Institute for Science and Education

ORISE is managed for DOE by Oak Ridge Associated Universities (ORAU), a nonprofit consortium of 100 doctoral-granting members and 14 associate members. ORISE focuses on scientific initiatives to research health risks from occupational hazards, assess environmental cleanup, respond to radiation medical emergencies, support national security and emergency preparedness, and educate the next generation of scientists. ORISE includes a 94 ha area on the southeastern border of the ORR that from the late 1940s to the mid-1980s was part of an agricultural experiment station owned by the federal government and, until 1981, was operated by the University of Tennessee.

The ORISE South Campus lies immediately southeast of the intersection of Bethel Valley Road and Pumphouse Road (Fig. 1.2). 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.

1.5 References

DOE. 2001. *Cultural Resource Management Plan, DOE Oak Ridge Reservation, Anderson and Roane Counties, Tennessee*. DOE/ORO 2085. U.S. Department of Energy, Washington, D.C.

LMES. 1997. *Wetland Survey of Selected Areas in the Oak Ridge Y-12 Plant Area of Responsibility, Oak Ridge, Tenn*. Y/ER-27. Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee.

MMES. 1993. *Identification and Characterization of Wetlands in the Bear Creek Watershed.* Y/TS-1016. Martin Marietta Energy Systems, Inc., Oak Ridge, Tennessee.

NOAA. 2009. *Annual 2009 Local Climatological Data Report for Oak Ridge, Tennessee (Site KOQT).* Published by the National Climate Data Center, Asheville, NC.

Parr, P. D., and J. F. Hughes. 2006. *Oak Ridge Reservation Physical Characteristics and Natural Resources*. ORNL/TM-2006/110, UT-Battelle, Oak Ridge, Tennessee.

Rosensteel, B. 1996. *Wetland Survey of the X-10 Bethel Valley and Groundwater Operable Units at Oak Ridge National Laboratory*. ORNL/ER-350, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Zurawski, Ann. 1978. *Summary Appraisals of the Nation's Ground-Water Resources—Tennessee Region*. U.S. Geological Survey Professional Paper 813-L.

2. Compliance Summary and Community Involvement

DOE's operations on the ORR 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. Principal among the regulating agencies are the Environmental Protection Agency and The Tennessee Department of Environment and Conservation. These agencies issue permits, review compliance reports, participate in joint monitoring programs, inspect facilities and operations, and oversee compliance with applicable regulations.

When environmental concerns or problems are identified during routine operations or during ongoing self-assessments of compliance status, the issues are typically discussed with the regulatory agencies. The following sections summarize major environmental statutes and 2008 status for DOE's operations on the ORR. Note that a number of facilities at the ETTP site have been leased to private entities over the past several years through the DOE Reindustrialization Program and the compliance status of those leasee operations are not discussed in this report.

2.1 Laws and Regulations

Table 2.1 summarizes the principal environmental standards applicable to DOE activities on the reservation, the 2008 status, and references to the report sections that provide more detailed information.

2.2 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.

B&W Y-12, UT-Battelle, and the Bechtel Jacobs Company (BJC) each use a graded approach for release of material and equipment for unrestricted public use. 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

Table 2.1. Applicable laws/regulations and 2008 status

Regulatory program description	2008 Status	Report sections
The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) provides the regulatory framework for remediation of releases of hazardous substances and of inactive hazardous waste disposal sites	The Oak Ridge Reservation (ORR) has been on the U.S. Environmental Protection Agency (EPA) National Priorities List (NPL) since 1989. The ORR Federal Facility Agreement (FFA) was initiated in 1992 among EPA, the Tennessee Department of Environment and Conservation (TDEC), and the Department of Energy (DOE). The FFA establishes the framework and schedule for developing, implementing, and monitoring remedial actions on the ORR	3.3 4.3.7 5.3.10
The National Environmental Policy Act (NEPA) requires consideration of how federal actions may impact the environment and an examination of alternatives to the actions. NEPA also requires that decisions include public input and involvement through scoping and review of NEPA documents	During 2008, UT-Battelle, Bechtel Jacobs Company (BJC), and B&W Y-12 activities on the ORR were in full compliance with NEPA requirements. Procedures for implementing NEPA requirements at the three major ORR sites have been fully developed and implemented	3.3 4.3.2 5.3.4
The National Historic Preservation Act provides protection for the nation's historical resources by establishing a comprehensive national historic preservation policy	The ORR has several facilities eligible for inclusion in the *National Register of Historic Places*. Proposed activities are reviewed to determine potential adverse effects on these properties, and methods to avoid or minimize harm are identified	3.3 4.3.2 5.3.4
The Clean Air Act (CAA) and Tennessee environmental conservation laws regulate the release of air pollutants through permits and air quality limits. Emissions of airborne radionuclides are regulated by EPA via the National Emission Standards for Hazardous Air Pollutants (NESHAPs) authorizations	EPA has delegated authority for implementation and enforcement of the CAA. In 2008, all three major ORR sites operated in conformance to the CAA Title V Operating Permit Program	3.4 4.3.3 5.3.5
The Clean Water Act (CWA) seeks to improve surface water quality by establishing standards and a system of permits. Wastewater discharges are regulated by National Pollutant Discharge Elimination System (NPDES) permits issued by TDEC	Discharges to surface water at each of the three sites are governed by NPDES permits. A compliance rate of greater than 99% was achieved by the three major ORR sites in 2008	3.5.1 4.3.4 5.3.6
The Safe Drinking Water Act (SDWA) establishes minimum drinking water standards and monitoring requirements	The city of Oak Ridge supplies potable water to the Y-12 Complex and to ORNL. The K-1515 sanitary water plant provides drinking water for ETTP and for an industrial park south of the site, and was transferred to the city of Oak Ridge in CY 2008	3.3 4.3.5 5.3.7

Table 2.1 (continued)

Regulatory program description	2008 Status	Report sections
Emergency Planning and Community Right-to-Know Act, also referred to as the Superfund Amendment Reauthorization Act (SARA Title III), requires reporting emergency planning information, hazardous chemical inventories, and environmental releases of certain toxic chemicals to federal, state, and local authorities	DOE facilities on the ORR are in full compliance with emergency planning and reporting requirements. There were no releases of hazardous substances exceeding reportable quantities in 2008. For a description of the major elements of this act, see Table 5.12	3.3 4.3.9.2 5.3.12
The Resource Conservation and Recovery Act (RCRA) governs the generation, storage, handling, and disposal of hazardous wastes. RCRA also regulates underground storage tanks containing petroleum and hazardous substances, universal waste, and recyclable used oil	The Y-12 Complex, ORNL, and ETTP are defined as large-quantity generators of hazardous waste because each generates >1,000 kg of hazardous waste per month. Each site is also regulated as a handler of universal waste. During 2008 each site operated in accordance with the RCRA permits that govern waste treatment, storage, and disposal units. ETTP received one NOV in 2008. The NOV stemmed from issues related to the TDEC inspection of the petroleum storage tanks at the K-1414 garage. All issues were resolved and there were no penalties	3.3 4.3.6 5.3.8
The Toxic Substances Control Act (TSCA) regulates the manufacture, use, and distribution of all chemicals	The ORR facilities manage TSCA-regulated materials, including polychlorinated biphenyls (PCBs). The ORR PCB Federal Facilities Compliance Agreement between EPA and DOE continued to provide a mechanism to addresses legacy PCB-use issues across the ORR	3.3 4.3.8 5.3.11
ORR Floodplains Management Programs are established 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	ORR Floodplains Management Programs incorporate management and protection goals into planning, regulatory, and decision-making processes through each site's NEPA program. Goals include flood loss reduction, minimization of the impact of floods, and the restoration and preservation of ORR floodplains	3.3 4.3.2 5.3.4
ORR Protection of Wetlands Programs are implemented to minimize the destruction, loss, or degradation of ORR wetlands and to preserve and enhance their beneficial values	Protection of approximately 243 ha of ORR wetlands is implemented through each site's NEPA program, and surveys for the presence of wetlands are conducted on a project- or program-as-needed basis	1.3.6.1 3.3 4.3.2
The Endangered Species Act prohibits activities that would jeopardize the continued existence of an endangered or threatened species, or cause adverse modification to a critical habitat	The ORR is host to several plant and animal species that are categorized as endangered, threatened, or of special concern and are protected in accordance with this Act	1.3.6.2

Table 2.1 (continued)

Regulatory program description	2008 Status	Report sections
DOE Order 231.1A, Environment, Safety, and Health Reporting, ensures timely collection, reporting, analysis, and dissemination of information on environment, safety, and health issues	The Oak Ridge Reservation Annual Site Environmental Report is prepared to summarize ORR environmental activities and to characterize environmental performance	All chapters
DOE Order 435.1, Change 1, ***Radioactive Waste Management***, is implemented to ensure that all DOE radioactive waste is managed in a manner that protects workers, public health and safety, and the environment	UT-Battelle, B&W Y-12, and BJC all generate radioactive waste and have implemented waste certification programs that are protective of workers, the public and the environment	3.8.1 4.2.3.4.2 5.2.1.9
DOE Order 450.1A, ***Environmental Protection Program***, has the objective of implementing sound stewardship practices that protect the air, water, land, and other natural and cultural resources affected by DOE operations. DOE facilities meet this objective by implementing environmental management systems	UT-Battelle, B&W Y-12, BJC and other DOE contractors on the ORR have implemented environmental management systems which are incorporated with the contractors' integrated safety management systems to promote sound stewardship practices	All chapters
DOE Order 5400.5, ***Radiation Protection***, was established to protect members of the public and the environment against undue risk from radiation. This order establishes standards and requirements for operations of DOE and DOE contractors	A dose assessment, performed to ensure that the total dose to members of the public from all DOE ORR pathways did not exceed the 100 mrem annual limit established by this Order, estimated the maximum 2008 dose to a hypothetically exposed member of the public from all ORR sources could have been about 8 mrem. The derived concentration guides provided in DOE Order 5400.5 are employed on the ORR to ensure that effluents and emissions result in doses that meet the dose limits and "as low as reasonably achievable" policy	2.3 Chap. 7

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 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 suspension. No scrap metal directly released from radiological areas is being recycled.

As the Spallation Neutron Source (SNS) and the High-Flux Isotope Reactor (HFIR) Cold Source at ORNL reach full user capacity, it will be necessary to release small samples of material that have been exposed to neutrons as part of various material research experiments. Because these samples have been exposed to neutrons, there is the potential for production of radioactivity within the volume of the sample due to neutron activation reactions. The amount of radioactivity will depend on many factors, including time in the neutron beam, beam energy and intensity, and decay time after removal from the beam. Like other material from radiological areas, these samples will be evaluated prior to release using the requirements specified in DOE Order 5400.5. For material with potential residual radioactivity in volume, the order specifies that authorized limits must be developed using a limiting dose of 1 mrem/year under a conservative exposure scenario and must be approved by DOE prior to implementation. UT-Battelle has developed an authorized limits request package for neutron experiment samples from SNS and HFIR. This request outlines the dose assessment process used to derive specific release limits for groups of radionuclides expected in neutron-scattering experiment samples that will ensure that potential doses to the general public from using or handling such samples will be well below 1 mrem/year. When the authorized limits are approved, samples will be released to researchers only after careful review of predicted activation levels and measurement of actual postexperiment levels to verify that the residual radioactivity is below authorized limits for release.

2.3 External Oversight and Assessments

Numerous appraisals, surveillances, and audits of ORR environmental activities were conducted during 2008 and are summarized in Table 2.2. This table does not include internal DOE prime contractor assessments for 2008.

The state of Tennessee also conducts a program of independent monitoring and oversight of DOE activities on the ORR through the Tennessee Oversight Agreement (TOA). The TOA is a voluntary agreement between DOE and the state of Tennessee and is designed to assure the citizens of Tennessee that their health, safety, and environment are being protected through existing programs and substantial new commitments by DOE. More information on the TOA and reporting of monitoring conducted under the TOA is available at http://www.state.tn.us/environment/doeo/.

2.4 Emergency Reporting of Spills and Releases

There were no releases of hazardous substances exceeding reportable quantities on the ORR during 2008. Two fish kills attributable to excessive discharges of chlorinated water into White Oak Creek at ORNL occurred in July and September 2008, resulting in a project to install improved dechlorination systems to guard against recurrence. The fish kills are discussed in more detail in Sect. 5.3.6.

On August 16, 2008, a main potable water supply line in Y-12 facility 9201-1 failed. The ruptured line was isolated to the building, but water from the ruptured line flowed into the basement of the facility and into East Fork Poplar Creek. While there was no environmental damage caused by the flood, potable water did overflow into the East Fork Poplar Creek, and an oil sheen was observed, prompting reporting to the National Response Center, the Tennessee Emergency Management Agency, and the Local Emergency Planning Committee.

Table 2.2. Summary of environmental audits and assessments conducted at ORR, 2008

Date	Reviewer	Subject	Issues
		ORNL	
February 19	TDEC	NPDES Permit Renewal Discussion	0
February 20	EPA/TDEC	Annual CAA Inspection	0
February 25	TDEC	CAA Visible Emissions Inspection	0
April 15	EPA/TDEC	Underground Tank Inspection	0
May 12–14	TDEC	TDEC Annual RCRA Inspection	0
July 2	TDEC	Fish kill Follow-up	0
July 22–25	NSF-ISR	EMS Assessment	2
September 16	TDEC	Fish kill Follow-up	0
September 25	TDEC	RATA for Predictive Emissions	0
October 27–29	TDEC	Annual RCRA inspection at Y-12 Complex	0
December 3	TDEC	RATA for Continuous Emissions	0
December 16	TDEC	Annual CAA Inspection	0
December 18	Knox County Air Quality Management Division	Annual Inspection (NTRC)	0
		ETTP	
February 4–6	TDEC	RCRA Storage Area	0
April 24	EPA/TDEC	TSCAI PCB Inspection	0
May 7	TDEC	K-1414 UST Inspection	2
May 14	City of Oak Ridge	Sewage Pretreatment Assessments	0
June 17	City of Oak Ridge	Sewage Pretreatment Assessments	0
September 11	EPA/TDEC	TSCAI PCB Inspection	0
November 18	TDEC	CNF, TSCAI CAA Inspection	0
November 21	City of Oak Ridge	Sewage Pretreatment Assessments	0
		Y-12 Complex	
January 10	EPA/TDEC	EPA/TDEC ORR PCB FFCA Site Visit	0
February 6–7	TDEC	TDEC Annual Clean Air Compliance Inspection	0
February 16–19	City of Oak Ridge	Semi-Annual Industrial Pretreatment Compliance Inspection	0
June 24	TDEC	EMS Evaluation for TP3 Performer Level Review	0
August 27	City of Oak Ridge	Semi-Annual Industrial Pretreatment Compliance Inspection	0
September 16–17	TDEC, Water Pollution Control	NPDES Compliance Evaluation Inspection	0
October 16	EPA/TDEC	EPA/TDEC ORR PCB FFCA Site Visit	0
October 27–30	TDEC	Annual RCRA Inspection	0

Table 2.2 (continued)

Date	Reviewer	Subject	Issues
		TWPC	
May 13–14	TDEC	TDEC Annual RCRA Inspection	0
		EnergX	
May 13–14	TDEC, RCRA	TDEC Annual RCRA Inspection	0

Abbreviations:

CAA	Clean Air Act
CNF	Central Neutralization Facility
EMS	Environmental Management System
EPA	Environmental Protection Agency
FFCA	Federal Facilities Compliance Agreement
NPDES	National Pollutant Discharge Elimination System
NSF-ISR	NSF International Strategic Registrations
NTRC	National Transportation Research Center
ORR	Oak Ridge Reservation
PCB	polychlorinated biphenyl
RATA	Relative Accuracy Test Audit
RCRA	Resource Conservation and Recovery Act
TDEC	Tennessee Department of Environment and Conservation
TP3	Tennessee Pollution Prevention Partnership
TSCAI	Toxic Substances Control Act Incinerator
TWPC	TRU Waste Processing Center
UST	underground storage tank

2.5 Notices of Violations and Penalties

There were no notices of violations (NOVs), penalties, or consent orders issued to Y-12 in 2008.

An NOV letter, dated June 16, 2008, was issued to ETTP from the Tennessee Division of Underground Storage Tanks, Knoxville Environmental Field Office, as a result of a May 7, 2008, inspection. DOE and BJC initiated two corrective actions: (1) installation of emergency shutoff valves on all three dispenser pumps were completed per manufacturer's instruction, and (2) surfacial concrete on a gasket that plugs an end of a chase was removed; no corrosion was observed. Both services were performed and completed by an independent service vendor. The two corrective actions were addressed, and the issues/violations were closed in August 2008.

No NOVs or penalties were issued for ORNL during 2008.

2.6 Community Involvement

2.6.1 Public Comments Solicited

DOE solicited comments on a variety of significant cleanup/remediation documents and plans in 2008. Items to which the public provided input include the following:

- an environmental assessment that evaluated the potential impacts of advancing the technology transfer mission at ORNL by establishing the Oak Ridge Science and Technology Project;
- a hazardous waste permit to allow a storage facility at ETTP to continue storing and treating hazardous waste;
- a hazardous waste permit to allow ORNL to continue to store and treat hazardous and mixed waste in containers at its facility on Bethel Valley Road;

- a covenant deferral request for the transfer of Building K-1501-H&L to the Community Reuse Organization of East Tennessee (CROET);
- a covenant deferral request for the transfer of Building K-1008-F to CROET;
- a notice of a revised proposed policy on providing technical and financial assistance for training of public safety officials to state and Indian tribes through whose jurisdiction DOE plans to transport spent nuclear fuel or high-level radioactive waste;
- an environmental assessment that evaluates the potential environmental impacts of proceeding with a modernization initiative at ORNL;
- a permit modification to allow additional treatment options and additional storage of mixed waste at the Transuranic Waste Processing Center;
- a waste characterization program for radioactive, contact-handled transuranic waste at ORNL that would be shipped to the Waste Isolation Pilot Plant in New Mexico;
- an environmental assessment on the disposition of radioactively contaminated nickel located at ETTP; and
- a public meeting held at Y-12 New Hope Center regarding the draft complex transformation supplemental programmatic environmental impact statement.

2.6.2 Oak Ridge Site Specific Advisory Board

The Oak Ridge Site Specific Advisory Board (ORSSAB), an independent, volunteer, federally appointed citizens' panel formed in 1995, posted several key accomplishments during 2008 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. The complete text of all ORSSAB recommendations is available at www.oakridge.doe.gov/em/ssab/recc.htm. The following are summaries of some of the accomplishments.

- Participated on the "Center for Oak Ridge Oral History" steering committee. Oral histories are a source of information that will help DOE EM to identify areas of the ORR in need of remediation.
- Cosponsored a public meeting to gather input on how to best preserve the historical significance of the K-25 Building at ETTP. Most of the mile-long, U-shaped building has been decontaminated in preparation for demolition, and initial plans called for retaining the north tower, the footprint of the U-shaped building, and the upper 10 ft of the inner basement area walls. However, due to extensive deterioration of the building, the plan was reevaluated. On February 19, 2008, the ORSSAB cosponsored a public meeting to gather input, and as a result, numerous comments were received and forwarded to DOE. ORSSAB followed up in March 2008, providing DOE EM with a recommendation on K-25 Building preservation and by addressing steps to prevent other buildings on the ORR with historic value from deteriorating.
- Worked with DOE to produce a stewardship map that shows all remediated areas on the ORR and the land use controls that are currently in place. The map is on display in the DOE Information Center and will also be made available at the American Museum of Science and Energy and on line at www-oreis.bechteljacobs.org/oreis/help/oreishome.html. References to all decision documents related to each remediated area will be also available with the map.
- Updated the ORRSAB exhibit at the American Museum of Science and Energy to include a scale model of the EM Waste Management Facility in Bear Creek Valley, which describes the magnitude of the cleanup effort on the ORR.
- Generated thirteen local recommendations on cleanup-related issues, including
  - conducting future verifications of cleanup,
  - engineering and technology development on the ORR, and
  - historic preservation of the K-25 Building.
- Worked with the chairs of the other six SSABs that compose the national EM SSAB to draft four joint recommendations to DOE on topics such as EM SSAB participation in the EM budget process and long-term stewardship incorporation into new EM projects and legacy waste decisions.

2.6.3 DOE Information Center

The DOE Information Center, located at 475 Oak Ridge Turnpike, Oak Ridge, Tennessee, 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 needs. A web site is available for users to search for information at the Center at www.oakridge.doe.gov and click on "Public Activities." Select the "Online Catalog" to begin the search.

2.6.4 Other Information Sources

- The ORR Local Oversight Committee (LOC) represents counties and communities affected most directly by DOE activities in Oak Ridge and is funded by a grant from TDEC's DOE Oversight Division. LOC board members are concerned with human health and the environment and with the economic and social well-being of the community. The LOC publishes the annual *Tennessee Department of Environment and Conservation Department of Energy Oversight Division's Status Report to the Public*, which presents an independent view of the safety and quality of the Oak Ridge environment. The LOC has established a citizen's advisory panel to enable interested citizens to study the issues in depth and make recommendations to the LOC. The LOC may be contacted at http://www.local-oversight.org, or at 865.483.1333.
- TDEC's Department of Energy Oversight Office provides independent state oversight of DOE's Oak Ridge activities. Information is available at http://www.state.tn.us/environment/doeo.
- DOE's Oak Ridge public affairs office covers programs in science, environmental management, and nuclear fuel supply at ORNL, ETTP, and ORISE. This office may be reached at 865.576.0885.
- The Y-12 National Security Complex public affairs office may be contacted for information on national security programs at 865.576.9918. Information is available at http://www.yso.doe.gov.
- A monthly calendar of meetings and announcements is highlighted on the web at http://www.oakridge.doe.gov under the "Public Activities" section.
- *The Public Involvement Plan for Comprehensive Environmental Response, Compensation, and Liability Act Activities at the U.S. Department of Energy Oak Ridge Reservation* (DOE 2007) highlights opportunities for public participation in environmental cleanup activities at Oak Ridge DOE sites. The plan is available at the DOE Information Center.
- The American Museum of Science and Energy contains exhibits highlighting the history of DOE in Oak Ridge along with educational displays on science, nuclear energy, national security, and environmental management. The museum is located at 300 S. Tulane Avenue in Oak Ridge. Public bus tours of the ORR are offered May through September. The museum may be reached at 865.576.3200 or through the website, http://www.amse.org.

Other information resources are available via internet sites or telephone:

- DOE Oak Ridge Office public information line: 1.800.382.6938,
- DOE: http://www.energy.gov,
- DOE Oak Ridge Office: http://www.oakridge.doe.gov,
- DOE Environmental Management Program: http://www.oakridge.doe.gov (click on "Programs" then select "Environmental Management"),
- Oak Ridge Accelerated Cleanup: http://www.bechteljacobs.com/doeclean/,
- ORNL: http://www.ornl.gov/, and
- B&W Y-12: http://www.y12.doe.gov/.

2.7 References

DOE. 2007. *The Public Involvement Plan for Comprehensive Environmental Response, Compensation, and Liability Act Activities at the U.S. Department of Energy Oak Ridge Reservation*. DOE/OR/01-2350&D2. October.

3. East Tennessee Technology Park

The ETTP was originally built during World War II as part of the Manhattan Project. Known as the K-25 Site, its primary mission was to enrich uranium for use in atomic weapons. After the war the mission was changed to include the enrichment of uranium for nuclear reactor fuel elements and recycling of spent fuel. The name was changed to the Oak Ridge Gaseous Diffusion Plant. In the 1980s, a reduction in the demand for nuclear fuel resulted in the shutdown of the enrichment process, and production ceased. The emphasis of the mission then changed to environmental management and restoration operations, and the name was changed to the East Tennessee Technology Park. Environmental management and remediation operations consist of such operations as waste management, the cleanup of outdoor storage and disposal areas, the demolition and/or cleaning up of the facilities, land restoration, and environmental monitoring. Proper disposal of the huge quantities of waste that were generated over the course of production operations is also a major task. Beginning in the 1990s, reindustrialization (the conversion of underutilized government facilities for use by the private sector) also became a major mission at ETTP. Reindustrialization allows private industry to lease underutilized facilities, thus providing both jobs and a new use for facilities that otherwise would have to be demolished. Bechtel Jacobs Company (BJC) is the prime environmental contractor for the ETTP environmental monitoring and surveillance program. Environmental monitoring consists of two main activities: effluent monitoring and environmental surveillance. Federally mandated effluent monitoring and environmental surveillance at ETTP involve the collection and analysis of samples of air, water, soil, sediment, and vegetation from ETTP and the surrounding area. Data from the monitoring are used to assess exposures to members of the public and the environment, to assess the performance of treatment systems, to help identify areas of concern and plan remediation efforts, and to evaluate the efficacy of these remediation efforts. In 2008, there was better than 99% compliance with permit standards for emissions from ETTP operations.

3.1 Description of Site and Operations

Construction of the ETTP, originally known as the K-25 site, began in 1943 as part of the World War II Manhattan Project. It was built as the home of the Oak Ridge Gaseous Diffusion Plant (ORGDP) (Fig. 3.1). 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.

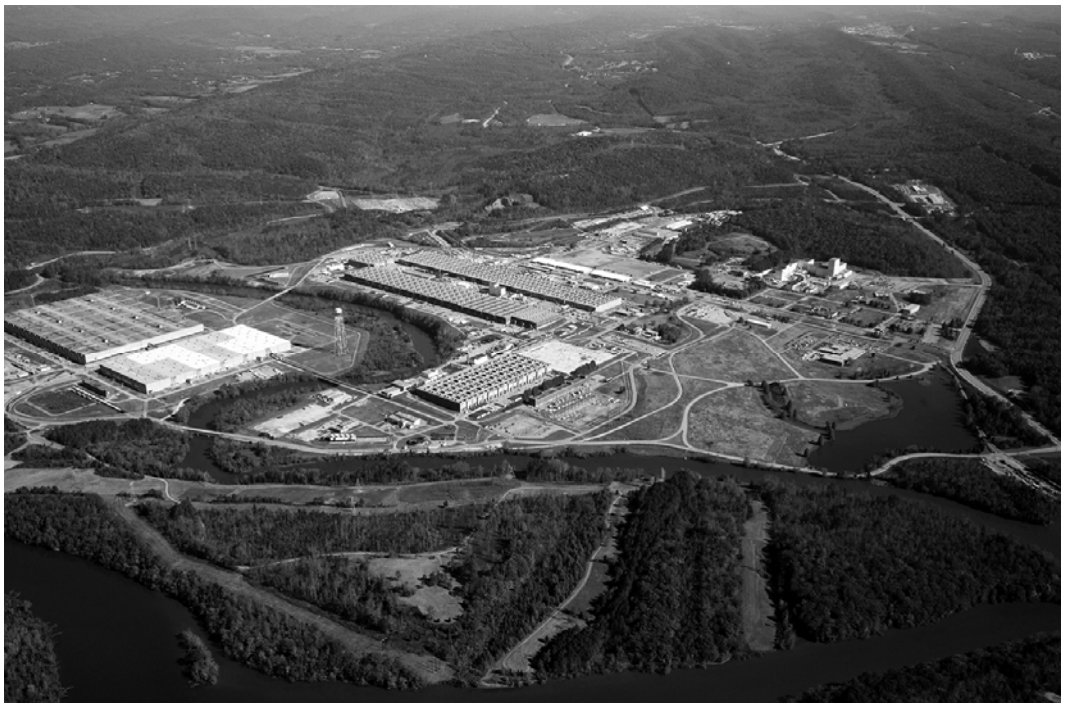


Fig. 3.1. East Tennessee Technology Park

DOE's long-term goal for ETTP is to convert as much as possible of the site into a private mixed-use business and industrial park. The site is undergoing environmental cleanup of the land as well as decontamination and decommissioning (D&D) of most buildings. The reuse of key facilities through title transfer is part of the site's closure plan. The cleanup approach makes land and various types of buildings (e.g., office, manufacturing) suitable for private industrial use and 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 through incorporation of commercial industrial organizations as partners in the ongoing environmental restoration, D&D, and waste treatment and disposal.

3.2 Environmental Management System

The Bechtel Jacobs Company LLC (BJC) corporate policy emphasizes the company's core values by promoting their commitment to an Integrated Safety Management Systems (ISMS). The objective of the ISMS is to systematically integrate environment, safety and health (ES&H), pollution prevention, waste minimization, and quality assurance (QA) into management and work practices at all levels so that workers, the public, and the environment are protected while the missions are accomplished in addition to obtaining feedback for continuous improvement.

Environmental protection considerations, as part of the ETTP ISMS, have taken on a new focus with the issuance of a presidential executive order and a DOE directive. The Environmental Compliance and Protection (EC&P) Oversight Program is an integral part of the BJC Environmental Management System (EMS) mandated by Presidential Executive Order 13423, "Strengthening Federal, Environmental, Energy, and Transportation Management," and its implementing document, DOE Order 450.1A, *Environmental Protection Program*. The DOE order requires that each DOE operation have an EMS to be implemented as part of its ISMS, which was established at DOE sites pursuant to DOE P 450.4, *Safety Management System Policy*. BJC uses its ISMS to implement the EMS, including EC&P considerations, into the line ES&H Oversight Program at DOE sites managed by BJC. DOE Order 450.1A also requires

implementation and development of pollution prevention (P2) and sustainable environmental stewardship goals.

BJC conserves and protects environmental resources by incorporating environmental protection and the elements of an enabling EMS into the daily conduct of business; fostering a spirit of cooperation with federal, state, and local regulatory agencies; and using appropriate waste management, treatment, storage, and disposal methods. The environmental performance objectives are to achieve zero unpermitted discharges to the environment; comply with all conditions of environmental permits, laws, regulations, and DOE orders; integrate EMS and environmental considerations as part of the ISMS; and, to the extent practicable, reduce waste generation, prevent pollution, maximize recycle and reuse potential, and encourage environmentally preferable procurement of materials with recycled and biobased content.

The EMS is part of the ISMS in that it relies on the existing ISMS five core functions, seven guiding principles, and worker participation to fully integrate EC&P considerations into all work processes. In addition, BJC's EMS is based on the elements and framework contained in International Organization for Standardization (ISO) 14001 (ISO 2004). Depending on the scope of work involved, there are EMS attributes or actions related to the environment that an individual could apply at each of the five core functions. Such actions are specifically relevant to environmental compliance, protection of natural resources, prevention of pollution, and minimization of waste. When EMS attributes or actions are applied through the ISMS process, the elements of the EMS Program become an integral part of a continuing cycle of planning, implementing, evaluating, and improving processes and actions. The EMS is supported at each of the five core functions of ISMS, and the ISMS provides the framework for implementing EMS policies, processes, and tools in all phases of work. BJC's definition of "safety" embodies protection of workers and the public health as well as the environment. BJC protects the safety and health of workers and the public by identifying, analyzing, and mitigating aspects, hazards, and impacts and by implementing sound work practices. All BJC employees and subcontractors are held responsible for complying with all ES&H requirements during all work activities and are expected to correct noncompliant conditions immediately. BJC internal management assessments also provide a measure of how well EMS attributes are integrated into work activities through the ISMS. BJC has embodied its program for environmental compliance and protection of natural resources in a company-wide environmental management and protection policy. The policy is BJC's fundamental commitment to incorporating sound environmental management practices into all work processes and activities.

3.3 Compliance Status

Operations at ETTP are governed by state and federal laws and the attendant regulations, by DOE orders, and by agreements with regulatory bodies. Table 3.1 provides a synopsis of the major environmental protection laws and programs at ETTP and the compliance status during 2008. Table 3.2 lists the major environmental permits in place at ETTP in 2008. Compliance is verified by internal audits and assessments as well as routine assessments by state and federal regulators (Table 3.3)

3.4 Air Quality Program

ETTP airborne discharges are generated from residual contamination, waste storage and treatment operations, site remediation and demolition activities, and site maintenance support activities. The primary source of radiological emissions at ETTP is the K-1435 Toxic Substances Control Act (TSCA) Incinerator (Fig. 3.2), which is the major active airborne radionuclide emission source at ETTP regulated under National Emission Standards for Hazardous Air Pollutants for Radionuclides (rad NESHAP) for DOE facilities. The TSCA Incinerator is equipped with extensive exhaust gas pollution control equipment, enabling it to operate in regulatory compliance with both the federal Clean Air Act (CAA) and the Tennessee Air Code.

Table 3.1. Major regulatory programs at East Tennessee Technology Park

Regulatory program description	Compliance status
The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) provides the regulatory framework for remediation of releases of hazardous substances and of inactive hazardous waste disposal sites. Regulators include the Environmental Protection Agency (EPA), DOE, and the Tennessee Department of Environment and Conservation (TDEC)	In 1989, the ORR was placed on EPA's National Priorities List, a list of facilities that pose a sufficient threat to human health and/or the environment and warrant cleanup under CERCLA. In 1992, the ORR Federal Facility Agreement among EPA, TDEC, and DOE became effective and established the framework and schedule for developing, implementing, and monitoring remedial actions on the ORR
The National Environmental Policy Act (NEPA) requires federal agencies to follow a prescribed process to anticipate the impacts on the environment of proposed major federal actions and alternatives	Activities of Bechtel Jacobs Company on the ORR are in full compliance with NEPA requirements. Procedures for implementing the NEPA requirements have been fully developed and implemented. At ETTP, a checklist incorporating NEPA and Environmental Management System requirements has been developed as an aid for project planners. For routine operations, generic categorical exclusions (CXs) have been issued. During 2008, no CXs were issued, and five review reports (for reindustrialization projects) were prepared
The National Historic Preservation Act identifies, evaluates, and protects historic properties eligible for listing in the *National Register of Historic Places*. Such properties can be archeological sites or historic structures, documents, records, or objects	On the ETTP, there are 135 facilities eligible for inclusion on the *National Register of Historic Places*. A memorandum of agreement states that two of these facilities will be maintained. The others are scheduled to be demolished as part of the site-wide remediation project. To date, 60 have been demolished. Artifacts of historical and/or cultural significance are identified prior to demolition and are cataloged in a database to aid in historic interpretation of the ETTP
The Clean Air Act (CAA) and Tennessee environmental conservation laws regulate the release of air pollutants, including radionuclides, through permits and air quality limits. Tennessee has implementation authority through the state construction and operating permit program or Title V Major Source Permitting Program. Emission measurement methods for radionuclides are regulated by EPA via the National Emission Standards for Hazardous Air Pollutants (NESHAP) authorizations. NESHAP source category emission standards for nonradionuclide hazardous air pollutants are regulated by EPA	EPA has delegated authority for implementing and enforcing the CAA to the state of Tennessee. ETTP facilities were in full compliance with the CAA during 2008
The Clean Water Act (CWA) seeks to improve surface water quality by establishing standards and a system of permits. Wastewater discharges and pump and haul systems for collection of sewage are regulated by National Pollutant Discharge Elimination System (NPDES) permits issued by TDEC	ETTP-permitted discharges include treated industrial wastewater, treated sanitary wastewater, and storm water discharges. In 2008, there were no noncompliances of the NPDES permits and CWA requirements (see Appendix E)
The Safe Drinking Water Act establishes minimum drinking water standards and monitoring requirements	The K-1515 sanitary water plant provides drinking water for ETTP and for an industrial park south of the site. In 2008, the ETTP sanitary water plant met all primary drinking water standards as well as operational and maintenance requirements, and was transferred to the City of Oak Ridge

Table 3.1. (Continued)

Regulatory program description	Compliance status
The Emergency Planning and Community Right-to-Know Act, also referred to as the Superfund Amendment Reauthorization Act (SARA), requires reporting emergency planning information, hazardous chemical inventories, and environmental releases of certain toxic chemicals to federal, state, and local authorities	ETTP operates in full compliance with emergency planning and reporting requirements. In 2008, ETTP inventories contained 13 regulated chemicals
The Resource Conservation and Recovery Act (RCRA) governs the generation, storage, handling, and disposal of hazardous wastes. RCRA also regulates underground storage tanks containing petroleum and hazardous substances, universal waste, and recyclable used oil	ETTP is permitted for storage and treatment of hazardous waste and is also registered as a large-quantity generator (>1,000 kg of hazardous waste per month) of hazardous waste and a large quantity handler of universal waste. TDEC's 2008 inspection of the hazardous/universal waste areas at ETTP resulted in no violations. Two underground storage tanks are permitted at ETTP. One Notice of Violation was issued for the tanks at the garage complex, and all issues have been resolved
The Toxic Substances Control Act (TSCA) regulates the manufacture, use, and distribution of all chemicals and mandates controls on toxic substances. It requires the administrator of the EPA to adopt rules requiring testing of chemical substances and mixtures that may present an unreasonable risk of injury to health or the environment. The administrator is authorized to regulate, limit, or prohibit the manufacture, processing, distribution, use, and disposal of these substances and mixtures	Facilities at ETTP manage TSCA-regulated materials, including polychlorinated biphenyls (PCBs), in compliance with all requirements. Almost all PCB-related activities at ETTP involve the TSCA Incinerator
The Federal Insecticide, Fungicide, and Rodenticide Act governs the manufacture, use, storage, and disposal of pesticides and herbicides, as well as pesticide containers and residuals	There are no restricted-use pesticide products used at ETTP
The ETTP Floodplains Management Program incorporates floodplain management goals into planning, regulatory, and decision-making processes to reduce the risk of flood loss, minimize the impact of floods, and restore and preserve natural and beneficial values served by floodplains	At ETTP, protection of floodplains is implemented through the NEPA program. Locations of new projects or programs are compared to the ETTP floodplain map as needed in order to determine if the activity will be located in a floodplain. If so, then the appropriate review process is initiated.
The ETTP Protection of Wetlands Program incorporates wetlands protection goals into planning, regulatory, and decision-making processes to reduce the risk of flood loss, minimize the impact of floods, and restore and preserve natural and beneficial values served by wetlands	At ETTP, wetlands protection is implemented through the NEPA program, and surveys for the presence of wetlands are conducted for projects or programs as needed

Table 3.2. Permit actions at East Tennessee Technology Park

Permit No.	Units covered	Issued	Expires	Comments
TNHW-015	TSCA Incinerator	Sep. 28, 1987	Sep. 28, 1997	Continued while renewal application being reviewed
TNHW-133	Container and tank storage and treatment units	Sep. 28, 2007	Sep. 28, 2017	Replaces TNHW-015A
TNHW-117	Container storage and treatment	Sep. 30, 2004	Sep. 30, 2014	Replaces TNHW-056
TNHW-121	Solid waste management units	Sep. 28, 2004	Sep. 28, 2014	Encompasses the entire Oak Ridge Reservation
TN0074225	Central Neutralization Facility Wastewater Treatment System	Oct. 1, 2003	Sep. 30, 2008	NPDES permit for treated liquid effluent; continued while renewal application being reviewed.
TN0002950	Storm water outfalls	Mar. 1, 2004	Mar. 31, 2008	121 permitted outfalls in 4 groups; continued while renewal application being reviewed.
045253P	K-1407-U VOC Air Stripper	Jun. 20, 1996	Oct. 1, 2000*	Operating Permit Tennessee Air Quality Act
958435P	K-1423 TSCA Solid Waste Repack Facility	Oct. 10, 2005	Oct. 10, 2006*	Permit to Construct Tennessee Air Quality Act
029895P	K-1425 Waste Oil/Solvent Storage Tank Farm	Sep. 21, 1990	Oct. 1, 1995*	Operating Permit Tennessee Air Quality Act
957808I	K-1435 TSCA Incinerator	Jan. 25, 2005	Oct. 13, 2009*	Permit to Construct Tennessee Air Quality Act
037460P	K-1435-C Liquid Waste Tank Farm	Mar. 31, 1994	Oct. 18, 1998*	Operating Permit Tennessee Air Quality Act
SOP-05068	Waste Transportation Project	Feb. 28, 2006	Feb. 28, 2009	Blair Road and Portal 6
SOP-99033	K-1310-DF trailer	April 29, 2005	April 29, 2010	
SOP-01042	K-1065 facility	November 30, 2006	May 31, 2010	

Table 3.2. (Continued)

Permit No.	Units covered	Issued	Expires	Comments
N/A	Sewage discharges	May 27, 2008	Ongoing	City of Oak Ridge Sewage Discharge Approval

*Permit shield: A Title V Major Source Operating Permit application was originally submitted in 1996 and updated in 2004 for ETTP operations; therefore, existing permits shall serve as operating permits until TDEC issues the Title V permit.

Abbreviations

NPDES National Pollutant Discharge Elimination System
TSCA Toxic Substances Control Act
VOC volatile organic compound

Table 3.3. Oversight and assessment at East Tennessee Technology Park, 2008

Date	Reviewer	Subject	Issues
February 4–6	TDEC	Annual RCRA Storage Area	0
April 24	EPA/TDEC	TSCA Incinerator PCB Inspection	0
	TDEC		2
May 7	TDEC	K-1414 UST Inspection	2
May 14	City of Oak Ridge	Sewage Pretreatment Assessments	0
June 17	City of Oak Ridge	Sewage Pretreatment Assessments	0
September 11	TDEC	TSCA Incinerator PCB Inspection	0
November 18	TDEC	Central Neutralization Facility, TSCA Solid Waste Repack Facility, TSCA Incinerator, TSCA Tank Farms Clean Air Act Inspection	0
November 21	City of Oak Ridge	Sewage Pretreatment Assessments	0

Abbreviations

EPA Environmental Protection Agency
PCB polychlorinated biphenyl
RCRA Resource Conservation and Recovery Act
TDEC Tennessee Department of Environment and Conservation
UST underground storage tank

Fig. 3.2. TSCA Incinerator

Characterization of the impact on public health of radionuclides released to the atmosphere from ETTP operations is accomplished by conservatively estimating the dose to the maximally exposed member of the public. The dose calculations are performed using the Clean Air Assessment Package (CAP-88) computer codes, which were developed under sponsorship of the U.S. Environmental Protection Agency (EPA) for use in demonstrating compliance with the rad NESHAP emission standard.

The TSCA Incinerator is the only operating source at ETTP required by rad NESHAP regulation to directly monitor stack emissions continuously for radionuclide emissions due to the potential to emit. During the 2008 period of performance, the TSCA Incinerator contributed more than 75% of the total ETTP dose to the ETTP-specific most exposed member of the public. Figure 3.3 conservatively illustrates the estimated monthly and annual dose from TSCA Incinerator operations during 2008. During this reporting period, tritium was the major dose contributor, followed by isotopes of uranium. The total estimated airborne dose is far below 10 mrem/year effective dose equivalent (EDE), which is the rad NESHAP regulatory limit that is the applicable standard for combined radionuclide emissions from all ORR facilities.

The TSCA Incinerator presently is the largest operating nonradionuclide air emissions source and is the largest source of criteria pollutant emissions such as nitrogen oxides (NO_x) and carbon monoxide (CO) for all sources listed in the DOE ETTP Major Source Operating Permit application. Total NO_x emissions for 2008 were 10.3 tons (20,547 lb). Total CO emissions were 2.6 tons (5,137 lb). Emissions of all nonradiological regulated air pollutants from TSCA Incinerator operations are noted in Figs. 3.4 through 3.6. In the three categories of data presented, emissions are compared with EPA ambient air quality standards and are identified as criteria pollutants, which are hazardous air pollutants as regulated under 40 CFR 63, Subpart EEE, "National Emission Standards for Hazardous Air Pollutants for Source Categories (Maximum Achievable Control Technology (MACT)" and other pollutants as regulated under Permit No.957808I, the current air permit issued by the Tennessee Department of Environment and Conservation (TDEC) for the TSCA Incinerator. Each data point on these figures represents the

accumulated pollutant emissions for a continuous 12-month period. Table 3.4 lists all TSCA Incinerator emission limits that include those pollutant parameters associated with Figs. 3.4 through 3.6. All graphical information is based on the allowable rates identified in the TSCA Incinerator air permit. Actual emissions are conservatively calculated using removal efficiencies as determined from the most recent permit-required air test or other previously approved compliance demonstration test.

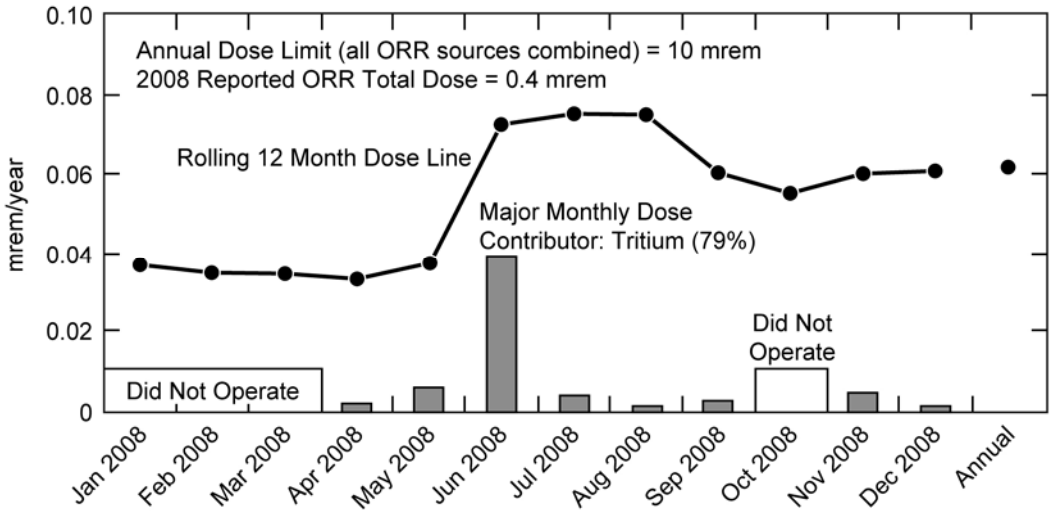


Fig. 3.3. Dose from TSCAI operations.

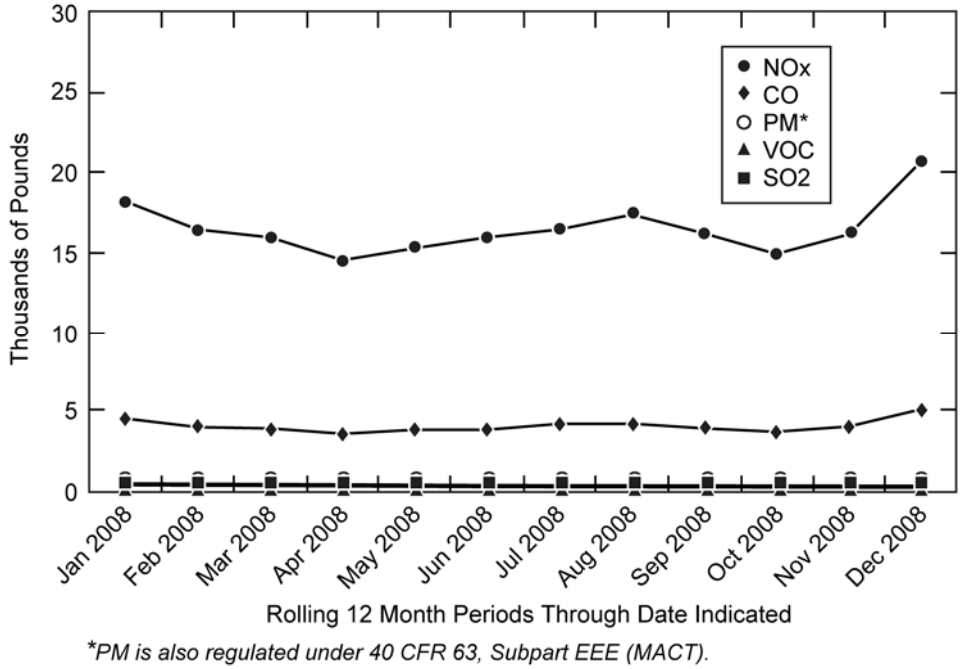


Fig. 3.4. TSCAI criteria pollutant emissions.

Table 3.4. Toxic Substances Control Act Incinerator allowable and actual emissions

Pollutant	Limitation	Annual equivalent	Actual emissions
Radionuclides	10 mrem/year—all combined DOE ORR emission sources	10 mrem/year—all combined DOE ORR emission sources	0.06 mrem/year
Particulate matter (PM)	30 mg/dscf	5.0 ton/year	0.21 ton/year
Sulfur dioxide (SO_2)	8.8 lb/h	38.5 ton/year	0.012 ton/year
Oxides of nitrogen (NO_x)	Not applicable	Not applicable	10.3 ton/year
Volatile organic compounds (VOCs)	1.15 lb/h	5.0 ton/year	0.23 ton/year
Carbon monoxide (CO)/total hydrocarbons (HC)	100 ppmv CO/10 ppmv HC	20.3 ton/year CO/ 2.03 ton/year HC	2.6 ton/year CO
Low-volatile metals:	92 µg/dscm combined As-Be-Cr	31.5 lb/year	2.6 lb/year
Beryllium (normal operations)	0.02 lb/d	7.3 lb/year	0.03 lb/year
Beryllium (compliance testing only)	0.075 lb/d	Not applicable	Not applicable
Semivolatile metals:	230 µg/dscm combined Cd-Pb	76.7 lb/year	12.8 lb/year
Manganese (Mn)	Not applicable	Not applicable	2.6 lb/year
Nickel (Ni)	Not applicable	Not applicable	0.32 lb/year
Mercury (Hg)	130 µg/dscm	43.1 lb/year	5.7 lb/year
Hydrogen chloride/chlorine	77 ppmv	6.5 ton/year	0.032 ton/year
Hydrogen fluoride	0.68 lb/h	5,957 lb/year	1.4 lb/year
Destruction and removal efficiency	99.99% for each principal organic pollutant/99.9999% for each principal organic hazardous pollutant	Not applicable	Not applicable
Dioxin/furan	0.4 ng/dscm (TEQ)	0.00013 lb/year	Not applicable

Abbreviations

DOE	U. S. Department of Energy
ORR	Oak Ridge Reservation
TEQ	toxic equivalent for dioxin

Units of measure

dscf	dry standard cubic foot
dscm	dry standard cubic meter
ppmv	parts per million by volume

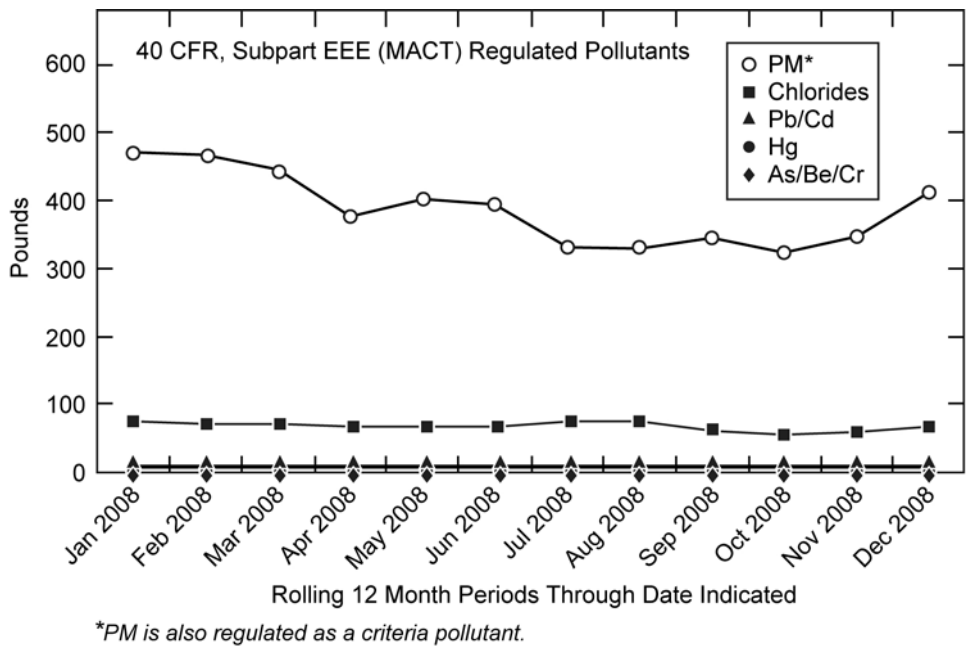


Fig. 3.5. TSCAI MACT regulated pollutant emissions.

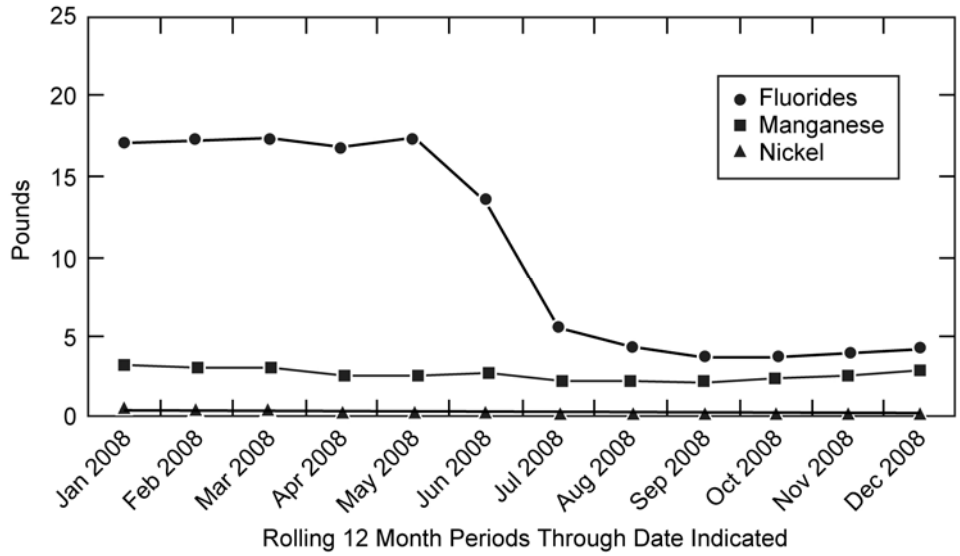


Fig. 3.6. TSCAI other regulated pollutant emissions.

All reported emission data for the TSCA Incinerator were within all permitted limits. For criteria pollutants, the highest emissions result against the permitted limit and based on an annualized comparison was CO at 12.6%. Emissions of the combination of Pb and Cd were only 2% of the permitted limit. The highest emissions result of any other regulated pollutant was for fluorides at less than 1%.

ETTP operations release airborne pollutants from a variety of sources, such as stacks, vents, and fugitive and diffuse activities. With the exception of the TSCA Incinerator, all other stack and vent emissions are calculated as allowed based on their low emissions. Compliance of fugitive and diffuse sources is demonstrated based on environmental measurements. The ETTP Ambient Air Quality Monitoring Program is designed to provide environmental measurements and to accomplish the following:

- measure background concentration levels of selected air contaminant species,
- measure the highest concentrations of the selected air contaminant species that occur in the vicinity of ETTP operations, and
- evaluate the impact of air contaminant emissions from ETTP operations on ambient air quality.

The sampling stations in the ETTP area are designated as base, supplemental, TSCA, or ORR perimeter air monitoring (PAM) stations. The base program consists of two locations using high-volume ambient air samplers. Supplemental locations are typically temporary, project-specific stations that would have samplers specific to a type of potential emissions. Samplers typically include high-volume systems, depending on the source emission evaluation of the project. The TSCA stations will only be triggered during designated operational upsets at the TSCA Incinerator. The radiological monitoring results of samples collected at the two ETTP area PAM stations were provided by ORNL and are included in the ETTP network for comparative purposes. Figure 3.7 shows the location of all ambient air sampling stations during this reporting period.

All base and supplemental stations collect continuous samples for radiological and selected metals analyses. Inorganic analytical techniques are used to test samples for the following nonradiological pollutants: As, Be, Cd, Cr, Pb, and total uranium. Radiological analyses of samples from the ETTP stations test for the isotopes ^{237}Np, ^{238}Pu, ^{239}Pu, ^{99}Tc, ^{234}U, ^{235}U, ^{236}U, and ^{238}U; samples from ORR stations are analyzed for ^{234}U, ^{235}U, and ^{238}U.

Figures 3.8 through 3.12 illustrate the air concentrations of As, Be, Cd, Cr, and Pb for the past 5 years, based on quarterly composites of weekly continuous samples. The results are compared with any applicable standards for each pollutant. Also, the minimum detectable concentration is shown for all metals, including uranium. The annualized levels of As, Be, Cd, and Pb all show results well below the indicated annual standards. Results for 2008 are typically lower than results reported for 2007 and are more comparable with historical trends. (See Appendix A for a discussion of the 2007 data anomaly.) The chromium results are conservatively compared with the standard for hexavalent chromium. A modification to the National Ambient Air Quality Standard for lead in October 2008 lowered the quarterly limit from 1.5 µg/m3 to 0.15 µg/m3. Lead measurement results still indicate that all levels are well within the new standard.

Total uranium metal was measured as a quarterly composite of continuous weekly samples from stations K2, K6, and K11. The total uranium mass for each sample was determined by the inductively coupled plasma-mass spectrometer (ICP-MS) analytical technique. Figure 3.13 illustrates the air concentrations of uranium metal for the past 5 years based on quarterly composites of weekly continuous samples. The uranium averages and maximum individual concentration measurements for all sites are presented in Table 3.5. The averaged results ranged from a minimum of approximately 0.000001, up to 0.000034 µg/m^3. The highest 12-month average result (0.000034 µg/m^3) was measured at Station K2. The annual average value for all stations due to uranium was 0.000018 µg/m^3 The ICP-MS results are compared with the derived concentration guide (DCG) for natural uranium as listed in DOE Order 5400.5. The DCG is based on an annual air concentration exposure that would give a dose of 100 mrem.

The highest annual result (K2) only corresponds to 0.01% of the DCG. The single sampling location with the highest quarterly concentration (0.000092 µg/m^3) was at station K2. If this concentration were extrapolated to a 12 month exposure, it would only represent 0.06% of the DCG. Radiochemical analyses were initiated during 2000 on quarterly composite samples collected at all 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 concentration and dose results for each of the nuclides are presented in Table 3.6 for 2008.

All parameters were chosen with regard to existing and proposed regulations and with respect to activities at ETTP. Changes of emissions from ETTP may warrant periodic reevaluation of the parameters being sampled and the monitoring site locations.

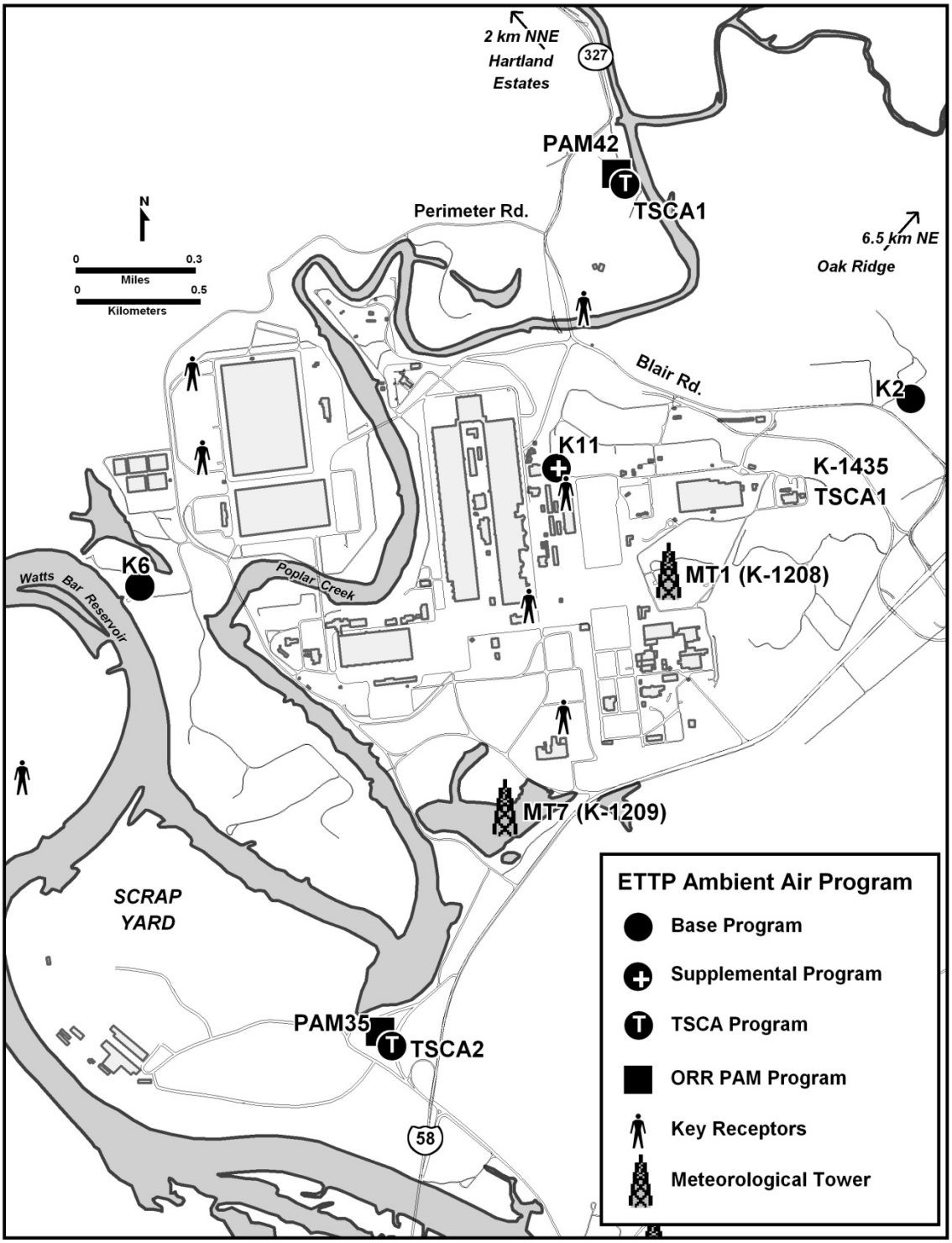
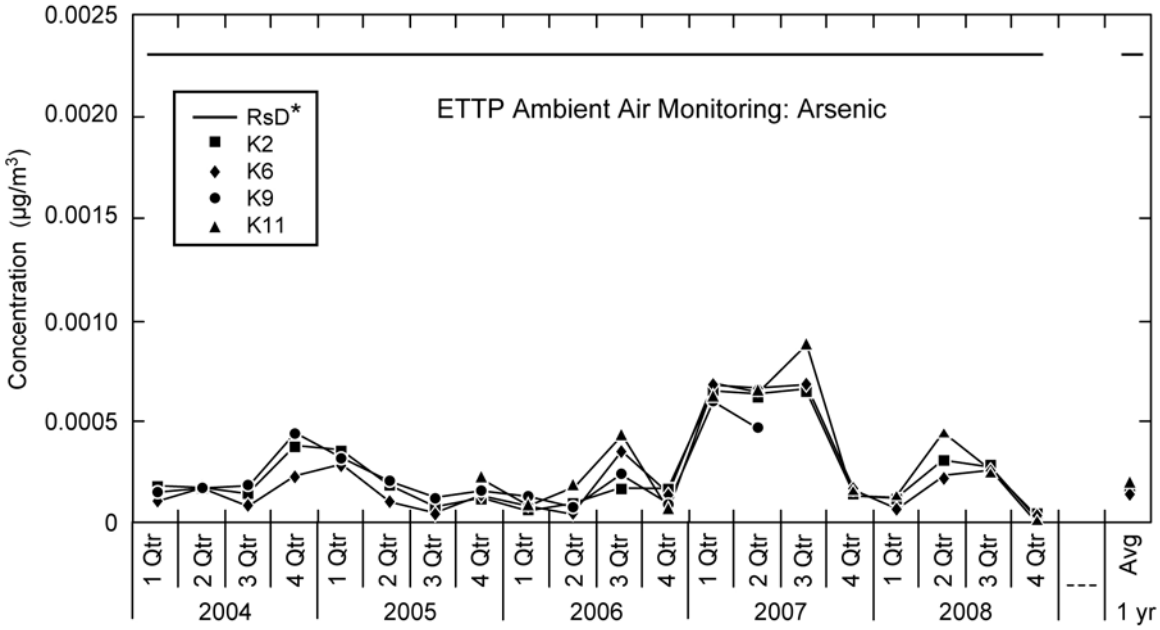
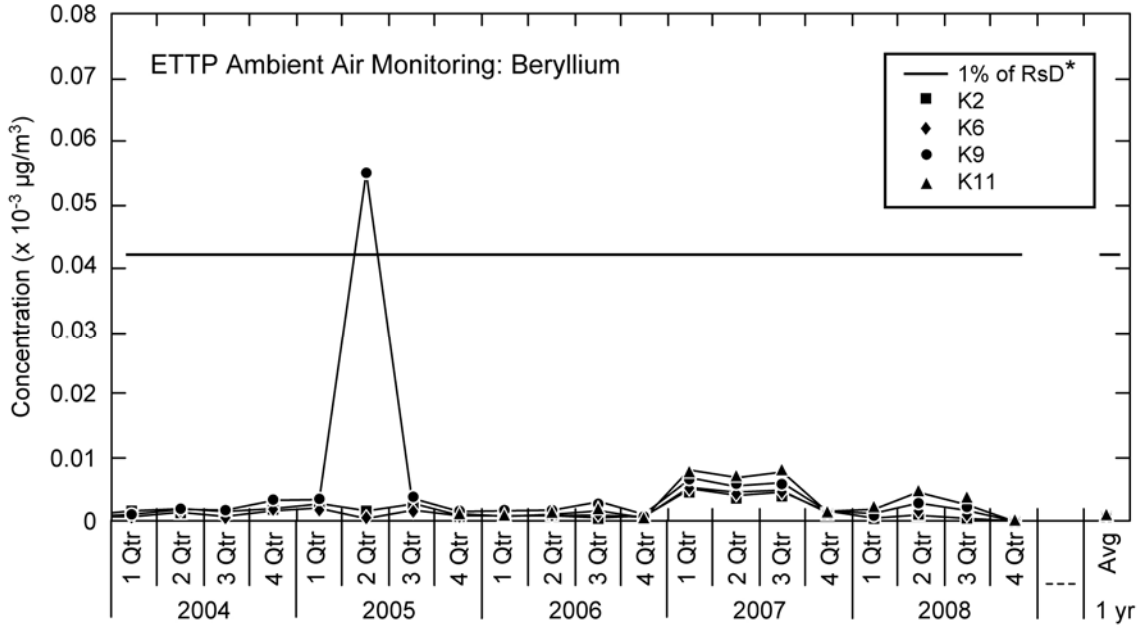


Fig. 3.7. ETTP ambient air monitoring station locations.



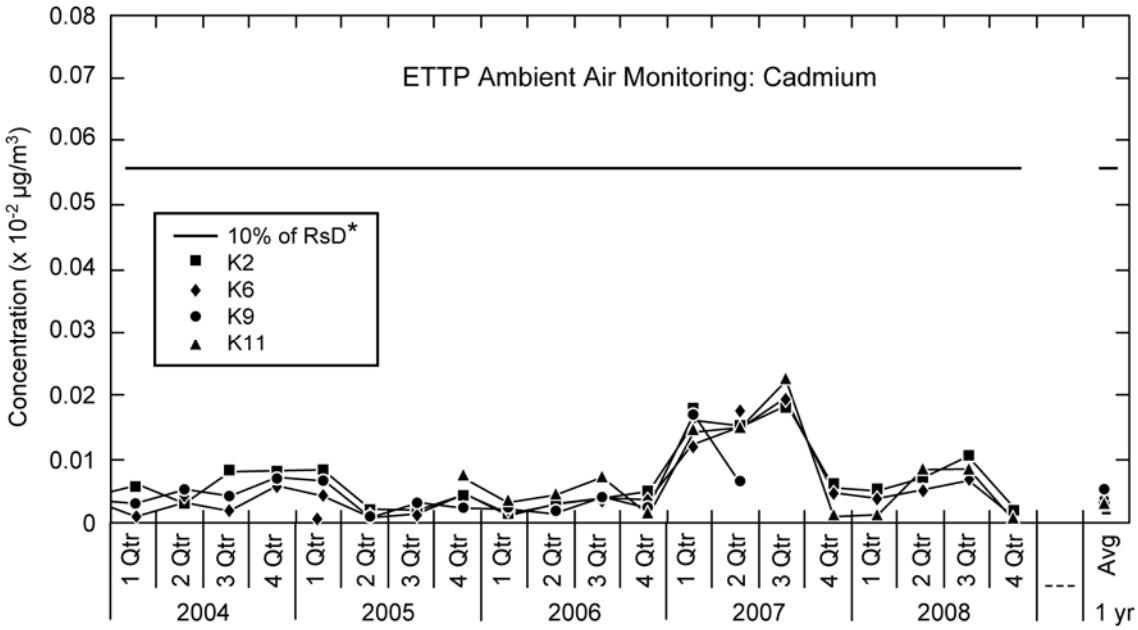
* *RsD - Risk-specific dose. EPA acceptable RsD for arsenic = 0.0023 µg/m^3.*

Fig. 3.8. Arsenic monitoring results: 5-year history through 2008.



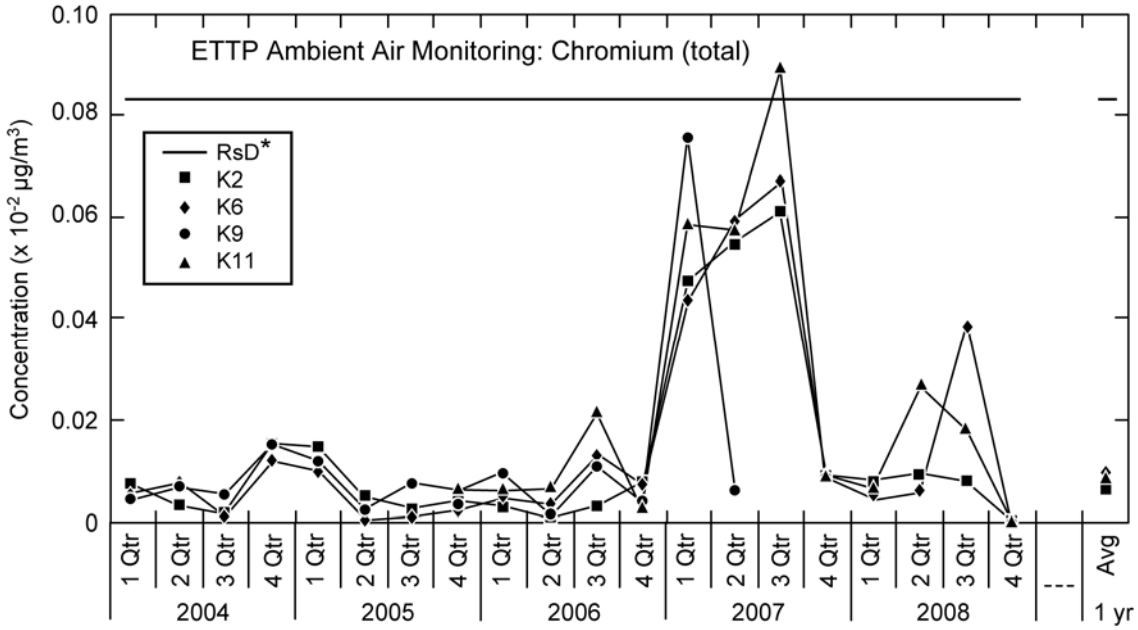
* *RsD - Risk-specific dose. EPA regulatory annual RsD for beryllium = 0.0042 µg/m^3 (40 CFR 266, App. V).*

Fig. 3.9. Beryllium monitoring results: 5-year history through 2008.



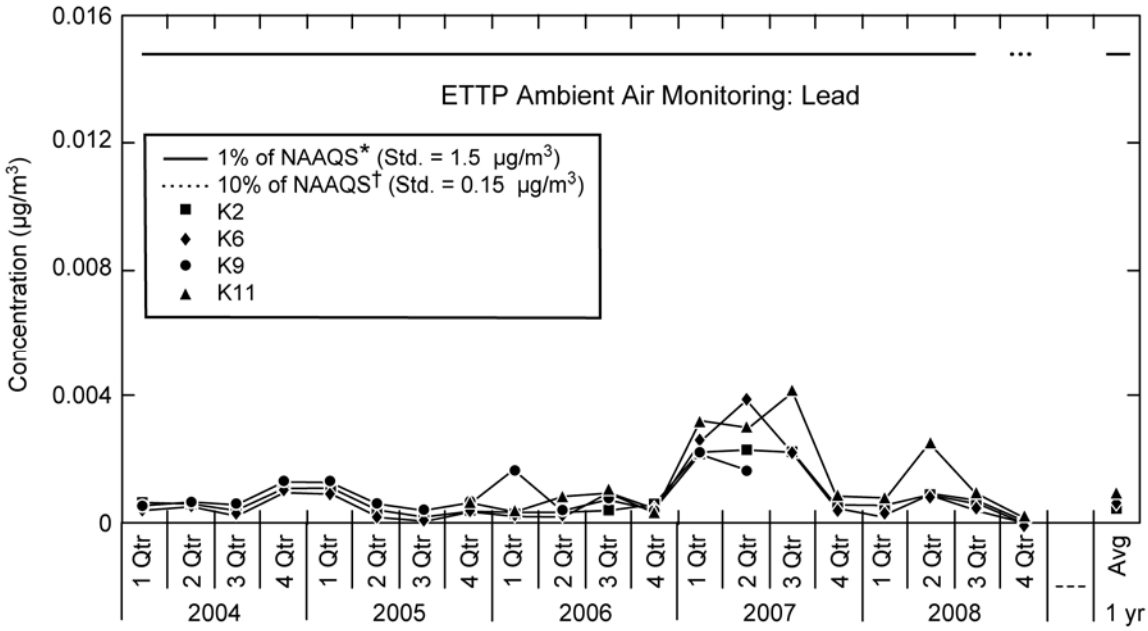
** RsD - Risk-specific dose. EPA acceptable RsD for cadmium = 0.0056 µg/m³.*

Fig. 3.10. Cadmium monitoring results: 5-year history through 2008.



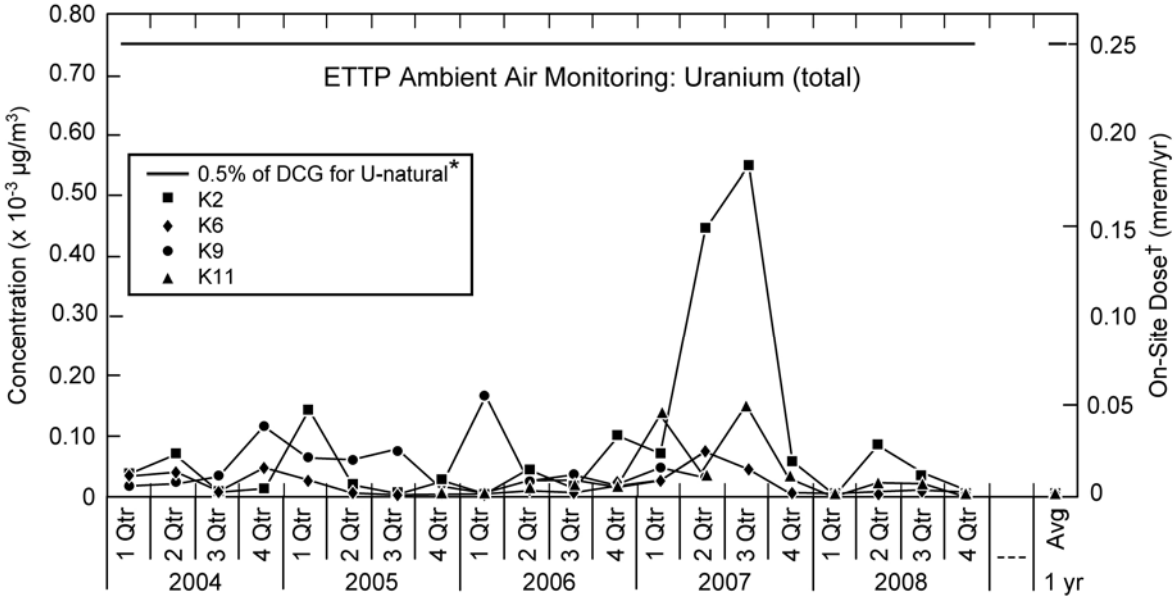
** RsD - Risk-specific dose. EPA acceptable RsD for chromium-VI = 0.00088 µg/m³.*

Fig. 3.11. Chromium monitoring results: 5-year history through 2008.



*National Ambient Air Quality Standard (NAAQS) for lead = 1.5 µg/m^3 per quarter through Sept. 2008.
†NAAQS for lead = 0.15 µg/m^3 per quarter beginning Oct. 2008.

Fig. 3.12. Lead monitoring results: 5-year history through 2008.



*DCG for natural U resulting in 100 mrem/year dose is 1.03E-13 µci/m^3 = 0.15 µg/m^3.
†EPA approved ORR on-site business receptor dose assumes a 50% annual occupancy.

Fig. 3.13. Uranium metal monitoring results: 5-year history through 2008.

Table 3.5. Total uranium in ambient air by inductively coupled plasma analysis at East Tennessee Technology Park, 2008

Station	No. of Samples	Concentration[a]				Percentage of DCG[b] (%)	
		μg/m^3		μCi/mL			
		Avg	Max[c]	Avg	Max	Avg	Max
K2	4	0.000034	0.000092	2.28E–17	6.14E–17	0.02	0.06
K6	4	0.000007	0.000018	4.62E–18	1.19E–17	<0.01	0.01
K11	4	0.000013	0.000027	8.85E–18	1.80E–17	<0.01	0.02
ETTP total	12	0.000018		1.21E–17		0.01	

[a]Mass-to-curie concentration conversions assume a natural uranium assay of 0.717% ^{235}U.

[b]DOE Order 5400.5 derived concentration guide (DCG) for naturally occurring uranium is an annual concentration of 1E–13 μCi/mL, which is equivalent to a 100 mrem annual dose.

[c]Maximum individual sample analysis result with dose calculations conservatively assuming the value to be an annual concentration.

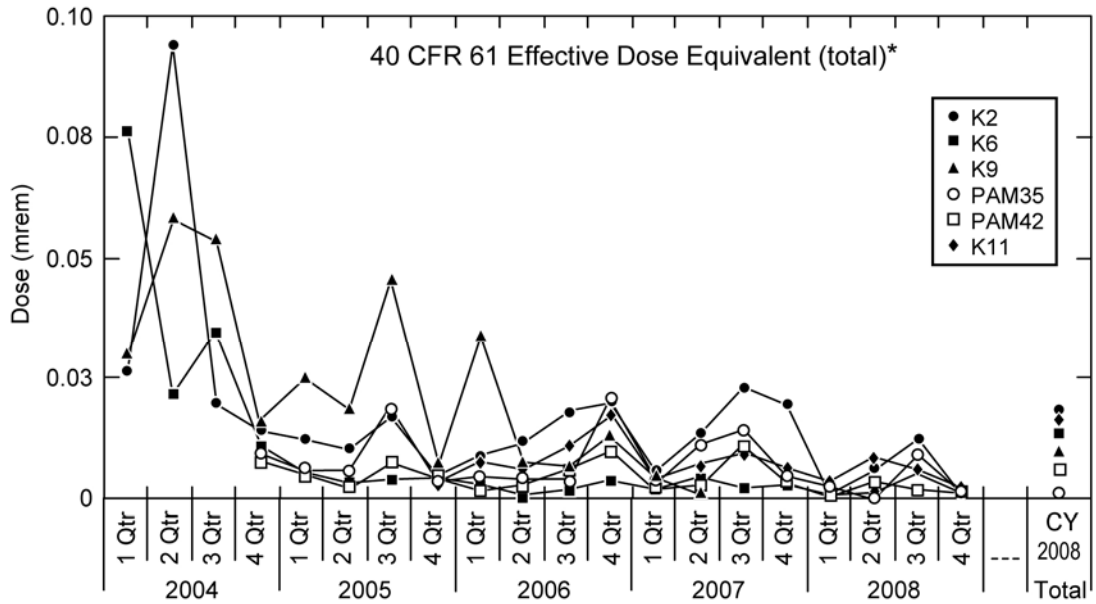
Table 3.6. Radionuclides in ambient air at East Tennessee Technology Park, 2008

Station	Concentration (μCi/mL)								
	Total U	^{237}Np	^{238}Pu	^{239}Pu	^{99}Tc	^{234}U	^{235}U	^{236}U	^{238}U
K2	3.35E–17	ND[a]	3.63E-18	ND	1.53E–16	9.95E–18	1.95E–18	1.95E-18	3.34E–17
K6	5.30E–18	1.70E-18	ND	ND	8.91E–18	3.93E–18	ND	ND	4.72E–18
K11	2.4E–17	ND	3.05E-18	ND	1.62E–15	1.32E–17	ND	ND	1.11E–17
Station	40 CFR 61, Effective dose equivalent (mrem/year)[b]								
	Total U	^{237}Np	^{238}Pu	^{239}Pu	^{99}Tc	^{234}U	^{235}U	^{236}U	^{238}U
K2	0.023	ND	0.008	ND	0.001	0.005	0.001	0.001	0.016
K6	0.004	0.004	ND	ND	<0.001	0.002	ND	ND	0.002
K11	0.012	ND	0.006	ND	0.007	0.007	ND	ND	0.005

[a]ND = not detected.

[b]40 CFR 61, Subpart H limit = 10 mrem per year for U.S. Department of Energy Oak Ridge Reservation combined radionuclide airborne emissions to the most exposed member of the public.

Figure 3.14 is a 5 year historical summary chart of dose-calculation results. Each quarterly result is the total dose from all measured radionuclides during the applicable measurement period. The 12 month rolling dose total is the summation of the previous four quarterly results. All data show potential exposures well below the 10 mrem annual dose limit.



*40 CFR 61, Subpart H limit = mrem per year DOE ORR combined radionuclide airborne emssions to the most exposed member of the public.

Fig. 3.14. Radionuclide monitoring results: 5-year history through 2008.

3.5 Water Quality Program

3.5.1 Clean Water Act Monitoring

The Clean Water Act (CWA)/National Pollutant Discharge Elimination System (NPDES) Program ensures compliance with applicable state and federal regulations, DOE orders, and site-specific policies and procedures for ETTP activities that produce discharges to waters of the United States. The ETTP CWA/NPDES Program provides management, oversight, and guidance to ETTP organizations to ensure compliance with applicable regulations and requirements.

ETTP discharges storm water into waters of the state of Tennessee under NPDES permit No. TN0002950, which became effective April 1, 2004. The ETTP NPDES permit regulates the discharge from ETTP of storm water runoff, groundwater infiltration, and groundwater from sumps to Mitchell Branch, Poplar Creek, and the Clinch River.

Currently available storm drain system configuration information made it possible to effectively group storm water outfalls based on the types of discharges they are most likely to receive. As part of the ETTP NPDES permit, storm water outfall grouping was performed in order to reduce the amount of required sampling that must be performed under the NPDES permit guidelines while providing sufficient monitoring and characterization data to meet TDEC and EPA requirements. The grouping of storm water outfalls in the ETTP NPDES permit was based on information obtained through sampling conducted under the previous NPDES permit, storm drain piping configuration studies, and smoke and dye testing results.

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 upon a variety of criteria, including

historical data, each storm water outfall was placed within a group of outfalls with shared characteristics. In each group, the most typical outfalls were selected to be representative of the group for monitoring purposes. All storm water monitoring and characterization sampling for the storm water outfall groupings are performed at the designated representative outfalls (Fig. 3.15). Sheet flow and runoff from small drainage swales in the drainage area of the groupings are considered part of the total flow of the grouping.

Fig. 3.15. Storm water sampling at ETTP.

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.

There are 121 permitted storm water outfalls at ETTP regulated under NPDES permit No. TN0002950. Of the 121 total outfalls, 38 representative outfalls are required to be sampled. The outfalls are grouped into four categories based on the types of flows being discharged through the outfalls.

- **Group IV storm water outfalls—**These outfalls generally flow continuously. They may discharge storm water runoff, groundwater infiltration, and groundwater from sumps. These outfalls receive storm water runoff from site industrial operations that have the greatest potential for contamination. The representative outfalls in this group must be monitored weekly for flow and pH and quarterly for oil and grease and total suspended solids (TSS) (Table 3.7).
- **Group III storm water outfalls**—These outfalls flow continuously or intermittently. They may discharge storm water runoff, groundwater infiltration, and groundwater from sumps. These outfalls receive storm water runoff from site industrial operations where there is a potential for contamination.

The representative outfalls in this group must be monitored monthly for flow and pH and quarterly for oil and grease and TSS (Table 3.8).

- **Group II storm water outfalls**—These outfalls flow intermittently. They may discharge storm water runoff, groundwater infiltration, and groundwater from sumps. These outfalls do not have a significant potential to discharge contaminants. The representative outfalls in this group must be monitored quarterly for flow and pH and annually for TSS (Table 3.9).

Table 3.7. Group IV storm water outfalls[a,b]

Parameter	Method	Frequency	Sample type	Minimum	Maximum	Screening level
Flow (mgd)	Estimated[c]	Weekly	NA	NA	NA	NA
pH (standard units)[d]	EPA-150.1	Weekly	Grab	6.0	9.0	<6.4 or >8.4
Total suspended solids (TSS) (mg/L)	SM-2540 D	Quarterly	Grab	NA	NA	70
Oil and grease (mg/L)	EPA-1664A	Quarterly	Grab	NA	NA	8.0
Total residual chlorine (TRC) (mg/L)[d,e]	SM-4500-CI D	Weekly	Grab	NA	0.140	Detectable

[a]Detailed results can be found in Table 1.1 of *Environmental Monitoring on the Oak Ridge Reservation: 2008 Results*, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 2009. The DOE document reference is to be determined.

[b]Storm water outfall 100 shall be sampled as being representative of Group IV. The following Group IV storm water outfalls will not be sampled: 128 and 130.

[c]Technical Report 55 method with rainfall data will be used by the Environmental Compliance and Protection Organization to estimate flows. Flow will be reported in millions of gallons per day (mgd) as estimated daily maximum values. No flow field measurements are required.

[d]The pH and TRC analyses shall be performed within 15 min of sample collection.

[e]TRC monitoring will be required only at those outfalls that discharge from an active once-through cooling water system (chlorinated effluent). TRC monitoring is not required if waters being discharged are not chlorinated. The acceptable methods for detection of TRC are any methods specified in 40 CFR 136 that reach a detection level allowing accurate evaluation of compliance with the permit limits. The required analytical quantitation level for TRC is the permit limit or 0.05 mg/L, whichever is lower. In cases where there appear to be matrix interferences and the permit limit is less than 0.05 mg/L, the permittee may request approval for using 0.05 mg/L as the analytical quantitation level that shall be used for compliance evaluations. A quantitation level other than 0.05 mg/L may be appropriate, but the permittee will not be approved to use it without supporting data for the wastewater in question. A request to use >0.05 mg/L or an alternate compliance evaluation detection level must be submitted to the regional Tennessee Environmental Assistance Center and to the Enforcement and Compliance Section. Use of any detection level higher than the permit limits for evaluating compliance is not permitted without prior approval from TDEC. TRC monitoring was performed through January 2008 but is no longer required.

- **Group I storm water outfalls**—These outfalls flow intermittently. They receive flow from remote areas of the site, from administrative and other nonindustrial operation areas, and from site roads and railways. They may discharge storm water runoff, groundwater infiltration, and groundwater from sumps. These outfalls pose little or no threat of discharging significant amounts of contaminants. The representative outfalls in this group must be monitored semiannually for flow and pH (Table 3.10).

Table 3.8. Group III storm water outfalls[a,b]

Parameter	Method	Frequency	Sample type	Minimum	Maximum	Screening level
Flow (mgd)	Estimated[c]	Monthly	NA	NA	NA	NA
pH (standard units)[d]	EPA-150.1	Monthly	Grab	4.0	9.0	< 6.0 or > 8.4
Total suspended solids (mg/L)	SM-2540 D	Quarterly	Grab	NA	NA	70
Oil and grease (mg/L)	EPA-1664A	Quarterly	Grab	NA	NA	8.0

[a]Detailed results can be found in Table 1.1 of *Environmental Monitoring on the Oak Ridge Reservation: 2008 Results*, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 2009. The DOE document reference is to be determined.

[b]The following storm water outfalls will be sampled as being representative of Group III: 05A, 154, 158, 170, 180, 190, 195, 210, 230, 280, 294, 340, 350, 360, 382, 390, 430, 490, 710, 724/760, and 992.The following Group III storm water outfalls will not be sampled: 156, 160, 162, 168, 200, 240, 270, 292, 330, 362, 387, 440, 700, 720, 730, 740, 750, 770, and 970. Outfall 724 will be sampled as being representative of this group, if possible. However, if seasonal fluctuations in the depth of the Clinch River cause this storm water outfall to become flooded, which will preclude sample collection efforts, storm water outfall 760 will be sampled instead.

[c]Technical Report 55 method with rainfall data will be used by the Environmental Compliance and Protection Organization to estimate flows. Flow will be reported in millions of gallons per day (mgd) as estimated daily maximum values. No flow field measurements are required.

[d]The pH analyses shall be performed within 15 min of sample collection.

Table 3.9. Group II storm water outfalls[a,b]

Parameter	Method	Frequency	Sample type	Minimum	Maximum	Screening level
Flow (mgd)	Estimated[c]	Quarterly	NA	NA	NA	NA
pH (standard units)[d]	EPA-150.1	Quarterly	Grab	4.0	9.0	< 6.0 or > 8.4
Total suspended solids (mg/L)	SM-2540 D	Yearly	Grab	NA	NA	70

[a]Detailed results can be found in Table 1.1 of *Environmental Monitoring on the Oak Ridge Reservation: 2008 Results*, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 2009. The DOE document reference is to be determined.

[b]The following storm water outfalls shall be sampled as being representative of Group II: 124, 142, 150, 250, 380, 510, 570, 690 and 890. The following Group II storm water outfalls will not be sampled: 120, 129, 140, 144, 146, 148, 262, 296, 297, 300, 310, 320, 530, 540, 550, 560, 580, 600, 610, 620, 640, 680, 692, 694, 696, 780, 800, 820, 830, 860, 870, 880 and 892.

[c]Technical Report 55 method with rainfall data will be used by the Environmental Compliance and Protection Organization to estimate flows. Flow will be reported in millions of gallons per day (mgd) as estimated daily maximum values. No flow field measurements are required.

[d]The pH analyses shall be performed within 15 min of sample collection.

Table 3.10. Group I storm water outfalls[a,b]

Parameter	Method	Frequency	Sample type	Minimum	Maximum	Screening level
Flow (gal/ day)	Estimated[c]	2/year	NA	NA	NA	NA
pH (standard units)[d]	EPA-150.1	2/year	Grab	4.0	9.0	< 6.0 or > 8.4

[a]Detailed results can be found in Table 1.1 of *Environmental Monitoring on the Oak Ridge Reservation: 2008 Results*, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 2009. The DOE document reference is to be determined.

[b]The following storm water outfalls shall be sampled as being representative of Group I: 198, 334, 410, 532, 660, 900 and 996. The following Group I storm water outfalls will not be sampled: 196, 197, 220, 322, 326, 332, 400, 420, 450, 460, 470, 500, 520, 522, 590, 650, 670, 897, 910, 920, 929, 930, 934, 940, 950, 960, 980 and 990.

[c]Technical Report 55 method with rainfall data will be used by the Environmental Compliance and Protection Organization to estimate flows. Flow will be reported in millions of gallons per day (mgd) as estimated daily maximum values. No flow field measurements are required.

[d]The pH analyses shall be performed within 15 min of sample collection.

3.5.1.1 Storm Water Pollution Prevention Program Requirements

The development of the ETTP Storm Water Pollution Prevention Program (SWP3) is required by Part IV of the ETTP NPDES permit No. TN0002950. The program is in place to minimize the discharge of pollutants in storm water runoff from ETTP and 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 the pollutant sources. SWP3 provides a means whereby sources of pollutants that are likely to affect the quality of storm water discharges are identified, best management practices that can be used to control the entry of pollutants into storm water discharges are developed, and methods for implementing pollution prevention practices are devised. Analytical parameters to be monitored at each storm drain as part of the ETTP SWP3 are chosen based upon a review of available analytical data from previous storm water sampling efforts and knowledge of past processes and practices at ETTP.

The storm water discharges into Mitchell Branch are fully characterized during each NPDES permitting period and in accordance with storm water pollution prevention plans. The NPDES permit can be issued for as long as 5 years, although the current ETTP site storm water permit was issued for a 4 year period so that the ETTP permit expiration date would be consistent with the state of Tennessee watershed schedule for the area of the state in which ETTP is located.

3.5.1.2 Comparison of SWP3 Sampling Results to Screening Criteria

Analytical results from the SWP3 sampling effort conducted in 2008 were compared with applicable screening criteria to identify locations where storm water runoff could be contributing pollutants to receiving waters. These criteria were applied to all data collected as part of the 2008 SWP3 storm water sampling effort. In general, the most stringent criterion that could be identified in the references given for a particular parameter was chosen as the screening criterion for that parameter. Applicable screening criteria for data collected as part of the SWP3 sampling program are listed in Table 3.11.

Table 3.11. Project quantitation levels, screening levels, and reference standards for storm water monitoring at East Tennessee Technology Park

Parameter	Project quantitation level	Screening level	Reference standard	Units
Radionuclides				
Gross alpha	5	15	15	pCi/L
Gross beta	5	50	50	pCi/L
^{60}Co	10	200	5,000	pCi/L
^{90}Sr	4	40	1,000	pCi/L
^{99}Tc	12	4,000	100,000	pCi/L
^{228}Th	1	16	400	pCi/L
^{230}Th	1	12	300	pCi/L
^{232}Th	1	2	50	pCi/L
^{226}Ra	0.3	4	100	pCi/L
^{3}H	300	80,000	2,000,000	pCi/L
^{234}U	1	20	500	pCi/L
^{235}U	1	24	600	pCi/L
^{236}U	1	20	500	pCi/L
^{238}U	1	24	600	pCi/L
Total U	1	31	770	µg/L
^{137}Cs	10	120	3,000	pCi/L
^{237}Np	0.4	1.2	30	pCi/L
^{238}Pu	1	1.6	40	pCi/L
$^{239/240}Pu$	1	1.2	30	pCi/L
Volatile organic compounds (VOCs)				
1,1,1-Trichloroethane	2	75	100	µg/L
1,1,2,2-Tetrachloroethane	2	30	40	µg/L
1,1,2-Trichloroethane	2	75	100	µg/L
1,1-Dichloroethane	2	75	100	µg/L
1,1-Dichloroethene	2	24	32	µg/L
1,2-Dichloroethane	2	75	100	µg/L
1,2-Dichloropropane	2	75	100	µg/L
2-Butanone	10	75	100	µg/L
2-Hexanone	10	75	100	µg/L
4-Methyl-2-pentanone	10	75	100	µg/L
Acetone (2-Propanone)	10	75	100	µg/L
Benzene	2	75	100	µg/L
Bromodichloromethane	2	75	100	µg/L
Bromoform	2	75	100	µg/L
Bromomethane (methyl bromide)	2	75	100	µg/L
Carbon disulfide	10	75	100	µg/L
Carbon tetrachloride	2	12	16	µg/L
Chlorobenzene	2	75	100	µg/L
Chloroethane	2	75	100	µg/L
Chloroform	2	75	100	µg/L
Chloromethane (methyl chloride)	2	75	100	µg/L
Cis-1,2-Dichloroethene	2	75	100	µg/L

Table 3.11. (Continued)

Parameter	Project quantitation level	Screening level	Reference standard	Units
Volatile organic compounds (VOCs) (Continued)				
Cis-1,3-Dichloropropene	2	75	100	µg/L
Dibromochloromethane	2	75	100	µg/L
Ethylbenzene	2	75	100	µg/L
Methylene chloride	2	75	100	µg/L
Styrene	2	75	100	µg/L
Tetrachloroethene	2	25	33	µg/L
Toluene	2	75	100	µg/L
trans-1,2-Dichloroethene	2	75	100	µg/L
trans-1,3-Dichloropropene	2	75	100	µg/L
Trichloroethene	2	75	100	µg/L
Vinyl chloride	2	18	24	µg/L
Xylenes (dimethyl benzene)	2	75	100	µg/L
Polychlorinated biphenyls (PCBs)				
PCBs	0.5	detectable	0.00064	µg/L
Metals				
Aluminum	100	NA	NA	µg/L
Antimony	100	480	640	µg/L
Arsenic	6	7	10	µg/L
Barium	100	NA	NA	µg/L
Beryllium	5	75	100	µg/L
Boron	100	NA	NA	µg/L
Cadmium	1	detectable	0.25	µg/L
Calcium	100	NA	NA	µg/L
Chromium, total	25	75	100	µg/L
Chromium, VI	5	8	11	µg/L
Cobalt	100	NA	NA	µg/L
Copper	3	6.8	9.0	µg/L
Iron	100	NA	NA	µg/L
Lead	2	2	2.5	µg/L
Lithium	5	75	100	µg/L
Magnesium	100	NA	NA	µg/L
Manganese	100	NA	NA	µg/L
Mercury	0.1	detectable	0.051	µg/L
Nickel	5	39	52	µg/L
Potassium	100	NA	NA	µg/L
Selenium	2	3.8	5	µg/L
Silver	1	2.4	3.2	µg/L
Sodium	100	NA	NA	µg/L
Thallium	5	detectable	0.47	µg/L
Vanadium	100	NA	NA	µg/L
Zinc	2	90	120	µg/L

Table 3.11. (Continued)

Parameter	Project quantitation level	Screening level	Reference standard	Units
		Field readings		
Dissolved oxygen (minimum)	4.0–8.0	<6.0	5.0	mg/L
pH (maximum)	14.0	>8.4	9.0	Standard units
pH (minimum)	1.0	<6.4	6.0	Standard units
Temperature	0-100	>27	NA	^{o}C

The screening criterion for a specific radionuclide is equal to 4% of the DCG for that radionuclide in water, as listed in DOE Order 5400.5, Chap. 3; the reference standard is the DCG for each radionuclide. Four percent of the DCG represents the DOE criterion of 4 millirem EDE from ingestion of drinking water. Screening criteria and reference standards are 15 pCi/L for gross alpha and 50 pCi/L for gross beta per the National Primary Drinking Water regulations, Subparts B and G (40 CFR 141).

Screening criteria and reference standards for other parameters are generally based on Tennessee water quality criteria (Rules of Tennessee Division of Water Pollution Control, Chap. 1200-4-3) and the criteria listed in the ETTP NPDES Permit TN0002950, Part III, A—Toxic Pollutants.

Exceedances of screening criteria indicate potential areas of concern. Screening levels are used to identify discharges that may require further investigation.

3.5.1.3 Storm Water Monitoring Conducted for the Phased Construction Completion Report

On January 5, 2007, a meeting was held with TDEC personnel to discuss monitoring expectations for contaminated slabs that remain following building demolition and that await remediation. A review of the *Balance of Site – Laboratory Phased Construction Completion Reports* (PCCRs) (DOE 2007, 2007a, 2007b) by TDEC personnel raised issues about monitoring of the building slabs. TDEC personnel expressed concern about the potential release of contaminants from the slabs and did not believe that the PCCRs currently describe the monitoring effort in sufficient detail. TDEC agreed that DOE meets the requirements of 10 CFR 835 and DOE Order 5400.5 through the Radiation Protection Program, storm water compliance monitoring, and ambient watershed exit pathway sampling. However, TDEC personnel stated that the PCCRs needed to be more specific in describing the location and frequency of monitoring for the slab in question.

In response to the concerns raised by TDEC personnel, it was agreed that the following actions would be taken:

- In general, loose contamination will not be left on slabs, removable contamination will be removed or fixed, and removable contamination will not be left above the criteria contained in 10 CFR 835.
- The pads would be characterized following demolition to identify the proper level of radiological posting. If contamination on the pad was fixed, annual monitoring would be adequate to determine whether or not it is migrating. For removable contamination, the monitoring would be focused on the perimeter of the pad and the direction of storm water flow off the pad. The frequency of monitoring would be varied based on the location and the level of the contamination.
- Storm water monitoring occurs at various outfall locations throughout the plant and at watershed exit pathway locations. More extensive analytical analysis would be indicated if elevated levels of contamination were identified in gross alpha and gross beta results.
- The PCCRs would be expanded to explain the radiation protection program survey schedules planned for the pads, the storm water monitoring applicable to the pads, and ambient watershed exit pathway sampling. Additional sampling would not be expected if the routine program was determined to be adequate.

- The PCCRs were revised to indicate that this radiological monitoring would be done on an interim basis until the pads are remediated. The remedial action (RA) PCCR would then replace the D&D PCCR in terms of monitoring.

In order to obtain additional analytical information to address some of TDEC's stated concerns with the PCCRs, sampling of storm water runoff was conducted at various locations where radiological contamination may be present on the concrete pads or footprints of buildings that have recently been demolished. Samples of storm water runoff from the concrete pads/building footprints in each of the areas were collected at nearby storm water catch basins or directly from the building pads. The samples were collected in order to obtain data that will be considered as the worst-case rad discharge from these areas. Runoff samples collected directly from the building pads were collected from areas where the flow is most prevalent or most concentrated into a distinct discharge.

Because some of the sampling of the building pads and catch basins required a fairly heavy and intense downpour, samples were collected when runoff from the pads was sufficient to allow all of the samples for the given analytical parameters to be collected, regardless of the amount or intensity of the rainfall event. Storm water outfalls were sampled as close as possible to the time that the building pads, or catch basins that drain to them, were sampled. This was done to allow some correlation of the contaminant levels in the runoff samples from the building pads with the levels of contaminants in the storm water outfall samples. Samples collected from each of the locations listed in Table 3.12 were analyzed for gross alpha/gross beta radiation, isotopic uranium, total uranium, and ^{99}Tc.

Table 3.12. Storm water sampling for the PCCR

Sampling location	Gross alpha/ gross beta	Transuranics	U isotopic	Tc-99
K-1420 Pad runoff	X	X	X	X
Outfall 158	X	X	X	X
Outfall 160	X	X	X	X
Outfall 170			X	

All of the runoff samples and outfall samples collected as part of this effort were taken using the manual grab sampling method. Manual grab samples were collected according to the guidelines specified in Sections 3.1.2 and 3.3.1 of the EPA's *NPDES Storm Water Sampling Guidance Document* (EPA 1992) and applicable procedures that have been developed by the sampling subcontractor. All guidelines stated in the ETTP *SWPP Program (SWP3) Sampling and Analysis Plan* (SAP) (BJC 2007, 2008) concerning sample documentation, analytical procedures, quality assurance (QA), and quality control (QC) were followed as part of this sampling effort.

As part of the 2008 SWP3 sampling effort, samples were collected at the north side of the K-1420 building footprint in an area near the former calciner room. Samples were also collected from storm water outfalls 158, 160, and 170 in concurrence with the K-1420 pad samples. Samples of building pad runoff from the area were scheduled to be collected on a monthly basis during wet weather conditions. However, due to the lack of qualifying storm events, the samples were not collected between April and August 2008.

Screening criteria for a specific radionuclide are equal to 4% of the DCG for that radionuclide in water, as listed in DOE Order 5400.5, Chapter 3; the reference standard is the DCG for each radionuclide. Four percent of DCG represents the DOE criterion of 4 millirem EDE from ingestion of drinking water. Screening criteria and reference standards are 15 pCi/L for gross alpha and 50 pCi/L for gross beta per the National Primary Drinking Water regulations, Subparts B and G (40 CFR Part 141). Table 3.13 presents the results of the radiological monitoring done for the PCCR.

Table 3.13. Results exceeding screening levels for radiological monitoring performed in conjunction with PCCR RA and D&D activities[a]

Sampling Location	Date sampled	Gross alpha radiation (pCi/L)	Gross beta radiation (pCi/L)	U-233/234 (pCi/L)	U-235/236 (pCi/L)	U-238 (pCi/L)	Total uranium (µg/L)
Outfall 158	Jan	121	–[b]	48.3	–	32.4	98
Outfall 158	Feb	23.8	–	–	–	–	–
Outfall 158	Mar	15.8	–	–	–	–	–
Outfall 158	Aug	245	66.0	121	–	68.2	206
Outfall 160	Jan	592	239	405	–	73.8	228
Outfall 160	Feb	188	–	130	–	–	65.7
Outfall 160	Mar	191	90.8	150	–	–	70.8
Outfall 160	Aug	296	135	216	–	59.7	182
Outfall 170	Mar	–	–	–	–	–	73.8
Outfall 170	Jun	–	–	–	–	–	53.4
K-1420 Pad runoff	Jan	26.7	–	–	–	–	–
K-1420 Pad runoff	Feb	16.1	–	–	–	–	–

[a]Screening levels are 15 pCi/L gross alpha radiation, 50 pCi/L gross beta radiation, 20 pCi/L U-233/234, 24 pCi/L ^{235}U and ^{238}U, and 31 µ/L total uranium.

[b]Dashes indicate that the value detected in the sample did not exceed the screening criteria.

Gross alpha radiation was detected in the discharge from storm water outfall 158 at levels greater than15 pCi/L, which is the maximum contaminant level (MCL) established by the Safe Drinking Water Act. The range of the gross alpha radiation data collected as part of the SWP3 sampling effort is fairly consistent with historical levels. Levels of gross beta radiation were detected in the discharge from storm water outfall 158 at levels that exceed the MCL of 50 pCi/L. The range of the gross beta radiation data collected as part of the 2008 SWP3 sampling effort is fairly consistent with historical levels. Uranium-233/234 was detected in the discharge from outfall 158 at levels that exceed the 4% of DCG level of 20 pCi/L for this radionuclide. The range of the U-233/234 data collected as part of the 2008 SWP3 sampling effort is fairly consistent with historical levels. Uranium-235 was not detected in the discharge from outfall 158 at levels that exceed the 4% of DCG level of 20 pCi/L for this radionuclide as part of 2008 SWP3 sampling. Uranium-238 was detected in discharges from outfall 158 at levels that exceed the 4% of DCG level of 24 pCi/L for this radionuclide. The range of ^{238}U levels in data collected as part of the 2008 SWP3 are below levels found in historical data and well below DCG levels of 600 pCi/L. Total uranium was detected in the discharge from storm water outfall 158 at levels that exceed the screening level of 31 µg/L for this analyte. Total uranium levels in data collected as part of the 2008 SWP3 are below DCG levels of 600 pCi/L. There are no historical results available for total uranium at outfall 158. No ^{99}Tc was detected at levels above the screening level of 4000 pCi/L in any of the more recent analytical results collected at outfall 158. No historical results are available for ^{99}Tc for outfall 158.

Gross alpha radiation was detected in the discharge from storm water outfall 160 at levels greater than the MCL of 15 pCi/L. The range of the gross alpha radiation data collected as part of the 2008 SWP3 sampling effort is fairly consistent with historical levels. Levels of gross beta radiation were detected in the discharge from storm water outfall 160 at levels that exceed the MCL of 50 pCi/L. The range of the

gross beta radiation data collected as part of the 2008 SWP3 sampling effort is fairly consistent with historical levels. Uranium-233/234 was detected in the discharge from outfall 160 at levels that exceed the 4% of DCG level of 20 pCi/L. The range of the U-233/234 data collected as part of the SWP3 sampling effort is fairly consistent with historical levels and well below the DCG standard of 500 pCi/L. Uranium-235 was not detected in the discharge from outfall 160 at levels that exceed the 4% of DCG level of 20 pCi/L for this radionuclide as part of SWP3 sampling conducted in 2008. Uranium-238 was detected in discharges from outfall 160 at levels that exceed the 4% of DCG level of 24 pCi/L. The range of ^{238}U levels in data collected as part of the 2008 SWP3 are below levels found in historical data and well below DCG levels of 600 pCi/L. Total uranium was detected in the discharge from storm water outfall 160 at levels that exceed the screening level of 31 µg/L. Total uranium levels in data collected as part of the 2008 SWP3 are below DCG levels of 600 pCi/L. There are no historical results available for total uranium at outfall 160. No ^{99}Tc was detected at levels above the screening level of 4000 pCi/L in any of the more recent analytical results collected at outfall 160. No ^{99}TC was detected at levels above the screening criteria of 4,000 pCi/L in any of the more recent analytical data from samples collected at outfall 160.

It is believed that contaminated sediments in the outfall 158 and outfall 160 drainage systems are contributing to the elevated levels of gross alpha and gross beta radiation as well as the elevated isotopic uranium results. Some of the samples collected as part of the 2008 SWP3 were taken during storm events where considerable amounts of rainfall occurred. The heavy rainfall could have caused sediments in the outfall 158 and 160 drainage systems to become suspended, resulting in elevated radiological results.

Total uranium was detected in the discharge from storm water outfall 170 at a level of 73.8 ug/L in March 2008. This level exceeds the screening criteria of 31 ug/L for this analyte. Total uranium was also detected in the discharge from storm water outfall 170 at a level of 53.4 ug/L in June 2008, which is well below the DCG value of 600 pCi/L. No isotopic uranium data or ^{99}Tc data were collected for outfall 170 as part of the 2008 SWP3 sampling.

Gross alpha radiation was detected in the runoff from the K-1420 pad at levels greater than the MCL of 15 pCi/L in samples collected as part of the 2008 SWP3 sampling effort. However, the levels of gross alpha radiation from the samples collected in 2008 were, in all cases, much lower than levels observed in the storm water outfalls associated with the K-1420 pad. Also, levels of gross alpha radiation have decreased dramatically from levels detected in historical samples. Levels of gross beta radiation were detected in runoff from the K-1420 pad at levels that exceed the MCL of 50 pCi/L. However, the levels of gross beta radiation from the samples collected in 2008 were, in most cases, much lower than levels observed in the storm water outfalls associated with the K-1420 pad. Uranium-233/234 was detected in the runoff from the K-1420 pad at levels that exceed the 4% of DCG level of 20 pCi/L. However, subsequent samples indicate that the levels of U-233/234 were much lower than levels observed in the storm water outfalls associated with the K-1420 pad. Uranium-235 was not detected in the runoff from the K-1420 pad at levels that exceed the 4% of DCG level of 20 pCi/L for this radionuclide as part of SWP3 sampling conducted in 2008. Uranium-238 was detected in discharges from the K-1420 pad at levels that exceed the 4% of DCG level of 24 pCi/L. The range of U-238 levels in data collected as part of the 2008 SWP3 are below levels found in historical data and well below DCG levels of 600 pCi/L. Total uranium was detected in the discharge from storm water outfall 160 at levels that exceed the screening level of 31 µg/L. However, this screening level was not exceeded in data from subsequent sampling performed at the K-1420 pad. No ^{99}Tc was detected at levels above the screening level of 4000 pCi/L in any of the runoff samples collected from the K-1420 pad.

The acceptable dose rate in surface water for piscivorous wildlife is 100 mrad per day. The total uranium activity on the slab that will result in a 100 mrad per day dose in Mitchell Branch is 2600 pCi/L. Recent analytical data indicate that total uranium concentrations are several orders of magnitude below the 2600 pCi/L level. The levels of radioactive contaminants were below screening criteria in samples collected during the last two sampling events. Therefore, it is recommended that additional monitoring of the K-1420 pad be reduced to once per year rather than once per month. If the concentration of total uranium in the pad runoff exceeds 2600 pCi/L as part of future sampling activities, action will be taken to determine the cause and correct it. However, because of the elevated levels of radioactive contaminants in

the outfalls 158, 160, and 170 drainage systems from legacy soil and sediment contamination, it is recommended that routine monitoring of these outfalls continue.

3.5.1.4 Radiological Monitoring of Storm Water Discharges

Table 3.14. Storm water sampling for radiological discharges,[a] 2008

Storm water outfall	Date sampled
124	8/26/08
158	7/10/08
160	10/9/08
180	3/20/08
190	7/10/08
195	3/4/08
360	3/5/08
380	8/7/08
382	9/9/08
490	10/9/08
740	2/4/08

[a]Including gross alpha, gross beta, transuranics (^{237}Np, ^{238}Pu, and $^{239/240}$Pu), U isotopic, and ^{99}Tc.

The ETTP conducts radiological monitoring of 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 the public. Sampling for gross alpha and gross beta radioactivity, as well as specific radionuclides, (namely transuranics including Np-237, Pu-238, and Pu-239/240), isotopic uranium, and Tc-99, is conducted as part of the SWP3sampling efforts (Table 3.14). Analytical results are used to estimate the total discharge of each radionuclide from ETTP via the storm water discharge system (Table 3.15). Results were calculated using activities as reported by the analytical laboratories. The activities may be below background levels, below the method detection limit, and/or less than zero.

Additional radiological monitoring of storm water discharges was performed as part of the 2008 SWP3 sampling effort in order to obtain up-to-date radiological results for calculating total radiological discharge. Storm water samples were collected from discharges resulting from a storm event greater than 0.1 in. that occurred within a time period of 24 h or less and that occurred at least 72 h after any previous rainfall greater than 0.1 in. in 24 h.

Table 3.15. Radionuclides released to off-site surface waters from the East Tennessee Technology Park storm water system, 2008 (Ci)[a]

Radionuclide	Amount
^{137}Cs	2.4E–6
^{99}Tc	1.2E–2
^{234}U	5.1E–3
^{235}U	4.1E–4
^{238}U	3.1E–3

[a]1 Ci = 3.7×10^{10} Bq.

Composite samples were collected at each outfall using automated sampling equipment. The composite samples consisted of at least three aliquots taken during the first 60 minutes of a storm event discharge. Samples composited by time (equal volume aliquots collected at a constant interval) were used. In situations where the use of an automated sampler was not feasible or practical, a series of at least three manual grab samples of equal volume were collected during the first 60 minutes of a storm event discharge and combined into a composite sample.

The results of the radiological monitoring of storm water discharges conducted as part of the 2008 SWP3 monitoring effort that exceeded screening levels are shown in Table 3.16.

Gross alpha radiation was detected in the discharge from storm water outfall 158 at a level of 89.6 pCi/L. This level exceeds the screening level for gross alpha activity of 15 pCi/L, which is the MCL established by the Safe Drinking Water Act. Gross beta radiation was detected in the discharge from storm water outfall 158 at a level of 60.7 pCi/L, which exceeds the MCL of 50 pCi/L for this analyte. These gross alpha and gross beta radiation results are comparable to historical results for gross alpha and gross beta radiation. Uranium-233/234 was detected in the discharge from storm water outfall 158 at a level of 40.9 pCi/L, which exceeds the 4% of DCG level of 20 pCi/L for this radionuclide. Uranium-238 was detected at a level of 30.9 pCi/L, which exceeds the 4% of DCG level of 24 pCi/L for this radionuclide. Total uranium was detected in the discharge at a level of 93.7 µg/L, which exceeds the screening level of 31 µg/L for this analyte. The uranium results are considerably elevated over analytical results from samples that were collected from this outfall prior to the demolition of Building K-1420. It is possible that contaminated sediments in the outfall 158 drainage system that could have resulted from the demolition of Building K-1420 are contributing to the elevated levels of gross alpha and gross beta radiation as well as the elevated isotopic uranium results.

Table 3.16. Storm water radiological results exceeding screening levels for radiological discharges, 2008 (pCi/L) [a, b]

Storm water outfall	Gross alpha radiation (pCi/L)	Gross beta radiation (pCi/L)	U-233/234 (pCi/L)	U-238 (pCi/L)	Total Uranium (µg/L)
158	89.6	60.7	40.9	30.9	93.7
180	61.5	–	28.4	–	45.7
360	21.6	–	–	–	–
380	15.2	–	–	–	–
740	47.9	–	21.2	–	44.7

[a] 1 pCi = 0.037 Bq.

[b] Screening levels are 15 pCi/L gross alpha radiation, 50 pCi/L gross beta radiation, 20 pCi/L U-233/234,

24 pCi/L U-235 and U-238, and 31 µ/L total uranium.

[c] Dashed line indicates no exceedances.

Gross alpha radiation was detected in the discharge from storm water outfall 180 at a level of 61.5 pCi/L, which exceeds the MCL of 15 pCi/L. Uranium 233/234 was detected at a level of 28.4 pCi/L, which exceeds the 4% of DCG level of 20 pCi/L. Total uranium was detected in the discharge from storm water outfall 180 at a level of 45.7 µg/L, which exceeds the screening level of 31 µg/L. Each of these results exceeds historical levels from samples collected in 2005, 2006, and 2007 by a factor of 4 or more. The outfall 180 receives flow from a large area of ETTP where radiation contamination may be present, including the K-1401 area and the K-1070-C/D burial grounds. These elevated results may be due to activities related to the demolition of Building K-1401.

Gross alpha radiation was detected in the discharge from storm water outfall 360 at a level of 21.6 pCi/L, which exceeds the MCL of 15 pCi/L. This result is approximately one-half of the level recorded for samples collected in 2005. Storm water outfall 360 receives storm water primarily from surface drainages, including the former location of the K-1066-D Cylinder Yard area. This area was once used for the storage and handling of uranium hexafluoride (UF6) cylinders. In addition, outfall 360 receives drainage from the K-1031 and K-1031-A buildings, which were once used to store wastes from uranium decontamination and recovery operations, including organic degreasers, uranium compounds, and trace quantities of transuranics.

Gross alpha radiation was detected in the discharge from storm water outfall 380 at a level of 15.2 pCi/L, which exceeds the MCL of 15 pCi/L. This result is approximately twice the level recorded for samples collected in 2005. Storm water outfall 380 receives storm water primarily from surface drainages, including runoff from the K-27 building and the K-1131 building.. The K-27 building was one of the primary locations where uranium enrichment took place. Building K-1131 served as a UF6 production facility and as a depleted UF6 tails withdrawal facility. All storm water runoff from Buildings K-27 and K-1131 that enter this drainage system pass through oil skimmer K-897-H before discharging through outfall 380.

Gross alpha radiation was detected in the discharge from storm water outfall 740 at a level of 47.9 pCi/L, which exceeds the MCL of 15 pCi/L. Uranium-233/234 was detected at a level of 21.2 pCi/L, which exceeds the 4% of DCG level of 20 pCi/L. Total uranium was detected in the discharge from storm water outfall 740 at a level of 44.7 µg/L, which exceeds the screening level of 31 µg/L. Each of these results is considerably lower than results from samples collected at this outfall in 2003. Storm water

outfall 740 carries runoff from the K-770 Scrap Metal Yard. Various types of metals generated during operation of the K-25 Site were stored at the K-770 area. Much of the material stored at this scrap yard was contaminated with radioactive material, especially uranium. All of the scrap metal has been removed from the K-770 Scrap Metal Yard. Contaminated soils will be removed from the area beginning in CY 2009.

3.5.1.5 Dry Weather Sampling of Non-Storm Water Discharges

As part of the 2008 SWP3 sampling effort, samples were collected from the ETTP storm drain system during dry weather conditions to check for metal contaminants in non-storm water discharges. Groundwater infiltration is the primary source of non-storm water discharges from the permitted storm drain system at ETTP. Groundwater plumes contaminated with metals have been identified for ETTP using data from groundwater wells. This dry weather sampling will help verify where metals-contaminated groundwater may be present in the storm drain system and which metals are present.

All samples were collected by the manual grab sampling technique during dry weather conditions, which is defined as a period of at least 72 hours after a storm event of 0.5 inch or greater. All appropriate procedures for the collection of manual grab samples were followed. All samples were analyzed as per EPA-200.7. Table 3.17 provides additional information on this sampling effort.

The quarterly sampling at outfalls 170, 180, and 190 was coordinated to coincide with the quarterly monitoring of Mitchell Branch that is conducted as part of the ETTP Environmental Monitoring Program (EMP). EC&P personnel provided information concerning the scheduling of EMP monitoring activities. All other designated outfalls were sampled only one time. Where possible, samples were collected in the first quarter of FY 2008. Because of flow conditions, sampling of some of the outfalls was delayed until the second quarter of FY2008.

Table 3.18 contains the results exceeding screening levels for the dry weather sampling effort.

Mercury was detected in the discharge from storm water outfall 05A at a level of 0.108 µg/L. This result is comparable to historical results for mercury from this outfall. Any detectable mercury is an exceedance of the screening level. In addition to serving as a discharge point for storm water runoff, Outfall 05A once served as an auxiliary discharge point for sewage that was treated at the K-1203 sewage treatment plant. Normal discharges from K-1203 were performed using gravity flow. However, if the water level in Poplar Creek was too high to permit gravity discharges, or if flow into the K-1203 system exceeded the facility's treatment capacity, effluent was diverted to outfall 05A. This outfall, which consists of a sump, sump pump, and discharge piping to Poplar Creek, provided a forced discharge to Poplar Creek. It is possible that mercury may have entered the sump at outfall 05A during its historical operation as part of the sanitary sewer system. The K-1203 facility is no longer in service and outfall 05A is no longer used in discharging effluent from the facility. Outfall 05A now receives and discharges only storm water runoff.

Mercury was detected in the discharge from storm water outfall 710 at a level of 0.0402 µg/L. Mercury was not detected in samples collected from this outfall in 2006. Outfall 710 receives storm water discharges from building K-33, a portion of building K-31, and the K-1065 waste storage facilities. All storm water runoff from buildings K-31 and K-33 that enter this drainage system pass through oil skimmer K-897-N before discharging through outfall 710. Buildings K-31 and K-33 are currently inactive. A decision on the final disposition of the buildings will be made in the future. The K-1065 facility remains active, but no discharges from the facility to the environment have been reported.

Total uranium was detected in the discharge from storm water outfall 170 at a level of 73.8 µg/L in the second quarter of FY 2008. This result exceeds the screening level of 31 µg/L. In subsequent sampling in 2008, total uranium was also detected in the discharge from storm water outfall 170 at a level of 53.4 µg/L. This result also exceeds the screening level of 31 µg/L for this analyte. These levels are considerably higher than the levels of total uranium detected in historical samples from this outfall. Outfall 170 receives flow from a large area of ETTP where radiation contamination may be present, including the K-1420 area and Building K-1037.

Table 3.17. Dry weather sampling of non-storm water discharges at ETTP[a,b]

Storm water outfall	Sampling frequency
05A	1/year
100	1/year
124	1/year
130	1/year
142	1/year
170	1/quarter[c]
180	1/quarter[c]
190	1/quarter[c]
195	1/year
230	1/year
340	1/year
382	1/year
430	1/year
490	1/year
710	1/year
724	1/year
992	1/year

[a]Samples were collected during dry weather conditions, which is defined as a period of at least 72 hours after a storm event of 0.5 inch or greater.

[b]Metals analyses included Al, Ag, As, Ba, Be, B, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, Se, V, Zn, and Tl. All samples were analyzed as per EPA-200.7.

[c]Quarterly sampling of outfalls 170, 180, and 190 was scheduled, to the extent possible, to coincide with ETTP EMP quarterly surface water monitoring in Mitchell Branch.

In sampling conducted in 2008, total uranium was detected in the discharge from storm water outfall 180 at a level of 45.7 µg/L, which exceeds the screening level of 31 µg/L. This result is considerably higher than the total uranium results obtained from sampling conducted in 2007. Outfall 180 receives flow from a large area of ETTP where radiation contamination may be present, including the K-1401 area and the K-1070-C/D burial grounds. These elevated results may be due to activities related to the demolition of Building K-1401.

Table 3.18. Non-storm water results exceeding screening levels at ETTP storm water outfalls

Storm water outfall	Arsenic (µg/L)	Cadmium (µg/L)	Thallium (µg/L)	Mercury (µg/L)	Lead (µg/L)	Copper (µg/L)	Zinc (µg/L)	Selenium (µg/L)	Nickel (µg/L)	Uranium (µg/L)	Chromium (µg/L)
05A	22.1	1.26	21.8	0.108	–	–	–	–	–	–	–
100	16.4	1.04	13.6	–	–	–	–	–	–	–	–
124	10.9	1.09	–	–	–	–	–	32.4	–	–	–
130	19.9	1.49	23.3	–	–	–	–	–	–	–	–
142	20.3	1.78	25.9	–	–	–	164	9.62	–	–	–
170	17.1	1.41	24.5	–	–	–	–	5.32	–	–	–
170	13.8	1.35	14.8	–	–	–	–	11.7	–	73.8	123
170	–	–	5.19	–	–	–	–	–	–	53.4	147
180	18.5	1.37	18.4	–	2.66	–	–	–	–	–	–
180	14.9	1.11	12.7	–	–	–	–	–	–	45.7	–
180	–	–	–	–	9.4	10.3	–	–	–	–	–
190	20.6	1.12	19.6	–	–	–	–	–	76.6	–	–
190	14.1	1.18	10.5	–	–	–	--	6.19	–	54.7	–
190	–	–	–	–	–	–	--	5.8	–	–	–
195	15	–	–	–	–	–	125	–	–	–	–
230	18.3	1.24	20.8	–	–	29.3	–	–	–	–	–
340	9.7	1.09	6.71	–	3.37	–	–	–	–	–	–
382	8.38	1.05	7.13	–	–	–	–	12.8	–	48.4	–
430	19.4	1.22	14.8	–	–	–	–	–	–	–	–
490	18.4	1.2	18.9	–	–	–	–	–	–	–	–
710	15.2	–	10.1	0.0402	–	–	–	–	–	–	–
724	–	–	–	–	5.99	8.13	–	–	–	185	–
992	16	2.74	7.41	–	–	8	91	72.9	–	–	–

Screening levels: arsenic (7 µg/L), cadmium (detectable), thallium (detectable), mercury (detectable), lead (2 µg/L), copper (6.8 µg/L), zinc (90 µg/L), selenium (3.8 µg/L), nickel (39 µg/L), total uranium (31 µg/L), total chromium (75 µg/L).

Total uranium was detected in the discharge from storm water outfall 190 at a level of 54.7 µg/L, which exceeds the screening level of 31 µg/L. This result is considerably higher than the total uranium results obtained from sampling conducted in 2007. Uranium-233/234 was detected at a level of 29.18 pCi/L, which exceeds the 4% of DCG level of 20 pCi/L. This result is also considerably higher than the U-233/234 results obtained from sampling conducted in 2007. Storm water outfall 190 receives flow from a large area of ETTP where radiation contamination may be present, including the K-1401 area and the K-1070-B burial ground. These elevated results may be due to activities related to the demolition of Building K-1401.

Total uranium was detected in the discharge from storm water outfall 382 at a level of 48.4 µg/L, which exceeds the screening level of 31 µg/L. This result is considerably greater than the U-233/234 results obtained as part of historical sampling events. This outfall carries storm water runoff from buildings K-131 and K-631. Both of these buildings were historically used in uranium processing activities.

Total uranium was detected at storm water outfall 724 at a level of 185 µg/L, which exceeds the screening level of 31 µg/L. This result is comparable to total uranium results obtained from historical sampling. Outfall 724 carries runoff from the K-770 Scrap Metal Yard. Various types of metals generated during operation of the K-25 Site were stored at the K-770 area. Much of the material stored at this scrap yard was contaminated with radioactive material, especially uranium. All of the scrap metal has been removed from the K-770 Scrap Metal Yard. Contaminated soils will be removed from the area beginning in CY 2009.

Chromium was detected at outfall 170 during second quarter sampling at a level of 123 µg/L. Chromium was also detected at outfall 170 during third quarter sampling at a level of 147 µg/L. Both of the chromium levels exceed the screening level of 75 µg/L. A chromium collection system consisting of an aquitard with two extraction wells and pumps was installed to pump water from the vicinity of outfall 170 for treatment at the CNF and discharge through the CNF NPDES outfall. Since the installation of this system and subsequent modifications to increase pumping rates, the levels of chromium in Mitchell Branch have been reduced to levels below the detection levels of 1 to 3 ug/L. The levels of chromium in the third and fourth quarters of 2008 were routinely measured at levels of less than 3 ug/L. It is believed that the primary source of the chromium is from contaminated groundwater from the K-1420 area.

Exceedances of screening criteria for several metals were noted in the dry weather sampling results collected in 2008 as shown in Table 3.18. Investigation of these screening criteria exceedances will be conducted as part of future SWP3 sampling efforts.

3.5.1.6 Storm Water Outfall Sampling for VOCs and Mercury

Analytical results for volatile organic compounds (VOCs) from several SWP3 samples collected at storm water outfalls had several data qualifiers assigned by laboratory personnel. Therefore, the data were deemed to not be as reliable or accurate as data that did not have these data qualifiers. To confirm the levels of VOCs at the outfalls where the data variances occurred, additional sampling for VOCs was conducted. Outfalls that were sampled included outfalls 05A, 170, 180, 190, 195, 382, and 710. These outfalls were sampled during both wet weather and dry weather conditions. The analytical laboratories were requested to use the lowest practicable detection limits to avoid additional data concerns. No VOCs above screening levels were identified in the effluent from any of these outfalls during wet weather or dry weather sampling.

A review of previous storm water monitoring results indicated the presence of detectable quantities of mercury at several storm water outfalls. Outfalls that were sampled included outfalls 05A, 170, 180, 190, 195, 382, and 710. The outfalls were sampled during both wet weather and dry weather conditions.

Table 3.19 indicates the results of this sampling effort.

Mercury was detected in the discharge from storm water outfall 180 at a level of 0.925µg/L. This result is somewhat higher than historical mercury results from this outfall. The mercury that was detected at outfall 180 is possibly due to the historical release of small amounts of the material from operations in Buildings K-1303 and K-1401, both of which were located in the outfall 180 watershed. These elevated results may be due to activities related to the Building K-1401 demolition.

Table 3.19. Storm water outfall locations where mercury exceeded screening level

Storm water outfall	Sampling period	Mercury[a] (µg/L)
05A	Dry weather	0.205
05A	Wet weather	0.135
L180	Dry weather	0.925

[a]Mercury in any detectable quantity is an exceedance of the screening level.

Mercury was detected in the discharge from storm water outfall 05A at a level of 0.205 ug/L as part of dry weather sampling and 0.135 ug/L as part of wet weather sampling events conducted in 2008. These results are comparable to historical results for mercury from this outfall. It is possible that mercury may have entered the sump at outfall 05A during its historical operation as part of the sanitary sewer system. Outfall 05A now receives and discharges only storm water runoff.

Additional investigation into the potential source(s) of the mercury in the discharge from outfalls 05A and 180 will be conducted as part of future SWP3 sampling efforts.

3.5.1.7 NPDES Monitoring at the CNF TSCA Waste Water Treatment System

Nonradiological monitoring of CNF effluent is conducted according to the requirements of NPDES Permit No. TN0074225. Monitoring requirements, frequencies, and sample types required under the permit are listed in Table 3.20. Wastewater from CNF is discharged through outfall 001 into the Clinch River.

Radiological sampling of effluent from the CNF and/or the K-1435 Waste Water Treatment System (WWTS) is conducted weekly. The weekly samples are then composited into a single monthly sample. Table 3.21 lists the total discharges in 2008 by isotope. These results are then compared with the DCGs. The sum of the fractions must be kept below 100% of the DCGs; in practice the effluent results from the WWTS were well below 100% of the DCG until 2007. Figure 3.16 shows a rolling 12 month average for 2008. Beginning in September 2006 and continuing at irregular intervals until October 2007, there were some anomalously high results for uranium isotopes, which caused spikes in comparisons of the sums of the fractions of the DCGs. In October 2007, the sum of the fractions of the DCGs exceeded 1.0 for the first time. Work continues on evaluating the most effective way to treat the waste. Operational changes that have taken place include more frequent changeout of the carbon filters, more frequent removal of built-up clarifier sludge, double treatment of the water when necessary, and the substitution of ferrous sulfate for ferric sulfate to cause the uranium to precipitate more readily. The substitution was made as a result of bench-scale jar tests to determine the most effective materials to use. Monitoring results for 2008 showed a marked decrease in the rolling 12 month average of the sum of the fractions of the DCGs from a high of 1.1 in January 2008 to 0.42 in December 2008.

Although uranium isotopes constitute the greatest mass (approximately 28 kg) of radionuclides discharged from CNF, ^{99}Tc and tritium account for the greatest activity, due to their much higher specific activities. Transuranic isotopes constitute a small fraction of the total.

Table 3.20. NPDES permit no. TN0074225 outfall 001 monitoring requirements

Parameter	Collection frequency	Sample type
Flow	Continuous	Recorder
pH	Continuous	Recorder
Total suspended solids (TSS)	Weekly	24-h composite
Chemical oxygen demand (COD)	Weekly	24-h composite
Benzene	Twice per month	Grab
Ethylbenzene	Twice per month	Grab
Toluene	Twice per month	Grab
Methylene chloride	Twice per month	Grab
Bromoform	Monthly	Grab
Carbon tetrachloride	Monthly	Grab
Chlorodibromomethane	Monthly	Grab
Chloroform	Monthly	Grab
Dichlorobromomethane	Monthly	Grab
Tetrachloroethylene	Monthly	Grab
1,1,1-Trichloroethane	Monthly	Grab
Trichloroethylene	Monthly	Grab
Vinyl chloride	Monthly	Grab
Naphthalene	Monthly	Grab
Oil and grease	Monthly	Grab
Total petroleum hydrocarbons (TPH)	Monthly	Grab
Chloride, total	Monthly	24-h composite
Polychlorinated biphenyls (PCBs)	Monthly	24-h composite
Uranium, total	Monthly	Monthly composite
Gross alpha radioactivity	Monthly	Monthly composite
Gross beta radioactivity	Monthly	Monthly composite
^{234}U	Monthly	Monthly composite
^{235}U	Monthly	Monthly composite
^{236}U	Monthly	Monthly composite
^{238}U	Monthly	Monthly composite
^{99}Tc	Monthly	Monthly composite
^{137}Cs	Monthly	Monthly composite
^{238}Pu	Monthly	Monthly composite
^{239}Pu	Monthly	Monthly composite
^{237}Np	Monthly	Monthly composite

Table 3.20. (Continued)

Parameter	Collection frequency	Sample type
Other radionuclides—determined monthly	Monthly	Monthly composite
Cadmium, total	Quarterly	24-h composite
Chromium, total	Quarterly	24-h composite
Copper, total	Quarterly	24-h composite
Lead, total	Quarterly	24-h composite
Nickel, total	Quarterly	24-h composite
Silver, total	Quarterly	24-h composite
Zinc, total	Quarterly	24-h composite
Mercury, total	Quarterly	24-h composite
Acetone	Quarterly	Grab
Acetonitrile	Quarterly	Grab
Methyl ethyl ketone	Quarterly	Grab
Chlordane	Quarterly	Grab
Total toxic organics (TTO)[a]	Quarterly	Grab
Settleable solids[b]	Twice per year	Grab
Cyanide, total	Yearly	Grab

[a]TTOs include, at a minimum, chloroform, bromoform, dichlorobromomethane, chlorodibromomethane, carbon tetrachloride, tetrachloroethylene, methylene chloride, naphthalene, benzene, ethylbenzene, toluene, and PCB. Other parameters listed in 40 CFR Part 433 are analyzed if their presence is suspected based on process knowledge.

[b]To comply with DOE Order 5400.5, Chap. II, 3.a.(4), the presence of settleable solids greater than 0.1 mg/L must be determined. If settleable solids are present, the sample will be filtered and the solids will be analyzed for total uranium, gross alpha radioactivity, and gross beta radioactivity. Sufficient volume shall be collected and held for radiological analyses. "Settleable solids" is not a NPDES permit parameter, and the result is not reported with the discharge monitoring report.

Table 3.21. Isotopic discharges from the Central Neutralization Facility/Waste Water Treatment System, 2008

Isotope	Curies	Isotope	Curies
^{241}Am	3.3E–6	^{239}Pu	1.2E–6
^{14}C	5.2E–4	^{99}Tc	8.3E–2
^{137}Cs	5.9E–4	^{230}Th	2.6E–5
^{60}Co	6.3E–5	^{234}Th	3.1E–3
^{3}H	9.0E–1	^{234}U	3.9E–3
^{131}I	7.0E–6	^{235}U	3.3E–4
^{237}Np	1.0E–5	^{236}U	1.1E–4
^{238}Pu	5.0E–6	^{238}U	9.3E–3

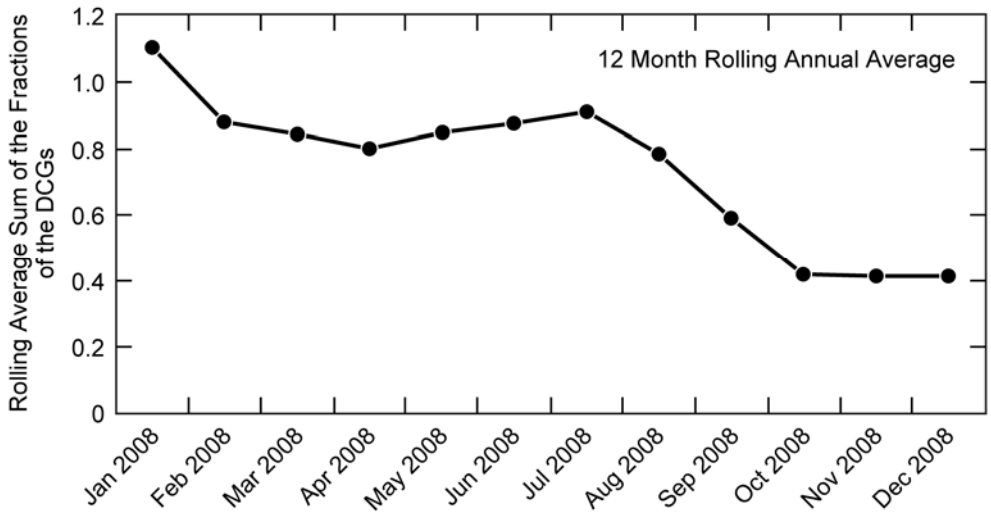


Fig. 3.16. Rolling sum of the fractions of the derived concentration guides at CNF.

3.5.1.8 NPDES Permit Noncompliances

There were no CWA or NPDES permit noncompliances at ETTP in 2008.

3.5.2 Surface Water Monitoring

The ETTP environmental monitoring program personnel conduct environmental surveillance activities at eleven surface water locations (Fig. 3.17). These stations monitor groundwater and storm water runoff (K-1700, K-1007-B, and K-901-A) or ambient stream conditions (CRK-16; CRK-23; K-1710; K-716; and MIK 0.5, 0.6, 0.7, and 1.4). Depending on the location, samples may be collected and analyzed for radionuclides quarterly (K-1700 and MIK 0.5, 0.6, 0.7, and 1.4) or semiannually (remainder of locations). Results of radiological monitoring are compared with the DCGs. Radiological data are reported as fractions of DCGs for reported radionuclides. If the sum of DCG fractions for a location exceeds 100% for the year, an analysis of the best available technology to reduce the sum of the fractions of the radionuclide concentrations to their respective DCGs to less than 100% would be required. Comparisons with DCGs are updated regularly to maintain an annual average. The monitoring results at all of the surveillance locations generally have remained less than 1% of the allowable DCG (Fig. 3.18). The exceptions are K-1700 and three of the most downstream locations on Mitchell Branch as indicated by the sums of the fractions of the DCGs for these locations as follows:

- K-1700: 3.4%,
- MIK 0.5: 2.3%,
- MIK 0.6: 2.6% , and
- MIK 0.7: 4.0 %.

The percentage of the DCGs at K-1700 (3.4%) was well below the percentage of the 2007 monitoring results (12%).

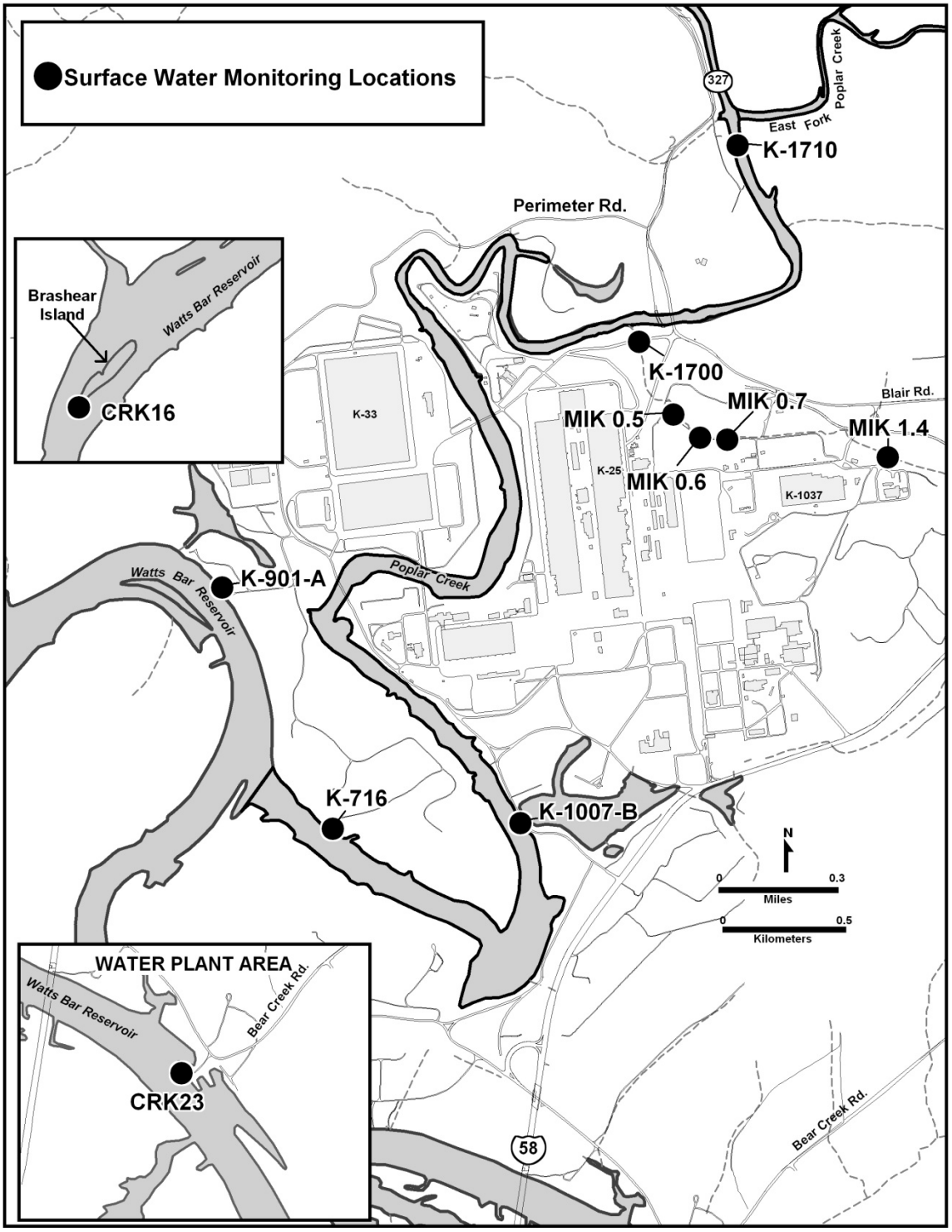


Fig. 3.17. Environmental monitoring program surface water monitoring locations.

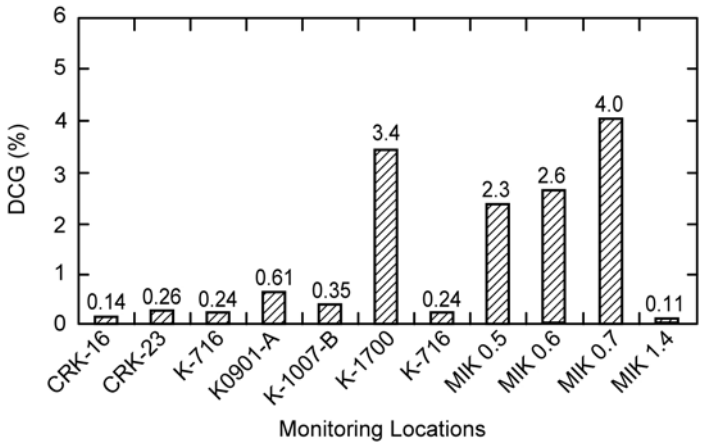


Fig. 3.18. Percentage of derived concentration guides (DCGs) at surface water surveillance locations, 2008.

Depending on the monitoring location, water samples may be analyzed for pH, selected metals, and VOCs. Analytical results were, in most cases, well within the appropriate water quality standards. The single instance where the result for the dissolved oxygen concentration was below the minimum standard can be traced to the natural stream conditions. The low dissolved oxygen result (4.3 mg/L) at K-901-A was during a period of very high temperatures and low stream flow. Similarly, the single instance of a pH exceedance was at K-1007-B during a period of low flow, high temperature, and high biological activity, which raised the pH to 9.3 standard units.

Figures 3.19 and 3.20 illustrate the concentrations of trichloroethene (TCE) and total 1,2-dichloroethene (1,2-DCE) from K-1700 (which monitors Mitchell Branch), the only surface water monitoring location where VOCs are regularly detected. Concentrations of TCE and total 1,2-DCE are below the Tennessee General Water Quality Criteria (WQC) for Recreation, Organisms Only (300 μg/L for TCE and 10,000 μg/L for trans 1,2-DCE), which are appropriate standards for Mitchell Branch. Moreover, the standards for 1,2-DCE apply only to the trans form of 1,2-DCE; almost all of the 1,2-DCE is in the cis-isomer. However, the concentrations of TCE often exceed the standards for recreation, water, and organisms of 25 μg/L. (Since the recreation, water, and organisms standards apply only to waterways that serve as a drinking water source, they do not apply to Mitchell Branch and are included solely for comparison purposes.) In addition, vinyl chloride has sometimes been detected in Mitchell Branch water (Fig. 3.21). In October 2007 a new, lower standard of 24 μg/L went into effect. The concentrations detected in Mitchell Branch did not exceed the WQC. However, there have been historical instances where the concentration levels in Mitchell Branch have come near but not exceeded the WQC. VOCs have been detected in groundwater in the vicinity of Mitchell Branch and in building sumps discharging into storm water outfalls that discharge into the stream; however, storm drain network monitoring generally has not detected these compounds in the storm water discharges. When detected, the concentrations are lower than in the stream. Therefore, it appears that the primary source of these compounds is contaminated groundwater.

Surface water has been routinely sampled by DOE contractors and TDEC for several years as part of environmental monitoring programs. The DOE contractor surface water sampling program is conducted in accordance with DOE order surveillance program guidance. In data collected as part of the DOE contractor's sampling effort, dry weather levels of total chromium over the past 10 years (Fig. 3.22) have been shown to be generally less than 0.01 mg/L, or in some instances, at nondetectable levels. Results from routine surface water monitoring conducted in fall 2006 showed a significant increase in the total chromium level in Mitchell Branch but still below the WQC for total chromium. Sampling performed in the spring of 2007 by DOE contractors and TDEC indicated that chromium levels had increased above the levels found in the fall 2006 sampling. The highest total chromium result was a value of 0.14 mg/L, which exceeded the then-applicable WQC of 0.10 mg/L. Based on these sampling results, a joint effort

among DOE contractor, TDEC surface water, and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) program personnel was initiated in June 2007. Historical maps and photographs, utility and waste process pipeline drawings, monitoring records for building sumps, and other sources of information were reviewed to search for possible uses and sources of chromium in the Mitchell Branch watershed. A chromium collection system employing two extraction wells and pumps was installed to pump water from the vicinity of storm water outfall 170 for treatment at the CNF. Since this system was installed, chromium levels in Mitchell Branch have dropped dramatically, with levels in the third and fourth quarters of 2008 being routinely measured at less than 3 µg/L.

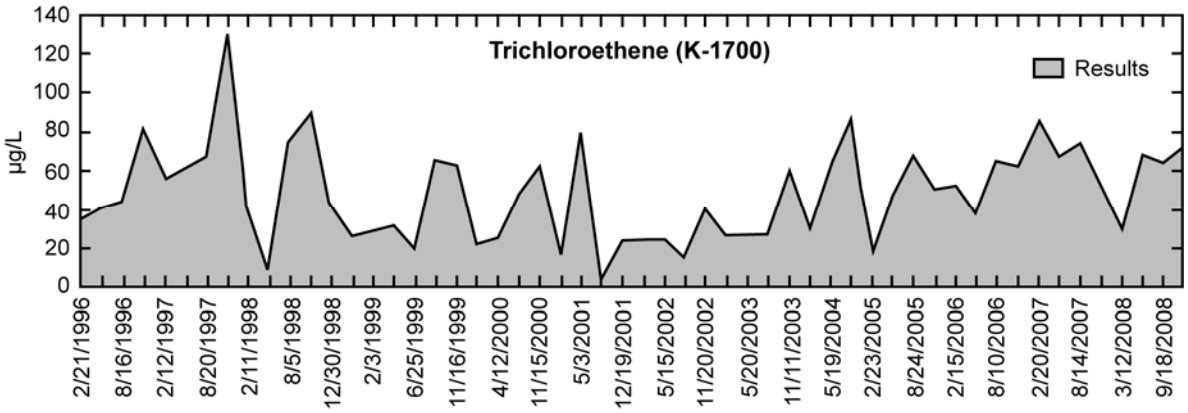


Fig. 3.19. TCE concentrations at K-1700.

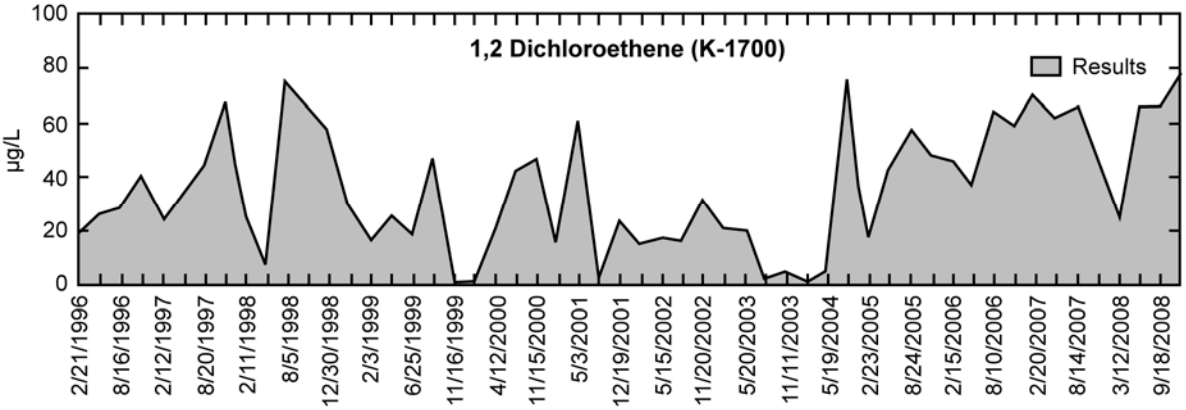


Fig. 3.20. 1,2-DCE concentrations at K-1700.

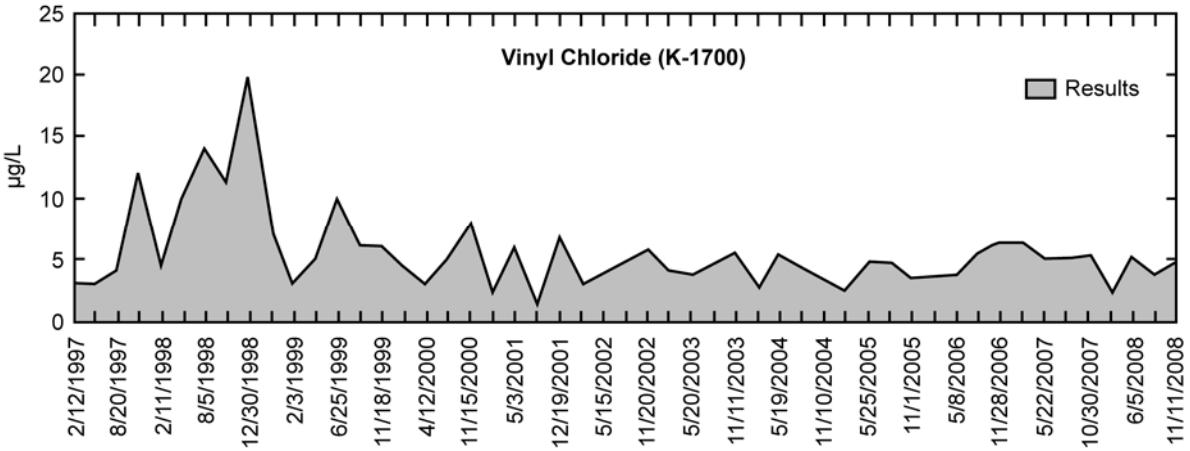


Fig. 3.21. Vinyl chloride concentrations at K-1700.

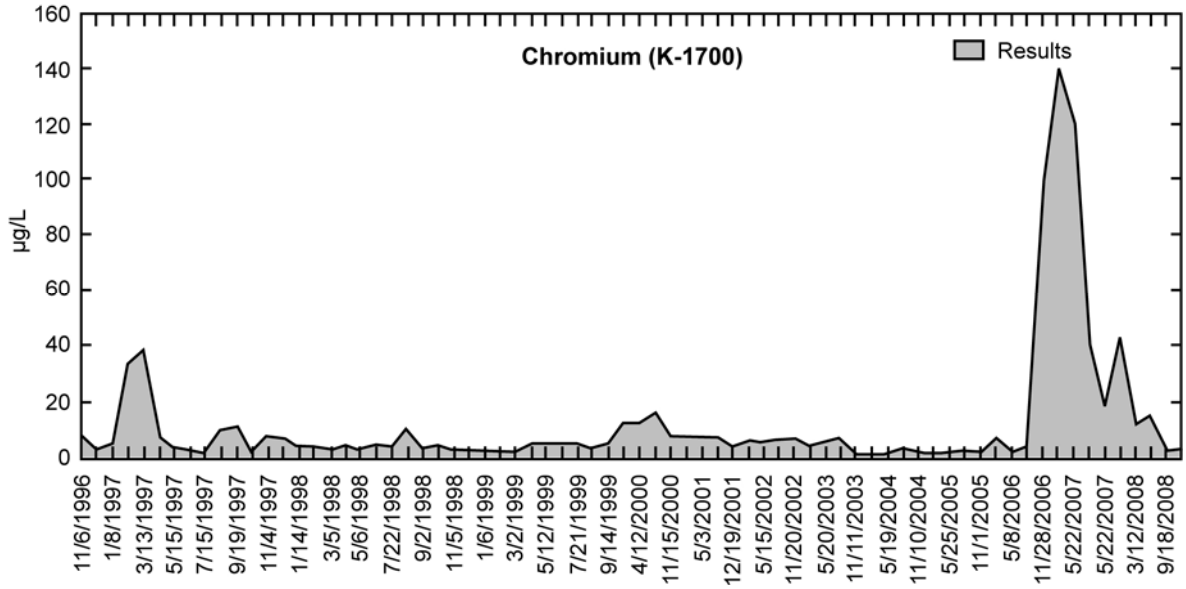


Fig. 3.22. Total chromium concentrations at K-1700.

3.6. Biological Monitoring

The ETTP *Biological Monitoring and Abatement Plan* (BMAP) consists of three tasks designed to evaluate the effects of ETTP operations on the local environment, identify areas where abatement measures would be most effective, and test the efficacy of the measures. Figure 3.23 shows the major water bodies at ETTP. These tasks are (1) toxicity monitoring of effluent and ambient waters from several locations within Mitchell Branch, (2) bioaccumulation studies, and (3) instream monitoring of biological communities. Figure 3.24 shows the monitoring locations along Mitchell Branch.

In March 2008, survival and reproduction toxicity tests were conducted on *Ceriodaphnia dubia* at four ambient locations in Mitchell Branch. At the same time, survival and reproduction toxicity tests were conducted on *Ceriodaphnia dubia* with effluent from storm water outfalls 170 and 190 (Table 3.22). In the tests, none of the water exhibited toxicity. Previously, the overall trend was one of consistent toxicity to *Ceriodaphnia* from storm water outfall 190, with infrequent toxicity from the ambient locations and occasional toxicity at storm water outfall 170. The sources of these problems were not definitively identified. The data gathered in previous studies indicate at least two possible sources. One possible source is groundwater percolating through waste in the K-1070-B Burial Ground and leaching out small quantities of metals. Some of that groundwater flows into the storm drain system and likely contributes to the toxicity at storm water outfall 190. Nickel and zinc were present in water collected from the storm drain system near K-1070-B, at levels that have been shown to be toxic to *Ceriodaphnia.*

The data from the study were used to calculate presumptive water effects ratios for each test location. At both storm water outfall 170 and MIK 0.8, the presumptive water effects ratio was greater than one (indicating that the test water would be expected to be less toxic than the control water). Using that ratio, the presumptive site-specific hexavalent chromium WQC would be 20 µg/L at Mitchell Branch downstream from the chromium seep (MIK 0.8).

Special toxicity studies conducted in November 2008 included collecting water samples from storm water outfall 170, MIK 1.4, and immediately downstream of the chromium seep at MIK 0.8. The samples were analyzed, and it was confirmed that hexavalent chromium concentrations at all three locations were at or below the detection limit. Hexavalent chromium was added to each sample in a dilution series (concentrations of 0, 12.8, 32, 80, 200, and 500 µg/L hexavalent Cr), and 6-day, three-brood *Ceriodaphnia* toxicity tests were conducted on each sample. As expected, increasing concentrations of

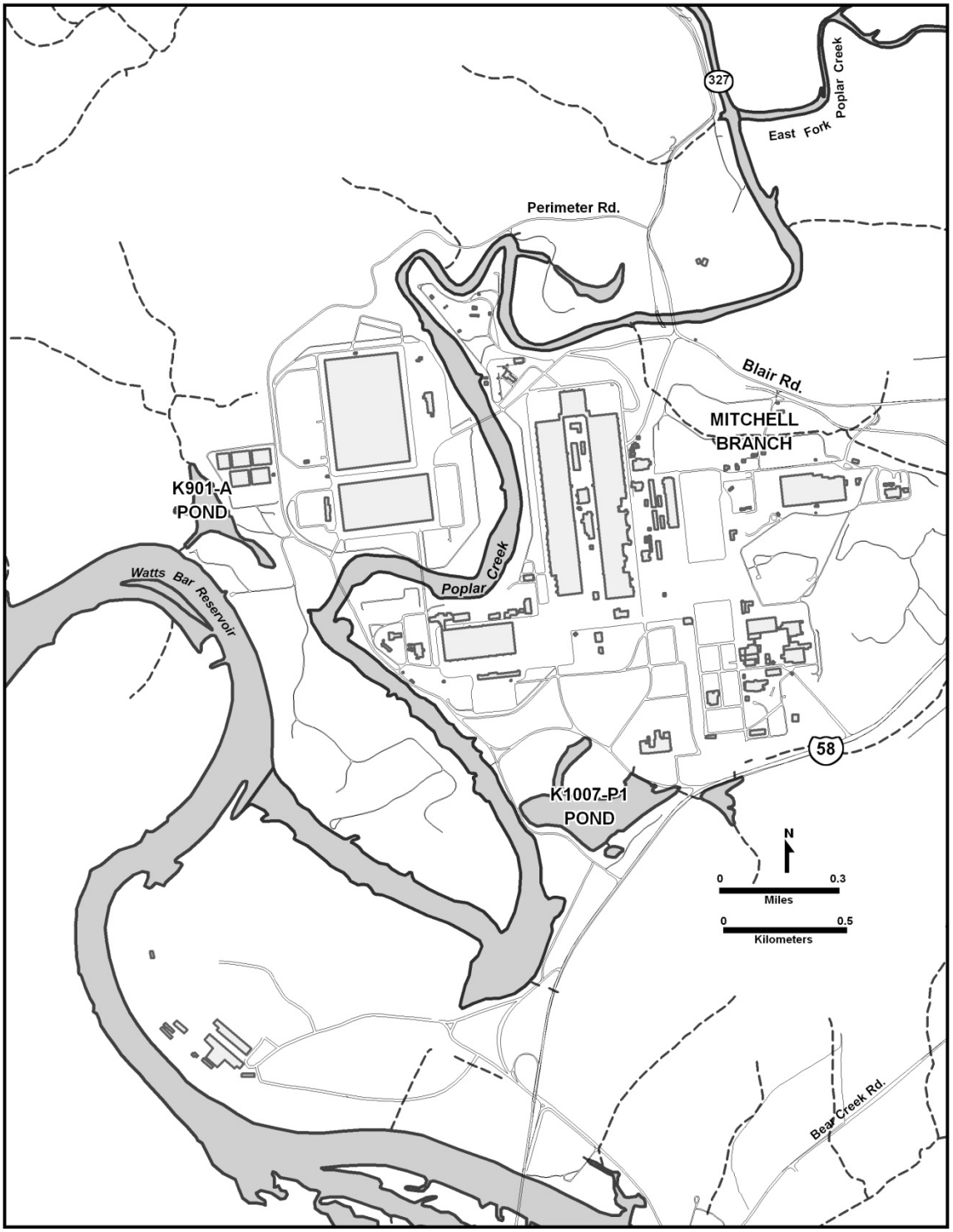


Fig. 3.23. Waterways at ETTP.

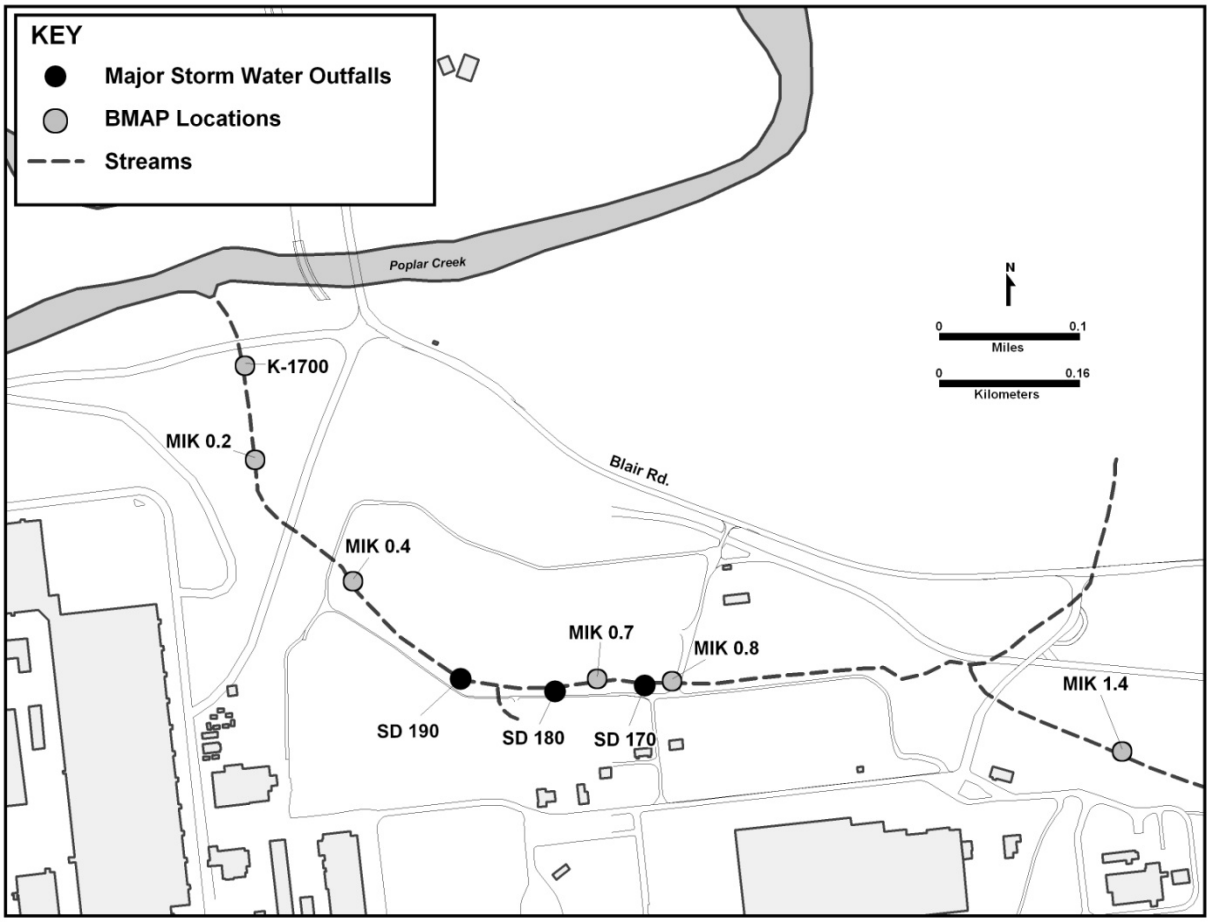


Fig. 3.24. Major storm water outfalls and biological monitoring locations on Mitchell Branch.

Table 3.22. Mitchell Branch and associated storm water outfall toxicity test results, March 2008 (sample concentrations of 100%)

Test	MIK 0.8	SD 170	MIK 0.7	SD 190	MIK 0.4	MIK 0.2
Ceriodaphnia survival (%)	100	100	100	100	100	100
Ceriodaphnia reproduction (%)	27.2	22.8	27.9	23.3	28.0	27.3

hexavalent chromium generally increased toxicity in water samples from any given location. However, toxicity in the samples from MIK 1.4, above most ETTP operational influences, proved to be greater than in water from the control. Conversely, toxicity in the water from storm water outfall 170 and MIK 0.8 was less than in the control. It is hypothesized that some factor in the water from storm water outfall 170 and MIK 0.8, perhaps related to elevated hardness or conductivity, mitigates the toxicity of the hexavalent chromium. However, at storm water outfall 170, the test results indicated that chronic toxicity was not observed until hexavalent Cr concentrations were as high as 163µg/L.

In June and July, 2008, caged clams *(Corbicula fluminea)* were placed at several locations around ETTP (Table 3.23). The clams were allowed to remain in place for 4 weeks, and then were analyzed for

uptake of polychlorinated biphenyls (PCBs). Results were consistent with those of previous years' trends. The highest concentrations were in the clams from the K-1007-P1 Pond (especially for the clams at storm water outfall 100) and Mitchell Branch (where concentrations increased dramatically in the clams from downstream of storm water outfall 190). Clams from the K-901-A Pond contained detectable concentrations of PCBs, but the levels were considerably lower. In the clams from Mitchell Branch, the PCBs detected were primarily Arochlor-1254. In the K-1007-P1 Pond, on the other hand, elevated levels of Arochlor-1248, Arochlor-1254, and Arochlor-1260 were detected. In the K-901-A Pond, low levels of Arochlor-1248, Arochlor-1254 and Arochlor-1260 were detected. In general, the concentrations at Mitchell Branch locations from the 2008 monitoring were similar to those from the 2007 effort, although there was considerable variation at individual locations. For example, levels at MIK 0.7 averaged 0.15 µg/g in the 2007 samples but averaged 0.41 µg/g in 2008, while at MIK 0.4, the average dropped from 2.6 µ/g in 2007 to 1.6 µg/g in 2008. Levels at MIK 0.2 were very similar in both years (2.5 µg/g in 2007 and 2.76 µg/g in 2008).

Fish were collected from Mitchell Branch, K-1007-P1 Pond and K-901-A Pond in May 2008 (Fig. 3.25). Largemouth bass were collected from the pond sites, and redbreast sunfish were collected from Mitchell Branch. Game fish of a size large enough to be taken by sportfishermen were selected both to provide more accurate data of potential human health concerns and to reduce the amount of n contamination levels in the individual fish due to age and size differences. Fillets were taken from each game fish and were analyzed for PCBs. Results from the Mitchell Branch and K-901-A Pond monitoring were higher than last year's results, but are within the range of historical results; fish from both locations contained concentrations (an average of 1.6 and 0.97 ppm, respectively) near the state of Tennessee posting limit of 1 ppm. In the bass from the K-1007-P1 pond, the 2008 results (an average of 20.2 ppm) showed an increase in PCB concentrations when compared with the 2007 monitoring results (14.2 ppm).

In April 2008, the benthic macroinvertebrate communities at four Mitchell Branch locations (MIK 0.4, 0.7, 0.8, and 1.4) were sampled using the traditional techniques developed by the ORNL Environmental Sciences Division (Fig. 3.26). MIK 1.4 serves as the reference location. In the last 10 years, the benthic macroinvertebrate communities at all locations in Mitchell Branch have generally increased in diversity and numbers of individuals. In the 2008 study, both the total taxa richness and the richness of the ephemeroptera, plecoptera, and trichoptera (EPT) species was greatest at MIK 1.4 and decreased with lower values at the downstream locations. EPT species are generally pollution intolerant, and lower values generally correlate to some degree of impact to the stream. Total density of all species at locations MIK 0.8 and MIK 0.7 were greater than at MIK 1.4, but the density of pollution-intolerant species was lower at all of the locations downstream of MIK 1.4. One possible explanation for the lower number of individuals at MIK 1.4 than at MIK 0.7 and MIK 0.8 may be that Mitchell Branch is shallower at MIK 1.4, and the lower flows may inhibit the population size.

In 2008, TDEC requested that the protocols developed by TDEC for benthic macroinvertebrate community studies be used at ETTP. Consequently, in August TDEC protocols were used at three locations on Mitchell Branch (MIK 0.4, 0.7, and 0.8). TDEC protocols differ from the ORNL protocols in several key respects. TDEC has established habitat goals for all streams in the eco-region. The habitat assessment (which primarily considers the physical aspects of the stream to determine the suitability of the stream to support invertebrate communities) indicated that Mitchell Branch does not meet the habitat goals for this region. The results of the semiquantitative assessment indicated that Mitchell Branch is slightly impaired, which is consistent with the results from the studies using the ORNL protocols.

Fish communities in Mitchell Branch (MIK 0.4 and 0.7) were sampled in March and April 2008. Species richness, density, and biomass were examined. The results for the community at MIK 0.4 were very similar to the 2007 results. Although new sunfish species appeared, some previously observed minnow species were absent, leaving the richness unchanged. Total density and biomass increased slightly. At MIK 0.7, species richness, biomass, and density showed increases from last year. Wide swings in those three parameters are typical of streams that have been severely impacted and that are in the process of recovery but have not yet reached the long-term stable state. The stream is still dominated by more-tolerant fish species. This pattern is often found in impacted streams, where less tolerant species are excluded by one or more conditions in water quality or other factors in the environment. 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.

Table 3.23. Average PCB concentrations in biota, 2008

Location	Species	Average PCB concentration (ppm)	Range (ppm)	Number above 1 ppm[a]/total
K-1007-P1 Pond	Largemouth bass	20.2	7.4–42	6/6
K-901-A Pond	Largemouth bass	0.97	0.35–1.74	3/6
Mitchell Branch	Redbreast sunfish	1.60	1.02–2.2	6/6
Hinds Creek (ref)	Redbreast sunfish	0.01	<0.01–0.01	0/6
MIK 0.99	Asiatic clam	0.16	NA	NA
MIK 0.8	Asiatic clam	0.33	NA	NA
MIK 0.7	Asiatic clam	0.41	NA	NA
MIK 0.5	Asiatic clam	0.68	NA	NA
MIK 0.4	Asiatic clam	1.61	NA	NA
MIK 0.2	Asiatic clam	2.76	NA	NA
SD100 (upper)	Asiatic clam	1.08	NA	NA
SD100 (lower)	Asiatic clam	4.11	NA	NA
SD 120	Asiatic clam	1.06	NA	NA
SD 490	Asiatic clam	1.17	NA	NA
K-1007-P1 outfall	Asiatic clam	0.65	NA	NA
K-901-A outfall	Asiatic clam	0.21	NA	NA
Sewee Creek (ref)	Asiatic clam	0.01	NA	NA

3.7. Quality Assurance Program

BJC is committed to developing, implementing, and maintaining a formal QA program that ensures the highest standards of performance by empowering employees in their respective areas of responsibility through fostering a “no fault” attitude toward the identification and reporting of quality deficiencies. The Quality Program provides the framework for a results-oriented management system that focuses on performing work safely and meeting mission and customer expectations while allowing BJC and its subcontractors to become more efficient through process improvement.

The BJC QA Program is a management system that addresses three major elements: managing work, performing work (whether self-performed or subcontracted), and assessing the adequacy of work. The management element encompasses management programs, including organizational structure and responsibilities, and management processes, including planning, scheduling, and resource considerations. The management element also includes personnel training and qualifications, continuous improvement, and documents and records. The performance element includes work processes, design, procurement, and inspection and acceptance testing. The assessment element includes external assessments, independent assessments, and management assessments.

Fig. 3.25. Collecting fish for bioaccumulation monitoring.

The BJC QA Program is based on the Title 10 *Code of Federal Regulations* (CFR) Part 830.120, "Quality Assurance Requirements" and is incorporated within the Integrated Safety Management System (ISMS). The program identifies the consensus standards used in its development and implementation and describes how the contractor responsible for the nuclear facility will implement the requirements contained in those documents. Where equivalent elements do not already exist, additional requirements for radioactive waste packaging are included from 10 CFR 71 Subpart H. DOE reviews changes made to the program annually.

The QA Program requirements are reflected in implementing procedures. Subcontractors must meet the same elements when developing and following their own QA plan for each scope of work, or when following the BJC QA Program in executing work scope. Through its BJC Park Worker Annual Training Program, BJC introduces and emphasizes the importance of the QA Program so that it is understood by BJC and subcontract personnel.

New and revised DOE standards (e.g., orders, manuals, technical standards, guides) are screened by BJC QA Organization staff for applicability to BJC work scope and to recommend an approach for developing BJC's position on incorporation into the contract. Applicable standards are routed to functional managers and subject matter experts. Necessary actions to address new and/or revised federal, state, and local laws and regulations are considered by the BJC Standards Review Board, whose responsibilities include evaluating issues to determine the need for considering changes to BJC contractual standards due to the following:

- challenges that relate to the appropriateness of safety standards;
- changes to federal, state, and local laws and regulations;
- changes to voluntary consensus standards included as contractual standards;
- changes to approved DOE directives that address safety requirements; and
- new work scope or hazards.

Fig. 3.26. Benthic Macroinvertebrate sampling.

Links to the current set of contractual standards and requirements are maintained on the BJC website. Additional links are provided for reference to DOE's directives. The BJC organizational structure, functional responsibilities, levels of authority, and interfaces for those planning, managing, performing, and assessing the work are defined in company policies, program plans, program procedures, directives, and subcontracts, as appropriate.

The BJC QA Organization has a key role in implementing continuous improvement and provides direct support to program and project teams throughout the company to facilitate integration of QA requirements into project activities. The BJC QA functional manager is responsible for providing central leadership, direction, and assessment of the BJC QA Program and for assisting BJC project managers and subcontract coordinators in verifying that, when required, subcontractors have an adequate QA plan in place before work is initiated.

BJC senior management is responsible for the leadership and commitment to quality achievement and improvement within a framework of public, worker, and environmental safety. BJC management also has the primary responsibility and accountability for the scope and implementation of the BJC QA Program. BJC personnel are held directly responsible for the quality of their work; line management has final responsibility for the achievement of quality. BJC personnel have the responsibility to immediately stop work if an operation or process seriously jeopardizes safety, health, or the environment or if it possesses imminent life-threatening implications as defined in BJC procedures. These responsibilities are passed down to subcontractors through language contained in each subcontract and through the *Worker Safety and Health Program Description and Environmental Compliance and Protection Plan*.

The BJC QA Program is implemented through management processes, which include training personnel and verifying their qualifications; identifying opportunities for improvement; controlling documents and records; and planning, scheduling, and identifying resources.

The quality of items, services, and processes is ensured for subcontracts through the procurement process by requiring subcontractors to work under the BJC QA Program or to provide a QA plan that identifies the specific quality requirements applicable to the subcontractor's scope of work.

Environmental management operations include environmental cleanup, waste management, and reindustrialization activities. The ultimate success of BJC's environmental program and projects depends on the quality of the environmental data collected and used in the decision-making process. Environmental data operations include the collection, management, use, assessment, retention, and reporting of such data.

All activities involving the generation, acquisition, and use of environmental data are planned and documented. The type and quality of the data are determined with respect to their intended use. The data quality objective process establishes the objectives for data collection and quality. Determining the type and quality of environmental data needed involves data users as well as personnel responsible for activities affecting data quality.

Selected programs or projects impose unique QA requirements on their activities. Such special QA Program requirements are added to, and where possible, integrated with the basic BJC QA Program requirements for the affected facilities and activities. For subcontracted work, the necessary QA requirements are included in subcontract language, or the subcontractor is required to develop a QA plan to be submitted to BJC for review and approval. These special QA requirements are applicable to a specific work scope and are monitored by BJC and/or subcontractor personnel, as appropriate.

3.7.1 BJC ISMS Program

It is the intent of the BJC QA Program to be fully consistent with and supportive of the company's ISMS Program. The BJC QA Program implements methodologies employed to do work processes safely, free of environmental insult, and in accordance with established procedures. It also describes the mechanism in place to seek continuous improvements by identifying and correcting deficiencies and preventing their recurrence.

The effective implementation of QA requirements supports the principles and functions of ISMS. The BJC fundamental quality expectations are that work be conducted safely and that it meet established requirements. In that regard, the QA Program ensures compliance with approved standards and requirements so that the expectation for safe work within controls is met and that workers, the environment, and the public are protected from harm. The BJC management systems ensure that quality and safety requirements are properly integrated to achieve their objectives.

The QA Organization has also established the BJC integrated assessment and oversight process as an integral part of the ISMS feedback and continuous improvement process. The QA Organization is responsible for the following:

- developing an integrated assessment process;
- planning and conducting closure project evaluations utilizing performance-based criteria with reports to senior management;
- screening assessment findings, observations, proficiencies, and resulting corrective actions for effectiveness and establishing company-wide priorities;
- evaluating feedback data to determine the effectiveness of safety management program implementation; and
- identifying opportunities for improvement.

3.7.2 Integrated Assessment and Oversight Program

QA Program implementation and procedural and subcontract compliance are verified through the BJC Integrated Assessment and Oversight Program. The program identifies the processes for planning, conducting, and coordinating assessment and oversight of BJC activities, including both self-performed and subcontracted activities, resulting in an integrated assessment and oversight process. The program is composed of three key elements: (1) external assessments conducted by organizations external to BJC, (2) independent assessments conducted by teams independently of the project/function being assessed, and (3) management assessments conducted as self-assessments by the organization or on behalf of the organization manager.

Self-assessments are performed by the organization/function having primary responsibility for the work, process, or system being assessed. Organizations and functions within the company plan and schedule self-assessments. Self-assessments encompass both formal and informal assessments. The formal self-assessments include management assessments and subcontractor oversight. Informal self-assessments include weekly inspections and routine walkthroughs conducted by subcontractor coordinators, ES&H representatives, quality engineers, and line managers.

QA issues identified from internal and external assessments are documented, causal analyses are performed, and corrective actions are developed and tracked to closure. Analyses are conducted periodically to identify trends for management action. Data from those processes are evaluated by senior management to identify opportunities for improvement.

3.8 Environmental Management Activities

3.8.1 Waste Management Activities

Restoration of the environment, D&D of facilities, and management of the legacy wastes constitute the major operations at ETTP.

The ETTP is home to the TSCA Incinerator, a thermal treatment facility. It is one of the few facilities licensed to incinerate both PCB waste and radioactive mixed waste. The TSCA Incinerator treats waste from all across the DOE complex and as such is a key component of DOE remediation efforts across the nation. The incinerator treated approximately 1.31 million lb of waste in 2008 (1.1 million lb of liquid waste and more than 142,000 lb of solid waste). DOE is planning to incinerate approximately 2.1 million lb of waste in TSCA Incinerator in 2009. The treatment quantities include fuel oil rinses of the tank farm as the incinerator is readied for closure in the final year of operation. Closure activities will begin in 2009 and continue into FY 2010.

The CNF, ETTP's primary wastewater treatment facility, which processes both hazardous and nonhazardous waste streams, treated more than 18.5 million gal of wastewater in 2008. Although the largest single contributor by far is the TSCA Incinerator, wastes also arise from other 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. TDEC is in the process of developing and issuing a new NPDES permit that will reflect the changing conditions at the ETTP.

The on-site CERCLA Waste Facility, located in Bear Creek Valley, is used for disposal of waste resulting from CERCLA cleanup actions on the ORR. The CERCLA Waste Facility is an engineered landfill that accepts low-level radioactive and hazardous wastes in accordance with specific waste acceptance criteria under an agreement with state and federal regulators. The CERCLA Waste Facility received approximately 6,500 truckloads of waste (Fig 3.27) accounting for 89,000 tons during FY 2008. In addition, approximately 1.8 million gal of leachate were collected and disposed of at the ORNL Liquids and Gases Treatment Facility. An additional 6.1 million gal of contact water were collected, analyzed, and released to the sediment basin after analyses confirmed that the water met the release criteria. ETTP projects that have disposed of waste at the CERCLA Waste Facility include the following:

Fig. 3.27. Loading truck with waste for disposal.

- ETTP removal actions, including the Scrap Removal Project, K-1070-B Burial Ground, K-1085, and Duct Island (soil removals);
- the K-25/K-27 D&D Project, including Building K-1030 and K-1024; and
- other ETTP D&D projects, including Building K-1004 Laboratories, K-1420, K-1401, and K-413.

3.8.2 Environmental Restoration Activities

The ETTP operated as an enrichment facility for four decades, during which time many of the buildings became contaminated to some degree with radionuclides, heavy metals, and toxic organic compounds. In addition, large quantities of wastes were generated, much of which was stored on the site.

The EMP is designed to demolish all unnecessary facilities and restore the site to a usable condition.

Safety and health of employees and the public is a constant focus. Cost-effectiveness is also a major consideration in the cleanup operations.

DOE has signed two of three key CERCLA records of decision (RODs) with the state of Tennessee and EPA authorizing environmental restoration of about 890 ha (2200 acres) of land at ETTP. The area encompasses approximately about 567 ha (1400 acres) outside the main plant security fence (Zone 1), and about 324 ha (800 acres) inside the fence within the former plant production area (Zone 2). The main objectives of the two decisions are to protect future industrial workers and the underlying groundwater from contamination in soil, slabs, and subsurface structures. Development of the final Site-Wide ROD for groundwater, surface water, sediment, and ecological soil risk is in progress.

One of the major ongoing operations at the ETTP site is dismantling the west wing of the K-25 building and preparing the east wing of the K-25 building for demolition. It is one of the largest D&D projects in the entire DOE complex. The three-story, U-shaped K-25 building, built during the Manhattan Project, covers 1.64 million ft^2 (approximately 18 ha) and contains 3,018 stages of gaseous diffusion process equipment and associated auxiliary systems, including approximately 400 miles of piping. Each stage consists of a converter, two compressors, two compressor motors, and associated piping. Removal

of the high-risk equipment components was completed in the west wing in 2008 and is expected to be completed in the east wing in 2010. Activities under way to prepare the east wing for demolition include radiological and chemical characterization; process system stabilization by foaming, removal and segmentation of high-risk components; removal of transite panels and excess materials, shipment of converters off site for disposal; and installing nets and barriers to protect workers from falling debris.

The first demolition activity on the K-25 building was successfully completed in 2008. The northwest bridge that connected the west wing to the base of the U-shaped structure has been removed. The bridge housed pipes that transferred uranium as it was undergoing enrichment between building wings. Workers used excavators and other heavy equipment to demolish the two-story, 143,000 ft^3 structure. The bridge removal paved the way for demolition of the west wing, which began in December 2008. Demolition of both wings of the building is scheduled to be completed by the end of 2011.

In 2008, three predominantly uncontaminated facilities and 13 low-risk/low-complexity facilities were demolished. Asbestos abatement and universal waste removal from K-1035 was completed. In the Poplar Creek area,

- asbestos abatement was completed in K-633, K-131, K-631, K-1231, and K-413;
- chemical treatment was completed in K-633 and the K-27/K-633 tie line;
- characterization was completed in K-413, K-1231, K-1233, K-633, and K-633/K-27 tie line;
- chemical treatment was completed on all facilities and 80% of the tie lines associated with hydrofluoric acid distribution to the uranium-processing facilities; and
- the remaining uranium hexafluoride cylinders from Building K-33 were disposed of.

Demolition of the K-413 Building structure was initiated and is 50% completed, with 50% of the building rubble having been disposed of at Environmental Monitoring and Waste Management Facility (EMWMF). The remaining rubble will be disposed of at the Nevada Test Site in 2009. The D&D of Building K-1401, a 500,000 ft^2 structure in the center of ETTP, was completed in 2007, and activities in the area in 2008 included backfilling the basement area and removing the concrete slabs of K-1401, the K-1008 change houses, and K-1020.

Remediation in the Zone 2 Balance of Site–Laboratories area was completed, including removing the K-1004-A, B, C, D, and L concrete slabs and removing seven acid pits from the laboratory area.

A remedial investigation/feasibility study (RI/FS) submitted to EPA and TDEC addressed the nature and extent of groundwater contamination, contamination of Mitchell Branch, and ecological concerns. The document addressed evaluating alternatives for remediation and provided the basis for the final remediation decision for ETTP. EPA and TDEC reviewed the document in 2007. A revision was prepared and reviewed by those agencies, and a second revision was prepared. This second revision is expected to be approved in 2008. Also in 2008, plans were initiated to conduct a groundwater treatability study, which will be conducted in FY 2009. A proposed plan was submitted to EPA and TDEC in 2007; however, it will be placed on hold until the RI/FS study is finalized.

3.8.3 Reindustrialization

The Reindustrialization Program was developed to accelerate cleanup of the site and to allow for beneficial reuse of underutilized facilities and land. Facilities that have been determined to be appropriate for reuse are leased or transferred to non-DOE entities such as CROET or the city of Oak Ridge. CROET is a not-for-profit corporation established to foster diversification of the regional economy by reutilizing excess DOE property for private-sector investment and job creation.

On May 29, 2008, DOE Oak Ridge Office's Reindustrialization Program transferred the K-1515 Water Treatment Plant Complex to the city of Oak Ridge. The K-1515 Water Treatment Plant transfer includes the intake structure, day tanks, and select portions of the potable water distribution system as well as select portions of the sanitary sewer collection system. Transfer of the K-1515 Water Treatment Plant complex is part of a comprehensive plan for the city of Oak Ridge to provide potable water service to ETTP as well as other development on the extreme western end of the city.

On January 4, 2008, DOE transitioned the 25,000-ft^2 ETTP K-1652 Fire Station (re-named Station No. 4) to the city of Oak Ridge, making it an official part of the Oak Ridge Fire Department. Station No. 4 was previously operated by BJC for DOE as an ETTP-site-only fire department. As part of the transfer, the city received fire engines, a rescue truck, a hazardous materials response truck, ambulances, and several trailers equipped with special rescue equipment. The City of Oak Ridge Fire Department also assumed operation of the DOE ambulances, which can respond to off-site emergencies as well as to those which may occur on DOE sites. With the addition of this new fire station, west end residents and businesses have closer access to firefighting and emergency medical services.

One land parcel, referred to as ED-5 West, has been identified for new construction. It was transferred to CROET on December 22, 2008. ED-5 West consists of approximately 10.5 ha located near the front of ETTP, behind Pond K-1007-P1 and adjacent to Poplar Creek and Parcel ED-5 East.

In addition to transfers, several facilities were leased to CROET during 2008. On February 12, 2008, K-1251, the barge area adjacent to the Clinch River west of ETTP, was leased to CROET. K-1251 was subsequently leased by CROET to Energy Solutions, Inc. Buildings K-796-A and K-791-B, along with the K-792 Switchyard area located in the northwest corner of ETTP, were leased to CROET on April 1, 2008.

These transfers and leases are part of DOE's plan to transform ETTP into a private-sector business and industrial park. Additional buildings at ETTP and several land areas are in various stages of the transfer process.

3.9 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 *2009 Remediation Effectiveness Report* (DOE 2009).

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 (i.e. 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 *2009 Remediation Effectiveness Report* (DOE 2009) includes summaries of groundwater monitoring actions required for individual cleanup actions at the ETTP, along with recommendations to modify any requirement that would further ensure protection of human health and the environment.

3.10 Direct Radiation Monitoring

Direct radiation monitoring is no longer necessary for locations that were formerly the UF_6 cylinder storage yards and the K-770 Scrap Yard at ETTP because direct dose measurements that have been taken have confirmed that they are no longer a source of potential dose to the public above the background levels.

3.11 References

BJC. 2007. *East Tennessee Technology Park Storm Water Pollution Prevention Program (SWP3) Sampling and Analysis Plan (SAP),* BJC/OR-758/R7. Bechtel Jacobs Company LLC, Oak Ridge, Tennessee.

BJC. 2008. *East Tennessee Technology Park Storm Water Pollution Prevention Program (SWP3) Sampling and Analysis Plan (SAP),* BJC/OR-758/R8. Bechtel Jacobs Company LLC, Oak Ridge, Tennessee.

DOE. 1999. *Accelerating Clean-Up: Paths to Closure*. U.S. Department of Energy Oak Ridge Office, Oak Ridge, Tennessee.

DOE. 2007. *Balance of Site – Laboratory*, *Phased Construction Completion Report (PCCR) for K-1420, Oak Ridge, Tennessee.* DOE/OR/01-2341&D2. September. U.S. Department of Energy, Washington, D.C.

DOE. 2007a. *Balance of Site – Laboratory*, *Phased Construction Completion Report (PCCR) for K-770, Oak Ridge, Tennessee.* DOE/OR/01-2348&D1. April. U.S. Department of Energy, Washington, D.C.

DOE. 2007b. *Balance of Site – Laboratory*, *Phased Construction Completion Report (PCCR)—Removal Action Report for Group II Buildings (K-1064 Area), Oak Ridge, Tennessee*. DOE/OR/01-2339&D1. May. U.S. Department of Energy, Washington, D.C.

DOE. 2009. 2009 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee Data and Evaluations. DOE/OR/01-2393&D1. U.S. Department of Energy, Washington, D. C.

EPA. 1992. NPDES Storm Water Sampling Guidance Document. U.S. Environmental Protection Agency, Washington, D.C.

ISO. 2004. *Environmenta*l *Management Systems—Requirements with Guidance for Use.* ISO 14001:2004. International Organization for Standardization. http://www.iso.org.

4. The Y-12 National Security Complex

The Y-12 National Security Complex, a one-of-a-kind manufacturing facility, currently operated by Babcock & Wilcox Technical Services Y-12, LLC (formerly BWXT Y-12), was built during World War II as part of the Manhattan Project. Today, as part of the National Nuclear Security Administration Nuclear Security Enterprise, and with more than 60 years of experience to draw from, Y-12 is uniquely qualified as a premier manufacturing facility dedicated to making our nation and the world a safer place. While we are extremely proud of our past, our challenge today is to lay a firm foundation for the Y-12 of tomorrow—a streamlined, modern complex that is sized to meet future missions and to do so in a safe, secure, environmentally sound, energy-efficient, and sustainable manner. Infrastructure reduction activities since 2001, in which more than 1.2 million ft^2 (284 buildings) have been demolished, have already significantly changed the face of the Y-12 Complex. Recently constructed facilities such as the Jack Case and New Hope centers provide modern office space. Completion of the Highly Enriched Uranium Materials Facility in 2008 provides another transformation success.

The environmental programs at Y-12 continue to be managed and implemented in accordance with applicable environmental laws, regulations and permits. We seek to continually improve our environmental performance, reducing impact on the environment; improvements include increased use of environmentally friendly products and processes and reduced waste and emissions. Our environmental stewardship accomplishments have been recognized by our customer, our community, and other stakeholders. The compliance status and results of monitoring and measurements conducted by the Y-12 environmental programs during 2008 are presented in this chapter.

4.1 Description of Site and Operations

4.1.1 Mission

The Y-12 Complex 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 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

- receipt, storage, and protection of special nuclear materials;
- quality evaluation/enhanced surveillance of the nation's nuclear weapon stockpile;
- safe and secure storage of nuclear materials;
- dismantlement of weapon secondaries and disposition of weapon components;
- providing technical support and know-how to National Nuclear Security Administration (NNSA) Defense Nuclear Nonproliferation Program;
- providing fuel for the nation's naval reactors program;
- transferring of technology to private industry;
- maintenance of DOE capabilities; and
- support to DOE, other federal agencies, and other national priorities.

Babcock & Wilcox Technical Services Y-12, LLC, (B&W Y-12) is the NNSA's management and operating contractor responsible for operation the Y-12 National Security Complex g. Located within the town limits of Oak Ridge, Y-12 covers more than 328 ha in the Bear Creek Valley, stretching 2.5 miles down the valley and nearly 1.5 miles wide. Approximately 6,000 people work on site, including employees of B&W Y-12, NNSA, Wackenhut Services (NNSA's security services contractor), other DOE contractors, and subcontractors.

NNSA-related facilities located off the Y-12 Complex site but in Oak Ridge include an analytical laboratory and a vehicle maintenance facility. The laboratory is a leased facility providing a wide range of routine and nonroutine analytical services for environmental and hazardous waste programs of NNSA, DOE, and other customers.

4.1.2 Transformation

Complex Transformation is NNSA's vision for a smaller, safer, more secure, and less expensive nuclear weapons complex that leverages the scientific and technical capabilities of its workforce and meets national security requirements.

The current complex is old; many of the facilities were required for the Cold War security environment but are no longer necessary to use or affordable to maintain. 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. The country's need to construct smarter, more environmentally friendly buildings is a focus of the new construction projects.

4.1.2.1 Infrastructure Reduction

Infrastructure activities have already significantly changed the face of the Y-12 Complex. In FY 2008, an additional 149,000 ft^2 of floor space was demolished, bringing Y-12's total to more than 1.2 million ft^2 (284 buildings) demolished since the program was initiated in 2001. Infrastructure reduction also supports Y-12's waste reduction goals and recycling initiatives. Since 2002, through infrastructure reduction, more than 41 pollution prevention projects have been completed, including ongoing recycling projects that have resulted in the elimination of more than 9.4 million lb of waste with an estimated cost avoidance of more than $1.21 million. This does not include the significant cost avoidances and waste reduction amounts for the various ongoing Y-12 Complex recycling initiatives (e.g., lamps, batteries, ballasts, furniture) that are supported by infrastructure reduction.

4.1.2.2 New Construction

Two recently constructed buildings, the Jack Case Center and the New Hope Center, typify Y-12's rich history and bright future (Fig. 4.1). The Jack Case Center, which houses administrative, technical, and engineering functions, is named in honor of Jack M. Case, who rose through the ranks to become plant manager and who had the longest tenure—15 years. The New Hope Center is located at the east end of the complex, where the small community of New Hope once stood. The structure houses a visitor's center, a Y-12 History Exhibit (see Sect. 4.3.2.2), and other functions requiring frequent interaction with the public. Together, these new facilities replaced about 1 million ft^2 of obsolete workspace with about 540,000 ft^2 of modern office and laboratory space for about 1,500 employees. Both the Jack Case Center and the New Hope Center have incorporated many Leadership in Energy and Environmental Design (LEED®) guided sustainable building practices and techniques, with New Hope achieving 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. From establishing parking spaces for alternative-fuel vehicles to installing low-flow water fixtures in the restrooms and four aboveground 12,000-gal rainwater-harvesting tanks, LEED has inspired an impressive list of "green" features throughout both facilities.

A number of other projects to replace key facilities and to upgrade site infrastructure systems are planned or ongoing. In some cases new facilities will be constructed to maximize protection of sensitive materials and operations; in other cases the new facilities will replace worn-out obsolete buildings and systems. Examples include the following.

- **Highly Enriched Uranium Materials Facility (HEUMF)**—This new, state-of-the-art storage facility (Fig. 4.2) is our nation's central repository for highly enriched uranium and Y-12's first significant milestone in its quest for a modernized Uranium Center of Excellence. Special nuclear material that is housed in multiple aging facilities will be consolidated in it. On Sept. 29, 2008, the facility was officially introduced to the public and the Y-12 population in a celebration at the site. One month earlier (on August 27) the HEUMF project had accomplished its milestone of essentially completing construction on the facility.

Fig. 4.1. Jack Case Center (upper) and New Hope Center.

Fig. 4.2. Y-12's new state-of-the-art storage facility.

- **Potable Water System Upgrades**—A $62.5 million potable water system upgrades project broke ground in 2008. As a major utility upgrade, the new system will provide Y-12 with a more reliable and cost-effective source of potable water. The 2-year project includes new water tanks, pumps, and distribution piping to provide a new primary and backup water supply to the Y-12 complex; underground pipe repairs and replacement of more than 9,000 ft of deteriorated original cast mains; and sprinkler system modifications.
- **The Steam Plant Life Extension Project**—The new plant will use natural-gas-fired package boilers with new burner technology instead of coal, creating much cleaner emissions. Sulfur dioxide will be reduced by 99.5%, nitrogen oxides by 94%, and particulate matter by 72%. In addition, the new plant will require less water and fewer chemicals because it uses reverse osmosis for water purification. Construction is ongoing and on track for completion by mid-January 2010.
- **Complex Command Center—**Building on the success of the Jack Case and New Hope centers, Y-12 is moving forward with plans for an additional third-party financed facility. The Complex Command Center (CCC) project's Critical Decision-1 package was approved November 19, 2008, by NNSA. The CCC will consolidate Y-12's emergency services within Y-12's Property Protected Area. The proposed CCC will house the fire department, the plant shift superintendent's office, the technical support/emergency operations center, and emergency management support. These functions are now scattered throughout the site in aging, outmoded facilities.

4.2 Environmental Management System

As part of B&W Y-12's commitment to environmentally responsible operations, an environmental management system (EMS) based on the rigorous requirements of the globally recognized International Organization for Standardization (ISO) 14001 (ISO 2004), has been implemented.

4.2.1 Integration with Integrated Safety Management System

The Integrated Safety Management System (ISMS) is the DOE's umbrella of environment, safety, and health (ES&H) programs and systems that provides the necessary structure for any work activity that could potentially affect the public, a worker, or the environment. B&W Y-12's ISMS has incorporated the elements of the ISO 14001 EMS in the overall umbrella of Integrated Safety Management (ISM) for environmental compliance, pollution prevention, waste minimization, and resource conservation. B&W Y-12 has self-declared implementation based on the principles of the ISO 14001 standard after verifying and validating implementation based on a second-party independent assessment. The assessment concluded that "The EMS is fully integrated within ISMS and the required elements from ISO 14001 have been achieved."

4.2.2 Policy

The environmental policy of B&W Y-12 and its commitment to providing sound environmental stewardship practices through the implementation of an EMS have been defined and are endorsed by top management and have been made available to the public via company-sponsored forums such as the Environment, Safety, and Health Expo (see Sect. 4.2.4.2), and public documents such as this one. The B&W Y-12 ES&H policy contains environmental commitments required by ISO 14001 as is presented in Fig. 4.3.

This policy has been communicated to all employees; has been incorporated into General Employee Training (GET) for every employee, guest, and contractor; and made available for viewing on the internal Y-12 Web Site. Y-12 personnel are made aware of the commitments stated in the policies and how the commitments relate to our work activities.

Y-12 Environment, Safety, and Health Policy

Policy: As we work to achieve the Y-12 mission and our vision of a modernized Y-12 Complex, we will do so by ensuring the safety and health of every worker, the public, and the environment. Every employee, contractor, and visitor is expected to take personal responsibility for their actions.

- Environmental Policy: We protect the environment, prevent pollution, comply with applicable requirements, and continually improve our environment.
- Safety and Health Policy: The safety and health of our workers and the protection of public health and safety are paramount in all that we do. We maintain a safe work place and plan and conduct our work to ensure hazard prevention and control methods are in place and effective.

In support of this policy, we are committed to:

- Integration of Environment, Safety and Health (ES&H) into our business processes for w ork planning, budgeting, authorization, execution, and change control in accordance with our Integrated Safety Management System.
- Continuously improving our processes and systems by establishing, tracking, and achieving goals that drive performance excellence.
- Direct, open, and truthful communication of this policy and our ES&H performance to our employees, contractors, customers, and stakeholders.
- Strive to minimize the impact of our operations on the environment in a safe, compliant, and cost-effective manner using sustainable practices for energy efficiency, fleet management, water consumption, pollution prevention, recycling/reuse, source reduction, resource conservation, and environmentally preferable purchasing.
- Incorporate sustainable design principles into the design and construction of facility upgrades, new facilities, and infrastructure considering life-cycle costs and savings.
- Incorporate the use of engineering controls to reduce or eliminate hazards whenever possible into the design and construction of facility upgrades, new facilities, and infrastructure.
- Strive to provide a clean and efficient workplace free of occupational injuries and illnesses (Target Zero).
- Foster and maintain a work environment of mutual respect and teamwork that encourages free and open expression of ES&H concerns.

Fig. 4.3. Y-12 environment, safety, and health policy.

4.2.3 Planning

The planning requirements of the ISO 14001 standard require B&W Y-12 to identify the environmental aspects and impacts of its activities, products, and services; to evaluate applicable legal and other requirements; to establish objectives and targets (goals); and to create action plans to achieve the objectives and targets. Selected accomplishments and continual improvement initiatives of 2008 are noted in the following sections.

4.2.3.1 Environmental Aspects

B&W Y-12 evaluates the operations, identifies the aspects that can impact the environment, and determines which of those impacts are significant. Environmental aspects are those elements of activities and services that can be controlled or influenced. They may be thought of as potential environmental hazards associated with a facility operation, maintenance job, or work activity.

Aspects and impacts are evaluated to ensure that the significant aspects and potential impacts continue to reflect stakeholder concerns and changes in regulatory requirements. The following aspects have been identified as potentially having significant environmental impact:

- waste generation,
- air emissions,
- liquid discharges,

- storage/use of chemicals and radioactive materials,
- legacy contamination,
- excess/surplus materials,
- historical and cultural resources,
- natural resource consumption (energy and water), and
- natural resource conservation (positive impacts).

The EMS provides the system to ensure that environmental aspects are systematically identified, monitored, and controlled in order to mitigate or eliminate potential impacts to the environment.

4.2.3.2 Legal and Other Requirements

To implement the compliance commitments of the ES&H policy and to meet legal requirements, systems are in place to review changes in federal, state, or local environmental regulations and to communicate those changes to affected staff. The environmental compliance status is documented each year in the ASER (see Sect. 4.3).

4.2.3.3 Objectives, Targets, and Environmental Action Plans

B&W Y-12 has established and maintains documented environmental objectives, targets (goals), and action plans. Goals and commitments are established annually and are agreed to by the Y-12 NNSA Site Office (YSO) and B&W Y-12 and are consistent with mission, budget guidance, ES&H work scope, site incentive plans, and continuous improvement. The environmental action plans designate responsibility for achieving the goals. The action plans may be amended to reflect new developments and new or modified activities as conditions change at the Y-12 Complex or as a result of management reviews. B&W Y-12 achieved 99% of planned environmental targets in 2008. Highlights included the following.

- Legacy low level waste—Dispositioned 50 of the 70 containers outside the barrier, which is a reduction of 71.4%, exceeding the goal of 30%.
- Mixed waste—Dispositioned 70.1% of the target inventory (1,500 of 2,139 items), which exceeded the goal of 50%.
- Building 9201-5 environmental liabilities—Finalized a project execution plan and schedule and made significant progress in disposing of hazardous materials.
- PrYde—All four of the Fiscal Year (FY) 2008 Clean Sweep areas have been verified acceptable by the YSO. Additionally, more than five customer-funded areas were completed during FY 2008.
- Outdoor low-level \waste areas – The number of outdoor areas was reduced 18%, which exceeds the 10% goal.

4.2.3.4 Programs

NNSA has developed and funded several important programs to integrate environmental stewardship into all facets of Y-12's missions. The programs also address the DOE order requirements for protecting various environmental media, reducing pollution, conserving resources, and helping to promote compliance with all applicable environmental regulatory requirements and permits.

4.2.3.4.1 Environmental Compliance

The B&W Y-12 Environmental Compliance Department (ECD) provides environmental technical support services and oversight for Y-12 Complex line organizations to ensure that site operations are conducted in a manner that is

- protective of workers, the public, and the environment;
- in compliance with applicable federal, state, and local environmental laws and regulations;

- in compliance with applicable DOE orders and standards related to protection of the environment; and
- consistent with our environmental policy and site procedures.

The ECD serves as the B&W Y-12 interpretive authority for environmental compliance requirements and as the primary point of contact between B&W Y-12 and external environmental compliance regulatory agencies such as the city of Oak Ridge, the Tennessee Department of Environment and Conservation (TDEC), and the U.S. Environmental Protection Agency (EPA). The ECD is structured in sections to mirror the major environmental legislation that affects Y-12 Complex activities. Compliance status and results of monitoring and measurements conducted by these compliance programs are presented in this document.

4.2.3.4.2 Waste Management

The B&W Y-12 Waste Management Department manages and supports the full life cycle of all waste streams within the Y-12 Complex. While ensuring compliance with federal and state regulations, DOE orders, waste acceptance criteria, and Y-12 procedures and policies, the Waste Management Department provides

- technical support to generators on waste management, pollution prevention, and recycling issues and
- waste certification in accordance with DOE orders and the Nevada Test Site (NTS) Waste Acceptance Criteria for waste to be shipped to NTS for disposition.

4.2.3.4.3 Sustainability and Stewardship

Numerous efforts at Y-12 have reduced its impact on the environment. Efforts include increased use of environmentally friendly products and processes and reductions in waste and emissions. During the past few years, the effects have been recognized by our customer, our community, and other stakeholders (see Sect. 4.2.4.2). Not only have pollution prevention efforts at Y-12 benefited the environment; they have also resulted in avoided costs (see Fig. 4.4).

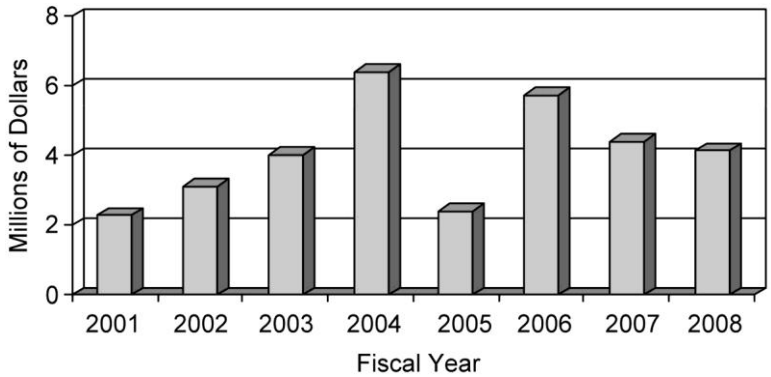


Fig. 4.4. Cost avoidance from Y-12 pollution prevention activities.

During FY 2008, B&W Y-12 implemented 96 pollution prevention initiatives (see Fig. 4.5) with a reduction of more than 30.2 million kg of waste and a cost savings/avoidance of more than $4.15 million. The completed projects include the activities described in the following sections.

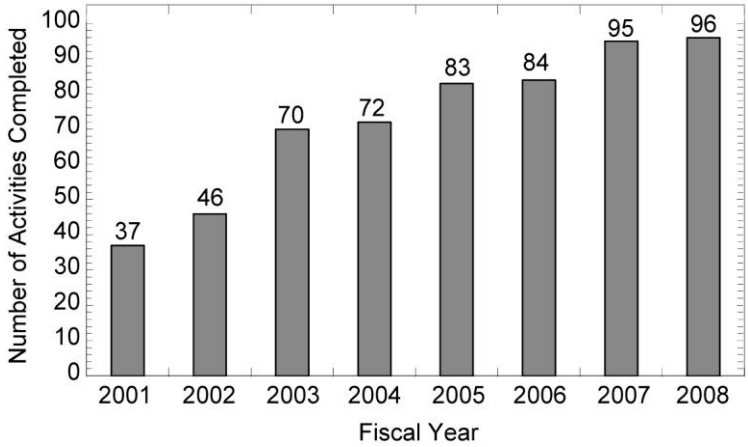


Fig. 4.5. Y-12 pollution prevention initiatives.

4.2.3.4.3.1 Sustainability Initiatives with Pollution Prevention Benefits

Sustainable initiatives have been embraced across the Y-12 Complex to reduce its impact on the environment and to increase operational efficiency. Many of Y-12's sustainable initiatives have pollution prevention benefits, including the 2008 activities highlighted in this section.

Y-12 Clean Sweep Program. The Clean Sweep Program improves the environment and supports the prevention of pollution through site cleanup efforts. The FY 2008 goal was to identify, clean, and maintain four areas within the Y-12 Complex utilizing the appropriate mechanism such as recycling, excessing, Clean Sweep Program, and disposing of material as appropriate. This goal was achieved. In addition, a pilot program was initiated during 2008 that provides a sustainable process to ensure that a clean sweep area/building is maintained to promote a safe and clean environment. This process provides periodic support from organizations such as Radiological Control and Waste Management to ensure proper disposition (e.g., recycling, excessing, reuse, disposal) of materials in a timely manner. This pilot program has been extremely successful and will continue into 2009.

Additionally, the management at a Y-12 production facility provided the opportunity for a "Clean Up" Day, which ensured that, for the entire day, all of the resources needed to properly disposition materials were available. This provided a starting point of a safe and clean environment that will only have to be maintained in the future. During the event, more than 346 tons of materials were properly dispositioned. Finally, the overall cleanup efforts are implemented using the 7S process (sort, set in order, shine, standardize, safety, security, and sustain) to ensure that work spaces are maintained and the excess/recycle and disposal of materials can continue on an ongoing basis.

Environmentally Preferable Purchasing. Environmentally preferable products, including recycled-content materials, are procured for use across the Y-12 Complex. In 2008, B&W Y-12 procured recycled-content materials valued at more than $4.67 million for use at the site.

4.2.3.4.3.2 Source Reduction Initiatives

B&W Y-12 continues to pursue source reduction initiatives across the site, thus reducing waste generation and reducing Y-12's impact on the environment. Many Y-12 source reduction activities have been implemented, including the 2008 activities highlighted in this section.

Invention of Innovative Negligible-Residue Tack Cloth. A research chemist at Y-12 invented a way to clean surfaces that leaves no sticky residue and won an R&D 100 award for his work. *R&D Magazine* issues the awards in recognition of the year's 100 most significant technological innovations.

The new invention, called the Negligible-Residue Tack Cloth (Fig. 4.6), traps dust, dirt, or other particles in the cloth as it is wiped over the surface of the material being cleaned. While the primary application for the tack cloth is removal of legacy beryllium contamination, it also has the potential for wide application in industry, including the semiconductor and electronics industries, where surface cleanliness is critical.

This invention will have wide spread application for decontamination of smooth surfaces across Y-12 as well as in industry nationwide, a true win for pollution prevention, DOE, and the nation.

4.2.3.4.3.3 Recycling Initiatives

B&W Y-12 has a well-established recycling program and continues to identify new material streams and to expand the types of materials that can be recycled by finding new markets and outlets for the materials. As shown in the Y-12 recycling results graph (Fig. 4.7), thousands of metric tons of materials were diverted from landfills and into viable recycle processes. Currently, recycled materials range from office-oriented materials, such as paper (including phone books), aluminum cans, and toner cartridges, to operations-oriented materials, such as scrap metal, tires, and batteries. Many recycling activities have been implemented, including the 2008 activities highlighted in this section.

Excess Tanker Cars Transfer. NNSA donated two 1941-vintage tanker cars to the Southern Appalachia Railway Museum, an off-site non-profit organization operated by volunteers, avoiding the generation of low-level waste while preserving some historic tanker cars for future generations. The tanker cars were used to transport materials during World War II and will continue to have a place in history at the

museum. The tanker cars are reportedly among only a handful of units of that particular type remaining in the United States. The donation of the tanker cars to the museum also complies with the National Historic Preservation Act and preserves and protects one of its historic resources while partnering with a local organization to convey the history of Y-12 to the community.

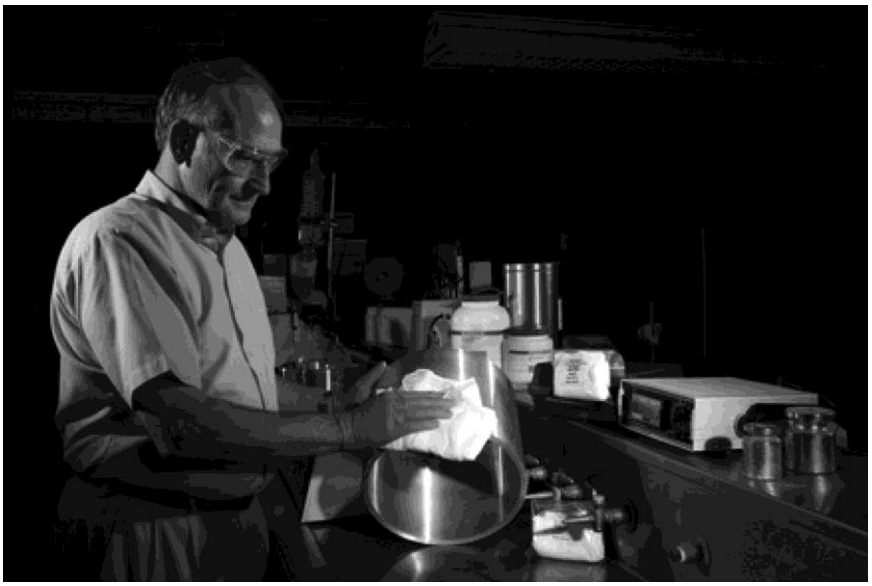


Fig. 4.6. Y-12's Ron Simandl with the negligible residue tack cloth.

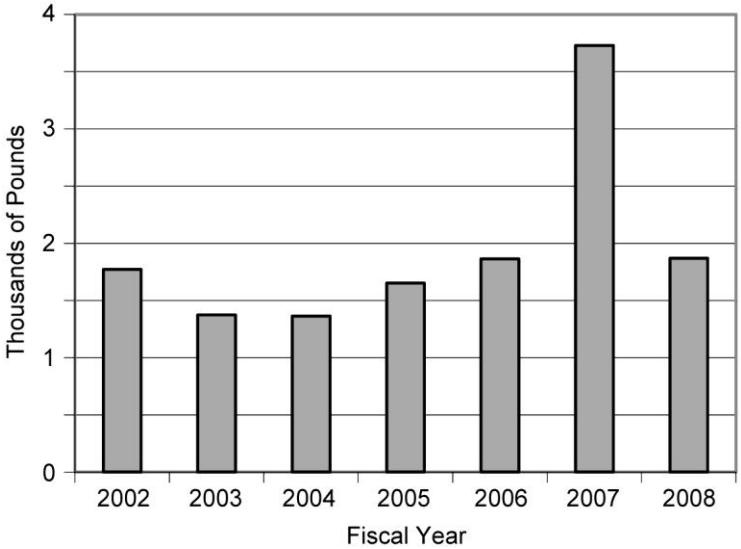


Fig. 4.7. Y-12 recycling results.

Through these joint efforts, approximately 94,600 lb of excess metal was transferred to the museum for reuse as tanker cars. The transfer of the tanker cars resulted in an overall cost avoidance of more than $40,790, while preserving historic items (see Fig. 4.8).

Expanded Recycling Program. B&W Y-12 expanded the Y-12 recycling initiatives to include the recycling of color toner cartridges, polychlorinated biphenyl (PCB) detectable oil (less than 50 ppm and more than 2 ppm PCB), and glass from New Hope and Jack Case Centers to an off-site recycling vendor. These recycling initiatives were fully-implemented during 2008.

Fig. 4.8. Preparing vintage railway tanker for donation to Southern Appalachia Museum.

4.2.3.4.4 Energy Management

In concert with Executive Order 13423, "Strengthening Federal Environmental, Energy, and Transportation Management," DOE established the Transformational Energy Action Management initiative (TEAM) and TEAM goals intended to meet and exceed the goals of the new Executive Order 13423. The Y-12 Energy Management Plan addresses all aspects of the TEAM initiative as defined by DOE. Energy management is an ongoing and comprehensive effort that contains a key strategy of implementing guidelines to reduce the consumption of energy, water, and fuel (including gasoline, diesel fuel, electricity, and natural gas). Energy savings performance contracts (ESPCs) have been used at Y-12 and are integral to the future of Y-12 as a means of funding modernization of the complex with energy-saving equipment. With the advent of requirements of Executive Order 13423, ESPCs have been reinvigorated as a method for recapitalizing energy saving investments at Y-12. Johnson Controls, Inc., has been selected as Y-12's energy savings contractor (ESCO). The ESPC kickoff meeting was conducted in January 2008, initiating the project development phase.

Energy consumption over the past several years has continued a steady downward trend. In FY 2008, the Y-12 Complex achieved the following total site energy commodity usage reductions from the 2003 baseline (Fig. 4.9):

- 22.0% reduction in electricity,
- 50.6% reduction in natural gas, and
- 16.3% reduction in coal.

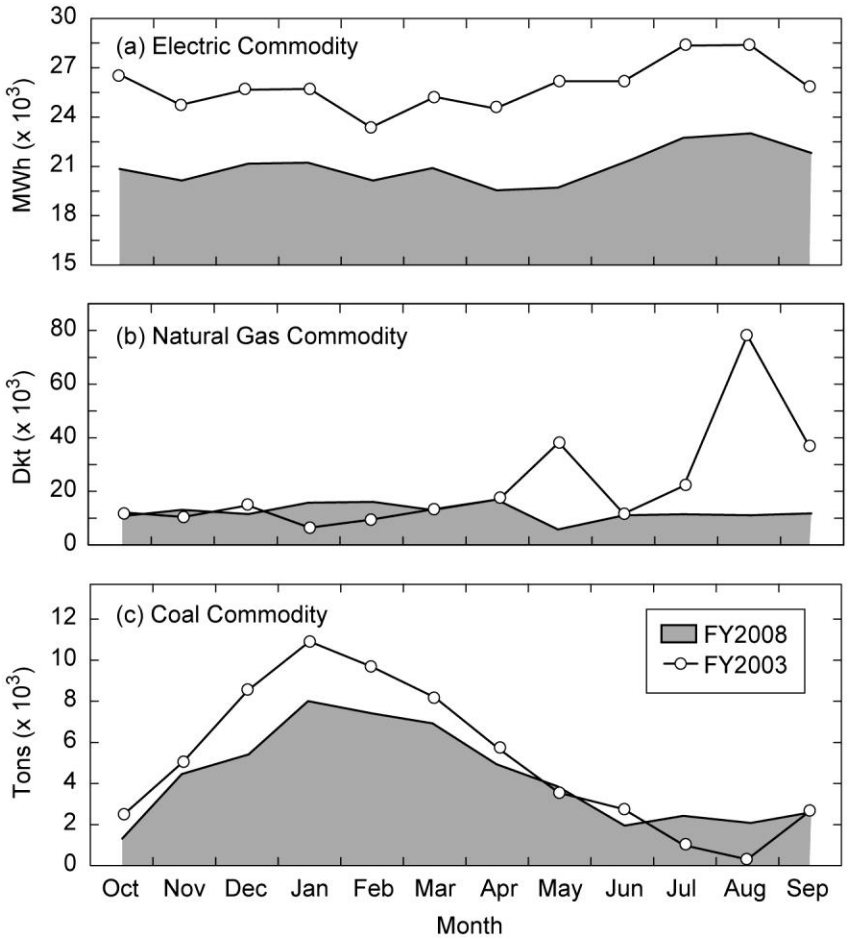


Fig. 4.9. Electrical (a), natural gas (b), and coal (c) consumption by month.

Based on reported facilities square footage, this reduction in commodity usage represents an overall 53.5% reduction in energy intensity (British thermal units per gross square foot) relative to the FY 2003 baseline. Figure 4.10 illustrates the current energy intensity reductions at Y-12 compared to the DOE TEAM goal.

The site is developing a phased approach to the implementation of the ESPC Phase I delivery commencing in FY 2009 and Phase II to begin in FY 2010. When coupled with the implementation of an energy management program at the site, NNSA anticipates achievement of the energy reduction goals.

The ESCO completed the development of the Initial Proposal (IP) for Delivery Order 1 and presented the five Y-12–supported projects to the NNSA Headquarters Review Board on July 27, 2008. The five projects supported are

- Chiller Plant Improvement,
- Condensate Return System Modification,

- Steam Trap Improvement,
- Cooling Tower Filtration, and
- Demineralized Water Production Facility Replacement.

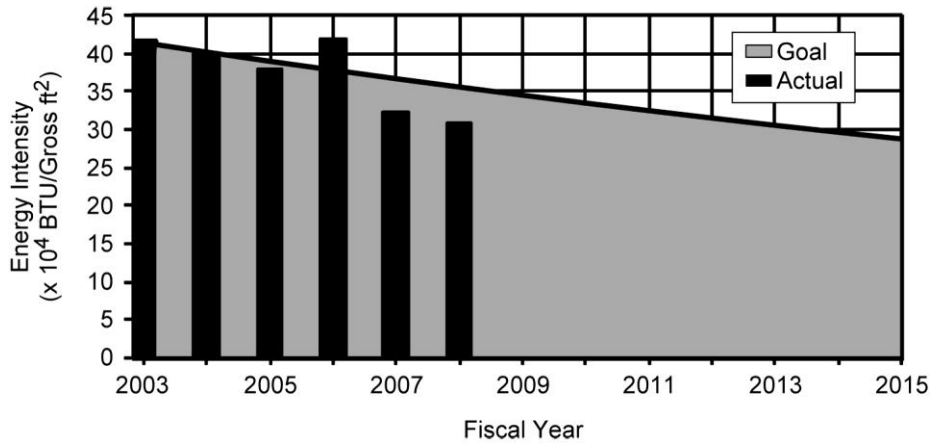


Fig. 4.10. Y-12 Energy intensity reductions compared to TEAM goal.

This IP implementation funding would be $21M and would provide annual energy, water, and Operations & Maintenance savings of $2.3M with a simple project payback of 8.99 years. NNSA approved the IP and issued the Notice of Intent to Award to the ESCO to initiate the Detailed Energy Survey. The survey kick-off was performed at Y-12 on August 14, 2008, and the ESCO began the system walkdowns and data gathering necessary to develop the project in October 2008.

The ESCO determined that the existing systems did not have existing metering capabilities to establish the baseline metering requirements. B&W worked with NNSA and the ESCO to identify the additional metering needs, and to develop a baseline metering installation plan. The baseline meters will be installed in early 2009.

4.2.3.4.5 Water Conservation

Potable water use has continued to decline (Fig. 4.11) due to the removal of excess buildings consisting of more than 1.2 million ft^2 of high-water-intensity facilities over the past 6 years. There are ongoing discussions between Y-12 and the potable water supplier, the city of Oak Ridge, regarding uncertainties with the accuracy of water supply metering. Therefore, the FY 2007 water intensity baseline, to be established per Executive Order 13423, is preliminary until the metering-accuracy questions are resolved. The city has agreed to install three new potable water supply meters. One new meter has been installed, and two additional meters were ordered in September 2008.

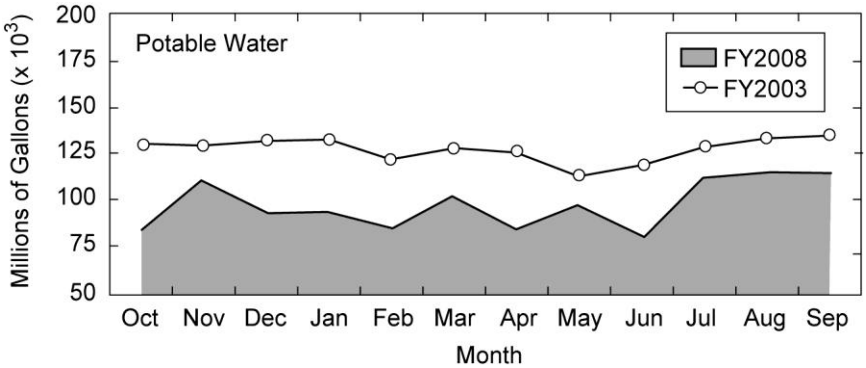


Fig. 4.11. Potable water consumption by month, FY 2003–2008.

4.2.3.4.6 Fleet Management

In order to track the continued success of the fuel-saving measures, the fleet manager monitors gasoline, E-85 ethanol, and B20 biodiesel fuel consumption by both Y-12 and General Services Administration vehicle fleets and maintains monthly reporting metrics. Future fleet management energy

savings will be achieved by continued strict monitoring of vehicle use. Increasing the use of alternative fuels and replacing gasoline-fueled vehicles with E-85-fueled vehicles will occur as funding permits.

Additional fleet highlights for FY 2008 are as follows.

- Compared with the 2005 baseline for fuel use, the site has reduced petroleum use by 22.2%.
- There has been a 233% increase in alternative fuel use since 2005.
- Of the current fleet at Y-12, 13% is alternative fuel vehicles.
- Use of biodiesel fuel has been ongoing since 2007.
- All flex fuel-capable vehicles were operated on E85 ethanol alternative fuel.

4.2.3.4.7 Electronic Stewardship

The Y-12 Complex completed the Federal Electronics Challenge (FEC) Facility Partner Registration form on March 31, 2008, on the FEC website. Registration involved the federal electronics challenge pledge, which included the ultimate goal to improve the management of electronic assets during all life-cycle phases: acquisition and procurement, operation and maintenance, and end-of-life management.

Additionally, Y-12 completed the FEC Baseline Survey of Current Practices form on May 7, 2008, on the FEC website. This Baseline Survey form was developed to assist Y-12 with identifying current electronics management practices and to recognize areas for improvements. Annual participation in the FEC Program will require completion of the Annual Reporting Form and Updated Goals. Finally, DOE plans to integrate all of the FEC reporting requirements into the annual pollution prevention reporting starting with FY 2008.

4.2.4 Implementation and Operation

4.2.4.1 Roles, Responsibility, and Authority

The safe, secure, efficient, and environmentally responsible operation of Y-12 requires the commitment of all personnel. All personnel share the responsibility for successful day-to-day accomplishment of work and the environmentally responsible operation of Y-12. Environmental and Waste Management technical support personnel assist the line organizations with identifying and carrying out their environmental responsibilities. Additionally, an Environmental Officer (EO) Program is in place to facilitate communication of federal- and state-mandated environmental regulatory requirements and to promote the EMS as a tool to drive continual environmental improvement at Y-12.

There are more than 30 EOs representing various organizations at Y-12. The EOs are appointed by managers of the various organizations located at Y-12. One of the primary responsibilities for EOs is to coordinate the organization's efforts to seek, accomplish, and maintain environmental regulatory compliance and to promote the implementation of EMS activities in their area of responsibility.

4.2.4.2 Communication and Community Involvement

Y-12 is committed to keeping the community informed in areas of operations, environmental concerns, safety, and emergency preparedness. The Community Relations Council serves to facilitate communication between Y-12 and the community. The council is composed of 20 members from a cross section of the community, including environmental advocates, neighborhood residents, Y-12 retirees, and business and government leaders. The council provides feedback to the company regarding its operations and ways to enhance communications and involvement with the community and public at large.

In addition, Y-12 has partnered with TDEC in a voluntary program designed to help all citizens do their part for the shared environment through the Tennessee Pollution Prevention Partnership. This network of Tennessee households, schools, government agencies, organizations, businesses, and industries demonstrates that pollution prevention protects the environment, saves money, and improves communities.

The Y-12 Pollution Prevention Program provided recycling and pollution prevention information to more than 150 local school-age children and teachers during FY 2008. Recycling, pollution prevention,

and alternative fuel information was provided to the students by the use of an interactive pollution prevention activity. They were given items made with recycled content to reinforce the pollution prevention philosophy.

Y-12 employees and their families supported the East Tennessee Clean Fuels Coalition (ETCFC) and its initiative to improve the environment by participating in the "Run for Clean Air" on April 12, 2008. The event provided information to participants about ETCFC's mission, alternative fuels, and other clean air initiatives. As a participating sponsor, Y-12 provided posters noting its recent environmental accomplishments and environmental policy commitments. Several alternative-fuel vehicles were on display and were available for test driving. The 50-member Y-12 team (Fig. 4.12) was the largest and fastest in the fifth annual event, which is a fund raiser for ETCFC.

Fig. 4.12. The Run for Clean Air—2008 Y-12 team.

4.2.4.2.1 2008 Awards and Recognition

Tennessee Chamber of Commerce and Industry. Y-12 received a Tennessee Chamber of Commerce and Industry award for Environmental Excellence and certificates for outstanding environmental accomplishments at the Twenty-sixth Annual Environmental Awards Conference in October 2008 (see Fig. 4.13). Award winners were selected by a panel of state officials who reviewed the nominations, accomplishments, and compliance records of the respective environmental programs. Award and achievement certificates were as follows:

- Solid Waste Management Award for Recycling Y-12 Transformers Reduces Solid Waste Generation,
- Water Quality Award for Y-12 Technology Exchange Results in Reduced Waste Water Generation through Implementation of Waste Coolant Evaporator,
- Comprehensive Environmental Excellence Achievement Certificate for Y-12's LEED Certification Process for New Hope Center, and
- Hazardous Waste Management Achievement Certificate for Y-12's EMS-Driven Green Online Auction and Product Exchange Reduces Hazardous Waste.

Fig. 4.13. Y-12 environmental accomplishments were recognized at the 2008 Tennessee Chamber of Commerce and Industry Awards.

NNSA Pollution Prevention Environmental Stewardship Award Certificates. The Y-12 Complex won five 2008 NNSA Pollution Prevention Environmental Stewardship Award Certificates:

- Y-12's Thinking Outside the Box Speeds Critical Quality Program, in the Waste/Pollution Prevention category;
- Y-12 Technology Exchange Results in Implementation of Waste Coolant Evaporator, in the Waste/Pollution Prevention category;
- Y-12 Recycling Transformers Reduces Unneeded Materials and Chemicals, in the Recycling category;
- Y-12 EMS-Driven Green Online Auction and Product Exchange, in the Environmental Management System category; and
- Y-12's LEED Certification Process for New Hope Center in the Sustainable Design/Green Building category.

The NNSA Pollution Prevention Environmental Stewardship Awards Program recognizes innovative and/or exemplary pollution prevention, recycling, environmental management systems, sustainable design/green buildings, and affirmative procurement projects and practices. This is the fifth consecutive year that the Y-12 Complex has received an NNSA award.

Tennessee Pollution Prevention Partnership. Y-12 was awarded a Tennessee Pollution Prevention Partnership Partner Membership certificate on March 15, 2007, for "making a commitment to positive environmental action through pollution prevention activities." On December 3, 2008, Y-12 was notified that the site had been awarded the Tennessee Pollution Prevention Partnership Performer level and will be receiving the green flag (Fig. 4.14) showing Y-12's commitment to pollution prevention in a ceremony planned for March 2009. Y-12 is only the second government facility in the state to be awarded this honor.

Y-12 documented five environmental success stories to achieve Performer status, demonstrating measurable results in pollution prevention. Notable results include reducing more than 436 metric tons of waste, including low-level and hazardous waste; reducing energy usage by more than 93 million kWh since FY 2004 through modernization activities; eliminated more than 5,000 lb or 70% as much trichlorofluoromethane (CFC-11) compared with 2005 levels; conserved more than 86,000 yd^3 of landfill space and established about 1.4 ha of native grasses; and reduced gasoline consumption in FY 2006 by 15,500 gal while increasing E-85 use by the flex fuel fleet to 100%.

Fig. 4.14. Y-12 has earned the honor to fly the "green flag" of the Tennessee Pollution Prevention Partnership.

4.2.4.3 Monitoring and Measurement

Y-12 maintains procedures that were established and implemented to monitor and measure key characteristics of its operations and activities that can have a significant environmental impact and to monitor overall environmental performance. Environmental effluent and surveillance monitoring programs have been established to monitor and measure liquid and gaseous effluents at the point of release to the environment and to take direct measurements of contaminants in air, water, groundwater, soil, foods, biota, and other media subsequent to effluent release. Results of the effluent and surveillance programs are reported elsewhere in the document.

In addition, Y-12 has implemented a process that includes the documenting of information to monitor progress in achieving Y-12's environmental objectives and targets. The data are compiled in graphical format where possible, reported to management, and posted on the internal EMS web site. In addition, a monthly program review meeting with counterparts from the YSO includes discussions of environmental compliance performance as well as progress in achieving objectives and targets.

4.2.4.4 Emergency Preparedness and Response

The Y-12 Emergency Management Program Organization is compliant and/or adherent with federal, state, and local laws, regulations, and ordinances. The emergency management program incorporates all the planning, preparedness, response, recovery, and readiness assurance elements necessary to protect on-site personnel, the general public, the environment, and property in the event of an operational emergency involving Y-12 facilities, activities, or operations. Site-level procedures include procedures for assessing hazards, reporting releases, responding to environmental incidents, isolating contaminated areas, performing containment and cleanup activities, and notifying appropriate organizations. Emergency management exercises are scheduled periodically to test the emergency preparedness and response systems.

4.2.4.5 EMS Assessments

To periodically verify that the EMS is operating as intended, audits are conducted as part of Y-12's assessment program. The audits are designed to ensure that any nonconformance to the ISO 14001 standard is identified and addressed. In addition, compliance with regulatory requirements is verified through routine inspections, surveillances, and focused compliance audits.

Environmental assessment activities are conducted in accordance with the Y-12 Assessment and Corrective Action Program. EMS assessment can be incorporated into other assessments, such as independent assessments of site-wide ISM performance (e.g., training, document control, corrective action).

TDEC conducted a review of Y-12's EMS on June 24, 2008. The review was the final step in Y-12's 4-year pursuit of a Green Flag awarded by the TDEC Tennessee Pollution Prevention Partnership Program; it will be flown to signify Y-12's commitment to environmental stewardship. Y-12's EMS scored 417 of 420 possible points (99%) from the TDEC assessment.

Two EMS management assessments were conducted in November. Both focused on entities responsible for ensuring implementation of the EMS-related requirements of Executive Order 13423, "Strengthening Federal Environmental, Energy, and Transportation Management"; DOE Order 430.2B, *Departmental Energy, Renewable Energy and Transportation Management;* and DOE Order 450.1A, *Environmental Protection Program*.

An EMS assessment of Information Technology and Procurement Operations was conducted November 10 through 13, 2008. An EMS assessment conducted on November 17 of organizations involved in fleet and transportation maintenance and management included

- business services, leased fleet, and facilities management;
- facility infrastructure and services, plant services, fleet maintenance, and transportation and material management; and
- the fleet maintenance facility.

The assessments served to increase awareness of EMS-related procurement, electronics stewardship, and transportation/fleet requirements and prepare the organizations for an external assessment planned for spring 2009. Opportunities for improvement were identified.

Per DOE Order 450.1A, the site EMS must make a formal declaration of conformance consistent with the requirements of the executive order by June 30, 2009. A formal assessment of the Y-12 EMS by a qualified party outside the control or scope of the EMS is planned for spring of 2009.

4.3 Compliance Status

Y-12 operations and activities 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. Many Y-12 processes and facilities operate under permits issued by regulatory agencies. Principal among the regulating agencies are the TDEC, the city of Oak Ridge, and EPA, which issue permits, review compliance reports, participate in joint monitoring programs, inspect facilities and operations, and oversee compliance with applicable regulations.

4.3.1 Environmental Permits

Table 4.1 notes environmental permits in force at Y-12 during 2008. More detailed information can be found within the following sections.

4.3.2 NEPA/NHPA Assessments

NNSA adheres to the National Environmental Policy Act (NEPA) regulations, which require federal agencies to evaluate the effects of proposed major federal activities on the environment. The prescribed evaluation process ensures that the proper level of environmental review is performed before an irreversible commitment of resources is made.

During 2008, environmental evaluations were completed for 34 proposed projects.

Table 4.1. Y-12 Complex environmental permits

Regulatory Driver	Permit Title/Description	Permit Number	Issue Date	Expiration Date	Owner	Operator	Responsible Contractor
CAA	New Steam Plant Package Boilers (Construction)	960947	9/06/2007	2/01/2009	DOE	DOE	B&W Y-12
CAA	Chip Oxidizer Operating Permit	554594	10/21/2004	10/21/2009	DOE	DOE	B&W Y-12
CAA	Operating Permit (Title V)	554701	10/21/2004	10/21/2009	DOE	DOE	B&W Y-12
CAA	Purification Facility/ Construction Permit (Expiration date pending TDEC conversion to Operating Permit)	956248P	06/17/2003		DOE	DOE	B&W Y-12
CAA	Steam Plant (existing) Clean Air Interstate Rule NO_x Permit	861316	6/9/2008	Upon renewal of Title V permit (554701)	DOE	DOE	B&W Y-12
CWA	Industrial & Commercial User Wastewater Discharge (Sanitary Sewer Permit)	No. 1-91	04/01/2005	03/31/2010	DOE	DOE	B&W Y-12
CWA	Pump & Haul 9720-82	SOP 04018	11/30/2004	11/30/2009	B&W Y-12	B&W Y-12	B&W Y-12
CWA	National Pollutant Discharge Elimination System Permit	TN0002968	03/13/2006	12/31/2008 Application for reissuance submitted 7/1/2008	DOE	DOE	B&W Y-12
CWA	General Stormwater Permit (Expires on approval of NOT)	TNR130714	02/06/2004		B&W Y-12	B&W Y-12	B&W Y-12
CWA	General Stormwater Permit Potable Water System Upgrade	TNR 132628	6/29/2007	5/30/2010	B&W Y-12	B&W Y-12	B&W Y-12
CWA	General Stormwater Permit Potable Water System Upgrade	TNR 132975	6/29/2007	5/30/2010	DOE	Washington Group	Washington Group
CWA	General Stormwater Permit Steam Plant Replacement Project	TNR 133198	7/2/2008	5/30/2010	DOE	G&S Construction	G&S Construction
RCRA	Hazardous Waste Transporter Permit	TN3890090001	1/21/2009	1/31/2010	DOE	DOE	B&W Y-12

Table 4.1 (continued)

Regulatory Driver	Permit Title/Description	Permit Number	Issue Date	Expiration Date	Owner	Operator	Responsible Contractor
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/B&W Y-12	B&W Y-12/ Navarro-GEM JV, co-operator
RCRA	Hazardous Waste Container Storage and Treatment Units	TNHW-127	10/06/2005	10/06/2015	DOE	DOE/B&W Y-12	B&W 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
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
Solid Waste	Industrial Landfill IV (Operating, Class II)	IDL-01-103-0075	Permitted in 1988—most recent modification approved 1/13/1994	N/A	DOE	DOE/BJC	BJC
Solid Waste	Industrial Landfill V (Operating, Class II)	IDL-01-103-0083	Initial permit 4/26/1993	N/A	DOE	DOE/BJC	BJC
Solid Waste	Construction and Demolition Landfill (Overfilled, Class IV Subject to CERCLA ROD)	DML-01-103-0012	Initial permit 1/15/1986	N/A	DOE	DOE/BJC	BJC
Solid Waste	Construction and Demolition Landfill VI (Postclosure care and maintenance)	DML-01-103-0036	Permit terminated by TDEC 3/15/2007	N/A	DOE	DOE/BJC	BJC

Table 4.1 (continued)

Regulatory Driver	Permit Title/Description	Permit Number	Issue Date	Expiration Date	Owner	Operator	Responsible Contractor
Solid Waste	Construction and Demolition Landfill VII (Operating, Class IV)	DML-01-103-0045	Initial permit 12/13/1993	N/A	DOE	DOE/BJC	BJC
Solid Waste	Centralized Industrial Landfill II (Postclosure care and maintenance)	IDL-01-103-0189	Most recent modification approved 5/8/1992	N/A	DOE	DOE/BJC	BJC

Abbreviations

BJC	Bechtel Jacobs Company
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CWA	Clean Water Act
DOE	U.S. Department of Energy
GEM-JV	GEM Technologies, Inc. Joint venture
NNSA	National Nuclear Security Administration
NOT	Notice of termination
ORR	Oak Ridge Reservation
RCRA	Resource Conservation and Recovery Act
ROD	record of decision
TDEC	Tennessee Department of Environment and Conservation

The *Complex Transformation Draft Supplemental Programmatic Environmental Impact Statement* (SPEIS) Record of Decision (ROD) was signed December 2008. The SPEIS presents alternatives to support NNSA's proposal to continue transforming the Complex by consolidating and eliminating operations. NNSA is making the Complex smaller, more secure, more efficient, and better able to respond to future changes. Of particular importance are the alternatives presented in the SPEIS regarding the location of the new consolidated Uranium Production Facility, including the preferred alternative to locate it at Y-12.

4.3.2.1 Site-Wide Environmental Impact Statement (SWEIS) for Y-12 Complex

The NEPA implementing procedures (10 CFR 1021 [1992]) requires a 5-year evaluation of the current Y-12 Complex sitewide environmental impact statement (SWEIS). A new SWEIS is being prepared to evaluate the new modernization proposals and to update the analyses presented in the original Y-12 SWEIS (issued in November 2001). The notice of intent was published in the *Federal Register* on November 28, 2006, and a public scoping meeting was held December 15, 2006, in Oak Ridge. The draft SWEIS is pending approval from DOE Headquarters prior to public review.

4.3.2.2 Preserving Y-12's History for Future Generations

In accordance with the National Historic Preservation Act (NHPA), NNSA is committed to identifying, preserving, enhancing, and protecting its cultural resources. The compliance activities in 2008 included completing an NHPA Section 106 review on 34 proposed projects, submitting the final machinery and equipment survey document to the Tennessee state historic preservation officer, conducting ongoing oral interviews, modifying the Y-12 History Exhibit Hall, and participating in various outreach projects with local organizations and schools.

Thirty-four proposed projects were evaluated to determine whether any historic properties eligible for inclusion in the *National Register of Historic Places* would be adversely impacted. Of the 34 proposed projects, it was determined that there were no adverse effects on historic properties eligible for listing in the *National Register* and that no further Section 106 documentation was required.

A machinery and equipment survey was conducted and completed in 2006 per the programmatic agreement. The survey documented the remaining machinery and equipment associated with historic missions of the Y-12 Complex during World War II and the Cold War. The final report was approved by the state historic preservation officer in November 2008.

The Y-12 Oral History Program and Knowledge Preservation Program continue with ongoing efforts to conduct oral interviews of current and former employees to document the knowledge and experience of those who worked at the Y-12 Complex during World War II and the Cold War era. The interviews provided information of day-to-day operations of the Y-12 Complex, the use and operation of significant components and machinery, and how technological innovations occurred over time. Some of the information collected from the interviews may be used in various media to include DVDs shown in the Y-12 History Exhibit Hall.

The Exhibit Hall (Fig. 4.15), located in The New Hope Center, has an updated look and features more artifacts and new signs. The Exhibit Hall displays exhibits, photographs, artifacts, brochures, DVDs, and other information associated with the history of Y-12 and the New Hope Community. The Exhibit Hall is open to the public Monday through Thursday from 8:00 a.m. to 5:00 p.m. and on Fridays by special request. A selection of materials, including DVDs, books, pamphlets, and fact sheets are available free to the public. Tours of the Exhibit Hall were conducted for organizations such as the Boys and Girls Club, Boy Scout Troops, local schools, and VIP visitors.

Outreach activities in 2008 consisted of providing tours of the Y-12 Complex for the Secret City Festival and for the American Museum of Science and Energy. The Secret City Festival, held in June, is an annual event sponsored by the city of Oak Ridge, the Convention and Visitor's Bureau, and the Arts Council of Oak Ridge. B&W Y-12 partnered with The Secret City Festival to promote the history of Oak Ridge by providing guided tours of the Y-12 Complex. B&W Y-12 also partnered with the American Museum of Science and Energy by providing guided public tours from June through September for over

1100 tourists from 49 states. Other outreach activities include visiting local schools and conducting presentations on the history of Y-12 and Oak Ridge.

Fig. 4.15. Y-12 History Exhibit Hall in New Hope Center.

4.3.3 Clean Air Act

Described in this section is a comprehensive review of the major elements of the Clean Air Program at the Y-12 Complex. There were several significant program highlights in 2008.

The Y-12 Complex was issued the Title V Major Source Operating Permits 554701 and 554594 in 2004, and required compliance implementation began April 1, 2005. More than 3,000 data points are collected and reported under the Title V operating permit every 6 months, and there are 5 continuous monitors for criteria pollutants as well as numerous continuous samplers for radiological emissions.

There were no noncompliances as a result of monitoring activities during 2008. A deviation from the requirement to conduct daily readings on a control device occurred and was reported. The deviation occurred as a result of a differential pressure recording device malfunction covering 6 days.

In 2008, three construction air permits were applied for and/or maintained. Under a permit issued in 2007, construction began in 2008 on the replacement steam plant (to be operational in about 2010). An existing construction permit was in place for a foundry operation for much of 2008 but was not renewed in October because construction was declared complete. A construction permit and compliance with its conditions are being maintained for a special materials facility until the permit conditions are combined into the Title V sitewide operating permit.

Construction began for a replacement steam plant project, which will ultimately result in the shutdown of the existing steam plant. More than 90% of the Y-12 Complex pollutant emissions to the atmosphere are attributed to the operation of the existing coal-fired and natural gas–fired steam plant. Emissions from the new steam plant will be significantly lower than those from the existing steam plant, resulting in an overall air quality improvement. The new steam plant will burn primarily natural gas and will have a fuel oil backup. The Clean Air construction permit for this project included a Best Available Control Technology analysis for certain criteria pollutants and a case-by-case Maximum Achievable Control Technology (MACT) analysis for hazardous air pollutants.

Prior-year efforts to increase usage of E-85 (i.e., a mixture of 85% ethanol and 15% gasoline) in flexible fuel vehicles continued to reap motor vehicle emission reductions in 2008.

In 2008, TDEC personnel performed an inspection of the Y-12 Complex on February 6 and 7 to verify compliance with applicable regulations and permit conditions. There were no compliance issues identified.

4.3.4 Clean Water Act and Aquatic Resources Protection

The Y-12 NPDES permit (TN0002968) was issued on March 13, 2006, and became effective on May 1, 2006. An application for reissuance of the NPDES permit was submitted to TDEC, Division of Water Pollution Control on July 1, 2008. On December 30, 2008, the permit was modified to change the required minimum flow in East Fork Poplar Creek at Station 17 to 5 million gal/day. The permit expired December 31, 2008, and Y-12 Complex discharges are continuing under the requirements of the present permit. 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.

During 2008 the Y-12 Complex continued its excellent record for compliance to water discharge permits. More than 3,200 data points were obtained from sampling required by the NPDES permit; only one noncompliance was reported. Some of the requirements in the 2006 permit are summarized below (additional details are provided in Sect. 4.5, “Surface Water Program”):

- chlorine limitations based on water quality criteria at three outfalls located near the headwaters of East Fork Poplar Creek and construction schedule for new dechlorinators (construction of new dechlorination systems was completed in 2007);
- 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. 4.5.2);
- implementation of a storm water pollution prevention plan requiring sampling and characterization of storm water (see Sect. 4.5.3);
- stormwater sampling of stream baseload sediment at four instream East Fork Poplar Creek locations (see Sect. 4.5.3);
- requirement for an annual storm water monitoring report, an annual report of the BMAP data;
- a requirement to manage the flow of East Fork Poplar Creek such that a minimum flow of 7 million gal/day is guaranteed by adding raw water from the Clinch River to the headwaters of East Fork Poplar Creek (see Sect. 4.5.4); and
- whole effluent toxicity testing limitation for the three outfalls of East Fork Poplar Creek (see Sect. 4.5.8).

A notice of appeal of certain permit terms and limits for legacy constituents of mercury and PCBs was filed by NNSA in April 2006. The permit limits for toxicity at three outfalls were appealed because legacy contamination may adversely affect toxicity and their cleanup is addressed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Chlorine limits at the headwaters of the creek were also appealed. Issues associated with the appeal were not resolved prior to expiration of the permit.

An application for renewal of the NPDES permit was completed in June 2008 and was submitted to TDEC on July 1, 2008. This work effort included special sampling needed to fully characterize effluents and to properly complete permit application forms. During 2008 permits for storm water associated with construction activity were in effect for three projects located in the Y-12 Complex. The projects are the Potable Water System (storage tanks and water lines), the Steam Plant Life Extension and Building 9720-82.

The Industrial and Commercial User Wastewater Discharge Permit (1-91) was issued by the city of Oak Ridge to Y-12 on April 1, 2005. The permit, which expires on March 31, 2010, provides requirements for the discharge of wastewaters to the sanitary sewer system as well as prohibitions for certain types of wastewaters. There were four permit exceedances of the permit in 2008. Two were for

exceeding the discharge limits (daily maximum and monthly average) for copper, and two were for exceeding the maximum daily allowable flow limit. During the year the city of Oak Ridge conducted two inspections under the Industrial Pretreatment Program (February 19, 2008, and August 27, 2008). Members of the Clean Water Program continued to work on surface water programs such as the Storm Water Pollution Prevention, including storm water sampling and site inspections, BMAP, and development of best management practices plans for projects and site activities. An example is the plan developed for the Potable Water Systems Upgrades project, which covered repair and construction of underground water lines and also addressed protection of receiving streams during sanitizing of the new system. Work continued on streamlining data management for compliance reporting, review, approval, and tracking of water discharges and connections to the storm and sanitary sewer systems.

4.3.5 Safe Drinking Water Act

The Tennessee Regulations for Public Water Systems and Drinking Water Quality, Chap. 1200-5-1, sets limits for biological contaminants and for chemical activities and chemical contaminants. Sampling for the following is conducted:

- total coliform,
- chlorine residuals,
- lead,
- copper,
- disinfectant by-product, and
- propylene glycol.

The city of Oak Ridge supplies potable water to the Y-12 Complex that meets all federal, state, and local standards for drinking water. The water treatment plant, located north of the Y-12 Complex, is owned and operated by the city of Oak Ridge.

In 2008, the Y-12 potable water system retained its approved status for potable water with TDEC. Y-12 continued sampling the potable water system for propylene glycol. TDEC instituted a requirement for sampling the site potable water system for propylene glycol in 2007 after learning that an unapproved cross connection exists between the Y-12 potable water system and the antifreeze fire sprinkler systems containing propylene glycol. All of the samples collected during 2008 resulted in laboratory results below the detection limits. A potable water system upgrade project is scheduled for the installation of approved backflow prevention devices, conversion to dry pipe, and/or disconnection of the antifreeze fire sprinkler systems by 2010.

All total coliform samples collected during 2008 were negative. Analytical results for disinfectant by-products (total trihalomethanes and haloacetic acids) for the Y-12 water systems were below the TDEC and Safe Drinking Water Act (SDWA) limits. The Y-12 potable water system is currently sampled triennially for lead and copper; sampling was completed in August 2008. The results were below the TDEC and SDWA limits and meet the established requirements.

The 5 year inspection of the west emergency potable water storage tank was also completed.

4.3.6 The Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) regulates hazardous wastes that, if mismanaged, could present risks to human health or the environment. The regulations are designed to ensure that hazardous wastes are managed from the point of generation to final disposal. In Tennessee, EPA delegates the RCRA program to TDEC; EPA retains an oversight role. Y-12 is considered a “large-quantity generator” because it may generate more than 1,000 kg of hazardous waste in a month and because it has RCRA permits to store hazardous wastes for up to 1 year before shipping off site to licensed treatment and disposal facilities. Y-12 also has a number of satellite accumulation areas and 90-day waste storage areas.

Mixed wastes are materials that are both hazardous (under RCRA guidelines) and radioactive. The Federal Facilities Compliance Act (1992) requires that DOE work with local regulators to develop a site treatment plan to manage mixed waste. Development of the plan has two purposes: to identify available treatment technologies and disposal facilities (federal or commercial) that are able to manage mixed waste produced at federal facilities and to develop a schedule for treating and disposing of the waste streams.

The *ORR Site Treatment Plan* (TDEC 2008) is updated annually and submitted to TDEC for review. The updated plan documents the current mixed-waste inventory and describes efforts undertaken to seek new commercial treatment and disposal outlets for various waste streams. NNSA has developed a disposition schedule for the mixed waste in storage and will continue to maintain and update the plan as a reporting mechanism, as progress is made. Y-12 is reducing inventory of legacy mixed waste as part of the plan (see Fig. 4.16).

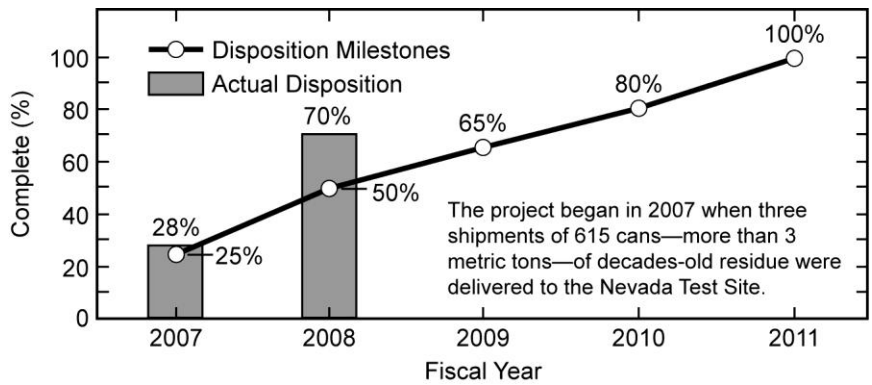


Fig. 4.16. Reducing inventory of legacy mixed waste as part of the *ORR Site Treatment Plan*.

The quantity of hazardous and mixed wastes generated by Y-12 increased in 2008 (Fig. 4.17). The increase was attributed to the treatment of more than 2,000,000 kg of additional contaminated groundwater. This directly correlates to 11 in. more rainfall in 2008 than in 2007. Waste resulting from repackaging and disposal of legacy mixed waste also increased. Legacy mixed wastes are being repackaged and disposed of in accordance with milestones in the *Oak Ridge Reservation Site Treatment Plan*. Progress on disposition of legacy mixed wastes exceeded established milestones for FY 2008. Of the amount of hazardous and mixed waste generated in 2008, 96% was generated as contaminated leachate from legacy operations. The Y-12 Complex currently reports waste on 129 active waste streams. In the 2008 RCRA report, 17 waste streams were closed due to inactivity (zero waste generation).

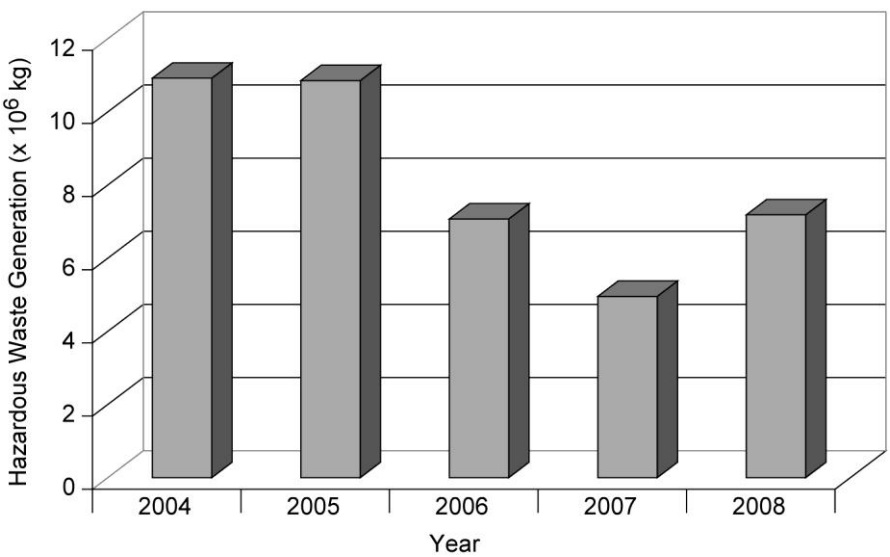


Fig. 4.17. Hazardous waste generation, 2004–2008.

Y-12 is a state-permitted treatment, storage, and disposal facility. Under its permits, Y-12 received 1,748 kg of hazardous and mixed waste from the off-site Union Valley analytical chemistry laboratory in 2008. In addition, 160,493 kg of hazardous and mixed waste was shipped to DOE-owned and commercial treatment, storage, and disposal facilities. Nearly 7 million kg of hazardous and mixed wastewater was treated at on-site wastewater treatment facilities.

TDEC conducted a comprehensive inspection of Y-12's hazardous waste program in October 2008, including permitted storage facilities, satellite accumulation areas, and 90-day accumulation areas. No violations were noted during the inspection. TDEC stated in their final report, "B&W Y-12, its employees, contractors, and subcontractors, place a high priority on regulatory compliance and environmental stewardship."

4.3.6.1 RCRA Underground Storage Tanks

TDEC regulates the active petroleum underground storage tanks (USTs) at Y-12. Existing UST systems that are to remain in service at the Y-12 Complex must comply with performance requirements described in TDEC underground storage tank regulations (TN 1200-1-15). Three specific requirements are considered:

- release detection for both the tank and piping,
- corrosion protection for both the tank and piping, and
- spill/overfill prevention equipment.

The Y-12 UST Program includes two active petroleum USTs that meet all current regulatory compliance requirements. The UST registration certificates for the tanks are current, and certificates are posted at the UST locations, enabling fuel delivery until March 31, 2010. All legacy petroleum UST sites at Y-12 have either been granted final closure by TDEC or have been deferred to the CERCLA process for further investigation and remediation. TDEC conducted a comprehensive inspection of Y-12's petroleum USTs in June 2008. No violations were found during that inspection.

4.3.6.2 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. The facilities are permitted by TDEC and accept solid waste from DOE operations on the ORR. In addition, one Class IV facility (Spoil Area 1) is overfilled by 11,700 yd^3 and has been the subject of a CERCLA remedial investigation/feasibility study. A CERCLA ROD 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 Table 4.1.

4.3.7 RCRA/CERCLA Coordination

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.

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 4.2). Postclosure care and monitoring of East Chestnut Ridge Waste Pile was incorporated into permit TNHW-128. Groundwater corrective actions required under the postclosure permits have been deferred to CERCLA. RCRA groundwater monitoring data will be reported yearly to TDEC and EPA in the annual CERCLA *Remediation Effectiveness Report* (DOE 2009) for the ORR.

Table 4.2. RCRA postclosure status for former treatment, storage, and disposal units on the ORR

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
Eastern S-3 Ponds Groundwater Plume	None for groundwater plume, see former S-3 Ponds (S-3 Site) for source area closure	Postclosure corrective action monitoring. Inspection and maintenance of monitoring network
Chestnut Ridge Hydrogeologic Regime (RCRA Postclosure Permit No. TNHW-128)		
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
East Chestnut Ridge Waste Pile	Engineered cap	Cap inspection and maintenance. Postclosure detection monitoring. Inspection and maintenance of monitoring network, leachate collection sump and survey benchmarks. Management of leachate
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-North, A-South and C-West, and the 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

Abbreviations

RCRA Resource Conservation and Recovery Act

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act

Periodic updates of proposed construction and demolition activities at the Y-12 Complex (including alternative financing projects) have been provided to managers and project personnel from the TDEC DOE Oversight Division and EPA Region 4. 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.

4.3.8 Toxic Substances Control Act

The storage, handling, and use of PCBs are regulated under TSCA. Capacitors manufactured before 1970 that are believed to be oil filled are handled as if they contain PCBs, even when that cannot be verified from the manufacturer's records. All equipment containing PCBs must be inventoried, except for capacitors containing less than 3 lb of dielectric fluid or items with a concentration of PCB source material of less than 50 ppm. Certain PCB-containing articles or PCB containers must be labeled. The inventory is updated by July 1of each year.

Given the widespread historical uses of PCBs at Y-12, along with fissionable material requirements that must be maintained, an agreement between EPA and DOE was negotiated to assist the ORR facilities in becoming compliant with TSCA regulations. This agreement, known as the *Oak Ridge Reservation Polychlorinated Biphenyl Federal Facilities Compliance Agreement* (ORR PCB FFCA), which came into effect in 1996, provides a forum with which to address PCB compliance issues that are truly unique to these facilities.

4.3.9 Preventing Spills and Reporting Spills/Releases

4.3.9.1 Preventing Oil Pollution and Spills

Y-12 maintains its *Spill Prevention, Control, and Countermeasures Plan* (SPCC Plan) to prevent spills of oil and hazardous constituents as well as the countermeasures to be invoked should a spill occur. A major revision to the SPCC Plan was initiated in 2007 and was approved for issuance in 2008. In general, the first response of an individual discovering a spill is to call the plant shift superintendent. Spill response materials and equipment are stored near tanks and drum storage areas and other strategic areas of the Y-12 Complex to facilitate spill response. All Y-12 personnel and subcontractors are required to have initial spill and emergency response training before they can work on site. This training is received as part of the GET Program.

4.3.9.2 Emergency Reporting Requirements

The Emergency Planning and Community Right-to-Know Act (EPCRA) and Title III of the Superfund Amendments and Reauthorization Act (SARA) require that facilities report inventories (i.e., Tier II Report sent to the local emergency planning committees and the state emergency response commission) and releases (i.e., Tier III Report submitted to state and federal environmental agencies) of certain chemicals that exceed specific release thresholds. Y-12 complied with those requirements in 2008 through the submittal of reports under EPCRA Sects. 302, 303, 311, and 312. In 2008 there were no releases of "extremely hazardous substances," which are reportable under Sect. 304.

The required Sect. 311 notifications were made in 2008 because hazardous materials were determined to be over the 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. Y-12 reported 69 chemicals in inventory during 2008.

Each ORR facility evaluates its respective operations to determine applicability for submittal of 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 inventory chemicals are compared with regulatory thresholds to determine which chemicals exceed the reporting thresholds based on amounts manufactured, processed, or otherwise used at each facility. After threshold determinations are made, releases and off-site transfers are calculated for each chemical that exceeded one or more of the thresholds.

Total 2008 reportable toxic releases to air, water, and land and waste transferred off site for treatment, disposal, and recycling were 104,497 lb. Table 4.3 lists the reported chemicals for the Y-12 Complex and summarizes releases and off-site transfers for those chemicals exceeding reporting thresholds.

Table 4.3. Emergency Planning and Community Right-to-Know Act Sect. 313 toxic chemical release and off-site transfer summary for the Y-12 Complex, 2008

Chemical	Year	Quantity[a] (lb)[b]
Chromium	2007	*c*
	2008	*c*
Cobalt	2007	*c*
	2008	*d*
Copper	2007	*c*
	2008	*c*
Lead/lead compounds	2007	6,729
	2008	21,652
Manganese	2007	*c*
	2008	*d*
Mercury/mercury compounds	2007	32
	2008	31
Methanol	2007	48,478
	2008	33,814
Nickel	2007	*c*
	2008	*c*
Nitrate compounds	2007	*c*
	2008	*d*
Nitric acid	2007	2,060
	2008	4,000
Ozone	2007	*c*
	2008	*c*
Silver	2007	*c*
	2008	*c*
Sulfuric acid (aerosol)	2007	41,000
	2008	45,000
Total	2007	98,299
	2008	104,497

[a]Represents 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.

[b]1 lb = 0.45359237 kg.

[c]Not applicable because releases were less than 5,000 lb, and hence a Form A was submitted.

[d]No reportable releases because the site did not exceed the applicable Toxic Release Inventory reporting thresholds.

4.3.9.3 Spills and Releases

Y-12 has procedures for notifying off-site authorities for categorized events at the Y-12 National Security Complex. Off-site notifications are required for specified events according to federal statutes, DOE orders, and the Tennessee Oversight Agreement. As an example, any observable oil sheen on East Fork Poplar Creek and any release impacting surface water must be reported to the EPA National Response Center in addition to other reporting requirements. Spills of CERCLA reportable quantity (RQ)

limits must be reported to the EPA National Response Center, DOE, the Tennessee Emergency Management Agency, and the Anderson County Local Emergency Planning Committee.

There were no releases of hazardous substances exceeding RQs and no fish kills at Y-12 during 2008. One observable oil sheen on upper East Fork Poplar Creek was reported due to a potable water line break (see Sect. 4.3.9.4).

4.3.9.4 Environmental Occurrences

A broken potable water line resulted in an occurrence report in the DOE Occurrence Reporting System (Y-12 National Security Complex, Building 9201-1 NA--YSO-BWXT-Y12NUCLEAR-2008-0029 - Water Main Break at Building 9201-1—[Significance Category 3]). On August 16, 2008, water was observed running out the front door of Building 9201-1. Approximately 6 to 12 in. of water and mud were observed in and around the shop area, and the entire first floor was covered to varying degrees with water and mud. The main potable water supply was isolated to the building to prevent further water damage. Possible environmental impacts and structural conditions were evaluated. Tenants were notified to evaluate their areas for damage, and the basement was pumped out.

Water from the ruptured line flowed into the basement of the facility and into East Fork Poplar Creek. The event created an oil sheen on East Fork Poplar Creek, and subsequently the National Response Center was notified. No apparent environmental impacts to aquatic life occurred. One immediate response was the pumping of water from the basement and elevator shaft to tankers and negotiating with the city of Oak Ridge to discharge the water to the sanitary system. This discharge had to meet discharge limits in the sanitary discharge permit. B&W Y-12 obtained approval from the city to discharge the water, set up an oil water separator to remove excess oil, and compliantly discharged more than 350,000 gal of water to the sanitary system. The water in the basement was removed with minimal impact on facility operations.

4.3.9.5 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 2008, spill response and waste services personnel conducted one removal and recovered an estimated 3.5 lb of mercury. Approximately 65 lb have been recovered since 2003; recovery of mercury is expected to continue in 2009.

4.3.10 Audits and Oversight

A number of federal, state, and local agencies oversee Y-12 activities. In 2008, Y-12 was inspected by federal, state, or local regulators on eight occasions. The TDEC Department of Energy Oversight Division maintained a part-time regulator on site who provided periodic oversight of Y-12 activities. In addition to external audits and oversight, Y-12 has a comprehensive self-assessment program. A summary of external regulatory audits and reviews for 2008 is provided in Table 4.4.

4.3.10.1 Enforcement Actions and Memos

No new consent orders were issued to Y-12 in 2008.

4.4 Air Quality Program

Permits issued by the state of Tennessee are the primary vehicle used to convey the clean air requirements that are applicable to the Y-12 Complex. New projects are governed by construction permits, and eventually, the requirements are incorporated into the site-wide Title V operating permit. Sections of the Title V permit contain requirements that are generally applicable to most industrial sites. Examples include requirements associated with asbestos controls, control of stratospheric ozone-depleting chemicals, and control of fugitive emissions as well as the general administration of the permit. The Title V permit also contains a section of specific requirements directly applicable to individual sources of air

emissions at Y-12. Major requirements included in that section include the National Emission Standards for Hazardous Air Pollutants for Radionuclides (Rad NESHAPs) requirements and the numerous requirements associated with emissions of criteria pollutants and other hazardous air pollutants (nonradiological). In addition, a number of sources that are exempt from permitting requirements under state rules but subject to listing on Title V permit application are documented, and information about them is available upon request from the state.

Table 4.4. Summary of external regulatory audits and reviews, 2008

Date initiated	Date completed	Conducted by	Title of assessment	Total findings
1/10/2008	1/10/2008	EPA/TDEC	EPA/TDEC ORR PCB FFCA Site Visit	0
2/6/2008	2/7/2008	TDEC	TDEC Annual Clean Air Compliance Inspection	0
2/16/2008	2/19/2008	City of Oak Ridge	Semi-Annual Industrial Pretreatment Compliance Inspection	0
6/24/2008	6/24/2008	TDEC	EMS Evaluation for TP3 Performer Level Review	0
8/27/2008	8/27/2008	City of Oak Ridge	Semi-Annual Industrial Pretreatment Compliance Inspection	0
9/16/2008	9/17/2008	TDEC, Water Pollution Control	NPDES Compliance Evaluation Inspection	0
10/16/2008	10/16/2008	EPA/TDEC	EPA/TDEC ORR PCB FFCA Site Visit	0
10/27/2008	10/30/2008	TDEC	TDEC Annual RCRA Inspection	0

Abbreviations

EMS	Environmental Management System
EPA	Environmental Protection Agency, Region 4
FFCA	Federal Facilities Compliance Agreement
NPDES	National Pollutant Discharge Elimination System
ORR	Oak Ridge Reservation
PCB	Polychlorinated Biphenyl
RCRA	Resource Conservation and Recovery Act
TDEC	Tennessee Department of Environment and Conservation
TP3	Tennessee Pollution Prevention Partnership

Ambient air monitoring, while not specifically required by any permit condition, is conducted at Y-12 to satisfy DOE order requirements, as a best management practice and/or to provide evidence of sufficient programmatic control of certain emissions. Ambient air monitoring conducted specifically for Y-12 (i.e., mercury monitoring) is supplemented by additional monitoring conducted for the ORR and by both on-site and off-site monitoring conducted by TDEC. In addition, the overall effectiveness of the Clean Air Act compliance program is assured by internal audits and external audits, such as the annual inspection conducted by state of Tennessee personnel.

4.4.1 Construction and Operating Permits

In 2008, three construction air permits were applied for and/or maintained. A construction permit for the replacement steam plant continued in 2008. An existing construction permit for a foundry operation was allowed to expire late in 2008 as construction was declared complete. A construction permit and compliance with its conditions were maintained for a special materials facility until the permit conditions are combined into the Title V site-wide operating permit.

The DOE/NNSA and Y-12 Title V permits, currently two permits with an outstanding request to combine them into one permit, include 37 air emission sources and more than 100 air emission points. All remaining emission sources are categorized as insignificant and exempt from permitting. During 2008, there were no modifications to theY-12 Complex Title V permit. Permit change requests still pending at the end of 2008 include

- a request to convert one construction permit to an operating permit;
- a request to combine permit 554594 (which only has one emission source) into the existing Y-12 sitewide permit;
- a request to add the new steam plant to the operating permit;
- requests to cancel four shutdown sources from the permit (a machine shop, a paper incinerator, a metal forming operation, and Arc Melt operation);
- a request to remove the Steam Plant Maximum Achievable Control Technology conditions based on the standard being vacated; and
- a request to add Fuel Station Stage 1 emission control requirements to the permit.

Demonstrating compliance with the conditions of air permits is a significant effort at the Y-12 Complex. Key elements of maintaining compliance are maintenance and operation of control devices, monitoring, record-keeping, and reporting. High-efficiency particulate air (HEPA) filters, baghouses, and scrubbers are control devices used at the Y-12 Complex. HEPA filters are found throughout the complex, and in-place testing of HEPA filters to verify the integrity of the filters is routinely performed. Baghouses and scrubbers are operated and maintained in accordance with source-specific procedures. Monitoring consists of tasks such as continuous stack sampling, one-time stack sampling, and monitoring the operation of control devices. Examples of continuous stack sampling are the radiological stack monitoring systems on numerous sources throughout the complex, continuous NO_x monitors on the steam plant, and continuous opacity monitors on the steam plant. The Y-12 Complex site-wide permit requires quarterly and semiannual reports. In addition, two major annual reports are required. One report is the overall ORR radiological NESHAP report, which includes specific information regarding Y-12 Complex emissions; the second is an annual Title V compliance certification report indicating compliance status with all conditions of the permit.

4.4.1.1 Generally Applicable Permit Requirements

The Y-12 Complex, like many industrial sites, has a number of generally applicable requirements that require management and control. Control of asbestos, ozone-depleting substances, and fugitive particulate emissions are notable examples.

The Y-12 Complex has 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. As part of the Infrastructure Reduction Program, more than 149,000 ft^2 of buildings were demolished in 2008 to bring the total square footage for the program to approximately 1,245,000 ft^2. Remediation and proper disposal of asbestos-containing materials in the buildings are precursors and major components of building demolition. No releases of RQs of asbestos were reported for the Y-12 Complex in 2008.

B&W Y-12 continues to investigate and implement actions to reduce the use of regulated ozone-depleting substances (ODSs), where possible, replacing them with materials that have less ozone-depleting potential. Since the ODS elimination program began in the early 1990s, more than 90% of its Class I ODSs used in heating, ventilation, and air-conditioning systems has been eliminated.

Past ODS phase-out and reduction efforts at the Y-12 Complex include

- retrofitting, replacing, or taking out of service chillers and air-conditioning systems;
- solvent substitutions for uses such as machining, cleaning, and cooling; and
- elimination or conversion of fixed fire protection systems that contained Halon 1301.

B&W Y-12 personnel continue to properly manage refrigerants via programs and actions such as

- certification of refrigerant recycling and recovery equipment,
- training and EPA certification of refrigerant technicians, and
- procedures for performance of leak checks and for response to equipment leaks.

Infrastructure reduction activities also led to the reduction of ODS materials on site. All refrigerants and solvents must be removed from equipment prior to disposal. If an ODS is no longer going to be used at the Y-12 Complex, it is dispositioned as follows:

- excessed to other DOE facilities;
- offered to other government agencies, such as the Defense Logistics Agency;
- sold to outside vendors for recycle; or
- properly disposed of.

Additionally, in 2008, Y-12 manufacturing eliminated the emission of more than 19,600 lb of Freon 113, which is both an ODS and a chlorofluorocarbon, through a recent change in a chip-cleaning manufacturing process. The reduction in Freon 113 emissions resulted in an estimated annual cost avoidance of approximately $277,000. In this project, Freon 113 was replaced with Vertrel XF, a more environmentally friendly and safer product.

As Modernization and Infrastructure Reduction efforts increase at the Y-12 Complex, the need also increases for good work practices and controls to minimize fugitive dust emissions from construction and demolition activities. Y-12 Complex personnel continue to use a mature project planning process to review, recommend, and implement appropriate work practices and controls to minimize fugitive dust emissions.

Permit administration fees in excess of $100,000 per year are paid to TDEC in support of the Title V program. Y-12 has chosen to pay the fees based on a combination of actual emissions (steam plant, methanol, solvent 140 volatile organic compound [VOC]) and allowable emissions (balance of plant). In years when a detailed air emission inventory is not required to be compiled for Y-12 operations, the emissions ledger compiled to support the annual fee payment is the most comprehensive presentation of total site emissions. In 2008, emissions categorized as actual emissions totaled 2,497.9 tons, and emissions calculated by the allowable methodology totaled 808.2 tons.

4.4.1.2 Radiological National Emission Standard for Hazardous Air Pollutants

The release of radiological contaminants, primarily uranium, into the atmosphere at the Y-12 Complex occurs almost exclusively as a result of plant production, maintenance, and waste management activities. The major radionuclide emissions contributing to the dose from the Y-12 Complex are the nuclides ^{234}U, ^{235}U, ^{236}U, and ^{238}U, which are emitted as particulates. The particle size and solubility class of the emissions are determined based on review of the operations and processes served by the exhaust systems to determine the quantity of uranium handled in the operation or process, the physical form of the uranium, and the nature of the operation or process. The four categories of processes or operations that are considered in the total of uranium emissions are

- those that exhaust through monitored stacks,
- unmonitored processes for which calculations are performed per Appendix D of 40 CFR 61,
- processes or operations exhausting through laboratory hoods also involving Appendix D calculations, and
- processes from room exhausts monitored by radiation control equipment.

Continuous sampling systems are used to monitor emissions from a number of process exhaust stacks at the Y-12 Complex. In addition, a probe-cleaning program is in place, and the results from the probe cleaning at each source are incorporated into the respective emission point source term. In 2008,

42 process exhaust stacks were continuously monitored, 35 of which were major sources; the remaining 7 were minor sources. (Stack US-011 did not run during 2008.) The sampling systems on these stacks have been approved by EPA Region 4.

During 2008, unmonitored uranium emissions at the Y-12 Complex occurred from 43 emission points associated with on-site, unmonitored processes and laboratories operated by B&W Y-12. Emission estimates for the unmonitored process and laboratory stacks were made using inventory data with emission factors provided in 40 CFR Part 61, Appendix D. The Y-12 Complex source term includes an estimate of those unmonitored emissions.

The Analytical Chemistry Organization laboratory, operated by B&W Y-12, is located in a leased facility on Union Valley Road, approximately 0.3 miles east of the Y-12 Complex, and is not within the ORR boundary. In 2008 there were no emission points (or sources) in the laboratory facility.

Additionally, estimates from room ventilation systems are considered using radiological control data on airborne radioactivity concentrations in the work areas. Where applicable, exhausts from any area where the monthly concentration average exceeds 10% of the derived air concentration (DAC) (as defined in the *Compliance Plan* [DOE 2005]) are included in the annual source term. Annual average concentrations and design ventilation rates are used to arrive at the annual emission estimate for those areas. Three emission points from room ventilation exhausts were identified in 2008 where emissions exceeded 10% of the DAC. Each of the emission points fed to monitored stacks, and any radiological emissions are accounted for monitored emission points.

A construction permit was issued by the state in November 1998 for Y-9998-F-143, a new 3,500-ton press in Building 9998. The source was designed and equipped with a stack monitor prior to the effective date of the September 9, 2002, final amendment to 40 CFR Part 61, Subpart H, which incorporated the use of the American National Standards Institute (ANSI) Standard ANSI/HPS N13.1-1999.

The Y-12 Complex was issued the Title V Major Source Operating Permits 554701 and 554594 in 2004. The permits required compliance implementation beginning April 1, 2005. Contained in the permits was a site-wide, streamlined alternate emission limit for enriched and depleted uranium process emission units. A limit of 2,000 lb per year of particulate was set for the sources for the purposes of paying fees. The compliance method defined for Permit 554701, Condition E3, and Permit 554594, Condition E4, requires the annual actual mass emission particulate emissions to be generated using the same monitoring methodologies required for Rad NESHAPs compliance. An estimated 0.0071 Ci (0.6 kg) of uranium was released into the atmosphere in 2008 as a result of Y-12 activities (Figs. 4.18 and 4.19).

4.4.1.3 Quality Assurance

Quality assurance activities for the Rad NESHAP program are documented in *Y-12 National Security Complex Quality Assurance Project Plan for National Emission Standards for Hazardous Air Pollutants (NESHAPs) for Radionuclide Emission Measurements* (Y-12 2005). The plan satisfies the quality assurance (QA) requirements in 40 CFR Part 61, Method 114, for ensuring that the radionuclide air emission measurements from the Y-12 Complex are representative to known levels of precision and accuracy and that administrative controls are in place to ensure prompt response when emission measurements indicate an increase over normal radionuclide emissions. The requirements are also referenced in TDEC regulation 1200-3-11-.08. The plan ensures the quality of the Y-12 radionuclide emission measurements data from the continuous samplers, breakthrough monitors, and minor radionuclide release points. It specifies the procedures for the management of the activities affecting the quality of the data. The QA objectives for completeness, sensitivity, accuracy, and precision are discussed. Major programmatic elements addressed in the QA plan are the sampling and monitoring program, emission characterization, the analytical program, and minor source emission estimates.

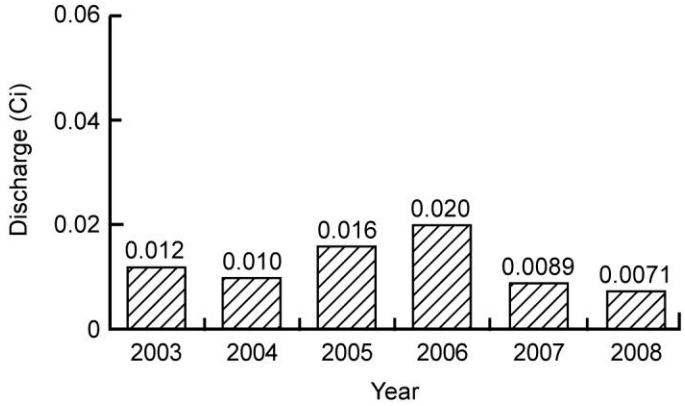


Fig. 4.18. Total curies of uranium discharged from the Y-12 Complex to the atmosphere, 2004–2008

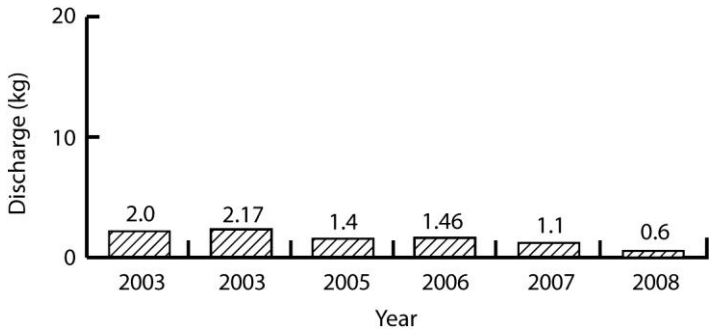


Fig. 4.19. Total kilograms of uranium discharged from the Y-12 Complex to the atmosphere, 2003–2007.

4.4.1.4 Source-Specific Criteria Pollutants

Proper maintenance and operation of a number of control devices (e.g., HEPA filters, baghouses, and scrubbers) are key to controlling emissions of criteria pollutants. 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 4.5. 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 2008, the opacity monitoring systems were operational for more than 95% of the operational time of the monitored units during each month. During 2008, nine 6-min periods of excess emissions occurred. Quarterly reports of the status of the Y-12 Steam Plant opacity monitors are submitted to TDEC personnel. Table 4.6 is a record of excess emissions and inoperative conditions for the east and west stack opacity monitors for 2008. Visible emission evaluations are also conducted at the steam plant semiannually to demonstrate compliance. The Y-12 Title V operating air permit also 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 2008 ozone season were 123 tons of NO_x; the limit is 232 tons (Fig. 4.20).

Particulate emissions from point sources result from many operations throughout Y-12. Compliance demonstration is achieved via several activities, including monitoring the operations of control devices, limiting process input materials, and using certified readers to conduct stack-visible emission evaluations.

Emissions of SO_2 are primarily from the combustion of coal at the steam plant. Sulfur in coal is analyzed, and calculations are performed to ensure that emissions remain below permit limits.

Table 4.5. Actual vs. allowable air emissions from the Oak Ridge Y-12 Steam Plant, 2008

Pollutant	Emissions (tons/year)[a]		Percentage of allowable
	Actual	Allowable	
Particulate	32	945	3.4
Sulfur dioxide	1,994	20,803	9.6
Nitrogen oxides[b]	469	5,905	7.9
Nitrogen oxides (ozone season only)	123[c]	232	53.0
Volatile organic compounds[b]	2	41	4.9
Carbon monoxide[b]	20	543	3.7

[a]1 ton = 907.2 kg.

[b]When 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, NC. January 1995 and September 1998.)

[c]Monitored emissions.

Table 4.6. Periods of excess emissions and out-of-service conditions for Y-12 Steam Plant east and west opacity monitors, 2008

Date	Stack	Condition	Comments
March 14	West	One 6-min period of excess emissions	Due bad/damaged bags in Baghouse 1
March 24	East	Two 6-min periods of excess emissions	Due to Boiler 4 ID fan damper actuator/controller failure which caused an upset condition that created the opacity malfunction
August 17	East	Three 6-min periods of excess emissions	Baghouse 4 bypass dampers opened due to a high temperature interlock. The high temperature was caused by a bearing failure on Preheater 4 which prevented the preheater from rotating
October 25	West	One 6-min period of excess emissions	Due to lose bags in Baghouse 1
December 21	West	One 6-min period of excess emissions	Due to lose bags in Compartment 5 of Baghouse 1
December 30	West	One 6-min period of excess emissions	Due to bag blown off in Compartment 3 of Baghouse 1

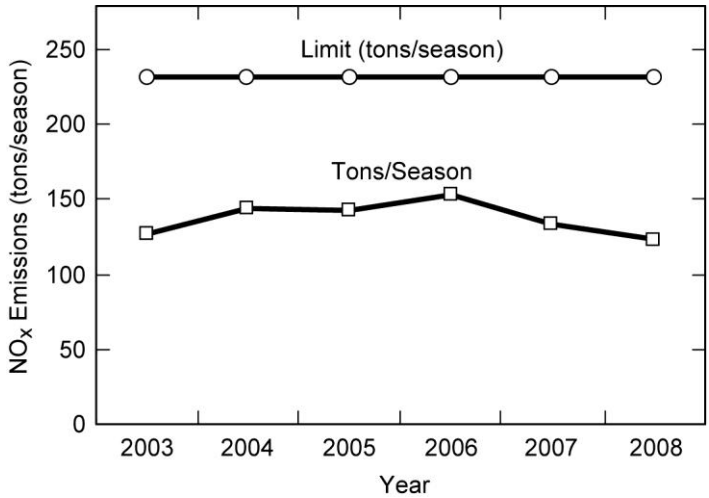


Fig. 4.20. Y-12 Steam plant NO_x emissions per ozone season.

Use of Solvent 140 and methanol throughout the complex along with use of acetonitrile at a single source are primary sources of VOC emissions. Material mass balances and engineering calculations are used to determine annual emissions.

The results of monitoring a number of process parameters along with stack-monitoring results are provided in reports to TDEC quarterly, semiannually, and annually. All monitored results were in compliance with the Title V permit in 2008.

4.4.1.5 Quality Control

Calibration error tests of the opacity monitoring systems are performed on a semiannual basis as required by the permit. The calibration error tests for the steam plant opacity monitors were performed two times for both the west and east stack opacity monitors. The reports were submitted to the TDEC technical secretary for the Division of Air Pollution Control for his approval and records.

The NO_x continuous emissions monitoring systems are operated in conformance with the requirements of 40 CFR 75. Requirements include a periodic relative accuracy test audit (RATA) for continuous nitrogen oxides emissions monitoring systems as part of the NO_x Budget Trading Program. A periodic RATA is required once annually, provided that the RATA is conducted after January 1. The periodic RATA for the NO_x analyzers was completed on February 2008 for all three boilers. The reports were submitted on March 31, 2008, to TDEC and EPA.

In addition, the NO_x analyzers are calibrated daily under the control of a data logger at a specified time during normal operation (as recorded by the data logger internal clock). On a weekly basis, the subcontractor personnel review the continuous emission monitoring system (CEMS) data reports that are generated on a daily basis by the data acquisition and handling system, including calibration error reports and data summary reports. On a daily basis, subcontractor personnel monitor the CEMS performance via telephone modem. Linearity checks on the NO_x analyzers are conducted on a quarterly basis. The linearity checks are conducted while the unit is combusting fuel at typical duct temperature and pressure. The linearity tests for NO_x pre-RATA test were conducted in February 2007. Tests were also conducted in June 2007 (second quarter). During the third quarter, the test was conducted in September 2007. The linearity tests are submitted with the NO_x electronic reports.

4.4.1.6 Hazardous Air Pollutants (Nonradiological)

Beryllium emissions from machine shops are regulated under a state-issued permit and are subject to a limit of 10 g per 24 h. Compliance is demonstrated through a one-time stack test and through monitoring of control device operations. Hydrogen fluoride is used at one emission source, and emissions are controlled through the use of scrubber systems. Methanol is released as fugitive emissions (e.g., pump and valve leaks) as part of the brine/methanol system. Methanol is subject to state air permit requirements; however, due to the nature of its release (fugitive emissions only) there are no specific emission limits or mandated controls. Mercury is a significant legacy contaminant at the Y-12 Complex, and cleanup is being addressed under the environmental remediation program. Like methanol emissions, mercury air emissions from legacy sources are fugitive in nature and therefore, are not subject to specific air emission limits or controls. On-site monitoring of mercury is conducted and is discussed under Sect. 5.5.2, “Ambient Air.”

Y-12 Steam Plant emissions, due to the combustion of coal, contain hazardous air pollutants such as mercury, hydrogen chloride, and other metals and gaseous hazardous air pollutants. In 2007 the EPA vacated a proposed MACT, which was intended to minimize hazardous air pollution emissions. The Y-12 Steam Plant would have become subject to certain elements of the new rule effective in 2007 had the rule not been vacated. It is anticipated at this time that the existing steam plant will be replaced and that coal will no longer be combusted, prior to the rule becoming effective. In 2007, a case-by-case MACT review was conducted as part of the construction permitting process for the Y-12 Replacement Steam Plant. Specific conditions aimed at minimizing hazardous air pollutant emission from the new steam plant will be incorporated into the operating permit for the new source.

Unplanned releases of hazardous air pollutants are regulated through the Risk Management Planning regulations. Y-12 Complex personnel have determined that there are no processes or facilities containing inventories of chemicals in quantities exceeding thresholds specified in rules pursuant to Clean Air Act, Title III, Sect.112(r), "Prevention of Accidental Releases." Therefore, the Y-12 Complex is not subject to that rule. Procedures are in place to continually review new processes and/or process changes against the rule thresholds.

4.4.2 Ambient Air

To understand the complete picture of ambient air monitoring in and around the Y-12 Complex, data from monitoring conducted on and off site specifically for Y-12, DOE reservation-wide monitoring, and on-site and off-site monitoring conducted by TDEC personnel must be considered. There are no federal regulations, state regulations, or DOE orders that require ambient air monitoring within the Y-12 Complex boundary; however, on-site ambient air monitoring for mercury and radionuclides is conducted 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.

4.4.2.1 Hydrogen Fluoride

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 HF. In anticipation of the start-up of the HF system during CY 2005, arrangements were made to monitor the community adjacent to the Y-12 Complex for the presence of fluorides. The monitoring was initiated in November 2004. The monitoring methodology chosen for use was in accordance with the American Society for Testing and Materials (ASTM) Standard D3266, which designates the use of a dual-tape sampler, which is scheduled for calibration and maintenance activities once per quarter. The time period over which the monitoring occurs was 7 days and resulted in a total of 56 samples being generated per week (3 h per sample, 8 samples per day; 7 days per week). The samples were submitted for analysis, along with six additional QA samples, via chain of custody, to the Y-12 Complex analytical chemistry laboratory, which uses industry-accepted analytical techniques and protocol. 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 $\mu g/m^3$.

Actual monitoring data collected from November 2004 through September 2008 were well below the 1.6 $\mu g/m^3$ secondary standard. The maximum of 0.114 $\mu g/m^3$ was detected during the first sample period reported November 9, 2004. Review of the ambient HF data collected during more representative Oxide Conversion Facility operations (between September 2006 and August 2008) also concluded that the ambient HF data collections were well below the regulatory secondary standards. Therefore, ambient HF air monitoring for Y-12 was discontinued on September 30, 2008.

4.4.2.2 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 concentrations 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 to the atmosphere at Y-12. Originally, four monitoring stations were operated at Y-12, including two within the former mercury-use area near the west end of Y-12. The two atmospheric mercury monitoring stations currently operating at Y-12, Ambient Air Station No. 2 (AAS2) and Ambient Air Station No. 8 (AAS8), are located near the east and west boundaries of Y-12, respectively (see Fig. 4.21). Since their establishment in 1986, AAS2 and AAS8 have monitored mercury in ambient air continuously with the exception of short intervals of downtime because of electrical or equipment outages. In addition to the monitoring stations located at Y-12, 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.

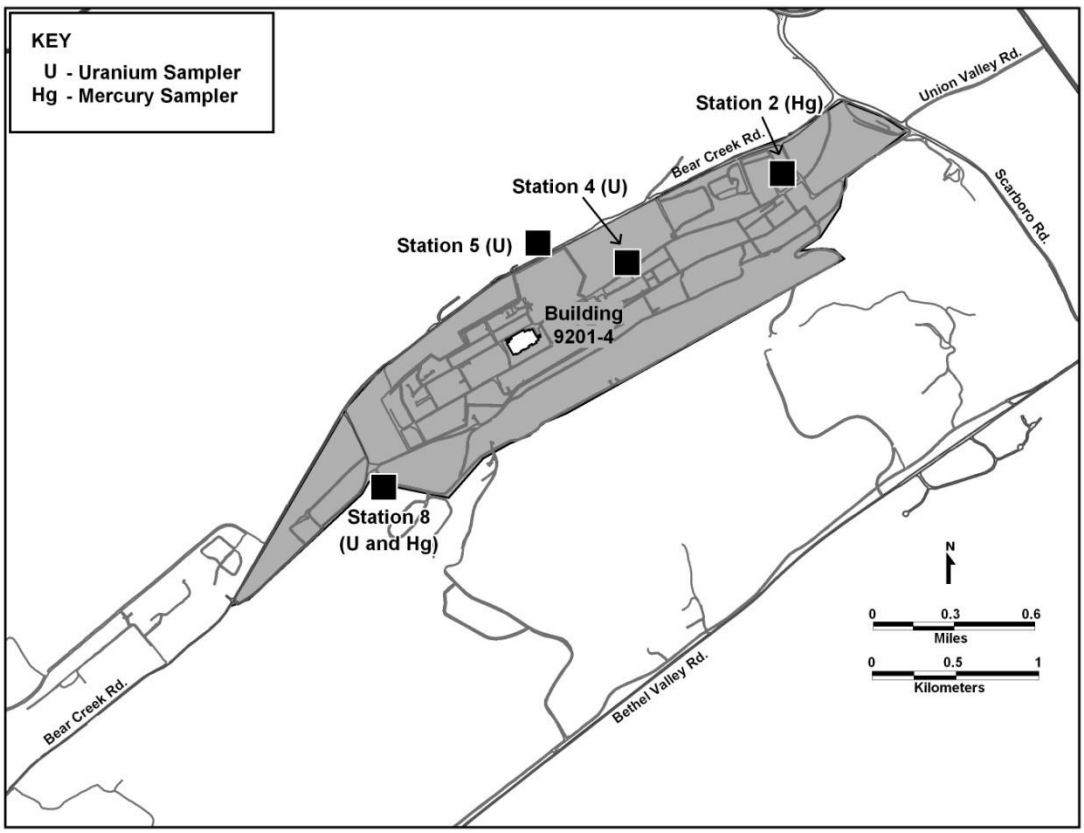


Fig. 4.21. Location of ambient air monitoring stations at the Y-12 Complex.

In order to determine mercury concentrations in ambient air, airborne mercury vapor is collected by pulling ambient air through a sampling train consisting of a Teflon filter and an iodated-charcoal sampling trap. A flow-limiting orifice upstream of the sampling trap restricts airflow through the sampling train to ~1 L/min. Actual flows are measured weekly with a calibrated Gilmont flowmeter in conjunction with the weekly change-out of the sampling trap. The charcoal in each trap is analyzed for total mercury using cold vapor atomic fluorescence spectrometry after acid digestion. The average concentration of mercury vapor in 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 sampling period.

As reported previously, average mercury concentration at the ambient air monitoring sites has declined significantly since the late 1980s. Recent average annual concentrations at the two boundary stations are comparable to concentrations measured in 1988 and 1989 at the Chestnut Ridge reference site (Table 4.7). Average mercury concentration at the AAS2 site for 2008 is 0.0029 μg/m^3 (N = 49; S.E. = ±0.0001), a slight drop from the previous year of 0.0036 μg/m^3. After noting a gradual increase in average annual concentration at AAS8 for the period 2005 through 2007 thought to be perhaps due to increased excavation and decontamination and decommissioning work on the west end during this period, the average concentration at AAS8 for 2008 was 0.0048 μg/m^3 (N = 39; SE = 0.0003) or similar to levels recorded prior to 2005. Utility work during November and December in the area of AAS8 resulted in an approximately 2-month power outage at the monitoring site, thus the reduced number of samples for 2008 at AAS8 (N = 39).

Table 4.7. Summary of data for the Oak Ridge Y-12 National Security Complex mercury in ambient air monitoring program, 2008

Ambient air monitoring stations	Mercury vapor concentration (μg/m^3)			
	2008 average	2008 maximum	2008 minimum	1986–1988[a] average
AAS2 (east end of the Y-12 Complex)	0.0029	0.0054	0.0013	0.010
AAS8 (west end of the Y-12 Complex)	0.0048	0.0127	0.0020	0.033
Reference Site, Rain Gauge No.2 (1988[b])	N/A	N/A	N/A	0.006
Reference Site, Rain Gauge No.2 (1989[c])	N/A	N/A	N/A	0.005

Table 4.7 summarizes the 2008 mercury results and results from the 1986 through 1988 period for comparison. Figure 4.22 illustrates temporal trends in mercury concentration for the two active mercury monitoring sites since the inception of the program in 1986 through 2008 (plots 1, 2) and seasonal trends at AAS8 from 1993 through 2008 (plot 3). The dashed line superimposed on plots 1 and 2 is the EPA reference concentration (RfC) of 0.3 μg/m^3 for chronic inhalation exposure. The large increase in Hg concentration at AAS8 observed in the late 1980s (plot 2) was thought to be related to disturbances of Hg-contaminated soils and sediments during the Perimeter Intrusion Detection Assessment System and utility restoration projects under way then. In plot 3, a monthly moving average has been superimposed over the AAS8 data to highlight seasonal trends in mercury at AAS8 from January 1993 through 2008.

In conclusion, 2008 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, i.e., the National Institute for Occupational Safety and Health recommended exposure limit of 50 μg/m^3 (time-weighted average or TWA for up to a 10-h workday, 40-h workweek), the American Conference of Governmental Industrial Hygienists workplace threshold limit value of 25 μg/m^3 as a TWA for a normal 8 h workday and 40 h workweek, and the current EPA reference concentration (RfC = 0.3 μg/m^3) for elemental mercury for daily inhalation exposure without appreciable risk of harmful effects during a lifetime.

4.4.2.3 Quality Control

A number of QA/QC steps are taken to ensure the quality of the data for the Y-12 Mercury in ambient air monitoring program.

An hour meter records the actual operating hours between sample changes. This allows for correction of total flow in the event of power outages during the weekly sampling interval.

The Gilmont correlated flowmeter used for measuring flows through the sampling train is shipped back to the manufacturer annually for calibration traceable to the National Institute of Standards and Technology.

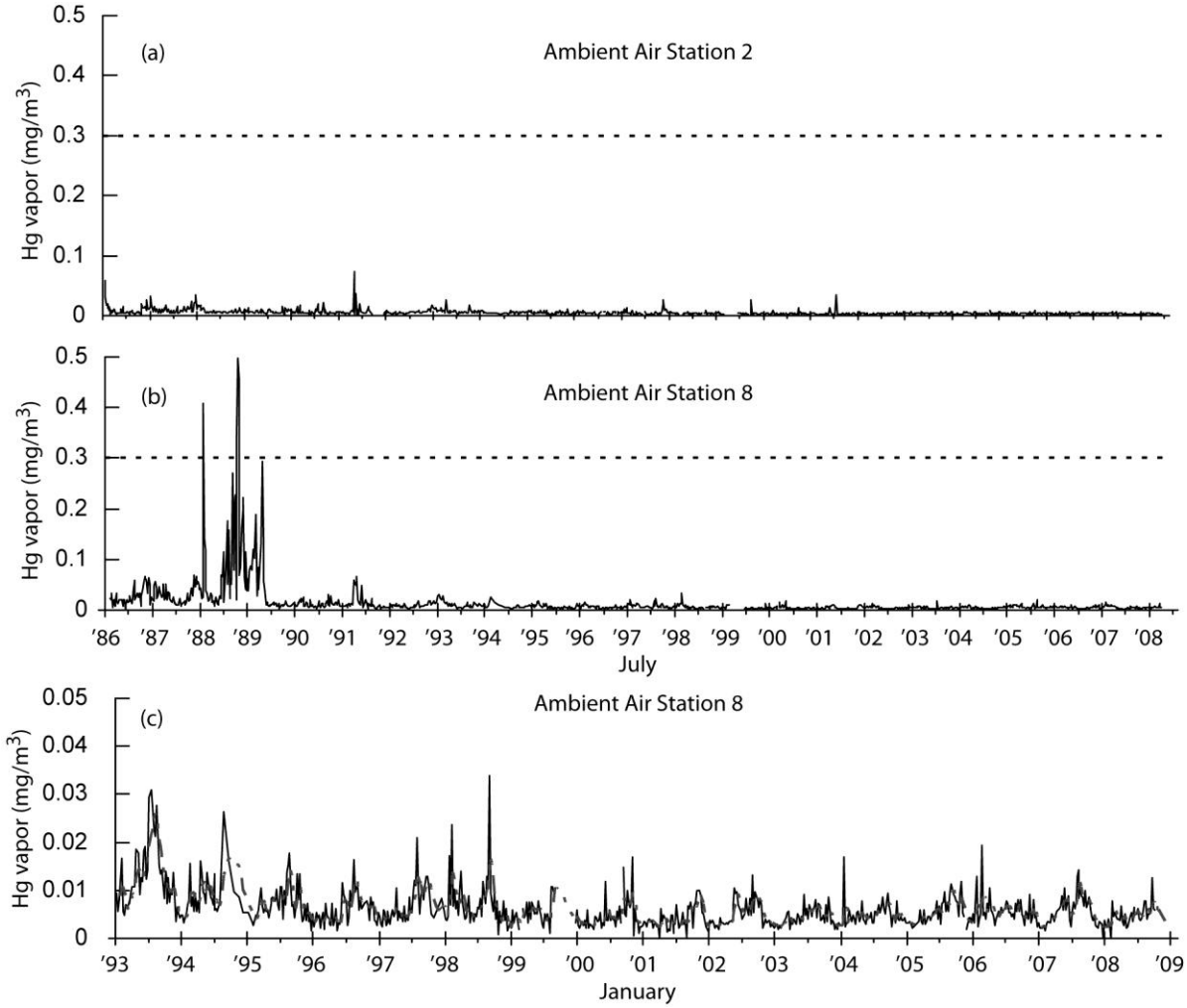


Fig. 4.22. Temporal trends in mercury vapor concentration for the boundary mercury monitoring stations at the Y-12 National Security Complex, July 1986 to January 2008 (Plots 1 and 2) and January 1993 to January 2008 for AAS8 (plot 3).

A minimum of 5% of the samples in each batch submitted to the analytical laboratory are blank samples. The blank sample traps are submitted "blind" to verify trap blank values and to serve as a field blank for diffusion of mercury vapor into used sample traps during storage prior to analysis.

In order to verify the absence of mercury breakthrough, 5 to 10% of the field samples have the front (upstream) and back segments of the charcoal sample trap analyzed separately. The absence of mercury above blank values on the back segment confirms the absence of breakthrough.

Chain-of-custody forms track the transfer of sample traps from the field techs all the way to the analytical lab.

Semiannually, a field performance evaluation is conducted to ensure that proper procedures are followed by the sampling technicians.

Analytical QA/QC requirements include

- use of prescreened and/or laboratory purified reagents,
- analysis of at least 2 method blanks per batch,
- analysis of standard reference materials,

- analysis of laboratory duplicates (1 per 10 samples; any laboratory duplicates differing by more than 10% at 5 or more times the detection limit are to be rerun [third duplicate] to resolve the discrepancy), and
- archival of all primary laboratory records for at least 1 year.

4.4.2.4 Ambient Air Monitoring Complementary to the Y-12 Ambient Air Monitoring

Ambient air monitoring is conducted at multiple locations near the ORR to measure radiological and other selected parameters directly in the ambient air. These monitors are operated in accordance with DOE orders. Their locations were selected so that areas of potentially high exposure to the public are monitored continuously for parameters of concern. This monitoring provides direct measurement of airborne concentrations of radionuclides and other hazardous air pollutants, allows facility personnel to determine the relative level of contaminants at the monitoring locations during an emergency, verifies that the contributions of fugitive and diffuse sources are insignificant, and serves as a check on dose-modeling calculations. 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 operations. This station is located near the theoretical area of maximum public pollutant concentrations as calculated by air-quality modeling. ORR network stations are also located at the east end of the Y-12 Complex (Station 40) and just south of the Country Club Estates neighborhood (Station 37).

The state of Tennessee is primarily responsible for ambient air monitoring to characterize the region in general and to characterize and monitor DOE operations specifically. This is accomplished in numerous ways. Specific to Y-12 operations, there are 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 uses 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 2 standard cubic feet per minute.

In addition, TDEC DOE Oversight Division air quality monitoring includes several other types of monitoring on the ORR, for example:

- RADNet air monitoring,
- fugitive radioactive air emission monitoring,
- ambient VOC air monitoring,
- perimeter air monitoring,
- real-time monitoring of gamma radiation,
- ambient gamma radiation monitoring using external dosimetry, and
- program-specific monitoring associated with infrastructure-reduction activities.

Results of these activities are summarized in annual status reports, which are issued by TDEC DOE Oversight Division.

The state of Tennessee also operates a number of regional monitors to assess ambient concentrations of criteria pollutants such as sulfur dioxide, particulate (various forms), and ozone, for comparison against ambient standards. The results are summarized and available through EPA and state reporting mechanisms.

4.5 Surface Water Program

This section provides a review of major components of the Y-12 Clean Water Compliance Program and activities associated with surface water monitoring at the Y-12 Complex. There were several significant highlights related to water compliance in 2008.

4.5.1 NPDES Permit and Compliance Monitoring

The current Y-12 NPDES permit (TN0002968) requires sampling, analysis, and reporting for approximately 65 outfalls. Major outfalls are noted in Fig. 4.23. 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 tributaries on the south side of Chestnut Ridge, all of which eventually drain to the Clinch River.

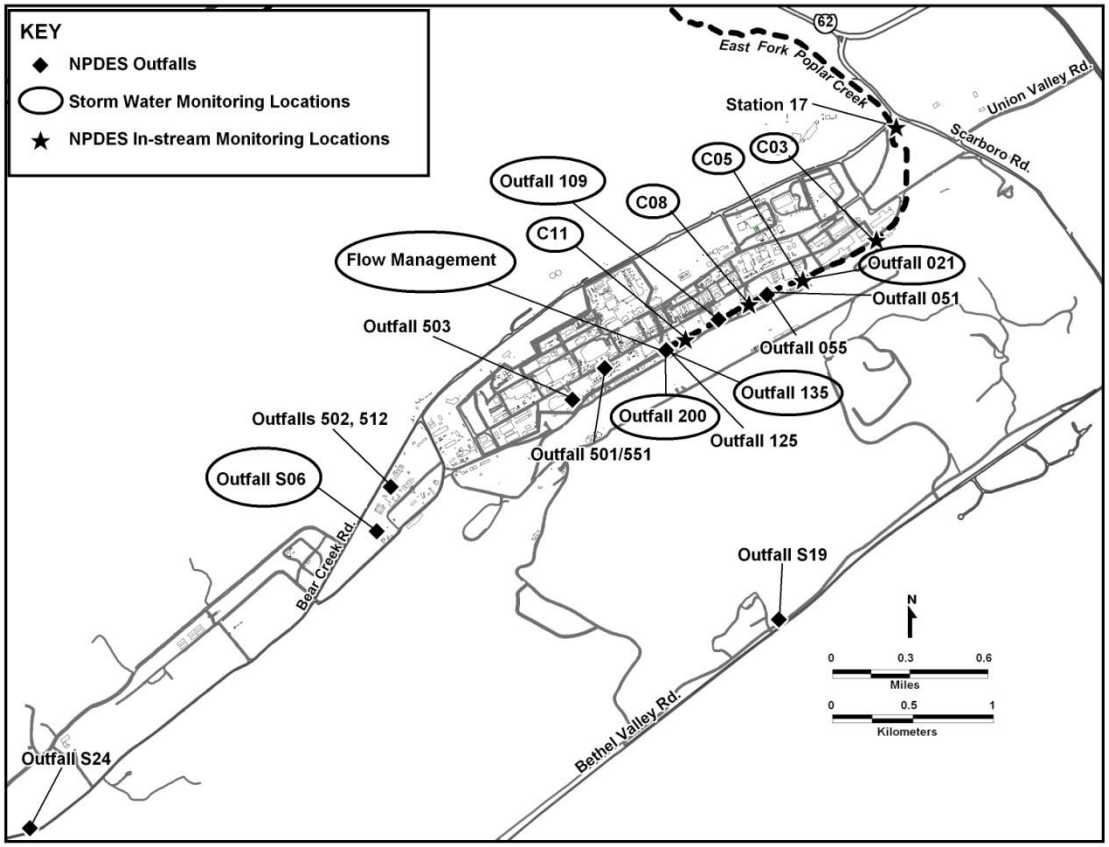


Fig. 4.23. Major Y-12 Complex National Pollutant Discharge Elimination System (NPDES) outfalls and storm water monitoring locations.

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 where applicable 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 legacy operations. Discharges from the Y-12 Complex processes flow into East Fork Poplar Creek before the water exits the Y-12 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.

Requirements of the NPDES permit for 2008 were satisfied and monitoring of outfalls and instream locations indicated excellent compliance. Data obtained as part of the NPDES program are provided in a monthly report to the TDEC. The percentage of compliance to the permit for 2008 was >99.9%. The only 2008 NPDES permit excursion this year occurred as a result of a January 9 field reading of 0.68 mg/L for total residual chlorine made at one outfall. This exceeds the allowable daily maximum concentration of 0.50 mg/L. At the time of the reading there were no observed adverse effects on the receiving stream.

Action was taken by checking operation of the tablet-type dechlorination units located upstream. All units were found to be in working order. Table 4.8 lists the NPDES compliance monitoring requirements and the 2008 compliance record.

4.5.2 Radiological Monitoring Plan and Results

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 radiological monitoring plan quarterly as an addendum to the NPDES discharge monitoring report. There were no discharge limits set by the NPDES permit for radionuclides; the 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 4.9). The current *Radiological Monitoring Plan for Y-12 Complex* (Y-12 2006) was last revised and reissued in June 2006.

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, and at an instream outfall on Bear Creek. Results of storm event monitoring during 2008 were reported in *Annual Storm Water Report for the Y-12 National Security Complex* (B&W Y-12 2009a), which was issued in January 2009. In addition, the monthly 7-day composite sample for radiological parameters taken at Station 17 on East Fork Poplar Creek likely includes rain events.

Radiological monitoring plan locations sampled in 2008 are noted in Fig. 4.24. Table 4.10 identifies the monitored locations, the frequency of monitoring, and the sum of the percentages of the derived concentration guidelines (DCGs) for radionuclides measured in 2008. Radiological data were well below the allowable DCGs.

In 2008, 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 75kg or 0.046Ci (Table 4.11). Figure 4.25 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.

The Y-12 Complex is permitted to discharge domestic wastewater to the city of Oak Ridge's publicly owned treatment works. 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. Results of radiological monitoring are reported to the city of Oak Ridge in a quarterly monitoring report.

4.5.3 Storm Water Pollution Prevention

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 as they are defined in the Tennessee Storm Water Multi

Table 4.8. NPDES compliance monitoring requirements and record for the Y-12 Complex, January through December 2008

Discharge point	Effluent parameter	Daily avg (lb/d)	Daily max (lb/d)	Daily avg (mg/L)	Daily max (mg/L)	Percentage of compliance	No. of samples
Outfall 501 (Central Pollution Control	pH, standard units			*a*	9.0	*b*	0
	Total suspended solids			31.0	40.0	*b*	0
	Total toxic organic				2.13	*b*	0
	Hexane extractables			10	15	*b*	0
	Cadmium	0.16	0.4	0.075	0.15	*b*	0
	Chromium	1.0	1.7	0.5	1.0	*b*	0
	Copper	1.2	2.0	0.5	1.0	*b*	0
	Lead	0.26	0.4	0.1	0.2	*b*	0
	Nickel	1.4	2.4	2.38	3.98	*b*	0
	Nitrate/Nitrite				100	*b*	0
	Silver	0.14	0.26	0.05	0.05	*b*	0
	Zinc	0.9	1.6	1.48	2.0	*b*	0
	Cyanide	0.4	0.72	0.65	1.20	*b*	0
	PCB				0.001	*b*	0
Outfall 502 (West End Treatment Facility)	pH, standard units			*a*	9.0	*b*	0
	Total suspended solids	19	36.0	31.0	40.0	*b*	0
	Total toxic organic				2.13	*b*	0
	Hexane extractables			10	15	*b*	0
	Cadmium	0.16	0.4	0.075	0.15	*b*	0
	Chromium	1.0	1.7	0.5	1.0	*b*	0
	Copper	1.2	2.0	0.5	1.0	*b*	0
	Lead	0.26	0.4	0.10	0.20	*b*	0
	Nickel	1.4	2.4	2.38	3.98	*b*	0
	Nitrate/Nitrite				100	*b*	0
	Silver	0.14	0.26	0.05	0.05	*b*	0
	Zinc	0.9	1.6	1.48	2.0	*b*	0
	Cyanide	0.4	0.72	0.65	1.20	*b*	0
	PCB				0.001	*b*	0
Outfall 503 (Steam Plant Waste Water Treatment Facility)	pH, standard units			*a*	9.0	*b*	0
	Total suspended solids	125	417	30.0	40.0	*b*	0
	Hexane extractables	63	83.4	10	15	*b*	0
	Iron	20.8	20.8	5.0	5.0	*b*	0
	Cadmium	0.16		0.075	0.15	*b*	0
	Chromium	0.8	0.8	0.20	0.20	*b*	0
	Copper	4.17	4.17	0.20	0.40	*b*	0
	Lead			0.10	0.20	*b*	0
	Zinc	4.17	4.17	1.0	1.0	*b*	0

Table 4.8 (continued)

Discharge point	Effluent parameter	Daily avg (lb/d)	Daily max (lb/d)	Daily avg (mg/L)	Daily max (mg/L)	Percentage of compliance	No. of samples
Outfall 512 (Groundwater Treatment Facility)	pH, standard units			*a*	9.0	100	12
	PCB				0.001	100	4
Outfall 520	pH, standard units			*a*	9.0	100	13
Outfall 200 (North/South pipes)	pH, standard units			*a*	9.0	100	54
	Hexane extractables			10	15	100	54
	Cadmium			0.001	0.025	100	12
	Lead			0.041	1.190	100	12
	PCB			0.002	0.002	100	4
Outfall 550	pH, standard units			*a*	9.0	*b*	0
	Mercury			0.002	0.004	*b*	0
Outfall 551	pH, standard units			*a*	9.0	100	53
	Mercury			0.002	0.004	100	53
Outfall 051	pH, standard units			*a*	9.0	100	12
Outfall 135	pH, standard units			*a*	9.0	100	13
	Lead			0.04	1.190	100	14
	PCB			0.002	0.002	100	4
Outfall 125	pH, standard units			*a*	9.0	100	12
	Cadmium			0.001	0.025	100	12
	Lead			0.04	1.190	100	12
	PCB			0.002	0.002	100	4
Outfall 055	pH, standard units			*a*	9.0	100	12
	Mercury				0.004	100	42
	Total residual chlorine				0.5	100	2
Outfall 109	pH, standard units			*a*	9.0	100	5
	Total residual chlorine				0.5	100	16
Outfall 021	pH, standard units			*a*	9.0	100	5
	Total residual chlorine				0.188	100	4
Outfall 077	pH, standard units			*a*	9.0	100	2
Outfall EFP	pH, standard units			*a*	9.0	100	262

Table 4.8 (continued)

Discharge point	Effluent parameter	Daily avg (lb/d)	Daily max (lb/d)	Daily avg (mg/L)	Daily max (mg/L)	Percentage of compliance	No. of samples
Outfall C11	pH, standard units			*a*	9.0	100	25
	Total residual chlorine				0.019	100	26
	Temperature (^{o}C)				30.5	100	24
Outfall S06	pH, standard units			*a*	9.0	100	3
Outfall S19	pH, standard units			*a*	9.0	100	3
Outfall S24	pH, standard units			*a*	9.0	100	5
Category I outfalls	pH, standard units			*a*	9.0	100	41
Category II outfalls	pH, standard units			*a*	9.0	100	39
	Total residual chlorine				0.5	97	36
Category III outfalls	pH, standard units			*a*	9.0	100	12
	Total residual chlorine				0.5	100	11

[a]Not applicable.
[b]No discharge.

Table 4.9. Radiological parameters monitored at the Y-12 Complex, 2008

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

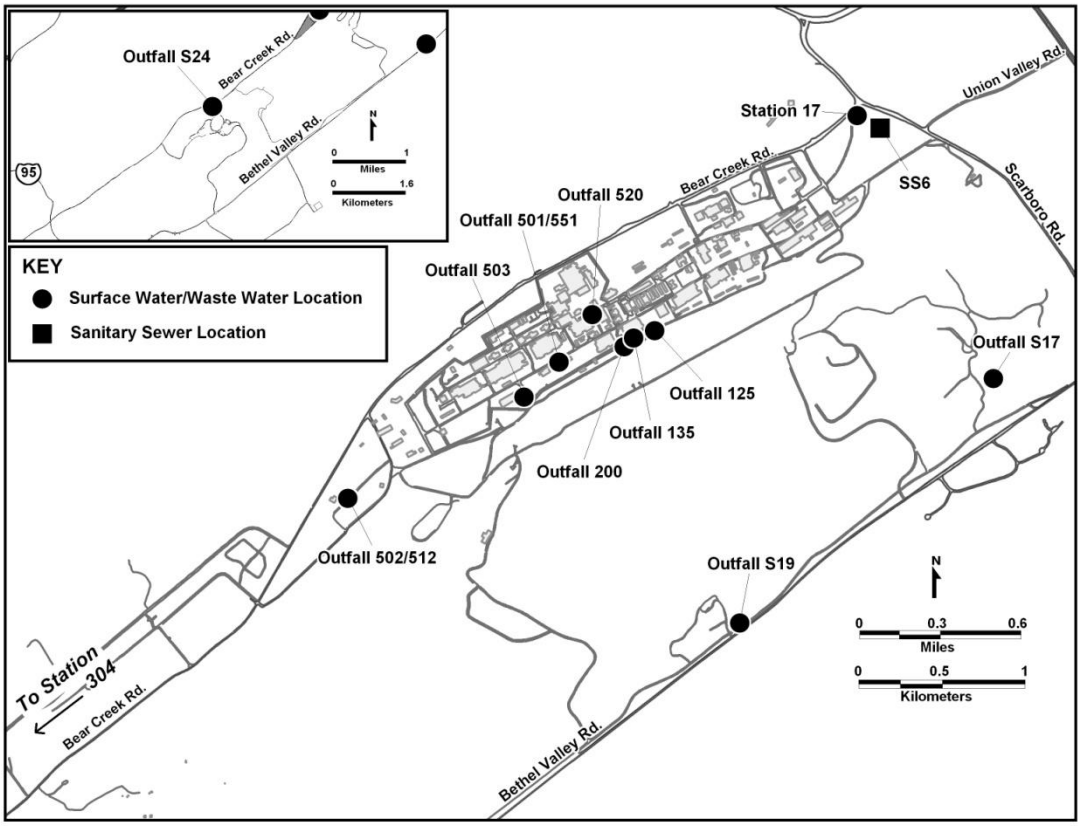


Fig. 4.24. Surface water and sanitary sewer radiological sampling locations at the Y-12 Complex.

Sector General Permit for Industrial Activities (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."

Storm water sampling for 2008 was conducted during September and October rain events. Results were provided in the Annual Storm Water Report, which was submitted to the Tennessee Division of Water Pollution Control in January 2009. Per the NPDES permit, storm water monitoring is performed each year for sector outfalls, three major outfalls that drain large areas of the Y-12 Complex, raw water flow, and four instream monitoring locations on East Fork Poplar Creek (see Fig. 4.23). In general, results of storm water 2008 monitoring indicated some improvement in the quality of storm water exiting the Y-12 Complex.

4.5.4 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 the 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). With the completion of the project, instream water temperatures decreased by approximately 5°C (from approximately 26°C at the headwaters).

Table 4.10. 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
551	Central Mercury Treatment Facility	4/year	24-hour composite	1.8
	Other Y-12 Complex point and area source discharges			
055	Outfall 055	4/year	24-hour composite	b
125	Outfall 125	4/year	24-hour composite	12.4
135	Outfall 135	4/year	24-hour composite	0
S17	Kerr Hollow Quarry	1/year	24-hour composite	1.8
S19	Rogers Quarry	1/year	24-hour composite	1.7
	Y-12 Complex instream locations			
S24	Outfall S24	4/year	7-day composite	12.2
Station 17	East Fork Poplar Creek, complex exit (east)	1/month	7-day composite	3.4
200	North/south pipes	1/month	24-hour composite	3.4
	Y-12 Complex Sanitary Sewer			
SS6	East End Sanitary Sewer Monitoring Station	1/week	7-day composite	0

[a]The *Radiological Monitoring Plan* was last updated in June 2006.

[b]Discontinued.

During a two week period in August 2008, the flow augmentation water was reduced in the uppermost reach of the stream by approximately 2 million gal/day. The minimum flow requirement was met by diverting 2 million gal/day of the raw water input to a downstream location (outfall 002) near Station 17. Mercury concentrations in EFPC were measured for two weeks prior, during, and after the diversion. This study demonstrated a reduction in the transport of mercury from a contaminated section of streambed could be expected by reducing flow through this stream section.

Table 4.11. Release of uranium from the Y-12 Complex to the off-site environment as a liquid effluent, 2004–2008

Year	Quantity released	
	Ci[a]	kg
	Station 17	
2004	0.067	161
2005	0.043	93
2006	0.050	131
2007	0.036	70
2008	0.046	75

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

A request to modify the NPDES permit to allow the minimum flow, measured at Station 17, to be reduced to 5 million gal/day was made, and on December 30, 2008, TDEC modified the permit. The modified permit requires 5 million gal rather than 7 million gal minimum daily flow as measured at the Station 17 location. In addition to water conservation, this action offers the additional benefit of reducing Y-12's water cost by $272K annually.

4.5.5 Y-12 Complex Ambient Surface Water Quality

To monitor key indicators of water quality, a network of real-time monitors located at three instream locations along Upper East Fork Poplar Creek are used. The Surface Water Hydrological Information Support System (SWHISS) is available for real-time water quality measurements, such as pH, temperature, dissolved oxygen, conductivity, and chlorine. The locations are noted in Fig. 4.26. The primary function of the SWHISS is to provide an indication of potential adverse conditions that could be causing an impact on the quality of water in Upper East Fork Poplar Creek. It is operated as a best management practice.

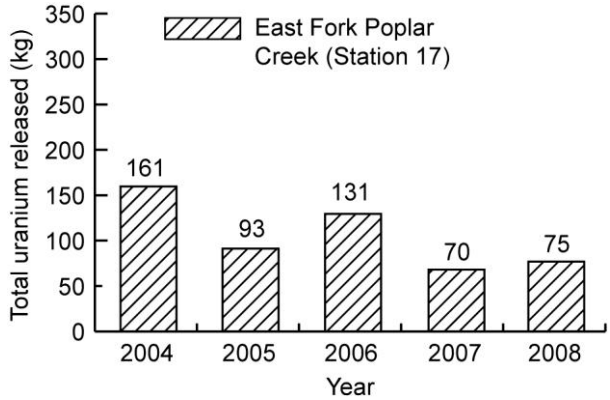


Fig. 4.25. Five-year trend of Y-12 Complex release of uranium to East Fork Poplar Creek.

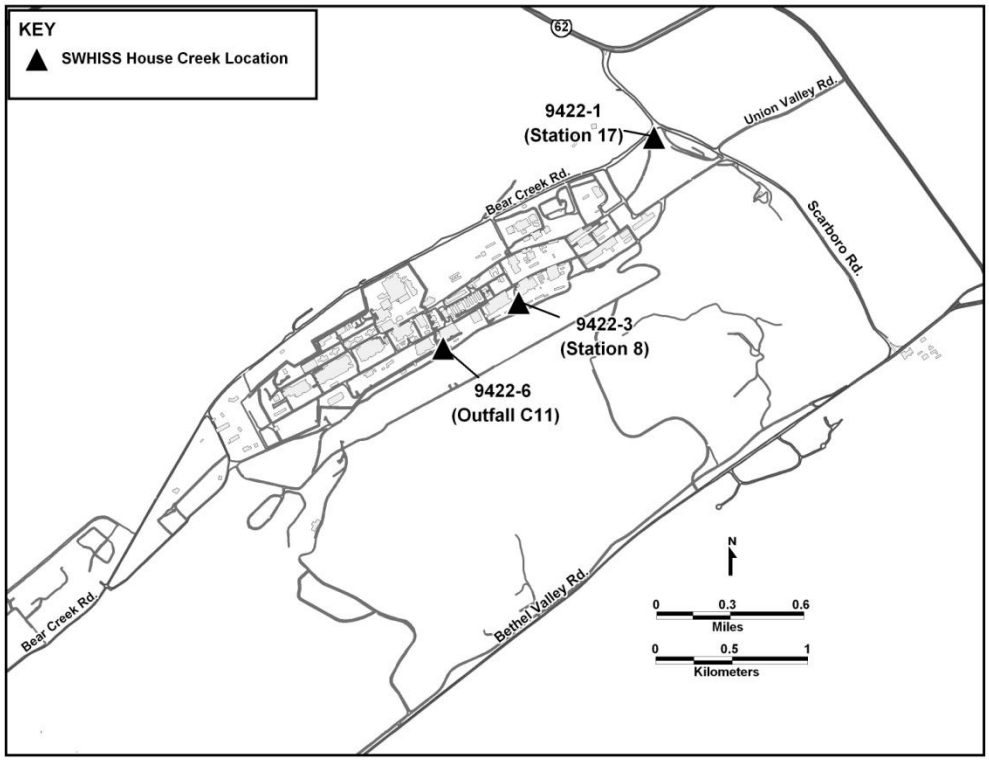


Fig. 4.26. Surface Water Hydrological Information Support System (SWHISS) monitoring locations.

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. 4.6).

4.5.6 Industrial Wastewater Discharge Permit

The Industrial and Commercial User Wastewater Discharge Permit No. 1-91 provides requirements for the discharge of wastewaters to the sanitary sewer system as well as prohibitions for certain types of wastewaters. It prescribes requirements for monitoring certain parameters at the East End Sanitary Sewer Monitoring Station. Limitations are set in the permit for most parameters. Samples for gross alpha, gross beta, and uranium are taken by a weekly 24 hour composite sample. The sample is analyzed for uranium

if the alpha and beta values exceed certain levels. Other parameters (including metals, oil and grease, solids, and biological oxygen demand) are monitored on a monthly basis. Organic parameters are monitored once per quarter. Results of compliance sampling are reported quarterly. Flow is measured 24 hours per day at the monitoring station.

As part of the city of Oak Ridge's pretreatment program, city personnel use the monitoring station to conduct compliance monitoring as required by the pretreatment regulations. City personnel also conduct twice yearly compliance inspections. Monitoring results during 2008 (Table 4.12) indicated four exceedances of permit limits. Two were for exceedance of permit limits (daily maximum and monthly average) for copper. The other two were for exceedance of the permit limit for maximum daily flow.

Table 4.12. Y-12 Complex Discharge Point SS6, Sanitary Sewer Station 6, January through December 2008

Effluent parameter	Number of samples	Daily average value (effluent limit)[a]	Daily maximum value (effluent limit)[b]	Percentage of compliance
Flow, mgd	366	NA	1.4	99
pH, standard units	14	NA	9/6[c]	100
Silver	14	0.05	0.1	100
Arsenic	14	0.01	0.015	100
Biochemical oxygen demand	14	200	300	100
Cadmium	14	0.0033	0.005	100
Chromium	14	0.05	0.075	100
Copper	14	0.14	0.21	93
Cyanide	15	0.041	0.062	100
Iron	14	10	15	100
Mercury	14	0.023	0.035	100
Kjeldahl nitrogen	14	45	90	100
Nickel	14	0.021	0.032	100
Oil and grease	15	25	50	100
Lead	14	0.049	0.074	100
Phenols—total recoverable	14	0.3	0.5	100
Suspended solids	14	200	300	100
Zinc	14	0.35	0.75	100

[a]Units in milligrams per liter unless otherwise indicated.
[b]Industrial and Commercial Users Wastewater Permit limits.
[c]Maximum value/minimum value.

4.5.7 Quality Assurance/Quality Control

The Environmental Monitoring Management Information System (EMMIS) is used to manage surface water monitoring data. EMMIS uses standard sample definitions to ensure that samples are taken at the correct location at a specified frequency using the correct sampling protocol.

Field sampling QA encompasses many practices that minimize error and evaluate sampling performance. Some key quality practices include the following:

- use of standard operating procedures for sample collection and analysis;
- use of chain-of-custody and sample identification, customized chain-of-custody documents, and sample labels provided by EMMIS;
- instrument standardization, calibration, and verification;
- sample technician training;
- sample preservation, handling, and decontamination; and
- use of QC samples, such as field and trip blanks, duplicates, and equipment rinses.

Surface water data are directly by the analytical laboratory into the Laboratory Information Management System (LIMS) on the day of approval. EMMIS routinely accesses LIMS electronically to capture pertinent data. Generally, the system will store the data in the form of concentrations.

A number of electronic data management tools enable automatic flagging of data points and allow for monitoring and trending data over time. Field information on all routine samples taken for surface water monitoring is entered in EMMIS, which also retrieves data nightly from the analytical laboratory. The system then performs numerous checks on the data, including comparisons of the individual results against any applicable screening criteria, regulatory thresholds, compliance limits, best management standards, or other water quality indicators, and produces required reports.

4.5.8 Biomonitoring Program

In accordance with the requirements of the 2006 NPDES permit (Part III-E, p. 9), a biomonitoring program is in place that evaluates three outfalls that discharge to the headwaters of East Fork Poplar Creek (outfalls 200, 135, and 125). Water from each outfall was tested once in 2008 using fathead minnow larvae and *Ceriodaphnia dubia*. Table 4.13 summarizes the inhibition concentration (IC_{25}) results of biomonitoring tests conducted during 2008 at 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, the lower the value, the more toxic the effluent. 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 2008.

Table 4.13. Y-12 Complex Biomonitoring Program summary information[a] for outfalls 200, 135, and 125 in 2008

Site	Test date	Species	IC_{25}[b] (%)
Outfall 200	12/16/08	*Ceriodaphnia*	>100
Outfall 200	12/16/08	Fathead minnow	>100
Outfall 135	12/16/08	*Ceriodaphnia*	>20
Outfall 135	12/16/08	Fathead minnow	>20
Outfall 125	12/16/08	*Ceriodaphnia*	>36
Outfall 125	12/16/08	Fathead minnow	>36

[a]The inhibition concentrations (IC_{25}) are summarized for the discharge monitoring locations, outfalls 200, 135, and 125.

[b]IC_{25} as a percentage of full-strength effluent from outfalls 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.

4.5.9 Biological Monitoring and Abatement Programs

The NPDES permit issued for the Y-12 Complex in 2006 mandates a 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 BMAP, which has been monitoring the ecological health of East Fork Poplar Creek since 1985, currently 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. Data collected on contaminant bioaccumulation and the composition and abundance of communities of aquatic organisms provide a direct evaluation of the effectiveness of abatement and remedial measures in improving ecological conditions in the stream.

Monitoring is presently being conducted at five primary East Fork Poplar Creek sites, 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. 4.27). 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 4.28).

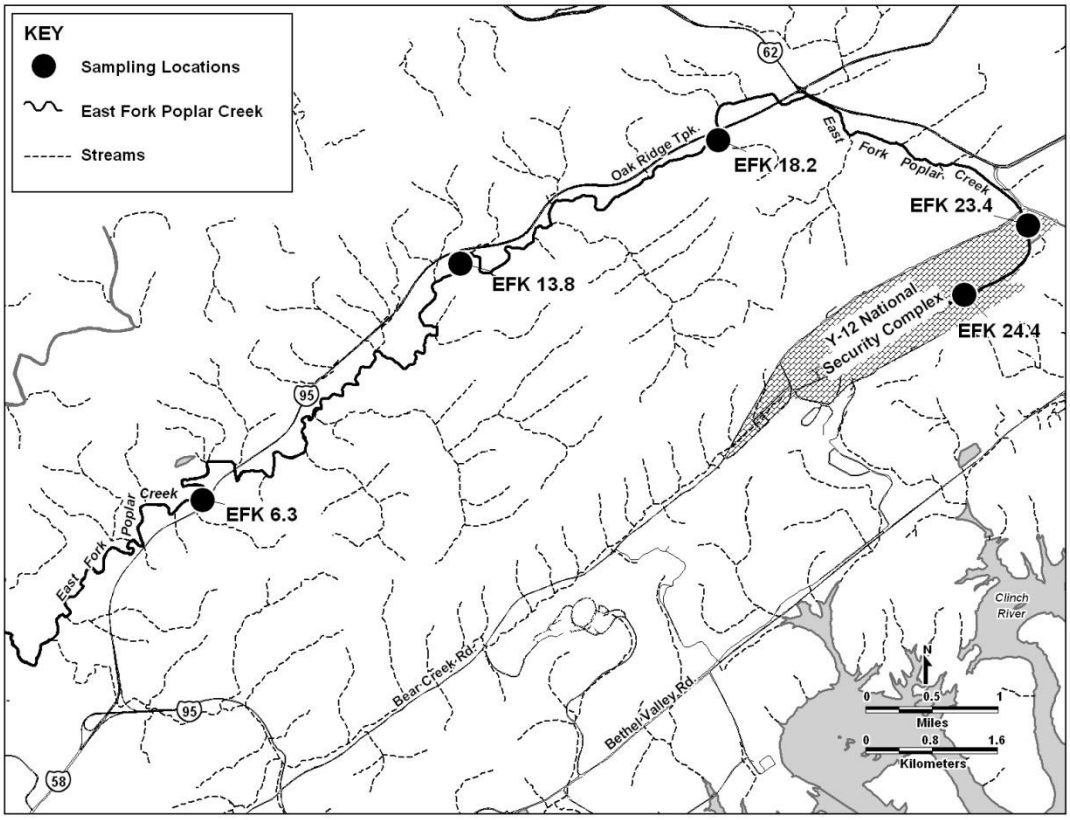


Fig. 4.27. Locations of biological monitoring sites on East Fork Poplar Creek in relation to the Oak Ridge Y-12 National Security Complex.

Significant increases in species richness and diversity in East Fork Poplar Creek over the last two decades demonstrate that the overall ecological health of the stream continues to improve. However, the pace of improvement in the upper reaches of East Fork Poplar Creek near the Y-12 Complex has slowed in recent years, and fish and invertebrate communities continue to be degraded in comparison with similar communities in reference streams.

4.5.9.1 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 and temporal trends in bioaccumulation associated with ongoing remedial activities and Y-12 Complex operations.

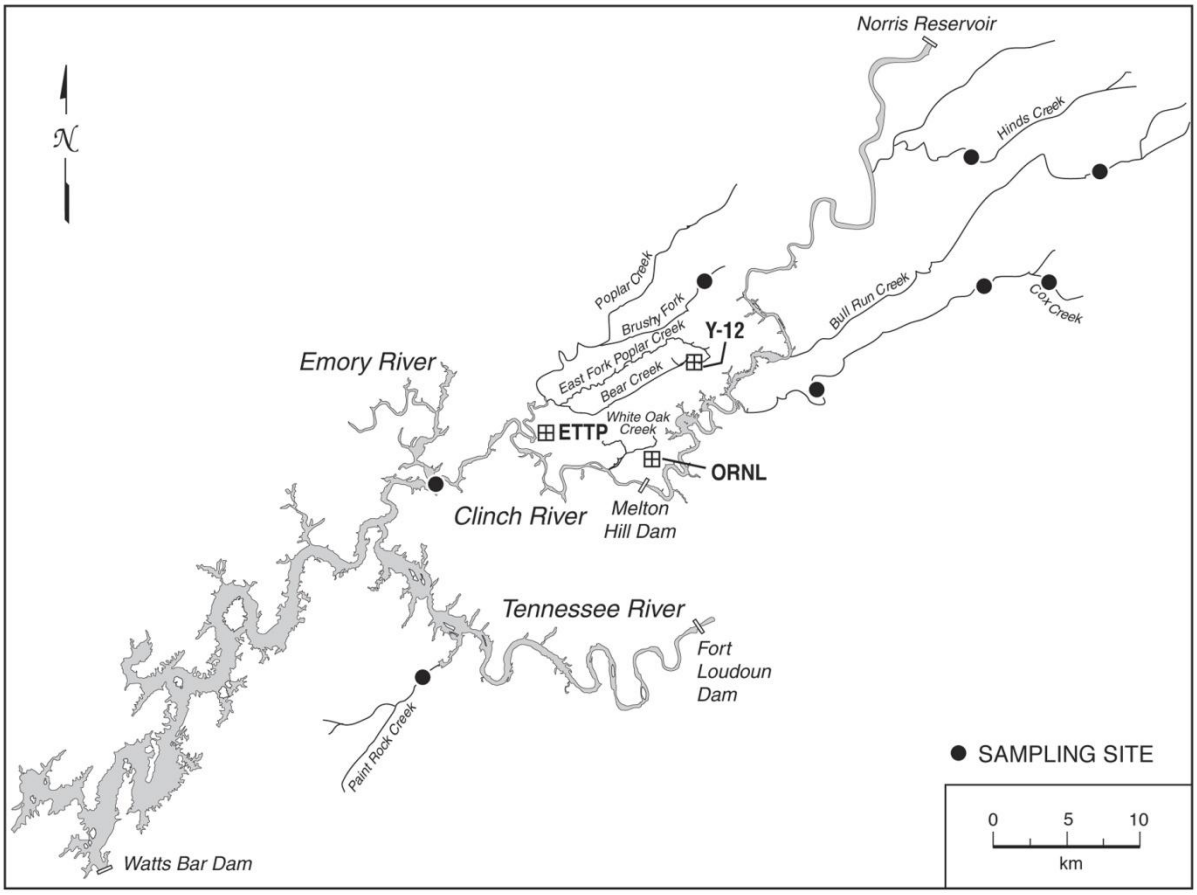


Fig. 4.28. Locations of biological monitoring reference sites in relation to the Oak Ridge Y-12 National Security Complex.

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). Mercury concentrations remained much higher during 2008 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 waterborne mercury concentrations in the upper reaches of East Fork Poplar Creek decreased substantially following the 2005 start-up of a treatment system on a mercury-contaminated spring (Fig. 4.29), mercury concentrations in fish have not yet decreased in response. Mean concentrations of PCBs in fish at EFK 23.4 (the site where PCBs in fish are highest) continued to be much lower in 2008 than peak concentrations observed in the mid 1990s, although PCBs did rise in 2008 relative to recent years (Fig. 4.30).

4.5.9.2 Benthic Invertebrate Surveys

Benthic macroinvertebrate communities were monitored at three sites in East Fork Poplar Creek and at two reference streams in the spring of 2008. The macroinvertebrate communities at EFK 23.4 and EFK 24.4 remained degraded as compared with reference communities, especially in the richness of pollution-sensitive taxa (Fig. 4.31). The benthic macroinvertebrate community at the upstream-most sites in East Fork Poplar Creek appears to have stabilized in recent years, with the magnitude of changes between years being comparable to those at the reference sites, including the decreases in both metrics at EFK 24.4.

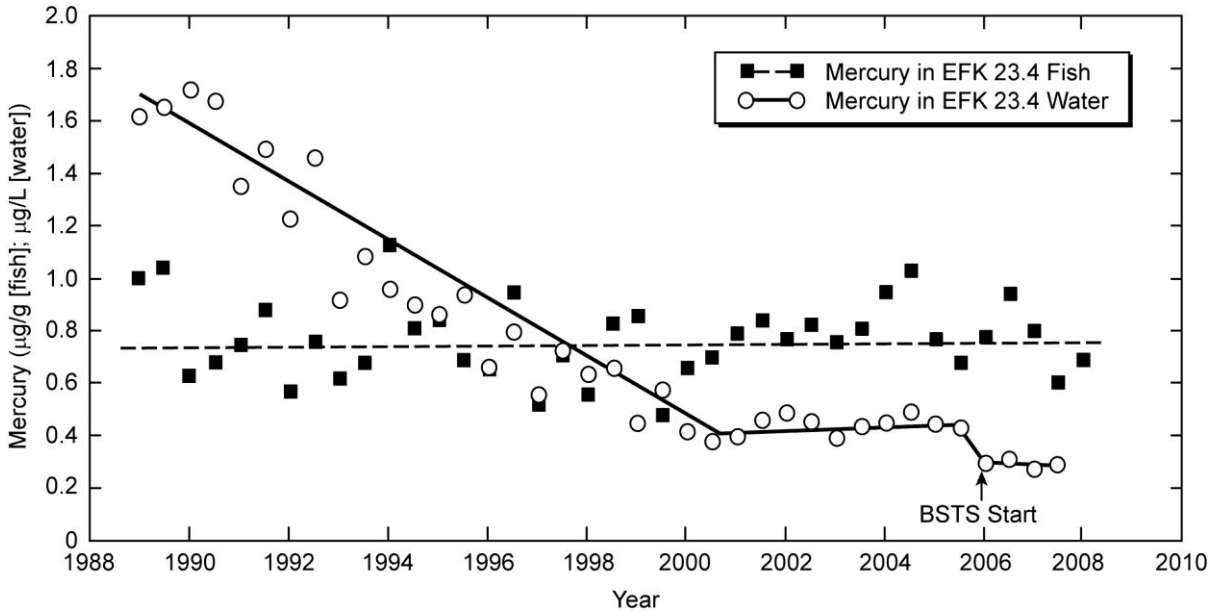


Fig. 4.29. Semiannual average mercury concentration in water and muscle fillets of redbreast sunfish and rock bass in East Fork Poplar Creek at EFK 23.4 through spring 2008. (BSTS = Big Spring Treatment System.)

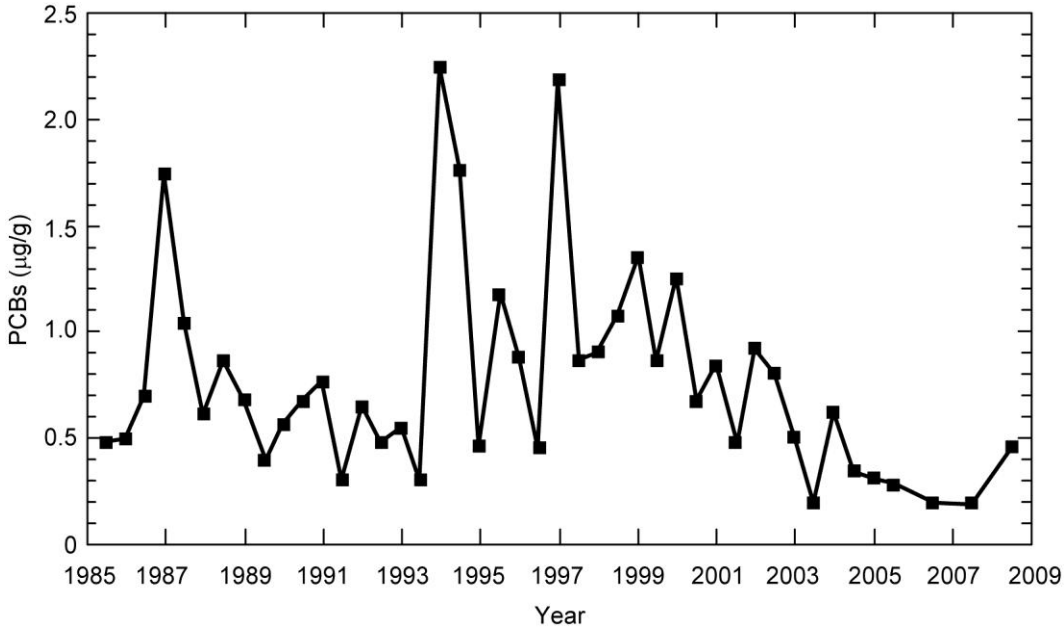


Fig. 4.30. Mean concentrations of PCBs in redbreast sunfish and rock bass muscle fillets in East Fork Poplar Creek at EFK 23.4 through 2008. (EFK = East Fork Poplar Creek kilometer.)

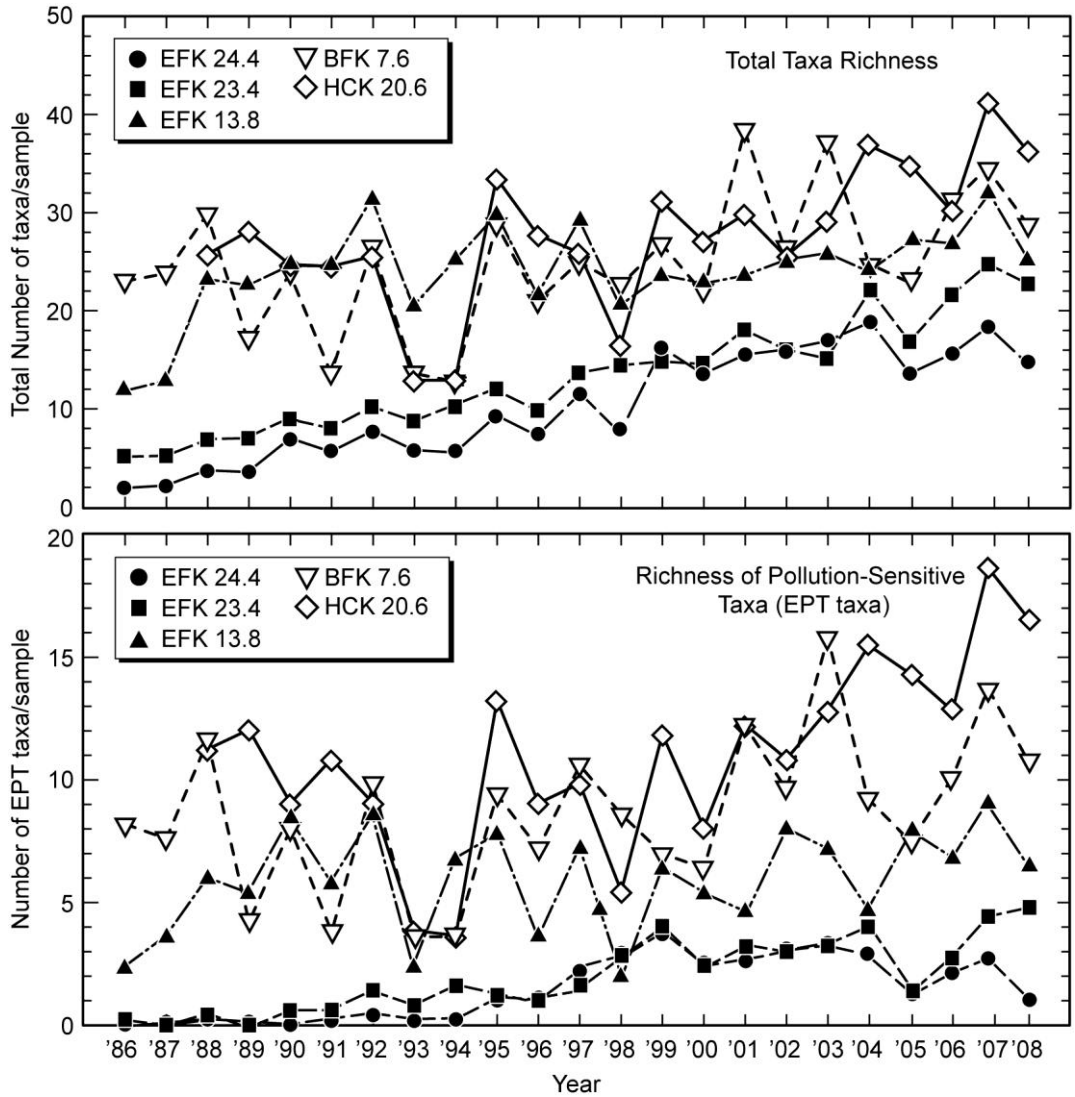


Fig. 4.31. Total taxonomic richness (mean number of taxa/sample) and total taxonomic richness of the Ephemeroptera, Plecoptera, and Trichoptera (EPT) (mean number of EPT taxa/sample) of the benthic macroinvertebrate communities sampled in spring from East Fork Poplar Creek and references sites on nearby Brushy Fork (BFK 7.6) and Hinds Creek (HCK 20.6).

4.5.9.3 Fish Community Monitoring

Fish communities were monitored in the spring and fall of 2008 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. 4.32) have increased at all sampling locations below Lake Reality. However, the East Fork Poplar Creek fish community continues to lag behind reference stream communities in most important metrics of fish diversity and community structure, especially at the monitoring site closest to the Y-12 Complex.

4.6 Groundwater at the Y-12 Complex

Groundwater is water that occurs and moves below the surface of the earth in pore spaces of soil, sediment, and rock formations. These formations, when saturated and permeable enough to be used as a water source, are referred to as aquifers, and are everywhere beneath our feet. Groundwater is an

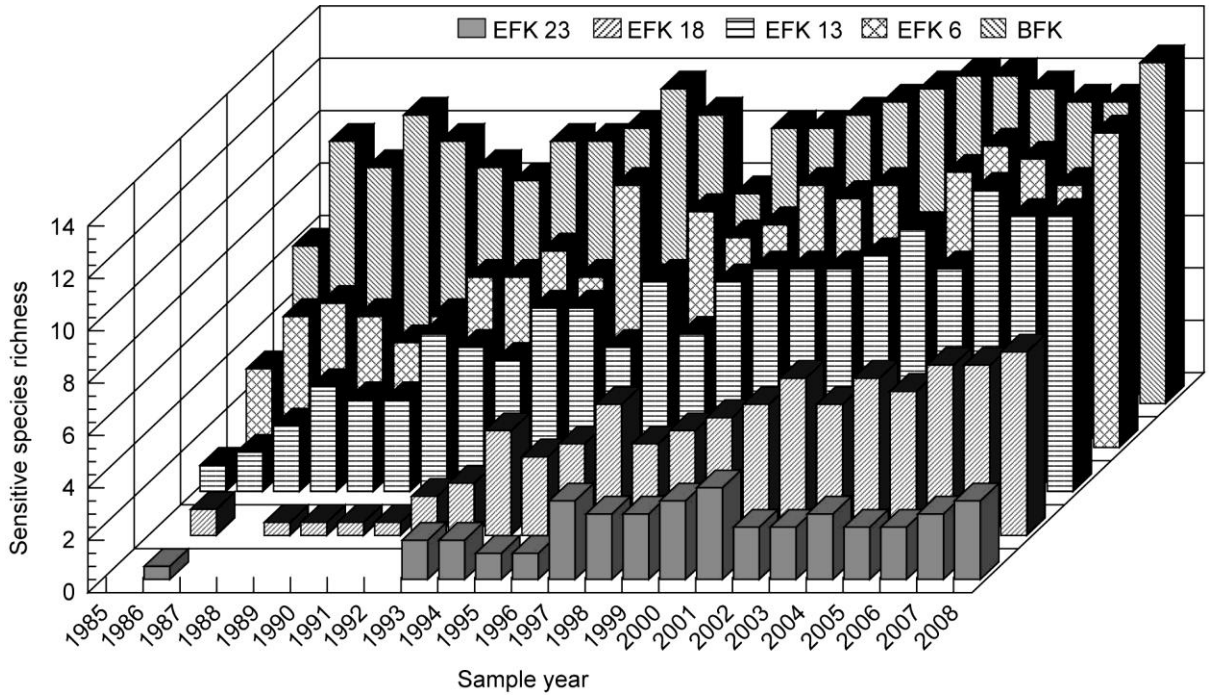


Fig. 4.32. Comparison of mean sensitive species richness (number of species) collected each year from 1985 through 2008 from four sites in East Fork Poplar Creek and a reference site (Brushy Fork).

important natural resource, especially in those parts of the country without ample surface-water sources, such as the arid West. More than 50% of the people in the United States, including almost everyone who lives in rural areas, use groundwater for drinking and other household uses. Groundwater is also used in some way by about 75% of cities and by many industries. The largest use of groundwater is crop irrigation.

Groundwater is an active and complex part of the Earth's hydrologic cycle. Recharging (or contributing to) aquifers is accomplished when rainfall seeps into the ground and percolates through soil and rock to the water table (the top of the saturated zone within the subsurface), or when surface waters contribute directly to groundwater. Discharges from groundwater are naturally occurring and commonly observed at natural springs and seeps but can also occur directly to streams, rivers, lakes, or oceans. Groundwater is not a stagnant underground lake, but instead is usually moving, allowing subsequent contributions from rainfall, runoff, and surface water. Groundwater is a renewable resource that has been used for thousands of years.

Operations at the Y-12 Complex reflect the growing awareness of the need to protect the environment, including groundwater systems. 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 operational and waste management practices. Because of that contamination, groundwater monitoring is performed to comply with regulations and DOE orders. Figure 4.33 depicts the major facilities or areas for which groundwater monitoring was performed during CY 2008.

4.6.1 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 located within the area. These regimes include the Bear Creek Hydrogeologic, the Upper East Fork Poplar Creek Hydrogeologic, and the Chestnut Ridge Hydrogeologic Regimes

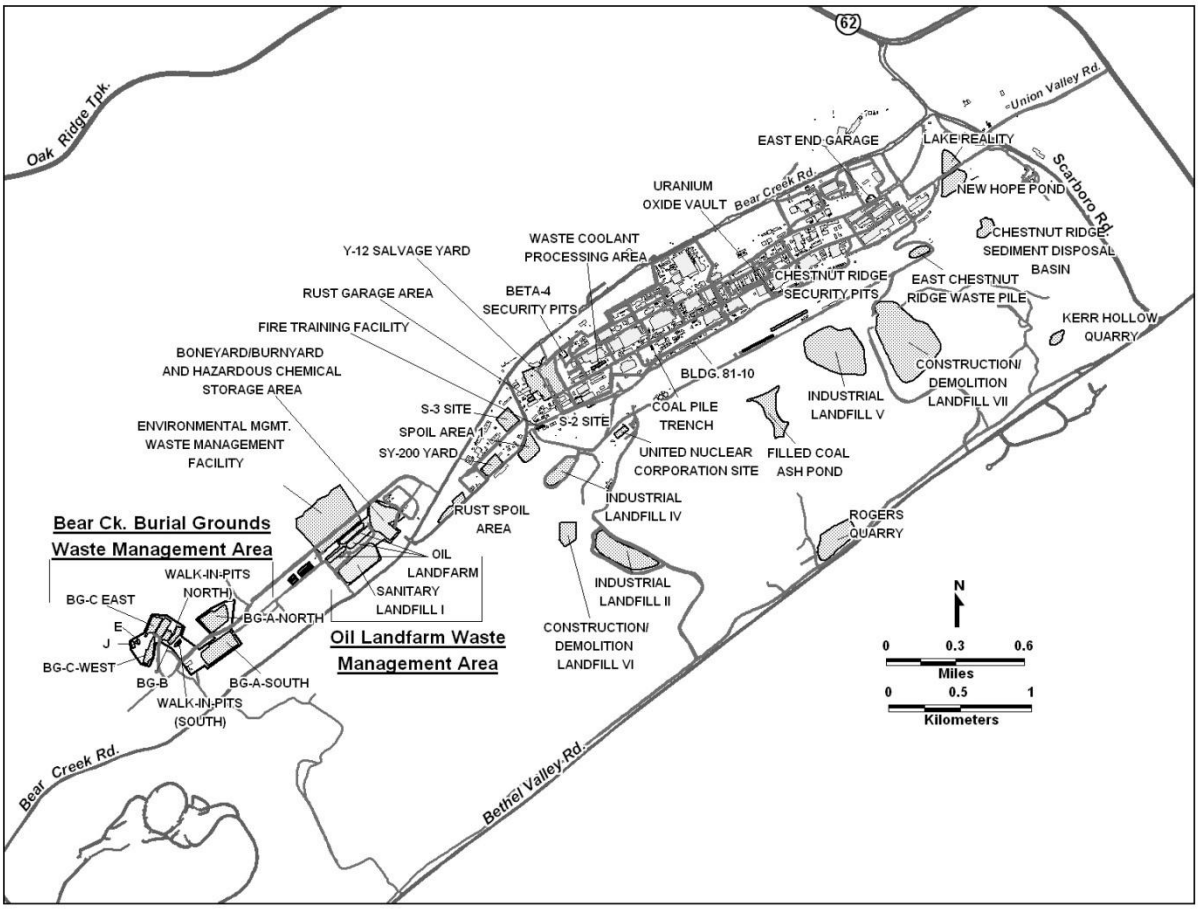


Fig. 4.33. Known or potential contaminant sources for which groundwater monitoring was performed at the Y-12 Complex during CY 2008.

(Fig. 4.34). Most of the Bear Creek and Upper East Fork Poplar Creek regimes are underlain by fractured noncarbonate rock. The southern portion of the two regimes is underlain by the Maynardville Limestone, which is part of the Knox Aquifer. The entire Chestnut Ridge regime is underlain by the Knox Aquifer. In general, groundwater flow in the water table interval follows topography. Shallow groundwater flow in the Bear Creek and the Upper East Fork regimes is divergent from the topographic and groundwater divide located near the western end of the Y-12 Complex that defines the boundary between the two. 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 noncarbonate rock, 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 fractured noncarbonate rock (<1 ft/year) but can be quite rapid within solution conduits in the Maynardville Limestone (tens to thousands of feet per day).

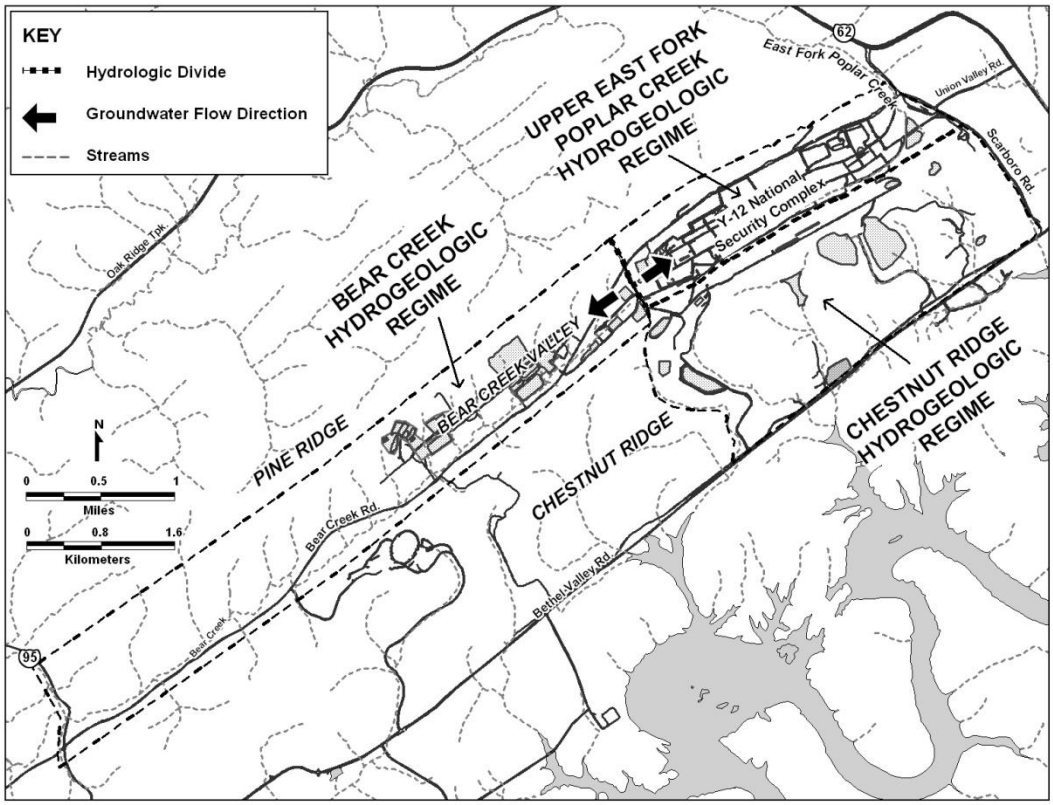


Fig. 4.34. Hydrogeologic regimes at the Y-12 Complex.

The rate of groundwater flow perpendicular to geologic strike from the fractured noncarbonate rock 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 underground utility traces and buried tributaries in the Upper East Fork regime. Strike-parallel transport of some contaminants can occur within the fractured noncarbonate rock for significant distances. Continuous elevated levels of nitrate within the fractured noncarbonate rock are known to extend east and west from the S-3 Site for thousands of feet. Volatile organic compounds at source units in the fractured noncarbonate rock, 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.

4.6.2 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 established regulatory and industry standards. Figure 4.35 shows a cross-section of a typical groundwater monitoring well. Piezometers are primarily temporary devices used to measure groundwater table levels. Other devices or techniques are sometimes employed to gather data,

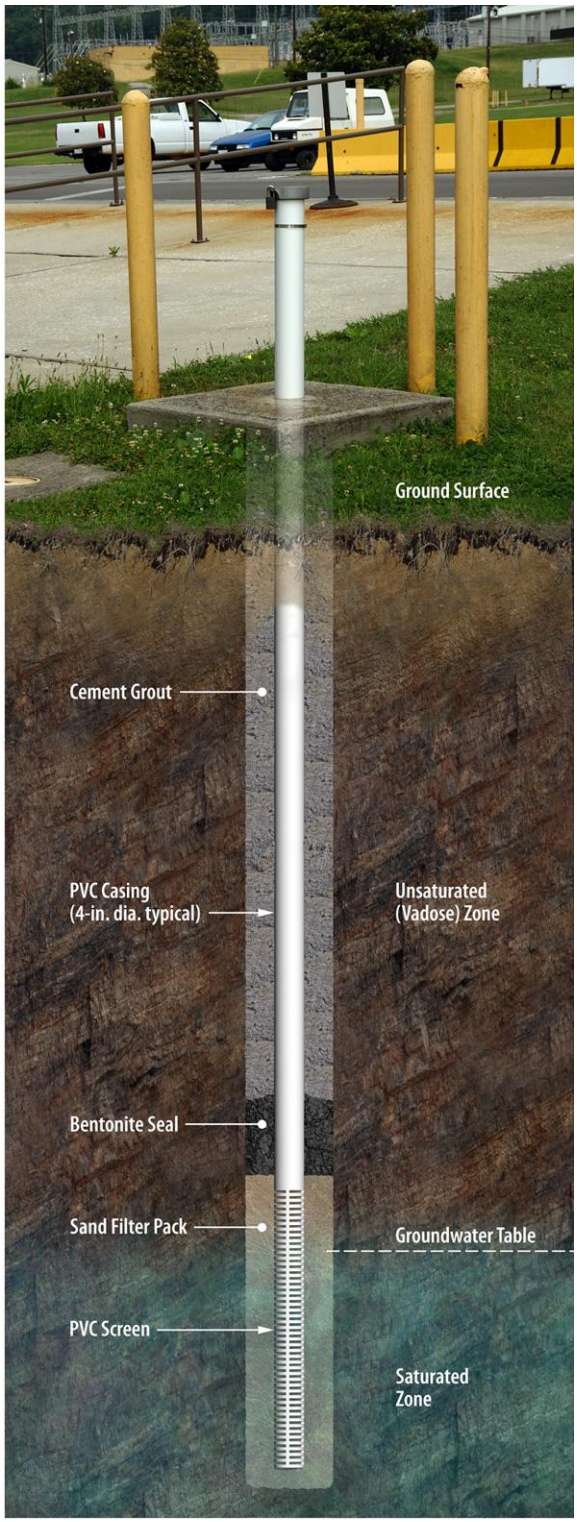


Fig. 4.35. Cross-section of a typical groundwater monitoring well.

including well points and push probes. In CY 2008, no compliance or surveillance monitoring wells were installed or plugged; however, ten wells were installed in support of research activities by the Environmental Remediation Sciences Oak Ridge Field Research Center. The purpose of the Field Research Center is to research the interactions and processes within a contaminated groundwater system to assist in the development of remediation strategies and tools for groundwater cleanup.

4.6.3 CY 2008 Groundwater Monitoring

Groundwater monitoring in CY 2008 was performed to comply with DOE orders and regulations by the Y-12 Groundwater Protection Program, the Water Resources Restoration Program, and other projects. Compliance requirements were met by monitoring 213 wells and 32 surface water locations and springs (Table 4.14, Fig. 4.36). Figure 4.37 shows the locations of Y-12 Complex perimeter/exit pathway groundwater monitoring stations.

Comprehensive water quality results of groundwater monitoring activities at Y-12 in CY 2008 are presented in the annual *Groundwater Monitoring Report* (B&W Y-12 2009b).

Details of monitoring efforts performed specifically for CERCLA baseline and remediation evaluation are published in the FY 2008 and FY 2009 Water Resources Restoration Program sampling and analysis plans (BJC 2007 and BJC 2008), and the 2009 *Remediation Effectiveness Report* (DOE 2009).

Groundwater monitoring compliance reporting to meet RCRA postclosure permit requirements can be found in the annual RCRA *Groundwater Monitoring Report* (BJC 2009).

4.6.4 Y-12 Groundwater Quality

Historical monitoring efforts have shown that there are four primary contaminants that have impacted groundwater quality at the Y-12 Complex: nitrate, volatile organic compounds, metals, and radionuclides. Of those, volatile organic compounds are the most widespread. In groundwater, uranium and technetium-99 are the radionuclides of greatest concern. Trace metals, the least extensive groundwater contaminants, generally occur close to source areas. Historical data have shown that plumes from multiple-source units have mixed with one another and that contaminants (other than nitrate and technetium-99) are no longer easily associated with a single source.

Table 4.14. Summary of groundwater monitoring at the Y-12 Complex, 2008

	Purpose for which monitoring was performed				
	Restoration[a]	**Waste management[b]**	**Surveillance[c]**	**Other[d]**	**Total**
Number of active wells	60	30	123	59	272
Number of other monitoring stations (e.g., springs, seeps, surface water)	12	6	14	5	37
Number of samples taken[e]	123	36 *	172	400	731
Number of analyses performed	6,662	3,688 *	16,624	6,557	33,531
Percentage of analyses that are non-detects	70.2	86.8	77.5	33	68.4
Ranges of results for positive detections, VOCs (µg/L)[f]					
Chloroethenes	0.1–3,500	0.14–8.9	0.9–50,000	NA	
Chloroethanes	0.1–470	0.27–25	1–3,000	NA	
Chloromethanes	0.2–1,300	ND	1–1,400	NA	
Petroleum hydrocarbons	0.1–8,300	ND	1–2,300	NA	
Uranium (mg/L)	0.0042–0.54	ND	0.0005–1.53	0.0031–77.96	
Nitrates (mg/L)	0.028–7,440	0.59–3.0	0.029–11,100	0.36–54,540.2	
Ranges of results for positive detections, radiological parameters (pCi/L)[g]					
Gross alpha activity	1.72–431	2–4.6	2.6–1,100	NA	
Gross beta activity	3.0–21,300	1.18–13.4	4.5–9,600	NA	

[a]Monitoring 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.

[b]Solid waste landfill detection monitoring; *=excludes CERCLA landfill (Environmental Monitoring Waste Management Facility) detection monitoring.

[c]DOE Order 450.1A surveillance monitoring.

[d]Research-related groundwater monitoring associated with activities of the DOE ORR Field Research Center.

[e]The number of samples, excluding duplicates, determined for unique location/date combinations. Samples are unfiltered except for those reported for "Other."

[f]These ranges reflect concentrations of individual contaminants (not summed volatile organic compound concentrations):

Chloroethene—includes tetrachloroethene, trichloroethene, 1,2-dichloroethene (*cis* and *trans*), 1,1-dichloroethene, and vinyl chloride.

Chloroethanes—include 1,1,1-trichloroethane, 1,2-dichloroethane, and 1,1-dichloroethane.

Chloromethanes—include carbon tetrachloride, chloroform, and methylene chloride.

Petroleum hydrocarbon—includes benzene, toluene, ethylbenzene, and xylene.

[g]1 pCi = 3.7×10^{-2} Bq.

Abbreviations

NA = Not applicable

ND = Not detected

Fig. 4.36. Groundwater sampling at Y-12.

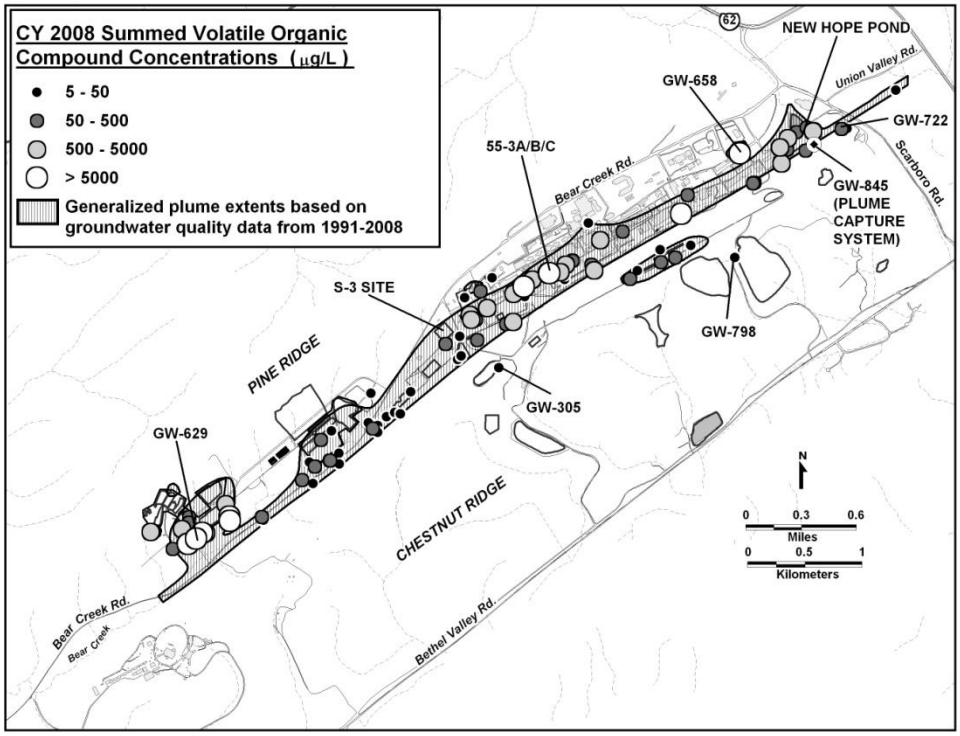


Fig. 4.37. Locations of Y-12 Complex perimeter/exit pathway well, spring, and surface water monitoring stations.

4.6.4.1 Upper East Fork Poplar Creek Hydrogeologic Regime

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 4.15. Chemical constituents from the S-3 Site (primarily nitrate and technetium-99) and volatile organic compounds from multiple source areas are observed in the groundwater in the western portion of the Upper East Fork regime; groundwater in the eastern portion, including Union Valley, is predominantly contaminated with volatile organic compounds.

Table 4.15. History of waste management units and underground storage tanks included in groundwater monitoring activities, Upper East Fork Poplar Creek Hydrogeologic Regime, 2008

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

Abbreviations
PCB = polychlorinated biphenyl
RCRA = Resource Conservation and Recovery Act
UST = underground storage tank

4.6.4.1.1 Plume Delineation

Sources of groundwater contaminants monitored during CY 2008 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 the Upper East Fork regime.

4.6.4.1.2 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 2008, groundwater containing nitrate concentrations as high as 11,200 mg/L (Well GW-109) occurred in the shallow bedrock just east of the S-3 Site (Fig. 4.38). These results are consistent with results from previous years.

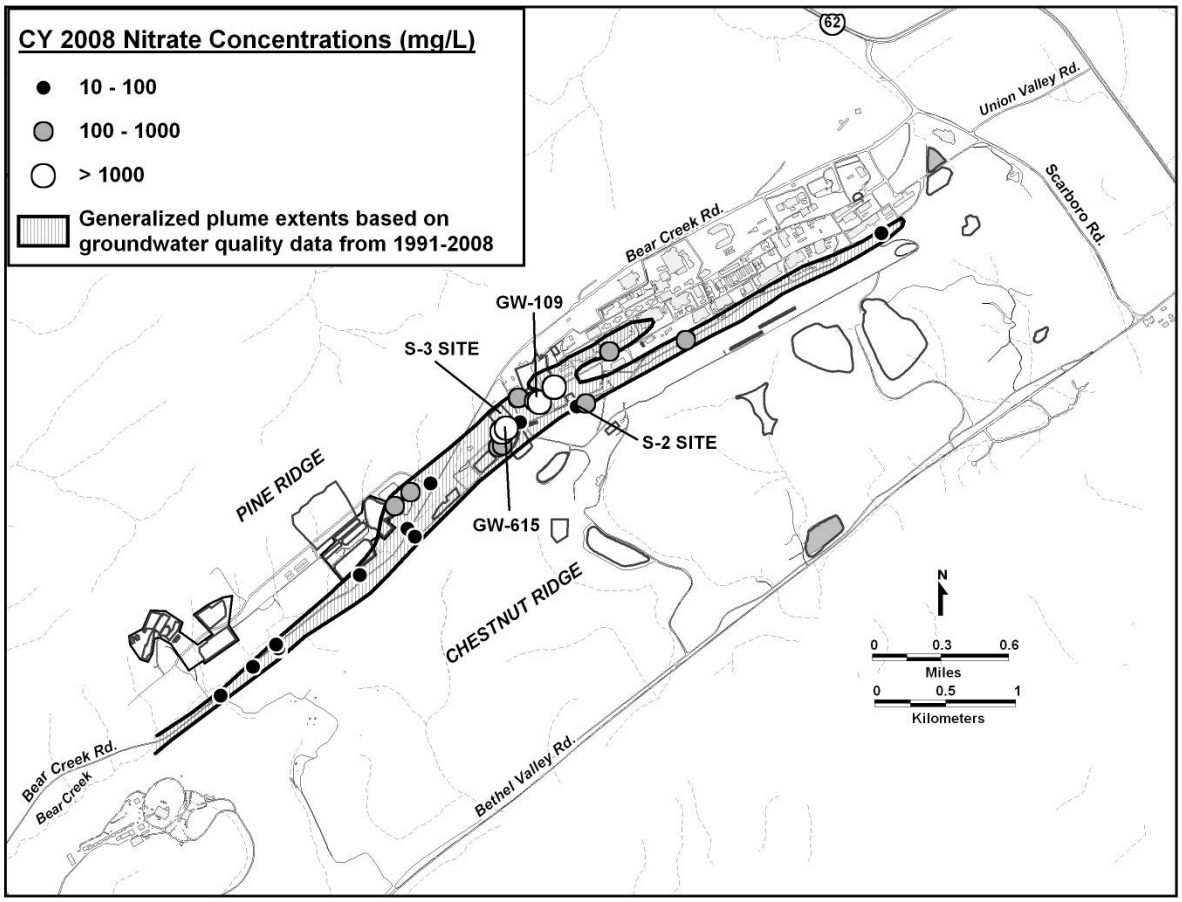


Fig. 4.38. Nitrate observed in groundwater at the Y-12 Complex, 2008.

4.6.4.1.3 Trace Metals

Concentrations of barium, beryllium, cadmium, chromium, lead, mercury, nickel, and uranium exceeded drinking water standards during CY 2008 in samples collected from various 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. 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.

4.6.4.1.4 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 2008, the highest summed concentration of dissolved chlorinated solvents (54,895 µg/L) was again 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 (20,100 µg/L) was obtained from Well GW-658 at the closed East End Garage.

The CY 2008 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 . 4.39). 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 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 chloroethene component of the East End volatile organic compound plume, indicating that some portions of the plume are still mobile. Additionally, concentrations are influenced by precipitation with dilution or flushing effects dominating in wells depending upon the permeability of the surrounding rock and proximity to sources and migration pathways. For example, Well 55-3B has an observable inverse correlation between annual rainfall rates and concentrations of chlorinated volatile organic compounds indicating that dilution effects dominate in the vicinity of this well within the noncarbonated fractured rock.

Within the exit pathway the general trends are also stable or decreasing. The 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 either migration is limited or some downgradient across-strike influence by the plume capture system is occurring.

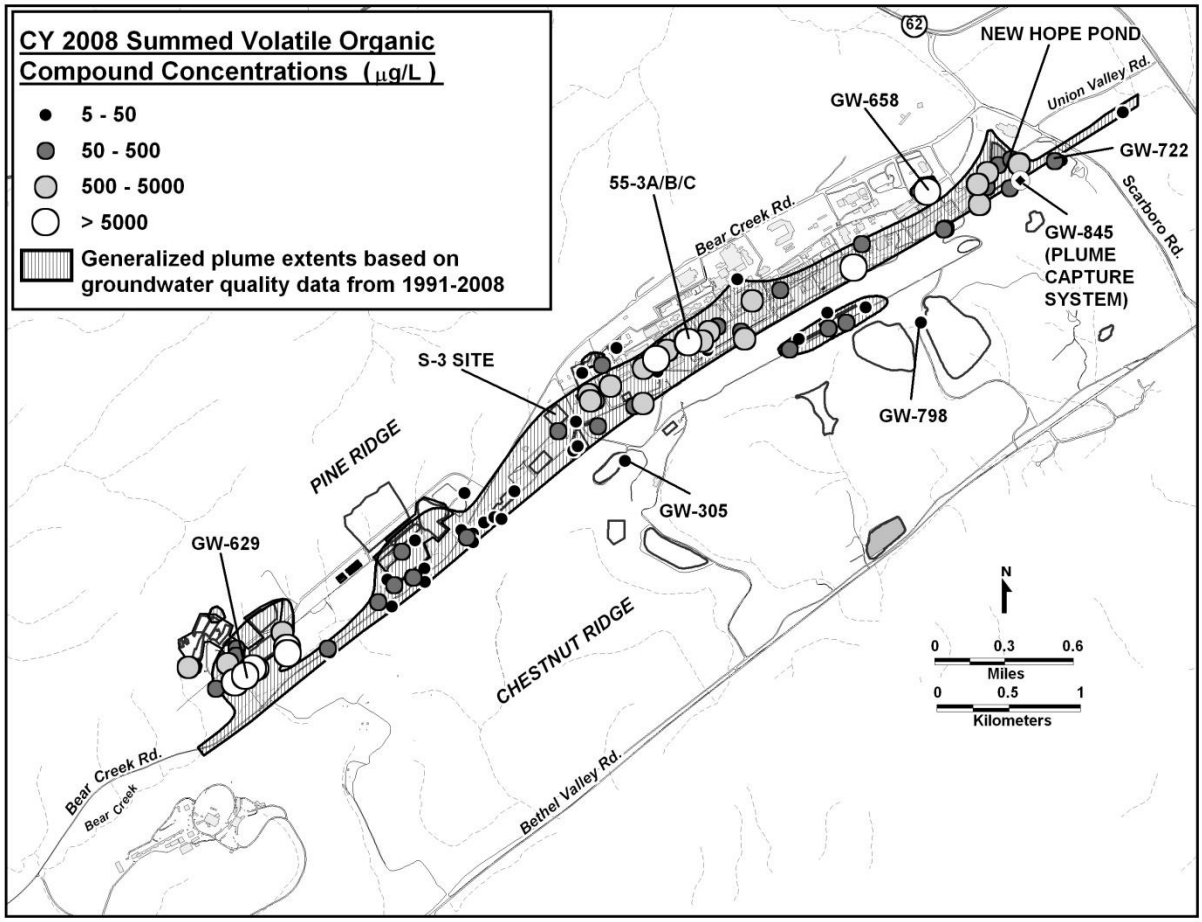


Fig. 4.39. Summed volatile organic compounds observed in groundwater at the Y-12 Complex, 2008.

4.6.4.1.5 Radionuclides

The primary alpha-emitting radionuclides found in the East Fork regime during CY 2008 are isotopes of uranium. Historical data show that gross alpha activity consistently exceeds the drinking water standard (15 pCi/L) 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 (431 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 (Fig. 4.40).

The primary beta-emitting radionuclides observed in the Upper East Fork regime during CY 2008 are technetium-99, isotopes of uranium, and associated daughter products. Elevated gross beta activity in groundwater in the Upper East Fork regime shows a pattern similar to that observed for gross alpha activity, where technetium-99 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. 4.41). The highest gross beta activity in groundwater was observed during CY 2008 from well GW-108 (21,300 pCi/L), east of the S-3 site.

4.6.4.1.6 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 exit pathway on the east

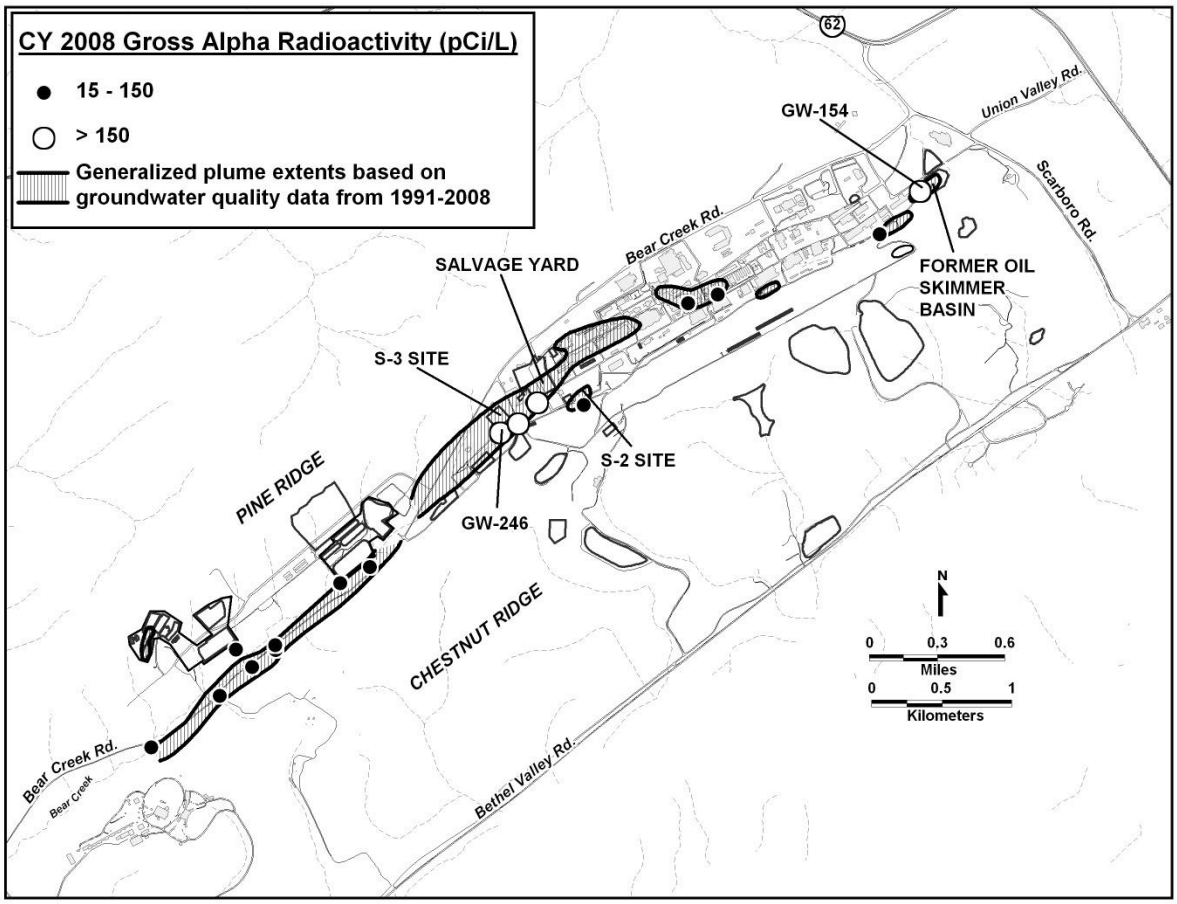


Fig. 4.40. Gross alpha radioactivity observed in groundwater at the Y-12 Complex, 2008.

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 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 2008, the observed concentrations of volatile organic compounds at the New Hope Pond distribution channel underdrain continue to remain low (Fig. 4.42). This may be because the continued operation of the groundwater plume-capture system in Well GW-845 southeast of 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 continue to show an 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

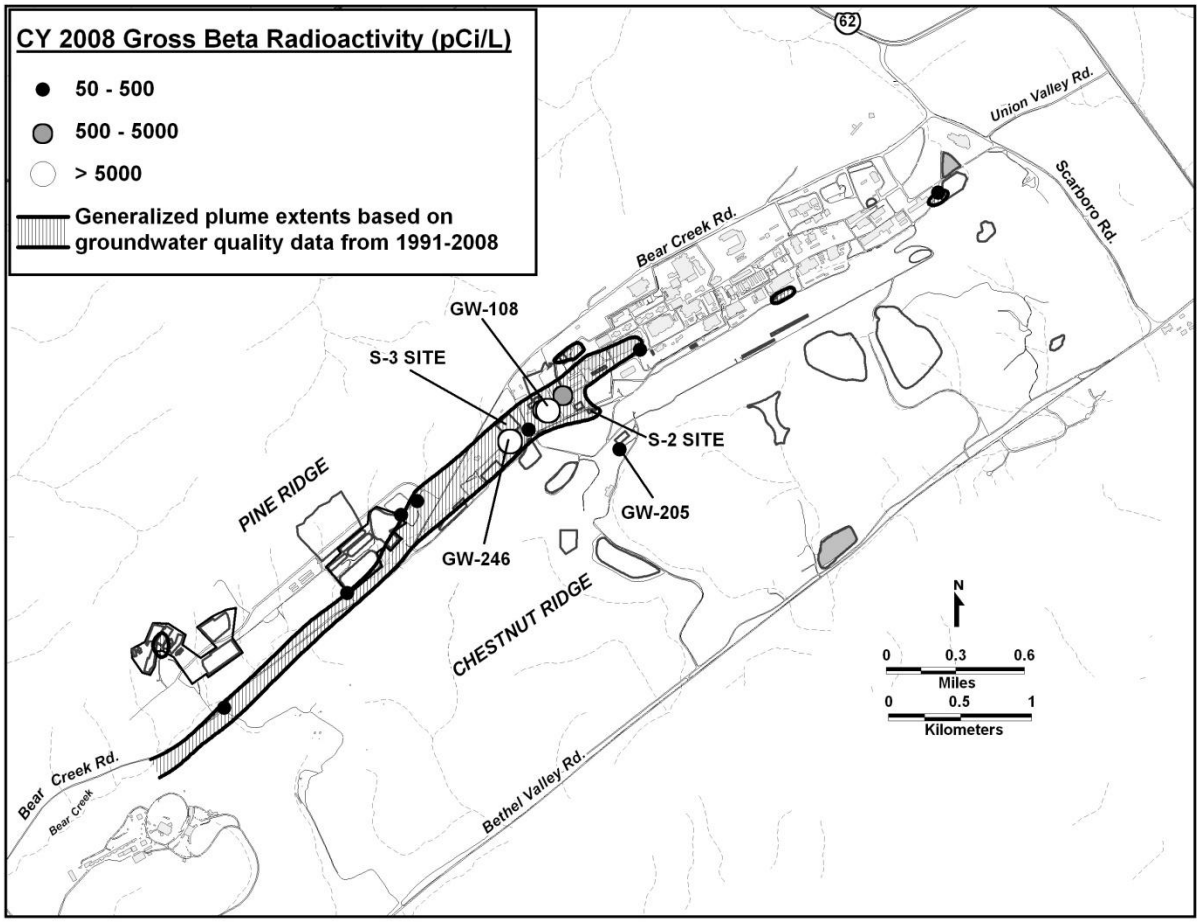


Fig. 4.41. Gross beta radioactivity observed in groundwater at the Y-12 Complex, 2008.

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 (Fig 4.42). 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.

Upper East Fork Poplar Creek flows north from the Y-12 Complex through a large gap in Pine Ridge. Shallow groundwater moves through the exit pathway, and very strong upward vertical flow gradients exist. Continued monitoring of the wells since about 1990 has shown no indication of any contaminants moving via that exit pathway (Fig. 4.37). Only one shallow well was monitored in CY 2008, and no groundwater contaminants were observed.

Three sampling locations continue to be monitored north and northwest of the Y-12 Complex to evaluate possible contaminant transport from the ORR. Those 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. One of the stations monitored a tributary that drains the north slope of Pine Ridge on the ORR and discharges into the adjacent Scarboro 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.

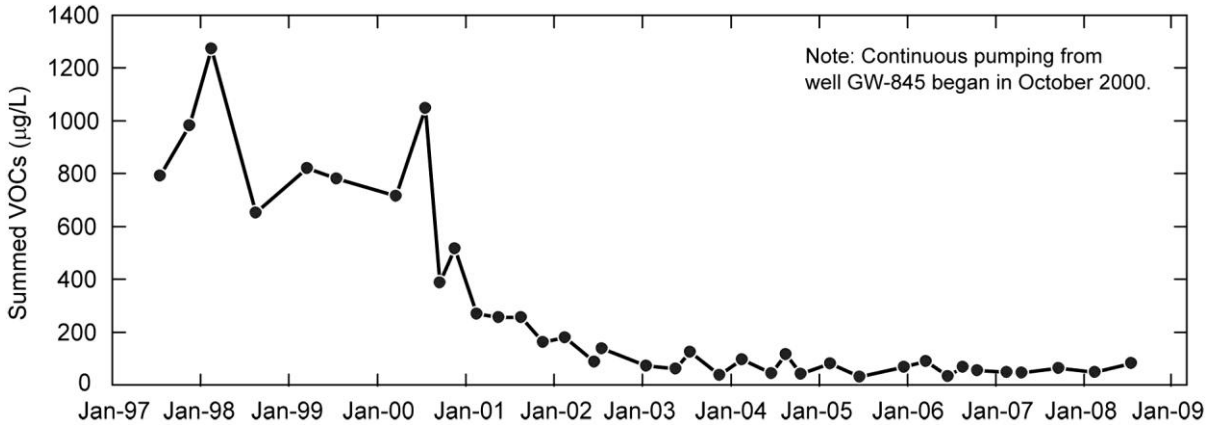


Fig. 4.42. Decreasing summed volatile organic compounds observed in exit pathway Well GW-722-17 near the New Hope Pond, 2008.

4.6.4.1.7 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 2008, monitoring of locations in Union Valley continued, showing an overall decreasing trend in the concentrations of contaminants forming the groundwater contaminant plume in Union Valley.

Under the terms of an interim ROD, administrative controls, such as restrictions on potential future groundwater use, have been established and maintained. 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 2009).

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. The Y-12 Complex east end volatile organic compound groundwater contaminant plume was acknowledged as the only confirmed off-site contaminant plume migrating across the ORR boundary. The report recognized that the institutional and administrative controls established in the ROD do not provide for reduction in toxicity, mobility, or volume of contaminants of concern, but they conclude that the controls are protective of public health to the extent that they limit or prevent community exposure to contaminated groundwater in Union Valley.

4.6.4.2 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 4.16 describes each of the waste management sites within the Bear Creek regime.

Table 4.16. History of waste management units included in CY 2008 groundwater monitoring activities, Bear Creek Hydrogeologic Regime

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 a mounts 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, nonradioactive 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

Abbreviations

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

4.6.4.2.1 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 contaminants. The Bear Creek Burial Grounds and the Oil Landfarm waste management areas are significant sources of uranium and other trace metals and volatile organic compounds. 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 fractured noncarbonate rock 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 (parallel to the valley axis) in both the Knox Aquifer and the fractured noncarbonate rock.

4.6.4.2.2 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 2008 indicate that nitrate concentrations in groundwater exceed the drinking water standard in an area that extends west from the source area at the S-3 Site. The highest nitrate concentration (11,100 mg/L) was observed at Well GW-615 adjacent to the S-3 Site at a depth of 223 ft below ground surface (Fig. 4.38), 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.

4.6.4.2.3 Trace Metals

During CY 2008, uranium, barium, cadmium, lead, beryllium, nickel, and arsenic 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. 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. 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.

The most prevalent trace metal contaminant observed within the Bear Creek regime is uranium, indicating that geochemical conditions are favorable for its migration. Early characterization indicated that the Boneyard/Burnyard site was the primary source of uranium contamination of surface water and groundwater. Historically, uranium has been 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, Bechtel Jacobs Company 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 yd^3 of waste materials were excavated and placed in the EMWMF (DOE 2009). 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 2008, a corresponding decrease in uranium concentrations is continuing to be observed downstream in Bear Creek (Table 4.17). Other trace metal contaminants that have been observed in the Bear Creek regime are boron, cobalt, copper, lithium, manganese, strontium, mercury, and zinc. Concentrations have commonly exceeded background values in groundwater near contaminant source areas.

Table 4.17. Nitrate and uranium concentrations in Bear Creek[a]

Bear Creek Monitoring Station (distance from S-3 site)	Contaminant	Average concentration (mg/L)				
		1990–1993	1994–1997	1998–2001	2002–2005	2006–2008
BCK[b] 11.84 to 11.97	Nitrate	119	80	80	79.5	37.0
(~0.5 miles downstream)	Uranium	0.196	0.134	0.139	0.133	0.123
BCK 09.20 to 09.47	Nitrate	16.4	9.6	10.6	11.3	9.9
(~2 miles downstream)	Uranium	0.091	0.094	0.171	0.092	0.069
BCK 04.55	Nitrate	4.6	3.6	2.6	2.9	1.0
(~5 miles downstream)	Uranium	0.034	0.031	0.036	0.026	0.022

[a]Excludes results that do not meet data quality objectives.
[b] BCK = Bear Creek kilometer

4.6.4.2.4 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 300 ft. Groundwater in the fractured noncarbonate rock that contains detectable levels of volatile organic compounds occurs primarily within about 1,000 ft of the source areas. The highest concentrations observed in CY 2008 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 28,631 µg/L in Well GW-629 (Fig. 4.39). This result is much higher than concentrations seen prior to 2006. This, coupled with increasing trends observed downgradient of the Bear Creek Burial Ground waste management area in the fractured noncarbonate rock (Fig. 4.43), indicates that some

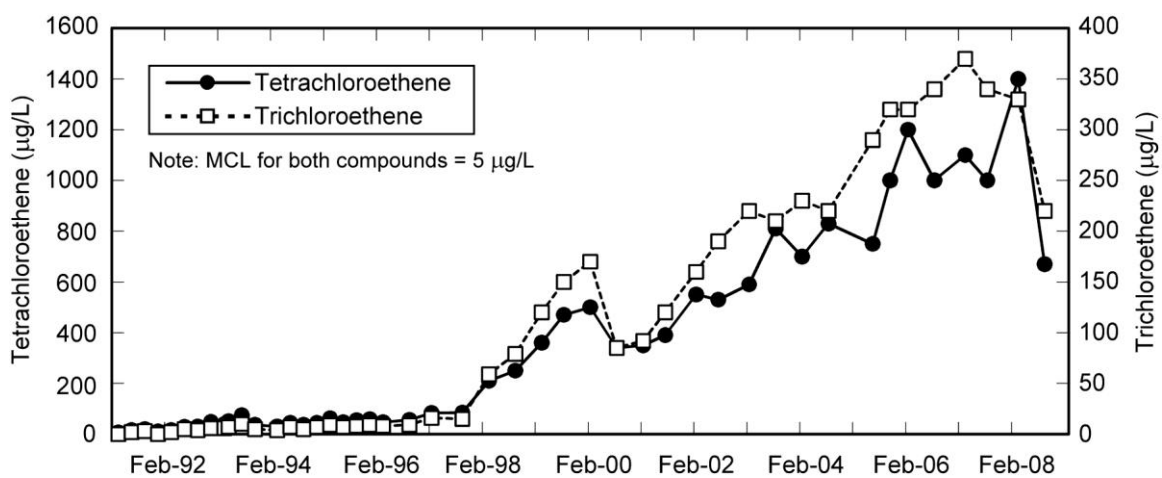


Fig. 4.43. Increasing volatile organic compounds observed in groundwater at Well GW-627 west and downgradient of the Bear Creek Burial Grounds, 2008. MCL = maximum contaminant limit.

migration of volatile organic compounds is occurring. This migration through the fractured noncarbonate rock 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 7,400 ft westward from the S-3 Site to just southeast of the Bear Creek Burial Ground waste management area.

4.6.4.2.5 Radionuclides

The primary radionuclides identified in the Bear Creek regime are isotopes of uranium and technetium-99. Neptunium, americium, 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 2008 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 fractured noncarbonate rock only near source areas (Fig. 4.40). 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 2008 was 420 pCi/L in Well GW-246 located adjacent to the S-3 Site.

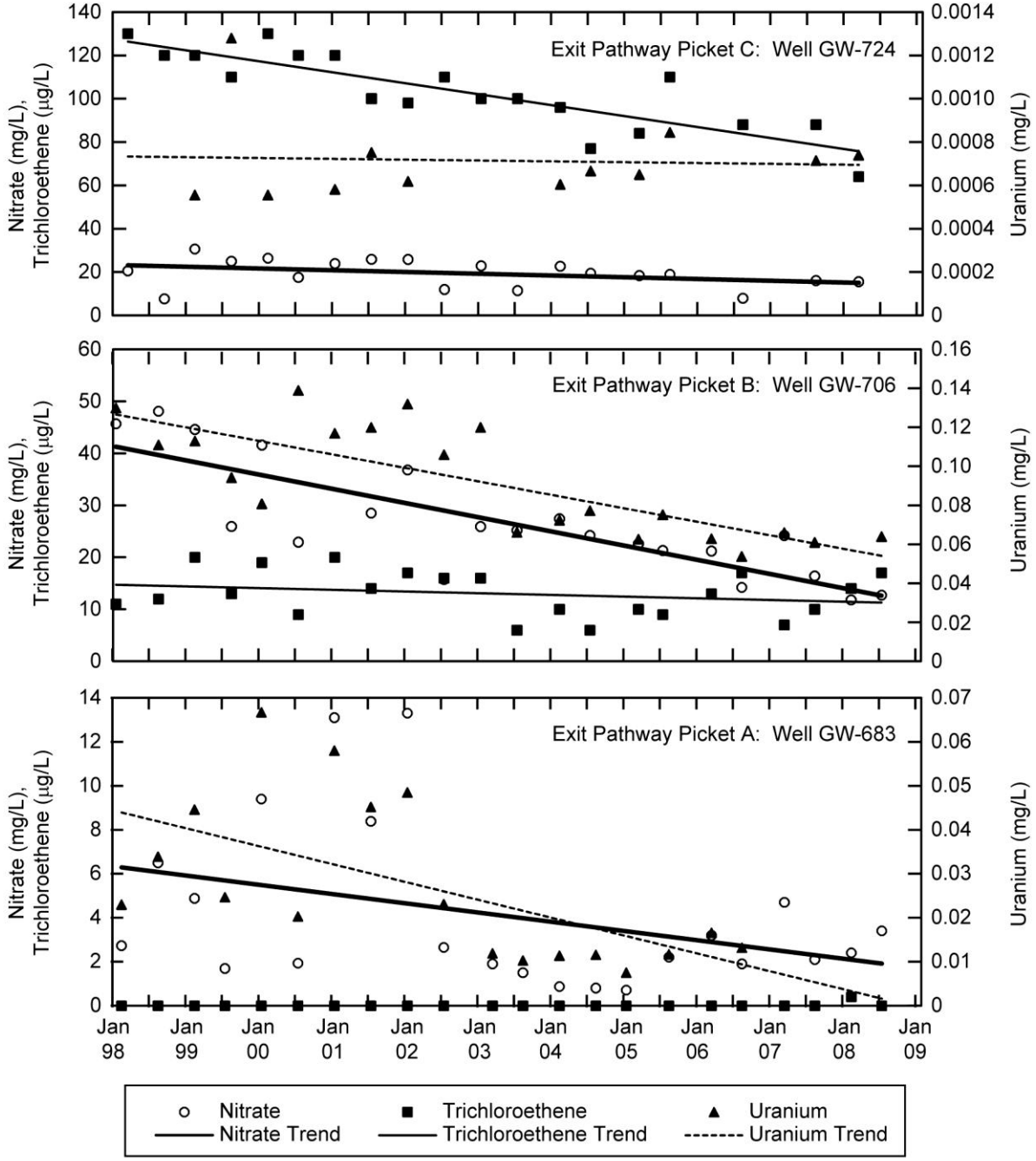
The distribution of gross beta radioactivity in groundwater is similar to that of gross alpha radioactivity. During CY 2008, it appears that the lateral extent of gross beta activity within the exit pathway groundwater interval and surface water above the drinking water standard has not changed from 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. 4.41). The highest gross beta activity in groundwater in the Bear Creek Regime in 2008 was 21,300 pCi/L at Well GW-108 located adjacent to the S-3 Site.

4.6.4.2.6 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 the surface water in Bear Creek, the springs along the valley floor, and the groundwater in the Maynardville Limestone are hydraulically connected. Surveys have been performed that identify gaining (groundwater discharging into surface waters) and losing (surface water discharging into a groundwater system) reaches of Bear Creek. The western exit pathway well transect (Picket W) serves as the perimeter well location for the Bear Creek regime (Fig. 4.37).

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 2008 from the exit pathway monitoring wells indicate that groundwater is contaminated above drinking water standards in the Maynardville Limestone as far west as Picket B and trends are generally decreasing (Fig. 4.44).

Surface water samples collected during CY 2008 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 A (B&W Y-12 2009). The concentrations in the creek decrease with distance downstream of the waste disposal sites (Table 4.17). 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.



Note: Only nitrate and uranium results above the detection limit are plotted; non-detected trichloroethene results are plotted at zero.

Fig. 4.44. Concentrations of selected contaminants in exit pathway monitoring wells GW-724, GW-706, and GW-683 in the Bear Creek Hydrogeologic Regime, 2008.

4.6.4.3 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. 4.34). 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 4.18 summarizes the operational history of waste management units in the regime.

4.6.4.3.1 Plume Delineation

Through extensive monitoring of the wells on Chestnut Ridge, the horizontal extent of the volatile organic compound plume at the Chestnut Ridge Security Pits seems to be reasonably well defined in the water table and shallow bedrock zones. With two possible exceptions, 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 2008 indicate that the western lateral extent of the plume of volatile organic compounds at the site has not changed significantly from previous years. However, a slight increase in the summed volatile organic compound concentrations may be due to an increase in degradation products due to chemical and biological attenuation of the contaminants. The continued observation of 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 apparent. Additionally, dye tracer test results and the intermittent detection of volatile organic compounds (similar to those found in wells adjacent to the Chestnut Ridge Security Pits) at a natural spring approximately 9,000 ft to the east and along geologic strike may indicate that Chestnut Ridge Security Pits groundwater contaminants have migrated much further than the monitoring well network indicates.

4.6.4.3.2 Nitrate

Nitrate concentrations were below the drinking water standard at all monitoring stations in the Chestnut Ridge Hydrogeologic Regime.

4.6.4.3.3 Trace Metals

Nickel concentrations above the drinking water standard (0.1 mg/L) were observed in the groundwater sample from one well (GW-305) at the Industrial Landfill IV (Fig. 4.33) with a maximum concentration of 0.11 mg/L. The presence of this trace metal in groundwater at the Y-12 Complex, with the exception of the S-3 Site, is not due to historical waste disposal, but is suspected to be 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).

4.6.4.3.4 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 shallow 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. 4.39). Elevated concentrations observed in GW-798 appear to fluctuate with changing precipitation conditions. The volatile organic compounds detected in CY 2008 in Well GW-798 continue to be characteristic of the Chestnut Ridge Security Pits plume.

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 2008, results from this well continue to show trace levels of volatile organic compounds; however, no exceedance of drinking water standards was observed.

Table 4.18. History of waste management units included in groundwater monitoring activities, Chestnut Ridge Hydrogeologic Regime, 2008

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. The postclosure 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

Abbreviations
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
RCRA = Resource Conservation and Recovery Act
TDEC = Tennessee Department of Environment and Conservation

4.6.4.3.5 Radionuclides

In CY 2008, no gross alpha activity above the drinking water standard of 15 pCi/L was observed in any groundwater samples collected in the Chestnut Ridge Hydrogeologic Regime. Gross beta activities exceeded the screening level of 50 pCi/L at monitoring well GW-205 (Fig. 4.41) at the United Nuclear Corporation site (the maximum detected activity was 68.2 pCi/L). This location has consistently exceeded

the screening level since August 1999. Isotopic analyses show a correlative increase in the beta-emitting radionuclide potassium-40, which is not a known contaminant of concern at the United Nuclear Corporation Site. The source of the radioisotope is not known.

4.6.4.3.6 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. A number of tracer studies have been conducted that show groundwater from Chestnut Ridge discharging into Scarboro Creek and other tributaries that feed into Melton Hill Lake. However, no springs or surface streams that represent discharge points for groundwater have been conclusively correlated to a waste management unit at Y-12 that is a known or potential groundwater contaminant source. Water quality from a spring along Scarboro Creek is monitored quarterly by the TDEC DOE Oversight Office, and trace concentrations of volatile organic compounds are intermittently detected. The detected volatile organic compounds are suspected to originate from the Chestnut Ridge Security Pits; however, this has not been confirmed.

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 2008. No contaminants were detected in any of these natural discharge points above drinking water standards. The volatile organic compound 1,1,2-trichloro-1,2,2-trifluoroethane, also known as Freon-113, was qualitatively detected at Spring SCR2.1SP at a very low concentration of 2 µg/L. This is the first detection at this perimeter monitoring station. This compound has been observed in groundwater samples from wells adjacent to the Chestnut Ridge Security Pits. However, due to the low mobility of Freon-113, it is unlikely that this compound would be the first to be detected. The detection is inconsistent with historical results for the spring and may be an outlier or analytical/sampling artifact. Future monitoring results will confirm or negate the presence of this contaminant in the groundwater from the spring.

4.6.5 Quality Assurance

All groundwater monitoring is performed under quality controls to ensure that representative samples and analytical results are obtained. Since there are a number of organizations responsible for performing groundwater sampling and analysis activities to meet separate requirements, there may be some minor differences in sampling and analysis procedures and methodology, but ultimately the final results are comparable for use by all projects and programs. This permits the integrated use of groundwater quality data obtained at the Y-12 Complex.

A number of quality assurance measures are performed to ensure accurate, consistent, and comparable groundwater results. These measures are described in sampling and analysis plans and include the following:

- Groundwater sampling is performed across the Y-12 Complex using a number of sampling methods and procedures. The predominant method of sampling is by using a low-flow minimum drawdown method. Under this method, a sample is obtained from a discrete depth interval without introducing stagnant water from the well casing. Groundwater is pumped from the well at a flow rate low enough to minimize drawdown of the water level in the well; field readings are also taken to ensure that the sample is representative of the groundwater system and not the well casing itself. All sampling methods follow industry-/regulatory-recognized protocols to ensure that consistent and repeatable samples are obtained.
- Quality controls such as field blank, trip blank, duplicate, and equipment rinsate samples were collected.
- All groundwater samples were controlled under chain of custody from their collection in the field through the analytical laboratory that performed the analyses.

- Laboratory analyses were performed using standard methodologies and protocols within established holding times.

4.7 Remedial Action and Waste Management

4.7.1 Upper East Fork Poplar Creek Remediation

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 initial project of the Phase 1 ROD, construction of the Big Springs Water Treatment System, was completed in 2006. The system has been fully operational since September 2006, removing mercury from local spring and sump waters that discharge to Upper East Fork Poplar Creek.

The focus of the second phase is remediation of the balance of contaminated soil, scrap, and buried materials within the Y-12 Complex. Decisions regarding final land use and final goals for surface water, groundwater, and soils will be addressed in future decision documents. The Phase 2 ROD was approved by all parties in April 2006. The initial project of the Phase 2 ROD is remediation of the Y-12 Old Salvage Yard.

Approximately 14,446 tons of scrap metal at the Y-12 Complex Old Salvage Yard require removal and disposal in an approved location. The scrap is generally contaminated with depleted uranium. Before 1995, the Old Salvage Yard received scrap into open piles. Since 1995, and prior to shutdown, procedures required that all scrap metal be placed inside containers.

In 2008, the Remedial Design Report/Remedial Action Work Plan and the Waste Handling Plan, which are Federal Facility Agreement milestone documents needed to plan the remediation, were submitted by DOE to TDEC and EPA for approval. Procurement planning was also initiated by DOE in 2008 to support establishment of a remediation contract. The remedial action contractor will be required to develop a comprehensive schedule for the overall effort, including all activities required to accomplish the scrap removal.

4.7.2 Waste Management

The CERCLA Waste Facility, located in Bear Creek Valley near the Y-12 Complex, is an ORR waste facility used for disposal of waste resulting from CERCLA cleanup actions on the ORR. It is an engineered landfill that accepts both low-level radioactive and hazardous wastes in accordance with specific waste acceptance criteria under agreement with state and federal regulators.

The CERCLA Waste Facility received approximately 6,500 truckloads of waste accounting for approximately 89,000 tons during FY 2008. Projects that have disposed of waste at the CERCLA Waste Facility during the fiscal year include the following:

- David Witherspoon, Inc., 1630 Site Remedial Action Project;
- K-25/K-27 Project, including hazardous materials abatement, excess materials removal, and K-1030 demolition debris;
- ETTP Decontamination and Decommissioning Project, including K-1401, K-1420, and K-413 demolition debris, Balance of Site Laboratory soils and debris, and K-1070-B Burial Ground waste;
- Upper East Fork Poplar Creek Project, including the Jack Case Center Force Main debris; and
- Melton Valley Project, including Molten Salt Reactor Experiment secondary waste.

Concurrent with the activities at the CERCLA Waste Facility, DOE also operates solid waste disposal facilities called the Oak Ridge Reservation Landfills (ORRL), which are located near the Y-12 Complex. The ORRL are engineered facilities permitted by the TDEC Division of Solid Waste for the disposal of sanitary, industrial, construction, and demolition waste that meet the waste acceptance criteria for each landfill. In FY 2008, more than 129,000 yd^3 of industrial, construction/demolition, classified, and spoil material waste were disposed of.

Operation of the ORRL generated more than 817,000 gal of leachate that was collected, monitored, and discharged to the Oak Ridge sewer system.

The CERCLA Waste Facility and the ORRL are serving the disposal needs of the ORR cleanup program as well as the active missions of the Y-12 Complex and ORNL.

4.7.3 Wastewater Treatment

Liquid waste management services are located in various locations throughout the Y-12 Complex. Examples include:

- the Big Spring Water Treatment System,
- the Central Mercury Treatment Facility,
- the Central Pollution Control Facility,
- the East End Volatile Organic Compound Plume Facility
- the Groundwater Treatment Facility,
- the West End Treatment Facility, and
- the West Tank Farm.

The NNSA program at the Y-12 Complex treated 122.5 million gal of ground/sump water at the Groundwater Treatment Facility, Central Mercury Treatment System, and East End Volatile Organic Compound System.

At the Big Spring Water Treatment System, 108.7 million gal of ground/sump water was processed. The West End Treatment Facility and the Central Pollution Control Facility at the Y-12 Complex processed 416,000 gal of wastewater, primarily in support of NNSA operational activities. This wastewater included hazardous materials such as cyanide, mercury, cadmium, chromium, and uranium. The hazardous materials end up in the sludge generated from wastewater treatment. The sludge is disposed off-site.

4.8 References

B&W Y-12. 2009. *Calendar Year 2008 Groundwater Monitoring Report.* Y/SUB/09-068789/1. U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee.

B&W Y-12. 2009a. *Annual Storm Water Report for the Y-12 National Security Complex*. Y/TS- 2035/R2, January 2009

BJC. 2009. *Calendar Year 2008, Resource Conservation and Recovery Act Annual Monitoring Report for the U. S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee*. BJC/OR-3195. Bechtel Jacobs Company LLC.

Bechtel Jacobs Company LLC. 2007. *Sampling and Analysis Plan for the Water Resources Restoration Program for Fiscal Year 2008 Oak Ridge Reservation, Oak Ridge, Tennessee*. (BJC/OR-2887).

Bechtel Jacobs Company LLC. 2008. *Sampling and Analysis Plan for the Water Resources Restoration Program for Fiscal Year 2009 Oak Ridge Reservation, Oak Ridge, Tennessee*. (BJC/OR-3121, Rev. 0).

DOE 2009. *2009 Remediation Effectiveness Report for the U. S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee Data and Evaluations*. (DOE/OR/01-2393&D1).

DOE. 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee.* U. S. Department of Energy, Office of Environmental Management, Oak Ridge, Tennessee, (DOE/OR/01-1641/V1-V4&D2).

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.

EPA. 1995 and 1998. *Compilation of Air Pollutant Emission Factors AP-42, Fifth Edition, Volume 1: Stationary Point and Area Sources*. U.S. Environmental Protection Agency, Research Triangle Park, N.C. January 1995 and September 1998.

ISO. 2004. "Environmental Management Systems—Requirements with Guidance for Use." International Organization for Standardization. http://www.iso.org.

LMES. 1999. *Technical Explanation for the Detected Increase in Nickel in Groundwater Monitoring Well GW-305 at the Industrial Landfill IV, IDL-47-103-0075, Department of Energy Y-12 Plant, Anderson County, TN*. (Y/TS-1774) Environment, Safety, and Health Organization, Y-12 National Security Complex, Oak Ridge, Tennessee.

TDEC. 2008. *Site Treatment Plan for Mixed Wastes on the U.S. Department of Energy Oak Ridge Reservation*. TDEC-REV. 13.0. October.

Y-12. 2005. *Y-12 National Security Complex Quality Assurance Project Plan for National Emission Standards for Hazardous Air Pollutants (NESHAPs) for Radionuclide Emission Measurements*.

Y-12. 2006. *Radiological Monitoring Plan for Y-12 Complex Surface Water.* Y/TS-1704R1. Oak Ridge Y-12 National Security Complex, Oak Ridge, Tennessee.

5. Oak Ridge National Laboratory

The Oak Ridge National Laboratory (ORNL), managed by UT-Battelle, LLC, is DOE's largest science and energy laboratory. ORNL has a staff of more than 4,200 and annually hosts approximately 3,000 guest researchers who spend two weeks or longer in Oak Ridge. Annual funding exceeds $1.2 billion. As an international leader in a range of scientific areas that support the Department of Energy's mission, ORNL has six major mission roles: neutron science, energy, high-performance computing, systems biology, materials science at the nanoscale level, and national security. ORNL's leadership role in the nation's energy future includes hosting the U.S. project office for the ITER international fusion experiment and the Office of Science–sponsored Bioenergy Science Center.

5.1 Description of Site and Operations

5.1.1 Mission

ORNL lies in the southwest corner of DOE's Oak Ridge Reservation (ORR) (Fig. 5.1). The main ORNL site occupies approximately 1,809 ha and includes facilities in two valleys (Bethel and Melton) and on a Chestnut Ridge. ORNL was established in 1943 as a part of the secret Manhattan Project to pioneer a method for producing and separating plutonium. During the 1950s and 1960s, and with the creation of DOE in the 1970s, ORNL became an international center for the study of nuclear energy and related research in the physical and life sciences. By the turn of the century, the Laboratory supported the nation with a peacetime science and technology mission that was just as important as, but very different from, the work carried out in the days of the Manhattan Project. ORNL is an international leader in a range of scientific areas that support DOE's mission. UT-Battelle's six major mission roles at ORNL include neutron science, energy, high-performance computing, bioenergy, materials sciences at the nanoscale level, and national security. ORNL is the home of the world's largest facility for materials research with the recently completed Spallation Neutron Source (SNS) and the upgraded High Flux Isotope Reactor (HFIR) as well as 16 other designated national user facilities. These facilities are available to national and international laboratory, industrial, and academic users.

UT-Battelle also manages several DOE Office of Science facilities and one DOE Office of Nuclear Energy facility located off of the main ORNL campus. Seven buildings and one trailer are located at the Y-12 Complex, and three buildings and one trailer, which house the American Museum of Science and Energy, are located in the city of Oak Ridge. In addition, UT-Battelle leases six buildings, five near Oak Ridge and one in Washington, D.C.

The National Transportation Research Center (NTRC), an alliance among ORNL; the University of Tennessee; 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-ft^2 building, located on a 2.4 ha site in the Pellissippi Corporate Center and is leased to UT-Battelle and the University of Tennessee separately by Pellissippi Investors LLC.

The Transuranic (TRU) Waste Processing Center (TWPC), managed by EnergX for DOE, is located on the western boundary of ORNL on about 2 ha of land adjacent to the Melton Valley Storage Tanks along State Route 95. The TWPC's mission is to receive TRU wastes for processing, treatment, repackaging, and shipment to designated facilities for final disposal. The TWPC consists of the Waste Processing Facility, the Personnel Building, and numerous support buildings and storage areas. The TWPC began processing supernatant liquid from the Melton Valley Storage Tanks in 2002, the contact-handled solids in December 2005, and the remote-handled solids in May 2008.

In March 2007, Isotek Systems LLC (Isotek) assumed responsibility for surveillance and maintenance activities at the Building 3019 Complex at ORNL. DOE awarded the contract to Isotek to accomplish the following principal objectives:

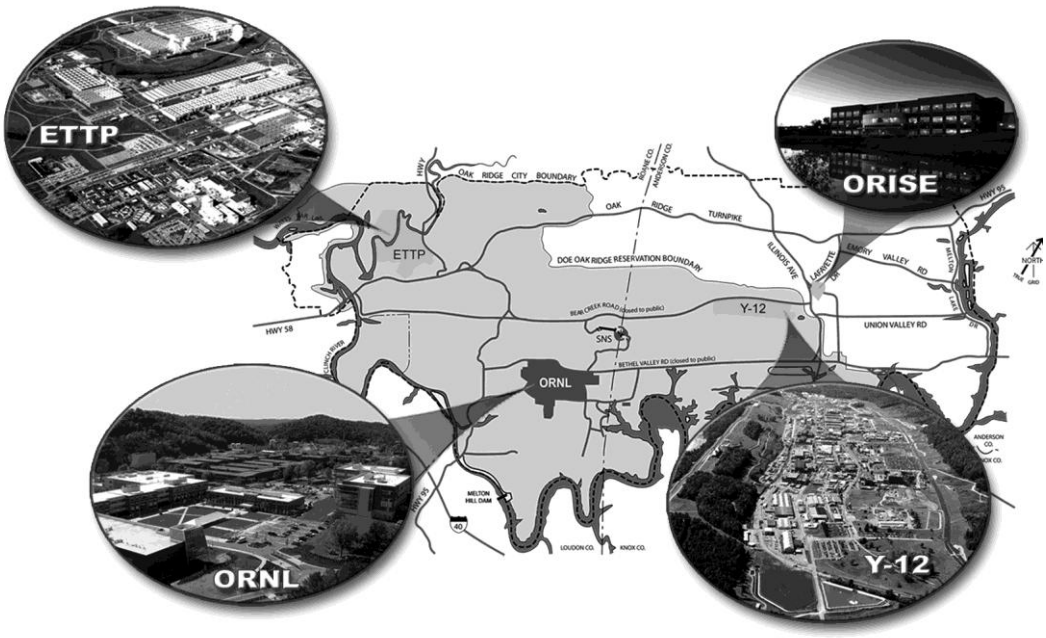


Fig 5.1. Location of ORNL within the ORR and its relationship to other local DOE facilities.

- process, down-blend, and package the DOE inventory of ^{233}U stored in the Building 3019 Complex to eliminate the need for safeguards, security, and nuclear criticality controls and to render the material suitable for disposition;
- remove the ^{233}U material from the Building 3019 Complex; and
- place the Building 3019 Complex in safe and stable shutdown mode for future decommissioning.

During CY 2008, Isotek has been active in planning for the design and construction of the operations needed to accomplish these objectives.

UT-Battelle continues to perform air and water quality monitoring for the 3019 facility, and the discussions in this chapter include the results for Isotek operations at ORNL.

Approximately 5 ha in the central portion of the ORNL has been leased to Halcyon, LLC, a subsidiary of the Community Reuse Organization of East Tennessee (CROET) for development into the Oak Ridge Science and Technology Park (ORSTP). The ORSTP will provide space for companies doing research at ORNL, partner universities, start-up companies built around ORNL technologies, and ORNL contractors to conduct business within a short distance of ORNL researchers and DOE user facilities such as the SNS, the Center for Nanophase Materials Sciences and the HFIR. Phase 1 of the Park's infrastructure was completed in 2008. Construction activities for the first ORSTP facility, Pro2Serve's 115,000 ft^2 National Security Engineering Center, are anticipated to be completed by the end of 2009. In addition, what was formally referred to as Building 2033 has been leased to Halcyon, LLC, and upgrades to the building were made in 2008. This multiple-tenant facility will be known as the Halcyon Commercialization Center.

5.1.2 Facilities Revitalization Program

In 1943, more than 6,000 workers began construction of some 150 buildings that became known as ORNL. Sixty-five years later, a massive effort to revitalize the site is literally rebuilding the Laboratory. Since 2000, more than 1,900,000 ft^2 of aged, expensive-to-maintain buildings have been vacated and some 1,000,000 ft^2 of new and renovated space has been constructed. The average age of ORNL facilities has decreased from 42 to 31 years. A combination of federal, state, and private financing has supported the construction of the new facilities (see Table 5.1).

Table 5.1. ORNL facilities constructed since 2000

Building number	Building name	Funding source
1060	Environmental and Life Sciences Laboratory	DOE
7972	Small-Angle Neutron Scattering Guide Hall Extension	DOE
1005	Laboratory for Comparative and Functional Genomics	DOE
7625	Multiprogram High Bay Facility	DOE
3625	Advanced Materials Characterization Laboratory	DOE
5200	Research Support Center	DOE
8610	Center for Nanophase Materials Sciences	DOE
NTRC	National Transportation Research Center	Private
5600	Computational Science Building	Private
5800	Engineering Technology Facility	Private
5700	Research Office Building	Private
5300	Multiprogram Research Facility	Private
5100	Joint Institute for Computational Sciences & Oak Ridge Center for Advanced Technologies	State
1520	Joint Institute for Biological Sciences	State
7880	TRU Waste Process Building	DOE
7880A	Contact-Handled Staging Area Building	DOE
7880B	Personnel Support Building	DOE
7880HH	Macroencapsulation Building	DOE
7880BB	Contact-Handled Marshalling Building	DOE
7880AA	Drum Venting Building	DOE

For the most part, the revitalization of ORNL's Chestnut Ridge and East Campuses is complete; the West and Melton Valley Campuses will be completed within the next 5 years. Over the next 10 years, UT-Battelle will continue to leverage federal, state, and private financing to deliver the site, facilities, and infrastructure for science and technical research at the Laboratory for the twenty-first century. Table 5.2 summarizes the levels and sources of funding for campus modernization to date.

Table 5.2. Levels and sources of funding for ORNL campus modernization, 2008

Source	Funding ($M)
DOE	525
Private sector	140
State of Tennessee	12
Total	677

5.1.2.1 2008 Modernization Activities at ORNL

During FY 2008, ORNL modernization efforts provided new facilities, enhanced staff interaction and space utilization, upgraded utility systems, and demolished old, expensive-to-maintain facilities. In FY 2008, ORNL expended approximately $8.8M to decrease the backlog of deferred maintenance in mission-critical facilities, to vacate substandard facilities, and to improve quality of remaining facilities.

East Campus

Design of the Modernization of Laboratory Facilities (MLF) project commenced in 2008. The new MLF will be located on ORNL's East campus, and will consist of a three-story building housing 160,000 ft^2 of research laboratory and support space thereby, enabling relocation of key research capabilities from aged facilities. MLF occupancy is scheduled for summer 2011.

Other 2008 projects in the East Campus addressed safety vulnerabilities and upgraded electrical and chilled-water capacity. Design and installation of early-warning smoke detectors in the corridors of Buildings 4500N and 4500S were initiated. In additional projects, the main power distribution point for Buildings 4500S, 4508, 4509, and 4515 was replaced. This replacement will prevent power loss to these buildings and will prevent loss of chilled water service to these and other facilities. Additionally, the 4000 Substation was reconfigured to increase power capacity to supply the power needed to support expanded growth in the East Campus Area. The 5000 Area 13.8 kV distribution system was upgraded to increase its capacity and reliability. Design of an underground chilled-water recirculating pipeline system to connect the 6000 Area with the chilled-water supply from Building 5800 (the Engineering Technology Facility) was also initiated in 2008. This project will also provide an underground recirculating chilled-water pipeline system, eventually enabling the transite chilled water pipeline between the 4509 Chilled Water Plant and the 6000 Area to be abandoned in place.

In keeping with its commitment to developing a sustainable campus, ORNL designed a 100 kW Elliott microturbine to provide electrical power to a general office building and to reclaim waste heat into building reheat loops. As part of this project, a large solar array panel north of the 3000 Area and Bethel Valley Road was assembled. The array provides 50 kW of electrical power previously derived from the main power grid. Use of reclaimed waste heat contributes to renewable energy goals set by DOE. The solar array and the micro-turbine conversion are two elements of a plan to transform Building 3137 into DOE's first zero-energy facility.

Central Campus

During 2008 design plans for an adjoining expansion to the Advanced Microscopy Laboratory (Building 3625) were initiated. The expansion to the Advanced Microscopy Laboratory will be constructed on the southwest side of the existing building to house a number of vibration sensitive instruments used for materials characterization.

West Campus

Renovations to existing West Campus facilities continued in 2008. First-floor laboratories and systems in Building 1505 were renovated to provide additional space for the Biological and Environmental Sciences Division staff. Construction of a quadrangle area in the West Campus was initiated in 2008. The quadrangle is an integral part of West Campus revitalization and is designed to integrate West Campus facilities and to facilitate an environment for growth and competitiveness in core research areas. Construction of the West End Research Support Facility, a 9,000 ft^2 preengineered metal building and supporting infrastructure was initiated in 2008. The facility will consolidate areas for research and operations storage as well as field sample collection and preparation. In late 2008, approval was received to proceed with design and construction of additional greenhouses on the West Campus in order to expand related research capabilities in the areas of bioenergy, ecosystems, bioremediation, and environmental genomics. Modernization of the West Campus will continue into 2009.

Chestnut Ridge Campus

Chestnut Ridge infrastructure investment continued in 2008, including design of three parking areas that provide a total of approximately 240 finished parking spaces; landscaping for approximately 16,000 ft^2 of area behind the site of the future Joint Institute for Neutron Sciences building; and design and construction of a cafeteria on the first floor of the Central Laboratory and Office building.

Melton Valley Campus

A warehouse in Melton Valley was designed and constructed during FY 2008. The warehouse will provide space to consolidate storage of equipment and materials previously stored across the ORNL site. Trailer 7964A, which housed staff, drawings, and records in Melton Valley, was replaced with a triple-wide trailer.

5.1.2.2 Integrated Facilities Disposition Initiative

Plans to disposition 1,500,000 ft^2 of aged, expensive-to-maintain facilities located at ORNL are proposed as part of the DOE Oak Ridge Office (DOE-ORO) Integrated Facility Disposition Project (IFDP). The IFDP is a multibillion-dollar collaborative proposal developed by DOE Offices of Environmental Management (EM), Science, and Nuclear Energy and the National Nuclear Security Administration (NNSA) that will complete the environmental cleanup of the ORR and that will enable ongoing modernization efforts at ORNL and the Y-12 National Security Complex. The IFDP will reduce risk to workers and the public, minimize ORNL and Y-12 mission risks resulting from the presence of deteriorating facilities and excess "legacy" materials, and provide valuable real estate for continued modernization. DOE approved the Alternative Selection and Cost Range Critical Decision-1 for the project in November 2008, and work on the 26-year project will continue in 2009 with development of the Critical Decision-2/3 package.

5.2 Environmental Management Systems

An important priority for DOE contractors performing management and operations activities at ORNL is the demonstration of environmental excellence through high-level policies that clearly state expectations for continual improvement, pollution prevention, and compliance with regulations and other requirements. UT-Battelle's policy for ORNL is stated in Fig. 5.2.

Both UT-Battelle and EnergX have implemented Environmental Management Systems (EMSs), modeled after the International Organization for Standardization (ISO) standard 14001:2004 (ISO 2004), an international environmental management standard, as a tool to measure, manage, and control environmental impacts. An EMS is a continuing cycle of planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental goals. UT-Battelle's EMS was initially registered to the ISO 14001 Standard by a third-party registrar in 2004, and was reregistered in June 2007 by NSF International Strategic Registrations, Ltd. Detailed information on the UT-Battelle EMS is provided in Sects. 5.2.1 through 5.2.4.2. EnergX's EMS for activities at the TTWPC was registered to the ISO 14001:2004 Standard by NSF International Strategic Registrations, Ltd., in May 2008. No nonconformances or issues were identified during this assessment and several significant practices were noted. Section 5.2.5 describes the EnergX EMS and associated implementation activities.

5.2.1. UT-Battelle EMS

The UT-Battelle EMS is a fully integrated set of environmental management services for UT-Battelle activities and facilities. Services include pollution prevention, waste management, effluent management, regulatory review, reporting, permitting, and other environmental management programs. Through the UT-Battelle Standards-Based Management System (SBMS), the EMS establishes the environmental policy and translates environmental laws, applicable DOE orders, and other requirements into Laboratory-wide subject area documents (procedures and guidelines). SBMS information is based on an evaluation of

external requirements (i.e., directives and federal, state, and local laws), corporate policies, and best management practices that have been determined applicable to UT-Battelle operations and processes. Through environmental protection officers/environmental compliance representatives, and waste service representatives, the EMS assists the line organizations in identifying and addressing environmental issues in accordance with the SBMS requirements.

Fig. 5.2. UT-Battelle policy for ORNL.

5.2.1.1 Integration with ISMS

The UT-Battelle EMS and Integrated Safety Management System (ISMS) 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 conservation. Therefore, the guiding principles and core functions in ISMS apply both to the protection of the environment and to safety. Figure 5.3 depicts the relationship between EMS and ISMS.

Fig. 5.3. The relationship between the UT-Battelle EMS and the ISMS.

The UT-Battelle EMS is consistent with ISMS and includes the following elements:

- environmental policy;
- planning;
- legal and other requirements;
- objectives, targets, and programs;
- implementation and operation;
- resources, roles, responsibility, and authority;
- competence, training, and awareness;
- communication;
- documentation;
- control of documents;
- operational control;
- emergency preparedness and response;
- checking;
- monitoring and measurement;
- evaluation of compliance;
- nonconformity, corrective action, and preventative action;
- control of records;
- internal audit; and
- management review.

5.2.1.2 UT-Battelle Policy

The UT-Battelle Policy for ORNL (Fig. 5.2) is the highest level statement of how UT-Battelle conducts business. By clearly stating expectations, the policy provides the framework for setting and reviewing environmental objectives and targets.

5.2.1.3 Planning

5.2.1.3.1 UT-Battelle Environmental Aspects

Environmental aspects are elements of an organization's activities, products, or services that can interact with the environment. UT-Battelle identifies environmental aspects associated with its activities, products, and services at both the project and activity level. Activities that are relative to any of these aspects are carefully controlled to minimize or eliminate impacts to the environment. The following aspects have been identified as potentially having significant environmental impacts:

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

5.2.1.3.2 UT-Battelle Legal and Other Requirements

Legal and other requirements that apply to the environmental aspects identified by UT-Battelle include federal, state, and local regulations, environmental permits, applicable DOE orders, UT-Battelle contract clauses, waste acceptance criteria, and voluntary requirements such as ISO 14001:2004. UT-Battelle has established procedures to ensure that all applicable requirements are reviewed and that changes and updates are communicated to staff and incorporated into work-planning activities.

5.2.1.3.3 UT-Battelle Objectives and Targets

UT-Battelle has established and implemented objectives, targets, and performance indicators for relative ORNL functions and activities. Where practical, the objectives, targets and performance indicators are measurable and in all cases, are consistent with the UT-Battelle Policy, and are supportive of the Laboratory Agenda.

5.2.1.3.4 UT-Battelle Programs

UT-Battelle has established an organizational structure to ensure that environmental stewardship practices are integrated into all facets of UT-Battelle's missions at ORNL. This system includes programs led by experts in environmental protection and compliance, energy and resource conservation, pollution prevention, and waste management to ensure that Laboratory activities are conducted in accordance with the environmental policy statements outlined in Fig. 5.2.

5.2.1.3.4.1 UT-Battelle Environmental Compliance Programs

UT-Battelle has established an organizational structure to help achieve full compliance with all applicable environmental regulatory requirements and permits. Environmental compliance experts provide critical support services to maintain a proper balance between cost and risk in the following areas:

- solid and hazardous waste compliance,
- National Environmental Policy Act (NEPA) compliance,
- air quality compliance,
- Water quality compliance,
- U.S. Department of Agriculture (USDA) compliance,
- environmental protection programs,
- environmental sampling and data evaluation, and
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) interface compliance.

The 2008 compliance status and information on UT-Battelle activities and accomplishments are presented in Sect. 5.3.

5.2.1.3.4.2 UT-Battelle Waste Management and Spill Response

The UT-Battelle staff includes experts who provide critical waste management and disposition support services to ORNL research, operations, and support divisions. These experts include

- waste services representatives who work with waste generators to identify, characterize, package, and certify wastes for disposal;
- the waste-handling team, which performs waste-packing operations and conducts inspections of waste items, areas, and containers;
- the waste and materials disposition team, which coordinates off-site disposition of ORNL's newly generated waste; and
- the hazardous material spill response team, which is ORNL's first line of response to hazardous materials spills and controls and contains such spills until the situation is stabilized.

5.2.1.3.4.3 Pollution Prevention Program

UT Battelle's Pollution Prevention (P2) Program has evolved from project-specific waste reduction efforts to a laboratory-wide philosophy of implementing sustainable practices that reduce ORNL's environmental impacts and provide monetary benefit to UT-Battelle, DOE, and the nation. The UT-Battelle EMS establishes annual goals and targets to reduce the impact of each organization's environmental aspects.

Over the past several years, UT-Battelle's P2 Program has been recognized by the U.S. Environmental Protection Agency (EPA) and DOE with the receipt of DOE Office of Science Pollution Prevention-Best in Class Awards in 2004, 2005, 2006, and 2008, two DOE P2 Star Awards in 2008, White House "Closing the Circle" Awards in 2004 and 2008, and an EPA WasteWise Gold Achievement Award in 2007.

During 2008, ORNL implemented 30 P2 initiatives with a reduction of more than 58 million kg of waste, resulting in a cost savings/avoidance of more than $3.5 million. The following sections describe some of UT-Battelle's 2008 sustainability, source reduction, and recycling projects.

ORNL's Green Transportation and Fleet Management Initiatives

UT-Battelle's Green Transportation Initiative has been recognized with a 2008 White House Closing the Circle Award in the Alternative Fuels and Fuel Conservation category and a DOE Pollution Prevention Star Award. Key features of the initiative include continuing expansion of the Laboratory's flex-fuel vehicle and biodiesel-fueled fleet, encouraging shared transportation, integrating maximized fuel efficiency features when upgrading roads, and encouraging personnel to walk and ride bicycles through innovative campus design. In 2008 the vehicle fleet included 150 flex fuel vehicles, which used 39,366 gal of E85, and 68 diesel vehicles and numerous pieces of equipment, which consumed 9,679 gal of biodiesel.

ORNL's Comprehensive Sustainability Initiative

In 2008, UT-Battelle received a DOE Pollution Prevention Star Award for the Comprehensive Sustainability Initiative, under which sustainable practices have been incorporated into planning, financing, and construction of new facilities and sustainable landscaping has been incorporated into the Laboratory's modernization campaign. ORNL's entire six-building East Campus, consisting of approximately 750,000 ft^2, is Leadership in Energy and Environmental Design (LEED®) certified by the U.S. Green Building Commission. Additionally during FY 2008, a new solar panel, one of the largest and most efficient in the state of Tennessee, was installed at ORNL at the intersection of Fifth Street and Bethel Valley Road (Fig. 5.4) as discussed in Sect. 5.1.2. The 288 × 10 ft solar panel generates 51.25 kW at peak power, and in combination with waste-heat recovery and other energy-efficiency techniques will enable the already Energy Star-rated Building 3147 to become a zero-energy building. Power from the solar panel will also be used to do research into power inverter technology and electric power distribution.

Fig. 5.4. The solar array installed in 2008 at ORNL generates 51.25 kW at peak power.

Environmentally Preferable Purchasing

Environmentally preferable purchasing, previously referred to as affirmative procurement, is a term used to describe an organization's policy to reduce packaging, and to purchase environmentally friendly products, such as products made with recycled material and bio-based materials. In 2008, purchases of recycled-content materials totaling more than $1.2 million were made for use at ORNL, demonstrating UT-Battelle's commitment to procure environmentally preferable materials.

ORNL's Transformers Transform to Biobased Oil

In 2008, the UT-Battelle Fusion Energy Division completed an initiative to replace petroleum-based oil in three transformers with a more environmentally friendly biobased oil (FR 3 Fluid). This project was also driven by the need to find a replacement oil with a higher flash point due to fire protection considerations. This initiative (1) improved fire protection safety, (2) replaced 1,200 gal of petroleum-based oil with an environmentally friendly biobased oil, (3) reduced used-oil generation, and (4) eliminated the need and associated cost to upgrade fire sprinkler systems.

Replacement of CRT Monitors with LCD Monitors

In 2008, UT-Battelle's Chemical Sciences Division, in conjunction with the Facilities Management Division, completed the Environmental Footprint Reduction Project, in which 176 cathode ray tube (CRT) monitors were replaced with more energy efficient liquid crystal display (LCD) monitors. The project resulted in both immediate and long-term energy reductions. It is estimated that LCDs require only 30% of the energy used by CRTs, in either the active or standby mode. By replacing the monitors, energy savings of 28,600 kWh and a cost avoidance of more than $1,500 were realized in 2008.

Materials Science and Technology Division Embraces Pollution Prevention

In FY 2008, the Materials Science and Technology Division identified and implemented two initiatives to reduce the types and amounts of waste generated as a result of division activities. The initiatives included (1) the replacement of lead in the storage of research samples and (2) the reduction of low-level radioactive waste (LLW) from used personal protective equipment (PPE). As a result, steel was substituted for lead, reducing the use of a hazardous material (lead) and decreasing the volume of mixed low-level radioactive waste and LLW at ORNL. UT-Battelle is investigating the possible expansion of these techniques to other ORNL operations. The two initiatives, which reduced lead use by 100 kg per year, mixed low-level radioactive waste by 100 kg per year, LLW by 10 yd^3 per year, resulted in an estimated nnual cost avoidance of $27,500.

UT-Battelle Reduces Water Use at ORNL through Pollution Prevention

UT-Battelle has implemented many-water-saving initiatives across ORNL, including the use of low-flow fixtures and faucets and the reuse of rainwater for irrigation of the newly modernized ORNL East Campus. UT-Battelle also incorporates water-saving strategies into research and support areas, including (1) closed-loop chiller systems (Figs. 5.5 and 5.6) in the Chemical Sciences Division, which were installed in FY 2008 and in previous years; (2) a cooling water elimination initiative implemented by the Nonreactor Nuclear Facilities Division; and (3) the ORNL steam plant water reduction initiative.

Fig 5.5. New closed-loop chilled water systems.

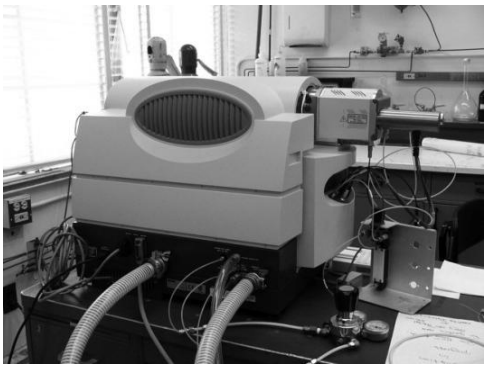


Fig. 5.6. Example of laboratory equipment using chilled water.

The initiatives not only reduced water usage and associated waste water generation by about 15 million gal per year but also improved operational efficiency, reduced the release of legacy mercury to the environment (White Oak Creek), reduced total regulated air emissions by 4,800 lb per year, saved 18,678 decatherms of natural gas and 3,446 gal of fuel oil, resulted in an estimated annual cost avoidance of $238,000, and increased the environmental awareness of lab personnel and the community. Further, to enhance water use and water quality awareness, UT-Battelle performs on-site lab-wide awareness activities, such as Earth Day events (Fig. 5.7), and conducts community outreach activities with water-awareness educational activities (e.g., assistance in the Appalachian Regional Commission—ORNL Summer Institute.

Fig. 5.7. ORNL Earth Day activities.

UT-Battelle Expands Oil Recycling

UT-Battelle has a well-established used-oil recycling program. During FY 2008 two additional used-oil streams were identified and were incorporated into the program: (1) used oil tainted with PCBs in the range of 2 to 50 ppm and (2) used Fomblin oil used in high vacuum equipment. Both streams were successfully reclaimed and recycled during FY 2008, resulting in a cost avoidance of more than $88,000. With the addition of the two newly identified streams, UT-Battelle recycled more than 6,100 gal of used oil during FY 2008.

UT-Battelle Radioactive Lead Recycling

UT-Battelle maintains an inventory of lead at ORNL for use in numerous laboratory activities. The lead is recycled so that the purchase and unnecessary disposal of lead as waste are minimized. During FY 2008, UT-Battelle successfully recycled a significant quantity of radioactively contaminated lead by making it available for use as a shielding material to an off-site DOE contractor. UT-Battelle established a multiorganizational team to ensure that all aspects of the transfer were completed safely, efficiently, and effectively. This project recycled 29,942 lb of radioactively contaminated lead.

UT-Battelle Solvent Purification and Recycling Initiative

The 2008 Center for Nanophase Materials Sciences (CNMS) Environmental Management System objectives and targets included a study to identify ways to reduce and eliminate solvent waste at the CNMS. Two alternatives were pursued: solvent recycle and solvent purification. CNMS identified the use of solvent-recycling systems as a means to minimize solvent use and waste generation on chromatography instruments in the polymer group and eliminated the need for five distillation systems by installing a solvent purification system. The solvent purification system relies on the purchase of higher-purity solvents that are passed through reusable/regeneratable columns, thereby removing the need for treatment with separate drying and purification chemicals that are usually one-time use. In addition, by not using distillation systems, CNMS eliminated the need for hazardous drying materials such as sodium-potassium alloy (NaK) or sodium metals, which require special handling and disposal. Consequently, this initiative (1) reduced the use of approximately 50 L of new solvent per year, (2) reduced the generation of approximately 50 L of hazardous waste solvent per year, and (3) resulted in an estimated annual cost avoidance of about $8,000.

Oak Ridge High School's Sustainable Green Transformation

Demonstrating its commitment to community outreach and sustainability, UT-Battelle, in cooperation with DOE, other DOE contractors, Oak Ridge corporate members, and Oak Ridge citizens, supported and participated in renovating the 53 year old Oak Ridge High School into a "green" learning environment that will serve current and future students well into the twenty-first century (Fig. 5.8). UT-Battelle provided corporate donations as well as technical expertise and resources that facilitated the "green" design and construction of this facility.

Fig. 5.8. Oak Ridge High School soccer field.

The "green" concepts that were integrated into the renovation will result in an estimated energy savings of 30%. They include the installation of a geothermal system consisting of 200 wells, each 300 ft deep. The system provides 50 to 60% of the school's heating and cooling needs. Other energy-saving features include using energy-efficient lighting and daylighting throughout the facility to reduce artificial lighting requirements, automatic light shutoff sensors, high-efficiency window systems, and high-emissivity roofing materials.

Additional green concepts integrated into the renovation include the use of recycled-content materials, low volatile organic compounds (VOC) materials, site reuse for a sustainable site, building material reuse, water conservation, use of local and regional materials, and integration of a recycling program.

Based on the incorporation of the of green concepts, this facility submitted an application for U.S. Green Building Council LEED Silver certification in February 2009. If certification is awarded, the Oak Ridge High School will be the first K–12 public school in Tennessee to be LEED certified.

5.2.1.4 Energy Management

UT-Battelle Energy Management and Conservation

The UT-Battelle Energy Management Program seeks to advance continuous improvements in energy efficiency in UT-Battelle facilities, coordinates energy related-efforts across UT-Battelle organizations, and promotes employee awareness of energy conservation programs and opportunities. The *Oak Ridge National Laboratory Executable Plan* (Palko 2008) outlines the general strategy for managing and implementing energy and energy-related activities at ORNL. The plan also addresses activities related to the accomplishment of the goals of Executive Order 13423, "Strengthening Federal Environmental, Energy, and Transportation Management" and the DOE Transformational Energy Action Management (TEAM) initiative. In a major effort, the DOE and Johnson Controls, Inc., energy savings performance contract (ESPC) has implemented the Sustainable Energy Education and Communications Program, which will allow ORNL staff to go through comprehensive web-based instructional modules on many aspects of energy management and conservation.

The Energy Policy Act (EPACT) of 2005 established the goal of reducing building energy intensity, using 2003 as the baseline year. Executive Order 13423 sets a more stringent reduction goal of 3% per year for the same time period, resulting in a planned 30% reduction over 10 years. As shown in Fig. 5.9, UT-Battelle energy conservation efforts have exceeded those levels with a 13.4% building energy intensity reduction between FY 2003 and FY 2008. In fact, UT-Battelle has realized energy intensity reductions at ORNL of about 34% since 1985.

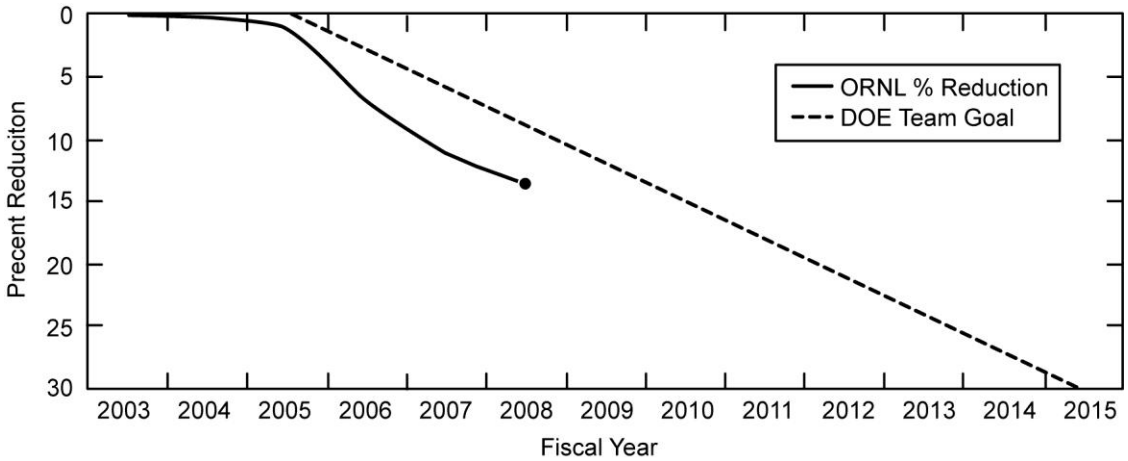


Fig. 5.9. ORNL building energy reduction vs the DOE TEAM goal.

The EPACT also requires federal agencies to install advanced electric metering, where practical, to improve the operating efficiencies of federal buildings. Measuring and managing energy use at the building level provide baseline data for assessing the effectiveness of energy savings programs and promote energy use awareness among building managers and occupants.

Data obtained through metering activities is essential for identifying cost-effective equipment retrofit opportunities, optimizing building and equipment operations, purchasing energy resources, planning, and allocating resources. UT-Battelle has proactively employed a policy of installing, as a minimum, standard electric meters at ORNL facilities for several years.

Sustainable Building Design

As discussed in Sects. 5.1.2.1 and 5.2.1.11, UT-Battelle continued to make significant progress on the implementation of the Facility Revitalization Project at ORNL during 2008. Sustainable building design principles continue to be incorporated into site selection, design, and construction of new facilities. The entire six-building East Campus, consisting of approximately 750,000 ft^2, is LEED certified. LEED promotes a whole-building approach to sustainability by recognizing performance in five key areas:

- sustainable site development,
- water savings,
- energy efficiency,
- materials selection, and
- indoor environmental quality.

These six new buildings save more than 14 million gal of water annually compared to the water used by similar older buildings at ORNL, and energy demands are 54% less than those at typical existing ORNL buildings. The heating and air-conditioning systems are 25 to 30% more efficient than American Society of Heating, Refrigerating and Air-Conditioning Engineers standard ASHRAE 90.1. The standard is a recognized, comprehensive industry standard that outlines the best practices and expectations for efficient, sound, heating, ventilating and air-conditioning design.

Energy Intensity Reduction Performance in Subject Buildings

DOE's TEAM initiative goal for reducing energy intensity in standard office and laboratory buildings is 3% per fiscal year using FY 2003 as the baseline year. The "subject" buildings are those buildings that are subject to legislated energy goals and that are not excluded from the goals that can be approved when buildings use an extraordinary amount of energy for research purposes. FY 2006 has been defined as the first performance year. (Major excluded buildings at ORNL are the HFIR, the Computational Sciences

Building's computer center, the Holifield Heavy Ion Research Facility, and the process buildings at the Spallation Neutron Source project.) In FY 2003, the baseline year, ORNL's energy intensity was 364,539 Btu per gross square foot (GSF), as shown in Fig. 5.9. After a brief plateau, ORNL's energy intensity is trending downward.

ORNL's energy intensity was 5.78% less in FY 2006 than it was in FY 2005, 6.31% less in FY 2007 than in was in FY 2006, and 1.54% less in FY 2008 than it was in FY 2007. Considering all years since the baseline year of FY 2003, the cumulative progress represents a 13.4% Btu/GSF reduction in energy intensity through FY 2008. Because FY 2008 was the third performance year, the target reduction was 9%; therefore, ORNL is currently ahead of the pace for meeting the FY 2015 goal of a 30% reduction. Various factors affect the results each quarter and each year, and fluctuations or plateaus in the results are not uncommon. Variables include the addition of new, efficient buildings; the shutdown or demolition of inefficient buildings; the implementation of new energy efficiency projects; the operation and management of systems that use energy; and weather conditions. Overall, ORNL's energy use trend is downward and currently on a pace to meet the DOE goal.

Energy Savings Performance Contracting

On July 30, 2008, Johnson Controls, Inc., was awarded an ESPC project at ORNL in support of the DOE TEAM Initiative. Recognizing that the core mission and responsibility of DOE is to lead the nation in promoting and using the best available energy management technologies and practices, the TEAM Initiative embarks on a program to meet, exceed, and lead in the implementation of the Executive Order 13423 energy, environmental and transportation goals.

The ESPC outlines various energy conservation measures (ECMs) that were developed to meet the goals of the DOE TEAM criteria, the *ORNL Ten-Year Site Plan*, and the Laboratory mission requirements.

The ECMs, savings projections, and project costs in the initial proposal were developed based on

- site visits by Johnson Controls personnel ,subcontracting partners and outside engineering support;
- extensive discussions with ORNL personnel, including facilities, utilities, energy management, contracting, accounting, master planning, and facility occupants and building users;
- analysis of facility construction documentation and ten-year site planning goals; and
- analysis of site energy consumption and history.

In addition to meeting the goals of the TEAM Initiative, the purpose of the ESPC effort is to support and modernize facility infrastructure, provide utility support and capacity, and ensure that mission-related activities can be performed without interruption.

ORNL will receive the following specific benefits from this project:

- modernization or significant infrastructure improvements of the existing steam plant and distribution system to create a world-class combined heat and power system fueled by renewable energy;
- improved chilled water system efficiency and reliability as a result of expanding and automating the plant;
- installation of advanced metering technology to continue ORNL's path toward meeting Sect. 103 of EPACT 2005;
- expansion of the Building Management System to provide automation in key areas and critical systems;
- extensive heating, ventilating, and air-conditioning system improvements and upgrades to improve comfort and meet facility consolidation needs;
- approximately $65 million in necessary deferred infrastructure improvements funded through energy savings;
- annual energy savings of 768,061 million Btu;
- water use reduction of about 170 million gal per year;

- carbon sequestration equivalent to 1,325,744 tree seedlings grown in an urban environment for 10 years or 11,751 acres of pine forests; and
- emission reductions equivalent to the reduction of 9,470 passenger vehicles; 120,242 barrels of oil; the energy used by 4,563 homes annually; or 270 coal rail cars.

Table 5.3 demonstrates the ESPC goals implemented to meet or exceed TEAM goals.

The status of the ECMs is outlined in Table 5.4.

Table 5.3. Energy savings performance contracting goals

	TEAM goal	Projected results
Percentage energy intensity reduction	30	50
Percentage water usage reduction	16	23
Required advanced electric metering installations	100	100
Percentage of energy from renewable sources	7.5	21
Measurement and verification of results	Yes	Yes
Incorporate sustainable designs	Yes	Yes

TEAM: Transformational Energy Action Management Initiative

Table 5.4. Energy conservation measure status

Measure	Status
Central Steam Plant Biomass Solution	Design and procurements are being finalized with construction to begin late FY 2009. Construction will be completed in mid-FY 2011
Select Steam Decentralization of Remote Buildings	Design and procurements are nearly complete. Some initial installation work is beginning with completion scheduled for fall 2009
Building Management System Upgrade	Design and procurements are being finalized and initial construction has started. Construction period is scheduled to be completed by spring 2010
Advanced Electric Metering	Design and procurement is complete, and installation is approximately 50% complete. Work is to be complete in May 2009
Comprehensive HVAC Upgrade	Design is being finalized and procurements have begun. An alternative scope of work may be needed for Bldg. 1505 due to another project; evaluation needs to be completed. Work is currently scheduled to be completed in February 2010
Energy-Efficient Lighting Upgrade	Design and procurements have been completed with construction approximately 50% complete. Scheduled for completion in September 2009
Water Conservation	Domestic water projects are complete. Once-through cooling project is still being designed with completion scheduled for FY 2009

Electric Metering

UT-Battelle has had a policy of metering for electricity at the building or substation level for many years. There are currently about 350 standard electric meters installed at ORNL (Table 5.5.) Almost all buildings that use electricity have at least a standard meter. While the site has approximately 450 structures identified as buildings, many of them are warehouses and equipment sheds that use little, if any, electricity. Of this total, approximately 120 buildings represent 70% of the space and 80% of the electricity use. Based on the criteria established in *Guidance for Electric Metering in Federal Buildings* (DOE 2006), thirty-eight buildings at ORNL which use over $32,000 in electricity each year, require advanced metering. When complete, buildings that account for 65% of UT-Battelle's total electrical consumption will have advanced metering and all buildings will have at least a standard meter (Table 5.6).

Table 5.5. Metering status

Building classification	Number of buildings
Total number of buildings at ORNL[a]	~450
Number of standard meters on site	~350
Total number of buildings considered for metering	121
Number of buildings with advanced meters[b]	18
Number of buildings with no existing meter/standard meter requiring advanced meters	20

[a]Many of the 450 structures at ORNL are warehouses, equipment sheds, and storage areas that use little or no electricity.

[b]Once implemented, advanced metering will be present in buildings representing 65% of the electrical consumption. All buildings will have at least a standard meter.

Table 5.6. Buildings to receive advanced meters by FY 2009 as part of ESPC

Year	Building number
2009	1005, 1060, 1505, 1506, 2519, 3020, 3047, 3144, 3500, 3525, 3608, 3625, 4500N, 4500S, 4501, 4505, 4508, 4509, 4515, 5100, 5200, 5300, 5500, 5505, 5510, 5510A, 5600, 5700, 5800, 6000, 6010, 7012, 7603, 7900, 7917, 7920, 7930, 7977

UT-Battelle Employee Energy Conservation Education and Involvement Opportunities

During 2008, UT-Battelle sponsored several events to promote employee awareness of opportunities to conserve energy and promote energy efficiency.

ORNL Earth Day Celebration

ORNL's Earth Day 2008 celebration, held on April 22, 2008, was headlined with a talk by Jeff Christian, focusing on his work on near zero energy homes in the Lenoir City Habitat for Humanity development. The slate of activities for the celebration also included an East Campus Pond tour. More than 2,000 people attended and were presented with a green recycled grocery bag containing energy efficiency, conservation, and sustainability items (Fig. 5.7).

ORNL Energy Awareness Month

October is National Energy Awareness Month, billed as a time to promote wise and efficient use of our nation's energy and a time to emphasize the commitment to a more secure energy future. The year's

theme was "Working to secure a clean energy future, where energy is abundant, reliable and affordable." ORNL participated in several October activities to promote energy awareness, beginning with the Energy Star Change a Light, Change the World Campaign. The campaign is a national call to action to encourage individuals to help change the world, one light—one energy-saving step—at a time.

New Transportation Options

During the month of October, ORNL highlighted two new transportation options on campus: bicycles and electric vehicles (see Figs. 5.10 and 5.11). Bikes are available for employees looking for an alternative to driving or walking from one building to another at ORNL. The Laboratory's extended campus makes transportation a periodic challenge, especially for those who are thinking about energy efficiency. The bike program is the joint effort of ORNL's Wellness Program and F&O's Energy Management group. The two-wheelers, which have automatic three-speeds, are stationed at various places around the campus and available for all staff. Safety training is required for employees who use the bikes.

Fig. 5.10. The fleet for the ORNL Bicycle Program.

Fig. 5.11. Example of the electric vehicles in service at ORNL.

ORNL is aggressively pursuing efficient energy management. The federal government as a whole spends more than $9 billion to power its vehicles, operations and approximately 500,000 facilities across America. As one of those facilities, the Lab is working to make buildings more efficient and our fleets less dependent on foreign sources of fuel. Bicycles provide an opportunity for employees to reduce fuel consumption and get exercise simultaneously. Electric vehicles also recently made their debut on campus as a means to improve the energy efficiency of the ORNL vehicle fleet.

Additional Photvoltaic Capacity Added

In 2008, ORNL installed 50 kW of solar photovoltaic generating capacity. This array is 10 ft wide and 280 ft long.

5.2.2 Implementation and Operation

5.2.2.1 Structure and Responsibility

The UT-Battelle policy statements (Fig. 5.2) represent the philosophy of UT-Battelle management for the conduct of research, operations, and other activities at ORNL. A key tenet of the policy is the integration of environmental and pollution prevention principles into work practices at all levels. Prior to performing any work at ORNL, all staff are required to complete comprehensive site orientation and training that outline employee responsibilities for environmental compliance and set forth expectations for all employees to comply with the policy statements and with the UT-Battelle EMS. Specific roles and responsibilities are further defined in position descriptions and individual performance plans.

An Environmental Protection Officer (EPO) Program, an Environmental Compliance Representative (ECR) Program, and a Waste Services Representative (WSR) Program have also been established to ensure that work planning activities for all UT-Battelle organizations address environmental protection and pollution prevention measures. The objectives of these programs are as follows:

- The EPO and ECR Programs
  - coordinate efforts to seek, accomplish, and maintain environmental compliance across all UT-Battelle organizations;
  - communicate environmental requirements and compliance strategies; and
  - provide liaisons between individual UT-Battelle organizations and the Environmental Protection and Waste Services Division.
- The WSR Program
  - provides a technical interface between waste generators and the Environmental Protection and Waste Services Division;
  - provides expertise in identifying, characterizing, packaging, and certifying wastes for disposal; and
  - coordinates the support required to complete necessary forms, properly classify waste streams, and develop characterization basis to successfully complete the waste certification and disposal process.

5.2.2.2 Communication and Community Involvement

Information on the UT-Battelle EMS is routinely communicated internally to staff and externally to stakeholders in several ways:

- EPO, ECR, WSR, and Management System owner meetings and workshops dedicated to EMS topics;
- Environmental Protection web sites;
- SBMS documentation available to all employees;
- EMS brochures and badge cards; and
- *ORR Annual Site Environmental Report*, which includes information on significant aspects, compliance status, pollution prevention programs, and other EMS elements and is made available to the public, to regulators, and to stakeholders.

5.2.3 Emergency Preparedness and Response

The Emergency Management System provides the resources and capabilities to provide emergency preparedness services and, in the event of an accident, emergency response services. Emergency Preparedness personnel perform hazard surveys and hazard assessments to identify potential emergency situations. Procedures and plans have been developed to prepare for and respond to a wide variety of potential emergency situations. Training is provided to ensure appropriate response and performance during emergency events. Frequent exercises and drills are scheduled to ensure the effective performance of the procedures and plans. An environmental subject matter expert is a member of the emergency

response team and participates in drills and exercises to ensure that environmental requirements are met and that environmental impacts from the event (and the response) are mitigated.

5.2.4 Checking

5.2.4.1 Monitoring and Measurement

UT-Battelle has developed monitoring and measurement processes for each operation or activity that can have a significant impact on the environment. Several SBMS subject areas include requirements for managers to establish performance objectives, indicators, and targets; conduct performance assessments to collect data and monitor progress; and evaluate the data to identify strengths and weaknesses in performance and areas for improvement.

5.2.4.2 EMS Assessments

Several methods are used by UT-Battelle to evaluate compliance with legal and other environmental requirements. Most of the compliance evaluation activities are implemented by the EMS or are a part of line organization assessment activities.

The SBMS Assessment subject area requires organizations to perform periodic environmental assessments that cover both legal and other requirements and requires management system owners to conduct annual self-assessments of their systems to ensure continual improvement.

UT-Battelle also uses the results from numerous external compliance inspections conducted by regulators to verify compliance to requirements. In addition to regulatory compliance assessments, there are internal and external EMS assessments performed annually to ensure that the UT-Battelle EMS continues to conform to ISO requirements. In 2008, an internal audit and an external surveillance audit were conducted and verified that the EMS continued to conform to ISO 14001:2004.

5.2.5 Environmental Management System for the Transuranic Waste Processing Center

EnergX's EMS for activities at the TWPC was registered to the ISO 14001:2004 Standard by NSF International Strategic Registrations, Ltd., in May 2008. No nonconformances or issues were identified during this assessment, and several significant practices were noted. The EnergX TWPC EMS and ISMS are integrated to provide a unified strategy for the management of resources; the control and reduction of risks; and the establishment and achievement of the organization's environment, safety, and health goals. The EMS and ISMS are incorporated into the *Integrated Safety Management Description Plan* at the TWPC. ISMS and EMS both strive for continual improvement through a "plan-do-check-act" cycle.

The EnergX EMS incorporates applicable environmental laws, DOE orders, and other requirements (i.e., directives and federal, state, and local laws) through the *EnergX Contract Requirements Document and Regulatory Management Plan*, which dictates how the various requirements are incorporated into TWPC subject area documents (procedures and guidelines). Through environmental program personnel and EMS representatives, the EMS assists the line organizations in identifying and addressing environmental issues in accordance with the EMS requirements.

Environmental aspects are elements of an organization's activities, products, or services that can interact with the environment. EnergX has identified environmental aspects associated with TWPC activities, products, and services at both the project and activity level and has identified waste management activities, air emissions, storm water contamination, and pollution prevention as potentially having significant environmental impacts. Activities that are relative to any of those aspects are carefully controlled to minimize or eliminate impacts to the environment.

EnergX has established and implemented objectives and measurable performance indicators for the targets associated with the identified significant impacts.

The P2 programs at the TWPC involve waste reduction efforts and implementation of sustainable practices that reduce the environmental impacts of the activities conducted at the TWPC. The EnergX EMS establishes annual goals and targets to reduce the impact of the TWPC's environmental aspects.

EnergX has a well-established recycling program at TWPC and continues to identify new material-recycling streams and to expand the types of materials included in the program. Currently, recycle streams at the TWPC range from office materials such as paper, aluminum cans, plastic drinking bottles, and toner cartridges to operations-oriented materials, such as scrap metal, cardboard, and batteries.

"Environmentally preferable purchasing" is a term used to describe an organization's policy to reduce packaging and to purchase products made with recycled material or bio-based materials and other environmentally friendly products. In 2008, EnergX procured environmentally preferable materials totaling more than $70,000 for use at TWPC.

Several methods are used by EnergX to evaluate compliance with legal and other requirements. Most of these compliance evaluation activities are implemented by internal and external environmental and management assessment activities and routine reporting and reviews. EnergX also uses the results from numerous external compliance inspections conducted by regulators and independent contractors to verify compliance to requirements.

5.3 Compliance Status

5.3.1 Environmental Permits

Table 5.7 contains a list of environmental permits that were effective in 2008 at ORNL.

5.3.2 Notices of Violations and Penalties

ORNL did not receive any notices of violations or penalties from regulators during 2008.

5.3.3 Audits and Oversight

Table 5.8 presents a summary of environmental audits conducted at ORNL in 2008.

5.3.4 National Environmental Policy Act/National Historic Preservation Act

NEPA provides a means to evaluate the potential environmental impact of proposed federal activities and to examine alternatives to those actions. UT-Battelle maintains compliance with NEPA through the use of site-level procedures and program descriptions that establish 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 5.9 summarizes NEPA activities conducted at ORNL during 2008.

During 2008, UT-Battelle continued to operate under a site-level procedure that provides requirements for project reviews and NEPA compliance. This procedure calls for a review of each proposed project, activity, or facility to determine the potential for impacts to the environment. To streamline the NEPA review and documentation process, DOE-ORO has approved "generic" categorical exclusions (CXs) that cover proposed bench- and pilot-scale research activities and generic CXs that 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 does 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 5.9 provides information on project-specific CXs that were approved by DOE-ORO during 2008.

UT-Battelle utilizes SBMS as the delivery system to manage and control work at ORNL. NEPA is an integral part of SBMS, and a UT-Battelle NEPA coordinator, along with principal investigators, environmental compliance representatives, and environmental protection officers within each UT-Battelle division, participate in determining appropriate NEPA decisions.

An Environmental Assessment was completed in 2008 for the *Oak Ridge National Laboratory Modernization Initiative* (DOE/EA-1618, July 2008) to provide facilities and infrastructure to accomplish DOE's research mission at ORNL. The proposed action will also enhance worker health and safety, reduce operating costs, accommodate project growth and allow relocation of staff, facilities and support services in the Central Campus.

Table 5.7. ORNL environmental permits, 2008

Regulatory driver	Permit title/description	Permit number	Issue date	Expiration date	Owner	Operator	Responsible contractor
CAA	Radioactive Materials Analytical Laboratory	556850	10-21-04	10-21-09	DOE	UT-B	UT-B
CAA	Radiochemical Development Facility	556850	10-21-04	10-21-09	DOE	UT-B	UT-B
CAA	Steam Plant	556850	10-21-04	10-21-09	DOE	UT-B	UT-B
CAA	Manipulator Boot Shop	556850	10-21-04	10-21-09	DOE	UT-B	UT-B
CAA	SNS Central Utilities Building Boilers	556850	10-21-04	10-21-09	DOE	UT-B	UT-B
CAA	Surface Coating and Cleaning Operation	556850	10-21-04	10-21-09	DOE	UT-B	UT-B
CAA	SNS and CNF (construction permit)	956542P	10-29-04	03-01-08	DOE	UT-B	UT-B
CAA	SNS Central Laboratory and Office Boilers	556850	10-21-04	10-21-09	DOE	UT-B	UT-B
CAA	EGCR Boilers	556850	10-21-04	10-21-09	DOE	UT-B	UT-B
CAA	Air Stripper (BJC permit)	547563	10-21-04	10-21-09	DOE	BJC	BJC
CAA	HFIR & Radiochemical Engineering Development Center	556850	10-21-04	10-21-09	DOE	UT-B	UT-B
CAA	Off Gas & Hot Cell Ventilation (BJC permit)	547563	10-21-04	10-21-09	DOE	BJC	BJC
CAA	NTRC	0904-12[b]	05-10-01	Annually	DOE	UT-B	UT-B
CAA	TN Operating Permit (Emissions Source)	057077P	04-13-04	10-31-14	DOE	EnergX	EnergX
CAA	NTRC Engine Test (Construction Permit)	C-0419-2	07-29-08	07-07-09	DOE	UT-B	UT-B
CWA	ORNL NPDES Permit (ORNL site-wide wastewater discharge permit)	TN0002941	07-01-08	07-30-13	DOE	DOE	UT-B, BJC
CWA	Tennessee General (NPDES) Permit No. TNR10-0000, Storm Water Discharges from Construction Activities—SNS	TNR139975	09-30-00	NA	DOE	DOE	UT-B

Table 5.7 (continued)

Regulatory driver	Permit title/description	Permit number	Issue date	Expiration date	Owner	Operator	Responsible contractor
CWA	Tennessee General (NPDES) Permit No. TNR10-0000, Storm Water Discharges from Construction Activities—ORNL Research Support Center	TNR130471	06-02-03	02-07-08	DOE	DOE	UT-B
CWA	General Permit For Construction & Removal of Minor Road Crossings-ORNL West Campus Improvements	NR0803.058	04-07-08	04-07-09	DOE	DOE	UT-B
CWA	Tennessee General (NPDES) Permit No. TNR10-0000, Storm Water Discharges from Construction Activities—ORNL 24-Inch Water Line Replacement	TNR132022	06-23-06	02-07-08	DOE	DOE	UT-B
CWA	Tennessee General Permit No. TNR10-0000, Stormwater Discharges from Construction Activity—ORNL Decommissioning & Demolishing Buildings	TNR1301343	05-26-05	NA	DOE	DOE	UT-B
CWA	Tennessee General Permit No. TNR10-0000, Stormwater Discharges from Construction Activity—ORNL West Campus Improvements	TNR132878	12-04-07	NA	DOE	DOE	UT-B
CWA	Tennessee General (NPDES) Permit No. TNR10-0000, Storm Water Discharges from Construction Activities—Pro2Serve National Security Engineering Center		10-06	NA	DOE	DOE	Pro2Serve
CWA	TN Operating Permit (sewage)	SOP-02056	02-01-08	12-31-12	DOE	EnergX	EnergX
CWA	Tennessee Multi-Sector General NPDES Storm Water Permit No Exposure Exclusion	TNR053814	11-22-05	11-22-10	TDEC	EnergX	EnergX
RCRA	Hazardous Waste Transporter Permit	TN1890090003	01-22-08	01-31-09	DOE	DOE	UT-B, BJC, Weskem

Table 5.7 (continued)

Regulatory driver	Permit title/description	Permit number	Issue date	Expiration date	Owner	Operator	Responsible contractor
RCRA	Hazardous Waste Corrective Action Permit	TNHW-121	09-28-04	09-28-14	DOE	DOE/all[e]	BJC/EnergX
RCRA	Hazardous Waste Container Storage and Treatment Units	TNHW-134[c]	09-26-08	09-26-18	DOE	DOE/UT-B[d]	UT-B[d]
RCRA	Hazardous Waste Container Storage and Treatment Units	TNHW-097	09-30-97	09-30-07[d]	DOE	DOE/BJC/ Weskem, EnergX	

Abbreviations:

BJC	Bechtel Jacobs Company
CAA	Clean Air Act
CNF	Central Neutralization Facility
CWA	Clean Water Act
DOE	U.S. Department of Energy
EGCR	Experimental Gas-Cooled Reactor
HFIR	High Flux Isotope Reactor
NPDES	National Pollutant Discharge Elimination System
NTRC	National Transportation Research Center
ORNL	Oak Ridge National Laboratory
RCRA	Resource Conservation and Recovery Act
SNS	Spallation Neutron Source
UT-B	UT-Battelle

[b]Permit issued by Knox County Department of Air Quality Management.
[c] Permit TNHW-10A reissued as TNHW-134 on September 26, 2008.
[d]BJC and WESKEM removed from permit and UT-Battelle added to permit on October 28, 2008.
[e]DOE and all Oak Ridge Reservation co-operators of hazardous waste permits

Table 5.8. Summary of environmental audits, assessments and regulatory visits conducted at ORNL, 2008

Date	Reviewer	Subject	Issues
		UT-Battelle	
February 19	TDEC	NPDES permit renewal discussion	0
February 20	TDEC/EPA	Annual CAA inspection	0
February 25	TDEC	CAA visible emissions inspection	0
April 15	EPA/TDEC	Underground tank inspection	0
May 12–14	TDEC, RCRA	TDEC annual RCRA inspection	0
July 2	TDEC	Fish kill follow-up	0
July 22–25	NSF-ISR	EMS assessment	2
September 16	TDEC	Fish kill follow-up	0
September 25	TDEC	RATA for predictive emissions	
October 27–29	TDEC	Annual RCRA inspection at Y-12 Complex	0
December 3	TDEC	RATA for continuous emissions	0
December 16	TDEC	Annual CAA inspection	0
December 18	Knox County Air Quality Management Division	Annual NTRC inspection	0
		Bechtel Jacobs Company/WESKEM/Energy Solutions	
May 12–14	TDEC, RCRA	TDEC Annual RCRA inspection	0
		EnergX	
May 13–14	TDEC, RCRA	TDEC Annual RCRA inspection	0

Abbreviations

CAA	Clean Air Act
EMS	Environmental Management System
EPA	Environmental Protection Agency
NPDES	National Pollutant Discharge Elimination System
NSF-ISR	NSF International Strategic Registrations, LTD
NTRC	National Transportation Research Center
ORNL	Oak Ridge National Laboratory
RATA	relative accuracy test audit
RCRA	Resource Conservation and Recovery Act
TDEC	Tennessee Department of Environment and Conservation

Compliance with National Historic Preservation Act (NHPA) at ORNL 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 2001).

5.3.5 Clean Air Act Compliance Status

The Clean Air Act (CAA), passed in 1970 and amended in 1977 and 1990, forms the basis for the national air pollution control effort. This legislation establishes comprehensive federal and state regulations to limit air emissions and includes four major regulatory programs: the National Ambient Air Quality Standards, State Implementation Plans (SIPs), New Source Performance Standards (NSPS), and National Emission Standards for Hazardous Air Pollutants (NESHAP). 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. There were no ORNL CAA violations or exceedances in 2008. Section 5.4 provides detailed information on 2008 UT-Battelle activities conducted in support of the CAA.

Table 5.9. National Environmental Policy Act (NEPA) activities, 2008

Types of NEPA documentation	Number of instances
ORNL	
Categorical exclusions (CXs) approved	1
Approved under general actions or generic CX documents	45[a]
Environmental assessment	1
EnergX	
Approved under general actions or generic CX documents	6[a]

[a]Projects that were reviewed and documented through the site NEPA compliance coordinator.

5.3.6 Clean Water Act Compliance Status

The objective of the Clean Water Act (CWA) is to restore, maintain, and protect the integrity of the nation's waters. This act serves as the basis for comprehensive federal and state programs to protect the nation's waters from pollutants. (See Appendix D for water reference standards.) One of the strategies developed to achieve the goals of the CWA was EPA's establishment of limits on specific pollutants allowed to be discharged to U.S. waters by municipal sewage treatment plants and industrial facilities. The EPA established the National Pollutant Discharge Elimination System (NPDES) Permitting Program to regulate compliance with pollutant limitations. The program was designed to protect surface waters by limiting effluent discharges into streams, reservoirs, wetlands, and other surface waters. EPA has delegated authority for implementation and enforcement of the NPDES program to the state of Tennessee.

In 2008, compliance with the ORNL NPDES permit was determined by approximately 4000 laboratory analyses and field observations. The NPDES permit limit compliance rate for all discharge points for 2008 was nearly 100% with only 6 measurements exceeding numeric NPDES permit limits. The noncompliances occurred at the former ORNL Coal Yard Runoff Treatment Facility (CYRTF), now known as the Steam Plant Wastewater Treatment Facility (SPWTF). Three of these noncompliances occurred in February 2008, when results of measurements for copper (0.205 mg/L) and iron (1.13 mg/L) exceeded daily maximum limits of 0.11 and 1.0 mg/L, respectively. The copper measurement resulted in a third, calculated exceedance of a monthly average limit. In July 2008, similar exceedances occurred, with daily maximum limit exceedances of silver and iron also resulting in a third, calculated exceedance of a monthly average iron limit. The February 2008 exceedances were attributed to a pump discharge line that froze and broke, and was promptly repaired. The July 2008 exceedances were investigated but were not attributable to any operational event or other known cause. Information on the exceedances is provided in Appendix E, Sect. E.3. None of the six exceedances resulted in any discernable ecological impact. Section 5.5 contains detailed information on the activities and programs carried out at 2008 by UT-Battelle in support of the CWA.

Two fish kills occurred in White Oak Creek at ORNL in 2008, one on July 1 and one on September 15. Each kill resulted in the death of about 180 aquatic organisms, including fish and other aquatic species. The kills were attributed to excessive chlorinated-water discharge from outfall 227. Both kills were investigated, and improved dechlorination systems are being installed to guard against recurrence.

In August 2008, TDEC issued a renewed NPDES permit to DOE for the ORNL site. The reissued permit reflects the current configuration of ORNL wastewater discharges and includes monitoring requirements geared toward more informative, adaptive monitoring strategies.

5.3.7 Safe Drinking Water Act Compliance Status

ORNL's water distribution system is designated as a Non-Transient, Non-Community water system by TDEC's Division of Water Supply. The *Tennessee Regulations for Public Water Systems and Drinking Water Quality*, Chap. 1200-5-1, sets limits for biological contaminants and for chemical activities and chemical contaminants. TDEC requires sampling for the following constituents for compliance with state and federal regulations:

- chlorine residual levels,
- bacteriological (total coliform),
- lead and copper, and
- disinfectant by-products (trihalomethanes and haloacetic acids).

The city of Oak Ridge supplies potable water to the ORNL water distribution system and meets all regulatory requirements for drinking water. The water treatment plant, located on the ORR, north of the Y-12 Complex, is owned and operated by the city of Oak Ridge.

In 2008, sampling results for ORNL's water system chlorine residual levels, bacterial constituents, and disinfectant by-products were all within acceptable limits. TDEC requires triennial sampling of the ORNL potable water system for lead and copper. The next scheduled sample period is June–September 2009.

5.3.8 Resource Conservation and Recovery Act Compliance Status

ORNL is regulated as a large-quantity generator of hazardous waste because the facility generates more than 1,000 kg of hazardous waste per month. This amount includes hazardous waste that is generated under permitted activities (including repackaging or treatment residuals). At the end of 2008, ORNL had roughly 375 generator accumulation areas for hazardous or mixed waste serving various contractor organizations, including UT-Battelle, Bechtel Jacobs Company, Energy Solutions, Isotek, EnergX, and others.

ORNL is also regulated as a handler of universal waste (e.g., fluorescent lamps, batteries, and other items regulated under 40 CFR 273). Mercury-containing equipment at ORNL is managed at UT-Battelle as hazardous waste.

ORNL is regulated as a generator of used oils under 40 CFR 279. At the end of 2008, ORNL had approximately 100 used oil areas for management of used oil prior to off-site recycle or disposal.

ORNL's NTRC was classified as a conditionally exempt small-quantity generator for CY 2008, meaning that the site generated less than 100 kg of hazardous waste per month. At the end of 2008, the NTRC operated three generator areas in support of operations that generate hazardous wastes and one used oil area for management of recyclable used oil.

In 2008, the DOE Office of Scientific and Technical Information (OSTI), ORNL Records, applied for and received an EPA identification (ID) number, TNR000026765 for the generation and temporary storage of hazardous waste. OSTI was classified as a large quantity generator for 2008 due to a cleanout of microfiche at the facility, which is considered hazardous waste because of its leachable silver content.

OSTI operated a 90 day accumulation area for temporary management of the waste. The waste was shipped off site for silver reclamation prior to the end of 2008; therefore, there were no generator areas open at the end of the calendar year.

The 0800 Area and the Freels Bend Area generated no regulated wastes or used oils in 2008.

ORNL is registered as a large-quantity generator under EPA ID No. TN1890090003 and is permitted to transport hazardous wastes, to operate a transfer facility for temporary storage of hazardous wastes

transported from off-site locations (such as NTRC), and to operate RCRA-permitted hazardous waste treatment and storage units. During 2008, 22 units operated as permitted units; another 6 units were permitted as proposed units (but will not be built and have been eliminated in a permit renewal application submitted in 2006).

ORNL's RCRA storage and treatment facilities (or units) operate under three permits: TNHW-097, TNHW-134, and TNHW-121. TNHW-121 is the existing RCRA Hazardous and Solid Waste Amendments permit for the ORR (see Table 5.10). The permits are modified when necessary. Permit TNHW-10A was reissued as TNHW-134 on September 26, 2008. Eight permit modifications were approved by TDEC in 2008. Most of the permit modifications submitted and approved in 2008 were minor and addressed administrative, editorial, or other nonintent changes. One Class 3 modification included adding additional storage and treatment capacity to TNHW-097, including WPF-6 Contact Handled Marshalling Building, T-2 Amalgamation Treatment, and T-3 Solidification/Stabilization. A temporary authorization was granted for TNHW-010A for hazardous waste deactivation and stabilization treatment processes. The renewal application for the TNHW-097 permit submitted in March 2007 was still pending throughout 2008.

Table 5.10. ORNL Resource Conservation and Recovery Act operating permits, 2008

Permit number	Building/description
	ORNL
TNHW-134[a]	Building 7651 Container Storage Unit
	Building 7652 Container Storage Unit
	Building 7653 Container Storage Unit
	Building 7654 Container Storage Unit
	Portable Units 1 & 2 Storage & Treatment Units
TNHW-097	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 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
	Building CHMB Waste Processing Facility 6
	Macroencapsulation T-1
	Amalgamation T-2[b]
	Solidification/Stabilization T-3 and T-4[b]
	Oak Ridge Reservation
TNHW-121	Hazardous Waste Corrective Action Permit

[a] Permit TNHW-10A reissued as TNHW-134 on September 26, 2008.
[b]Treatment operating units within Building 7880.

5.3.9 RCRA Underground Storage Tanks

Underground storage tanks (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 1200-1-15; however, hazardous-substance USTs are still regulated by EPA.

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 not in service that were deferred or exempt from Subtitle I because they were regulated by other statutes (1 UST under the RCRA Subtitle C and 1 UST under the CWA).

Of the 49 closed USTs, 24 were replaced by double-walled, concrete-encased aboveground storage tanks; three 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.

5.3.10 Comprehensive Environmental Response, Compensation, and Liability Act Compliance Status

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 (NPL) 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.

In 1989, the ORR was placed on the NPL. In 1992, the ORR Federal Facility Agreement among EPA, TDEC, and DOE became effective and established the framework and schedule for developing, implementing, and monitoring remedial actions on the ORR. The on-site CERCLA Environmental Management Waste Management Facility (EMWMF), located in Bear Creek Valley, is used for disposal of waste resulting from CERCLA cleanup actions on the ORR, including ORNL. The EMWMF is an engineered landfill that accepts low-level radioactive, hazardous, asbestos, and PCB wastes and combinations of the aforementioned wastes in accordance with specific waste acceptance criteria under an agreement with state and federal regulators.

5.3.10.1 ORNL RCRA-CERCLA Coordination

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.

In May 2005 ORNL applied for, but has not yet received, a RCRA postclosure permit for SWSA 6. RCRA groundwater monitoring data is reported yearly to TDEC and EPA in the annual CERCLA *Remediation Effectiveness Report* (DOE 2008a) for the ORR.

Periodic updates of proposed construction and demolition activities and facilities at ORNL have been provided to managers and project personnel from the TDEC DOE Oversight Division and EPA Region 4. A CERCLA screening process is used to identify proposed construction and demolition projects and facilities 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.

5.3.11 Toxic Substances Control Act Compliance Status

5.3.11.1 Polychlorinated Biphenyls

PCB waste generation, transportation, and storage at ORNL is regulated under the EPA ID number TN1890090003. In 2008, UT-Battelle, LLC operated approximately 11 PCB waste storage areas in generator buildings and RCRA-permitted storage buildings at ORNL for longer-term storage of PCB/radioactive wastes when necessary. Two PCB waste storage areas were operated at Y-12 facilities. The continued use of authorized PCBs in electrical systems and/or equipment (e.g., transformers, capacitors, rectifiers) is regulated at ORNL. The majority of equipment at ORNL that required regulation under the Toxic Substances Control Act has been disposed of. However, some of the ORNL facilities at Y-12 continue to use (or store for future reuse) PCB equipment (such as transformers, capacitors, and rectifiers).

Because of the age of many of the ORNL facilities and the varied uses for PCBs in gaskets, grease, building construction and equipment, DOE self-disclosed unauthorized use of PCBs to EPA in the late 1980s. As a result, DOE and ORNL contractors negotiated a compliance agreement with EPA (see Sect. 5.3.11.1.1) to address the compliance issues related to these unauthorized uses and to allow for continued

use pending decontamination or disposal. As a result of that agreement, DOE continues to notify EPA when additional unauthorized uses of PCBs, such as PCBs in paint, adhesives, electrical wiring, or floor tile are found at ORNL.

5.3.11.1.1 PCB Compliance Agreements

The ORR PCB 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 and 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.

EPA is updated annually on the status of DOE actions with regard to management and disposition of PCBs covered under the ORR PCB FFCA.

5.3.12 Emergency Planning and Community Right-to-Know Act Compliance Status

The Emergency Planning and Community Right-to-Know Act (EPCRA) and Title III of SARA require that facilities report inventories and releases of certain chemicals that exceed specific release thresholds. The reports are submitted to the local emergency planning committee and the state emergency response commission. Table 5.11 describes the main elements of the act. UT-Battelle complied with these requirements in 2008 through the submittal of reports under EPCRA Sects. 302, 303, 311, and 312.

ORNL had no releases of extremely hazardous substances, as defined by EPCRA, in 2008.

Table 5.11. Descriptions of the main parts of the Emergency Planning and Community Right-to-Know Act (EPCRA)

Title	Description
Sections 302 and 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
Sections 311–312, Material Safety Data Sheet (MSDS)/Chemical Inventory	Requires that either MSDSs or lists of hazardous chemicals for which they 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 (EPA)
Section 313, Toxic Chemical Release Reporting	Requires that releases of toxic chemicals be reported annually to EPA

5.3.12.1 Material Safety Data Sheet/Chemical Inventory (Sects. 312)

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 2007 on the ORR, 28 were located at ORNL.

Private-sector lessees associated with the reindustrialization effort were not included in the 2008 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.

5.3.12.2 Toxic Chemical Release Reporting (Sect. 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 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.

For CY 2008, ORNL reported releases of 25,739 lb of nitric acid and 47,000 lb of nitrate compounds (Table 5.12). Of this, 25,456 lb of the nitric acid was not actually released but rather was used for waste treatment at the Process Waste Treatment Complex and at HFIR. This use is considered a "release" under the Toxic Release Inventory regulations. The remaining 283 lb was sent off site for disposition. Nitrate compounds are coincidentally manufactured as by-products of neutralizing nitric acid waste and as by-products of sewage treatment. The neutralized nitric acid is not released; it is stored for future disposal as radiological waste because it becomes radioactive during the treatment process. The nitrate compounds from the sewage treatment plant are released into the environment. The discharge of nitrate compounds is not regulated in the NPDES permit for the sewage plant.

Table 5.12. Emergency Planning and Community Right-to-Know Act Sect. 313 toxic chemical release and off-site transfer summary [a] for ORNL, 2008

Chemical	Year	Quantity (lb)[b]
Nitrate compounds	2007	35,000
	2008	47,000
Nitric acid	2007	26,904
	2008	25,739
Total	2007	61,904
	2008	72,739

[a]Represents 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.

[b]1 lb = 0.45359237 kg.

5.4 Air Quality Program

5.4.1 Nonradiological Monitoring

UT-Battelle holds a Title V permit for ten emission sources. 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. The units use fossil fuels; therefore, criteria pollutants are emitted. Actual and allowable emissions from the sources are compared in Table 5.13. Actual emissions were calculated from fuel use and EPA emission factors. All UT-Battelle emission sources operated in compliance with Title V permit conditions during 2008.

Boiler 6, a 125-MMBtu/h boiler, is subject to the new source performance standards of 40 CFR 60 Subpart Db with continuous emission monitoring requirements for NO_x and opacity. During 2008, no permit limits were exceeded. ORNL also holds one construction permit for the Central Exhaust Facility at the SNS. The initial start-up certification for the SNS was submitted to TDEC on January 11, 2008.

Table 5.13. Actual vs allowable air emissions from ORNL steam production, 2008

Pollutant	Emissions (tons per year)[a]		Percentage of allowable (%)
	Actual	Allowable	
SO_2	7	1277	0.5
PM	4	71	5.0
CO	38	196	19.4
VOC	3	14	21.4
NO_X	69	380	18.0

[a] 1 ton = 907.2 kg.

The facility will collect, monitor, and discharge radionuclides from SNS operational components. Sources will include accelerator tunnels, beam dumps, and the target building. On March 16, 2007, UT-Battelle submitted a Title V operating permit application to TDEC, requesting that the UT-Battelle Title V permit be modified to include the SNS Central Exhaust Facility. In accordance with the provisions of the construction permit, the SNS can continue to operate until TDEC incorporates the source in the UT-Battelle Title V Permit.

From July 1, 2007, through June 30, 2008, UT-Battelle paid $6,378.21 in annual emission fees to TDEC. The fees are based on a combination of actual and allowable emissions.

The TWPC holds an operating air permit for one emission source. During CY 2008, no permit limits were exceeded.

5.4.2 NESHAP for Asbestos

There are numerous buildings and pieces of equipment at ORNL 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 ORNL during 2008.

5.4.3 ORNL Radiological Airborne Effluent Monitoring

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. (See Appendix F, Table F.1, for a list of radionuclides and associated radioactive half-lives.) The 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 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. In December 2007, commencement of user operations for beamlines was authorized. In 2008, the SNS facility was fully operational. SNS radionuclide emissions 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 to the most exposed member of the public; therefore, continuous emission sampling or monitoring is required.

The major radiological emission point sources for ORNL consist of the following six stacks located in Bethel and Melton Valleys (Fig. 5.12); 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 Molten Salt Reactor Experiment Facility;
- 7880 TWPC;
- 7911 Melton Valley complex, which includes HFIR and the Radiochemical Engineering Development Center; and
- 8915 SNS Central Exhaust Facility stack.

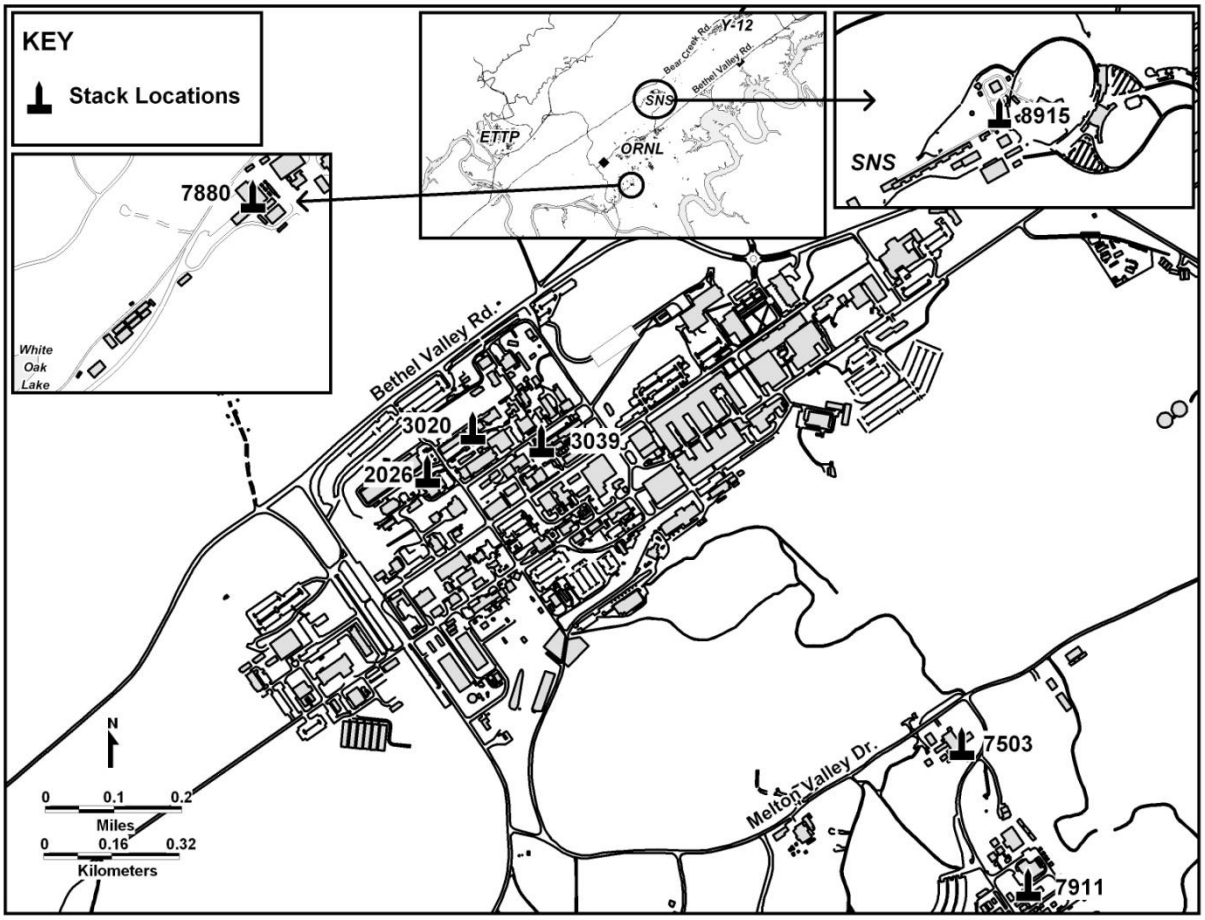


Fig. 5.12. Locations of major stacks (radiological emission points) at ORNL.

The Radioactive Materials Analytical Laboratory was moved from Building 2026 to Building 4501 in 2007. Building 2026 has been slated for decontamination and decommissioning. However, the building name is still Radioactive Materials Analytical Laboratory.

In 2008, there were 15 minor point/group sources, and emission calculations/estimates were made for each of them.

5.4.3.1 Sample Collection and Analytical Procedure

Five of the major point sources (2026, 3020, 3039, 7503, and 7911) are equipped with in-stack source-sampling systems that comply with criteria in the American National Standards Institute (ANSI) standard ANSI N 13.1-1969 (ANSI 1969). The sampling systems generally consist of a multipoint in-stack sampling probe, a sample 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 7880 stack is equipped with an in-stack source-sampling system that complies with criteria in the ANSI Health Physics Society standard ANSI/HPS N13.1-1999 (ANSI 1999). The system consists of a stainless-steel, shrouded probe; an in-line filter-cartridge holder placed at the probe to minimize line losses; a particulate filter; a sample transport line; a rotary vane vacuum pump; and a return line to the stack. The sample probe is annually removed, inspected, and cleaned. The 8915 stack is equipped with an in-stack radiation detector that complies with criteria in ANSI/HPS N13.1-1999. 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 sources and at 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. For the 7880 stack, an annual comparison between the effluent flow rate totalizer and EPA Method 2 is performed. The stack effluent flow rate monitoring system response is checked quarterly against the manufacturer's instrument test procedures. The stack sampler rotameter is calibrated at least quarterly in comparison with a secondary (transfer) standard. Only a certified secondary standard is used for all rotameter tests.

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 UT-Battelle 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 EPA criteria. The minor sources are evaluated on a 1 to 5 year basis. Emissions, major and minor, are compiled annually to determine the overall ORNL source term and associated dose.

The charcoal cartridges, particulate filters, and silica-gel traps are collected weekly to biweekly. 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. At Stack 7880, the filters are composited monthly and 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 water vapor that may contain tritium. 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 7880, and the rinsate is collected and submitted for isotopic analysis identical to that performed on the particulate filters. A probe-cleaning program has been determined unnecessary for 8915 because the sample probe is a scintillator probe used to detect radiation and not to extract 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 filter composites are compiled to give the annual emissions for each major source and some minor sources.

5.4.3.2 Results

Annual radioactive airborne emissions for ORNL in 2008 are presented in Table 5.14. 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 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.

Table 5.14. Radiological airborne emissions from all sources at ORNL, 2008 (Ci)[a]

Isotope	Stack								
	X-2026	X-3020	X-3039	X-7503	X-7911	X-7880	X-8915	Total minor sources	Total ORNL
^{225}Ac								1.00E-06	1.00E-06
^{228}Ac								7.49E-06	7.49E-06
^{110m}Ag						4.75E-06			4.75E-06
^{241}Am			3.20E-07	4.26E-09		3.29E-06		2.59E-09	3.62E-06
^{241}Am	7.36E-08	2.83E-07			1.57E-08			4.29E-07	8.01E-07
^{243}Am								7.40E-10	7.40E-10
^{41}Ar					5.78E+03		3.38E+00	1.85E-01	5.78E+03
^{139}Ba					1.30E-01				1.30E-01
^{140}Ba					1.04E-04				1.04E-04
^{7}Be			1.06E-05			3.63E-05		4.33E-07	4.73E-05
^{7}Be	2.96E-07				1.42E-05			1.35E-05	2.80E-05
^{213}Bi								1.10E-05	1.10E-05
^{214}Bi								2.61E-06	2.61E-06
^{11}C							2.71E+02	2.47E-01	2.71E+02
^{14}C								5.09E-10	5.09E-10
^{252}Cf[b]					3.37E-09			1.00E-07	1.03E-07
^{242}Cm								5.65E-08	5.65E-08
^{243}Cm						9.00E-07		6.42E-10	9.01E-07
^{243}Cm								7.20E-12	7.20E-12
^{244}Cm			8.44E-08	2.22E-08		9.00E-07		3.25E-09	1.01E-06
^{244}Cm	5.77E-07	1.33E-08			4.01E-08			4.21E-06	4.84E-06
^{57}Co								2.09E-06	2.09E-06
^{58}Co								3.37E-07	3.37E-07
^{58}Co						1.95E-06			1.95E-06
^{60}Co			9.33E-06			5.84E-06			1.52E-05
^{60}Co								1.58E-04	1.58E-04
^{51}Cr								2.87E-08	2.87E-08
^{134}Cs								1.06E-08	1.06E-08
^{134}Cs						4.99E-06			4.99E-06
^{135}Cs								2.18E-13	2.18E-13
^{135}Cs						2.91E-06			2.91E-06
^{137}Cs	1.60E-06	1.48E-06			2.63E-06			2.18E-03	2.19E-03
^{137}Cs			8.57E-05			5.19E-06		7.77E-07	9.17E-05
^{138}Cs					7.38E+02				7.38E+02
^{152}Eu								2.62E-07	2.62E-07
^{154}Eu								1.58E-07	1.58E-07
^{155}Eu								2.49E-10	2.49E-10
^{55}Fe								2.37E-07	2.37E-07
^{59}Fe								1.13E-10	1.13E-10
^{59}Fe						2.81E-06			2.81E-06
^{153}Gd								1.06E-13	1.06E-13
^{3}H	1.52E+00		1.29E+01	1.64E+00	5.61E+01		2.34E+01	8.76E-01	9.64E+01
^{203}Hg								9.28E-07	9.28E-07
^{124}I								4.03E-16	4.03E-16
^{125}I							5.00E-02	7.72E-08	5.00E-02
^{126}I								1.19E-08	1.19E-08
^{129}I								1.08E-05	1.08E-05

Table 5.14 (continued)

Isotope	Stack								
	X-2026	X-3020	X-3039	X-7503	X-7911	X-7880	X-8915	Total minor sources	Total ORNL
^{131}I					1.90E-02			3.21E-06	1.90E-02
^{132}I					2.16E-01				2.16E-01
^{133}I					1.02E-01				1.02E-01
^{134}I					1.74E-01				1.74E-01
^{135}I					3.23E-01				3.23E-01
^{192}Ir								1.01E-06	1.01E-06
^{40}K								3.58E-05	3.58E-05
^{40}K						2.14E-05			2.14E-05
^{79}Kr							5.88E+00	2.09E-10	5.88E+00
^{81}Kr								5.80E-13	5.80E-13
^{83m}Kr								8.92E-04	8.92E-04
^{85}Kr					1.09E+03			2.80E+01	1.12E+03
^{85m}Kr					5.60E+00		1.81E+01	1.22E-03	2.37E+01
^{87}Kr					8.75E+01		7.82E+00	4.55E-03	9.53E+01
^{88}Kr					9.13E+01		3.19E+00	3.39E-03	9.45E+01
^{89}Kr[c]					6.70E+01			3.92E-05	6.70E+01
^{140}La					1.09E-04				1.09E-04
^{140}La						1.15E-05			1.15E-05
^{177}Lu								1.50E-07	1.50E-07
^{54}Mn								3.45E-08	3.45E-08
^{54}Mn						5.34E-06			5.34E-06
^{93}Mo								4.07E-10	4.07E-10
^{99}Mo						3.77E-03			3.77E-03
^{13}N							5.93E+00	9.28E-01	6.86E+00
^{22}Na								3.72E-14	3.72E-14
^{93m}Nb								2.05E-11	2.05E-11
^{94}Nb								7.36E-12	7.36E-12
^{94}Nb						1.02E-06			1.02E-06
^{95}Nb								5.79E-08	5.79E-08
^{59}Ni								1.06E-07	1.06E-07
^{63}Ni								1.34E-07	1.34E-07
^{237}Np								6.81E-11	6.81E-11
^{239}Np								2.33E-12	2.33E-12
^{191}Os			1.27E-03						1.27E-03
^{212}Pb	4.76E-01	3.10E-01			2.94E-02			9.45E-06	8.15E-01
^{212}Pb			1.07E+00	1.25E-01				1.31E-02	1.21E+00
^{238}Pu			3.33E-08	1.70E-09		1.08E-06		5.43E-10	1.12E-06
^{238}Pu	3.07E-08	2.74E-08			1.71E-09			5.08E-07	5.68E-07
^{239}Pu			8.47E-07	6.63E-09				9.38E-10	8.55E-07
^{239}Pu	1.06E-07	1.80E-07			5.77E-08			1.49E-07	4.93E-07
^{240}Pu								3.73E-08	3.73E-08
^{240}Pu								4.28E-10	4.28E-10
^{241}Pu								1.78E-07	1.78E-07
^{242}Pu								4.55E-13	4.55E-13
^{225}Ra								1.00E-06	1.00E-06
^{226}Ra						1.88E-05			1.88E-05
^{228}Ra								7.49E-06	7.49E-06
^{88}Rb							1.06E+00		1.06E+00
^{188}Re								5.20E-07	5.20E-07
^{103}Ru								1.01E-09	1.01E-09
^{106}Ru								1.00E-05	1.00E-05
^{35}S								3.68E-11	3.68E-11
^{124}Sb								2.29E-10	2.29E-10
^{125}Sb								1.14E-09	1.14E-09
^{125}Sb						2.52E-06			2.52E-06
^{46}Sc								5.87E-11	5.87E-11
^{75}Se								1.41E-11	1.41E-11
^{75}Se			9.49E-06			4.37E-06			1.39E-05

Table 5.14 (continued)

Isotope	Stack								
	X-2026	X-3020	X-3039	X-7503	X-7911	X-7880	X-8915	Total minor sources	Total ORNL
^{113}Sn								1.15E-11	1.15E-11
^{119m}Sn								1.39E-10	1.39E-10
^{85}Sr								1.00E-08	1.00E-08
^{89}Sr	1.70E-07	6.05E-07			3.14E-06			1.89E-05	2.28E-05
^{89}Sr			1.29E-06	5.30E-09				3.34E-08	1.32E-06
^{90}Sr	1.70E-07	6.05E-07			3.14E-06			9.72E-04	9.76E-04
^{90}Sr			1.29E-06	5.30E-09		9.24E-06		3.44E-08	1.06E-05
^{179}Ta								5.95E-14	5.95E-14
^{182}Ta								3.23E-11	3.23E-11
^{99}Tc								9.87E-11	9.87E-11
^{99}Tc						2.21E-05			2.21E-05
^{125m}Te								1.20E-06	1.20E-06
^{129}Te								9.92E-12	9.92E-12
^{129m}Te								1.55E-11	1.55E-11
^{228}Th	1.69E-08	1.19E-08	7.31E-09	5.89E-10	6.83E-09	1.33E-06		3.19E-07	1.69E-06
^{229}Th								2.00E-10	2.00E-10
^{230}Th			3.73E-09	2.16E-10				4.89E-10	4.43E-09
^{230}Th	5.03E-10	1.87E-10			4.06E-09			4.67E-09	9.42E-09
^{232}Th	3.46E-10	8.79E-10			8.98E-09			3.53E-09	1.37E-08
^{232}Th			1.02E-06	5.94E-09		4.47E-06		1.56E-10	5.50E-06
^{234}Th								3.49E-05	3.49E-05
^{170}Tm								1.00E-09	1.00E-09
^{232}U								2.83E-12	2.83E-12
^{233}U								3.85E-12	3.85E-12
^{233}U						4.01E-07		7.05E-06	7.45E-06
^{234}U	1.13E-07							4.20E-07	5.33E-07
^{234}U		8.40E-08	8.67E-08	6.85E-09	3.14E-08	4.01E-07		7.06E-06	7.67E-06
^{235}U	1.04E-09							1.16E-04	1.16E-04
^{235}U		2.92E-09	1.08E-08	3.35E-10	5.13E-09	7.21E-07		4.52E-07	1.19E-06
^{236}U								1.23E-09	1.23E-09
^{236}U								5.03E-07	5.03E-07
^{238}U	8.04E-10							6.77E-04	6.77E-04
^{238}U		7.48E-09	3.25E-08	4.88E-10	1.01E-08	7.24E-07		8.53E-07	1.63E-06
^{181}W								1.19E-11	1.19E-11
^{185}W								3.57E-08	3.57E-08
^{188}W								5.65E-08	5.65E-08
^{125}Xe							4.37E+00		4.37E+00
^{127}Xe							5.77E+00	3.98E-09	5.77E+00
^{129m}Xe								4.65E-08	4.65E-08
^{131m}Xe					5.57E+01			6.09E-06	5.57E+01
^{133}Xe					5.23E+00			4.73E-04	5.23E+00
^{133m}Xe					2.05E+01			1.09E-03	2.05E+01
^{135}Xe					3.51E+01			3.97E-03	3.51E+01
^{135m}Xe					1.61E+01			1.13E-02	1.61E+01
^{137}Xe[d]					5.02E+01			5.12E-04	5.02E+01
^{138}Xe					8.87E+01			1.39E-02	8.87E+01
^{88}Y						7.00E-06			7.00E-06
^{91}Y								1.60E-08	1.60E-08
^{65}Zn						1.25E-05			1.25E-05
^{65}Zn								5.31E-11	5.31E-11
^{95}Zr						8.67E-06			8.67E-06
^{95}Zr								2.61E-08	2.61E-08

[a]1Ci = 3.7E+10 Bq.
[b]Cf-248 was used as a surrogate for ^{252}Cf.
[c]Kr-88 was used as a surrogate for ^{89}Kr.
[d]Xe-135 was used as a surrogate for ^{137}Xe.

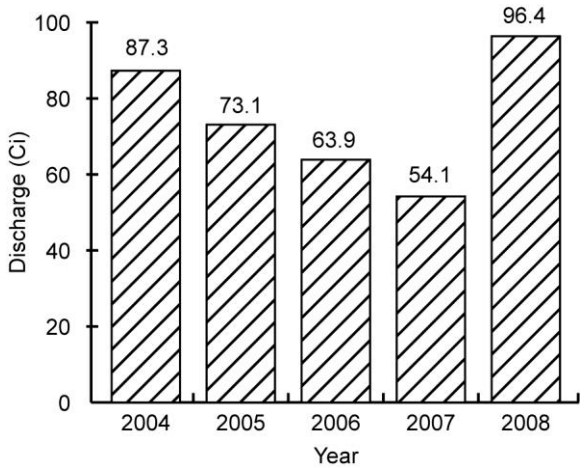


Fig. 5.13. Total discharges of ^{3}H from ORNL to the atmosphere, 2004–2008.

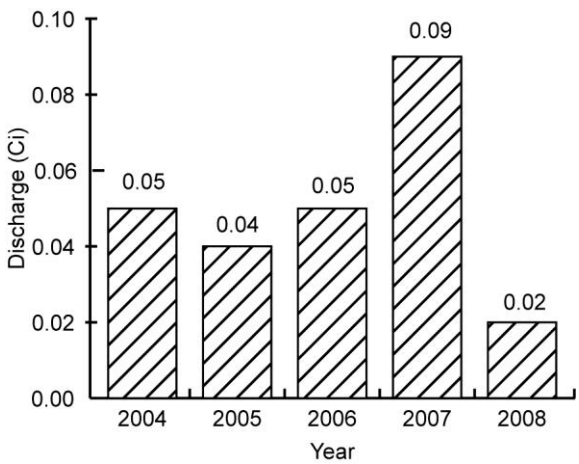


Fig. 5.14. Total discharges of ^{131}I from ORNL to the atmosphere, 2004–2008.

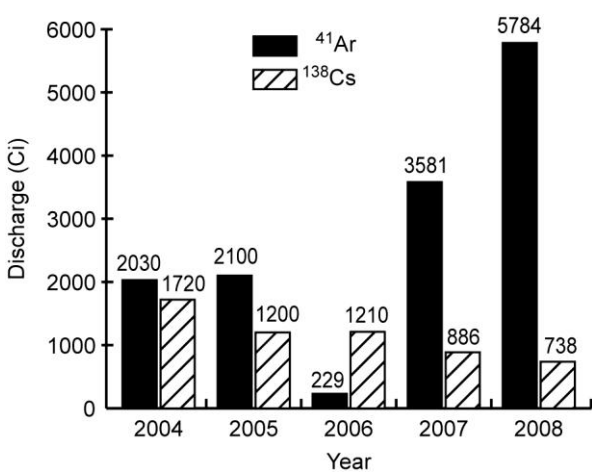


Fig. 5.15. Total discharges of ^{41}Ar and ^{138}Cs from ORNL to the atmosphere, 2004–2008.

Historical trends for tritium and ^{131}I are presented in Figs. 5.13 and 5.14, respectively. The tritium emissions for 2008 totaled approximately 96.4 Ci (Fig. 5.13), which is an increase from 2007. The ^{131}I emissions for 2008 totaled 0.02 Ci (Fig. 5.14), which is an 80% decrease from 2007 and the lowest it has been in the past 5 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. Emissions of ^{41}Ar result from HFIR operations and research activities. However, from 2001 to 2006, ^{138}Cs became the major contributor to the off-site ORNL plant dose because HFIR was down for an extended maintenance period and the installation of the Cold Neutron Source. Emissions of ^{138}Cs result from research activities in the Radiochemical Engineering Development Center, which also exhausts through the 7911 Melton Valley complex stack. In 2007 and 2008, HFIR was in full operation and completed several operating cycles, which resulted in ^{41}Ar once again becoming the major off-site dose contributor to the ORNL plant dose (approximately 61% in 2008). Cesium-138 contributed approximately 14% of the ORNL plant dose in 2008. The ^{41}Ar emissions for 2008 were 5,784 Ci; ^{138}Cs emissions were 738 Ci (Fig. 5.15). The calculated radiation dose to the maximally exposed off-site individual from all radiological airborne release points at ORNL during 2008 was 0.4 mrem. This dose is well below the NESHAP standard of 10 mrem and is less than 0.13 % of the 300 mrem that the average individual receives from natural sources of radiation. (See Sect. 7.1.2.1 for an explanation of how the airborne radionuclide dose was determined.)

5.4.4 Stratospheric Ozone Protection

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

5.4.5 Ambient Air

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 ORNL and to provide for emergency response capability. Four stations, identified as Stations 1, 2, 3, and 7 (Fig. 5.16) 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 5.15).

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 bi-weekly. 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.

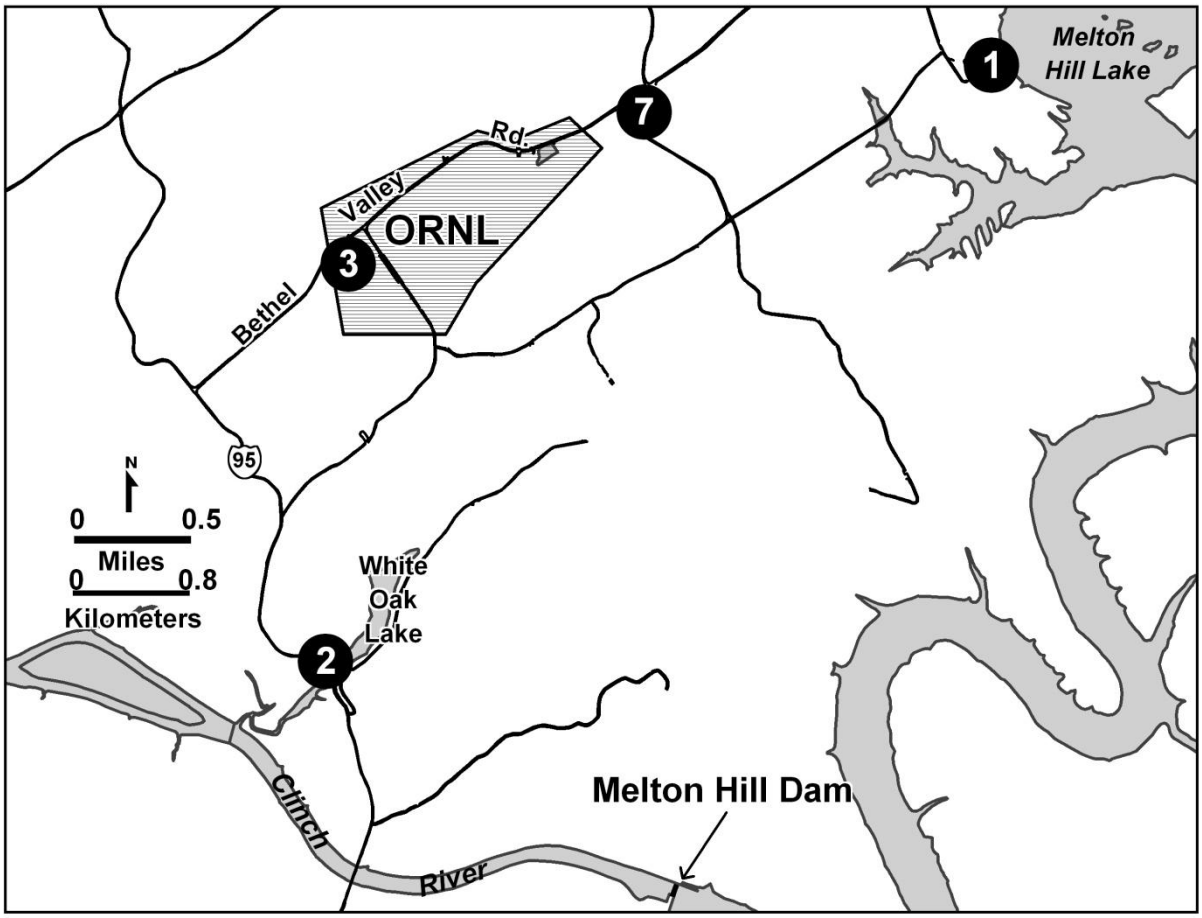


Fig. 5.16. Locations of ambient air monitoring stations at ORNL.

5.4.5.1 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 5.15) 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 DCGs in all cases.

Table 5.15. Radionuclide concentrations (pCi/mL)[a] measured at ORNL perimeter air monitoring stations, 2008

Parameter	No. detected/ sampled	Concentration		
		Average	Minimum	Maximum
		Station 1		
Alpha	1/1	5.6E-09	*b*	*b*
^{7}Be	1/1	2.6E-08	*b*	*b*
Beta	1/1	1.9E-08	*b*	*b*
^{3}H	0/4	6.9E-08	-1.7E-06	1.3E-06
^{40}K	28/28	2.7E-07	1.3E-07	5.3E-07
^{234}U	1/1	6.7E-12	*b*	*b*
^{235}U	0/1	2.2E-13	*b*	*b*
^{238}U	1/1	9.0E-12	*b*	*b*
Total uranium	1/1	1.6E-11	*b*	*b*
		Station 2		
Alpha	1/1	5.0E-10	b	*b*
^{7}Be	1/1	2.2E-08	b	*b*
Beta	1/1	1.9E-08	b	*b*
^{3}H	2/4	2.9E-06	-1.4E-07	9.7E-06
^{40}K	28/28	3.1E-07	1.3E-07	5.7E-07
^{234}U	1/1	5.3E-12	b	*b*
^{235}U	0/1	9.4E-13	*b*	*b*
^{238}U	1/1	5.0E-12	*b*	*b*
Total uranium	1/1	1.1E-11	*b*	*b*
		Station 3		
Alpha	1/1	1.8E-09	*b*	*b*
^{7}Be	1/1	2.1E-08	*b*	*b*
Beta	1/1	1.9E-08	*b*	*b*
^{3}H	0/4	7.1E-08	-2.8E-06	3.5E-06
^{40}K	28/28	3.2E-07	1.1E-07	1.2E-06
^{234}U	1/1	6.6E-12	*b*	*b*
^{235}U	0/1	4.2E-13	*b*	*b*
^{238}U	1/1	7.0E-12	*b*	*b*
Total uranium	1/1	1.4E-11	*b*	*b*
		Station 7		
Alpha	1/1	1.4E-09	*b*	*b*
^{7}Be	1/1	2.2E-08	*b*	*b*
Beta	1/1	2.1E-08	*b*	*b*
^{3}H	0/4	1.1E-06	-1.5E-07	2.9E-06
^{40}K	28/28	1.9E-07	1.7E-07	4.8E-07
^{234}U	1/1	6.4E-12	*b*	*b*
^{235}U	1/1	1.4E-12	*b*	*b*
^{238}U	1/1	7.1E-12	*b*	*b*
Total uranium	1/1	1.5E-11	*b*	*b*

[a]1 pCi 3.7×10^{-2} Bq.
[b]Not applicable.

5.5 Water Quality Program

5.5.1 NPDES/Surface Water

5.5.1.1 NPDES Permit Monitoring

ORNL's wastewater discharges are monitored and regulated under NPDES Permit TN0002941, which was renewed by TDEC on July 1, 2008, and became effective on August 1, 2008. The permit includes 168 separate outfalls and monitoring points, including 3 outfalls at the TWPC facility, and includes NPDES permit conditions and monitoring requirements for effluents from the SNS facility that were previously established in a separate NPDES permit for the SNS site (TN0077895). The NPDES permit for the SNS site was terminated when permit for the overall ORNL site was renewed in July 2008. Table 5.16 includes SNS NPDES compliance information from January through July 2008, the time at which the SNS permit was terminated. ORNL NPDES compliance information, including that for the SNS facility that was gathered from July through December 2008, is included in Table 5.17. Compliance information for the ORNL site from January through July 2008, excluding the SNS facility, is described in Table 5.18.

Table 5.16. National Pollutant Discharge Elimination System (NPDES) compliance at Spallation Neutron Source, 2008

NPDES permit effective December 1, 2003 through July 31, 2008

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	61	100
Total residual chlorine			0.011	0.019		0	61	100

[a]Percentage compliance 100 – [(number of noncompliances/number of samples) H 100].

Table 5.17. National Pollutant Discharge Elimination System (NPDES) compliance at ORNL, 2008

(NPDES permit effective August 1, 2008)

Effluent parameters	Permit limits					Permit compliance		
	Monthly average (lbs/d)	Daily max. (lbs/d)	Monthly average (mg/L)	Daily max. (mg/L)	Daily min. (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance[a]
X01 (Sewage Treatment Plant)								
LC_{50} for *Ceriodaphnia* (%)					69.4	0	2	100
LC_{50} for fathead minnows (%)					69.4	0	2	100
Ammonia, as N (summer)	6.26	9.39	2.5	3.75		0	40	100
Ammonia, as N (winter)	13.14	19.78	5.25	7.9		0	56	100
Carbonaceous BOD	19.2	28.8	10	15		0	93	100
Dissolved oxygen					6	0	93	100
Escherichia coliform (col/100 mL)			941	126		0	93	100
IC_{25} for *Ceriodaphnia* (%)					12.3	0	2	100

Table 5.17. (Continued)

Effluent parameters	Permit limits					Permit compliance		
	Monthly average (lbs/d)	Daily max. (lbs/d)	Monthly average (mg/L)	Daily max. (mg/L)	Daily min. (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance[a]
IC_{25} for fathead minnows (%)					12.3	0	2	100
Oil and grease	19.2	28.8	10	15		0	93	100
pH (std. units)				9	6	0	93	100
Total suspended solids	57.5	86.3	30	45		0	93	100
X02 (Coal Yard Runoff Treatment Facility)								
pH (std. units)				9.0	6	0	30	100
Total suspended solids				50		0	30	100
X12 (Process Waste Treatment Complex)								
LC_{50} for *Ceriodaphnia* (%)					100	0	1	100
LC_{50} for fathead minnows (%)					100	0	1	100
Arsenic, total			0.007	0.014		0	4	100
Cadmium, total	1.73	4.60	0.003	0.038		0	4	100
Chromium, total	11.40	18.46	0.22	0.44		0	4	100
Copper, total	13.8	22.53	0.07	0.11		0	4	100
Cyanide, total	4.33	8.00	0.008	0.046		0	2	100
Lead, total	2.87	4.60	0.028	0.69		0	4	100
IC_{25} for *Ceriodaphnia* (%)					30.9	0	1	100
IC_{25} for fathead minnows (%)					30.9	0	1	100
Oil and grease	66.7	100	10	15		0	5	100
pH (std. units)				9.0	6.0	0	22	100
Temperature (ºC)				30.5		0	22	100
Instream chlorine monitoring points								
Total residual oxidant			0.011	0.019		0	120	100

[a]Percentage compliance 100 – [(number of noncompliances/number of samples) * 100].

Abbreviations

LC_{50} the concentration (as a percentage of full-strength wastewater) that kills 50% of the test species in 48 h.

BOD biological oxygen demand.

IC_{25} inhibition concentration; the concentration as a percentage of full-strength wastewater that caused 25% reduction in survival, reproduction, or growth of the test organisms.

Table 5.18. National Pollutant Discharge Elimination System (NPDES) compliance at ORNL, 2008
NPDES permit effective February 3, 1997 through July 31, 2008

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]
X01 (Sewage Treatment Plant)								
LC_{50} for *Ceriodaphnia* (%)					41.1	0	2	100
LC_{50} for fathead minnows (%)					41.1	0	2	100
Ammonia, as N (summer)	2.84	4.26	2.5	3.75		0	40	100
Ammonia, as N (winter)	5.96	8.97	5.25	7.9		0	56	100
Carbonaceous BOD	8.7	13.1	10	15		0	93	100
Dissolved oxygen					6	0	93	100
Fecal coliform (col/100 mL)			1000	5000		0	93	100
NOEC for *Ceriodaphnia* (%)					12.3	0	2	100
NOEC for fathead minnows (%)					12.3	0	2	100
Oil and grease	8.7	13.1	10	15		0	93	100
pH (std. units)				9	6	0	93	100
Total residual chlorine			0.038	0.066		0	93	100
Total suspended solids	26.2	39.2	30	45		0	93	100
X02 (Coal Yard Runoff Treatment Facility)								
LC_{50} for *Ceriodaphnia* (%)					4.2	0	2	100
LC_{50} for fathead minnows (%)					4.2	0	2	100
Copper, total			0.07	0.11		2[b]	14	86
Iron, total			1.0	1.0		3[c]	14	79
NOEC for *Ceriodaphnia* (%)					1.3	0	0[d]	100
NOEC for fathead minnows (%)					1.3	0	0[d]	100
Oil and grease			10	15		0	30	100
pH (std. units)				9.0	6	0	30	100
Selenium, total			0.22	0.95		0	14	100
Silver, total				0.008		1[e]	14	93
Total suspended solids				50		0	30	100
Zinc, total			0.87	0.95		0	14	100

Table 5.18 (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 *Ceriodaphnia* (%)					100	0	2	100
LC_{50} for fathead minnows (%)					100	0	2	100
Cadmium, total	0.79	2.09	0.008	0.034		0	31	100
Chromium, total	5.18	8.39	0.22	0.44		0	31	100
Copper, total	6.27	10.24	0.07	0.11		0	31	100
Cyanide, total	1.97	3.64	0.008	0.046		0	3	100
Lead, total	1.3	2.09	0.028	0.69		0	31	100
Nickel, total	7.21	12.06	0.87	3.98		0	31	100
NOEC for *Ceriodaphnia* (%)					30.9	0	2	100
NOEC for fathead minnows (%)					30.9	0	2	100
Oil and grease	30.3	45.4	10	15		0	31	100
pH (std. units)				9.0	6.0	0	93	100
Silver, total	0.73	1.3		0.008		0	31	100
Temperature (ºC)				30.5		0	93	100
Total toxic organics		6.45		2.13		0	7	100
Zinc, total	4.48	7.91	0.87	0.95		0	31	100
Instream chlorine monitoring points								
Total residual oxidant			0.011	0.019		0	154	100
Steam condensate outfalls								
pH (std. units)				9.0/8.5	6.0/6.5	0	9	100
Groundwater/pumpwater outfalls								
pH (std. units)				9.0/8.5	6.0/6.5	0	3	100
Cooling tower blowdown outfalls								
pH (std. units)				9.0	6.0	0	3	100
Category I outfalls								
pH (std. units)				9.0	6.0	0	3	100
Category II outfalls								
pH (std. units)				9.0	6.0	0	9	100
Category III outfalls								
pH (std. units)				9.0	6.0	0	39	100
Category IV outfalls								
pH (std. units)				9.0	6.0	0	192	100

Table 5.18 (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]
Cooling tower blowdown/cooling water outfalls								
pH (std. units)				9.0	6.0	0	14	100
Total residual oxidant			0.011	0.019		0	28	100

[a]Percentage compliance 100 – [(number of noncompliances/number of samples) * 100].

[b]The copper measurement from February 2, 2008, resulted in a daily max. concentration exceedance and an average monthly concentration exceedance.

[c]The iron measurement from February 2, 2008 resulted in a daily max. concentration exceedance. The iron measurement from July 16, 2008 resulted in a daily max. concentration exceedance and an average monthly concentration exceedance.

[d]Insufficient discharge for chronic test and determination of no-observed-effect concentration for each of the quarterly tests.

[e]The silver measurements from July 10, 2008, and July 16, 2008, resulted in an average monthly concentration exceedance.

Abbreviations

LC_{50} the concentration (as a percentage of full-strength wastewater) that kills 50% of the test species in 96 h.

BOD biological oxygen demand.

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.

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 their discharge into receiving waters or before being mixed with any other wastewater stream (see Fig. 5.17). Under the existing permit, there are numeric and narrative effluent limits applied at the following locations:

- X01—Sewage Treatment Plant;
- X02—SSPWTF;
- X12—Process Waste Treatment Complex (PWTC);
- X13—Melton Branch (MB1);
- X14—White Oak Creek (WOC);
- X15—White Oak Dam (WOD);
- instream chlorine monitoring points (X16–X27); and
- Category outfalls (storm drains, water discharged under best management practices, groundwater, water condensate, cooling water, cooling tower blowdown, and other facility wastewaters).

Instream 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.

DOE is required by Part IV of the new ORNL NPDES permit to develop and implement a water quality protection plan (WQPP). The WQPP, which was implemented in January 2009, functionally replaces several monitoring plans that were required by the previous NPDES permit, including the Biological Monitoring and Abatement Program (BMAP), Chlorine Control Strategy, *Non-Storm Water Best Management Practices Plan*, *Radiological Monitoring Plan*, and *Storm Water Pollution Prevention*

Plan (SWP3). The WQPP also includes a monitoring program for category outfalls, which were previously included in specific permit requirements.

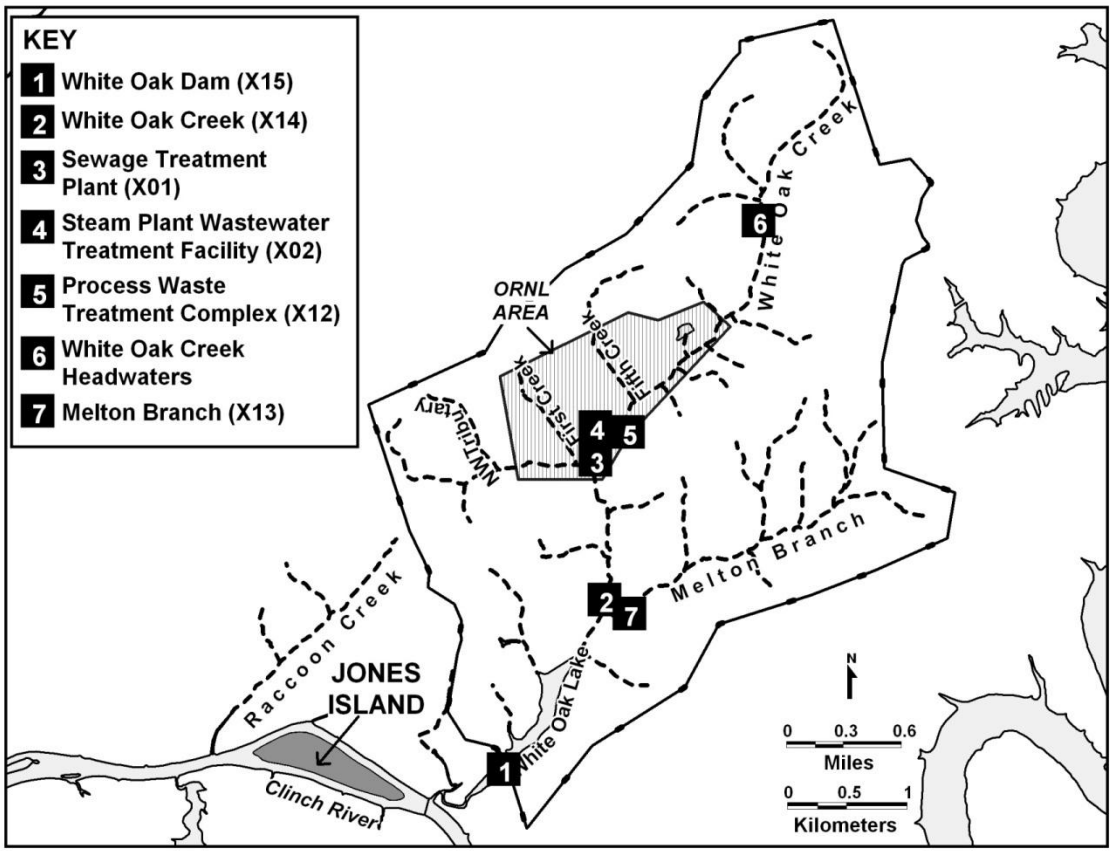


Fig. 5.17. ORNL surface water, National Pollutant Discharge Elimination System and reference sampling locations.

The WQPP is composed of two volumes. Volume 1 describes the policies and actions, or best management practices that will be implemented to protect the quality of aquatic and riparian resources on the ORNL site. Volume 2 contains descriptions of effluent monitoring, ambient water quality monitoring, and biological community monitoring that will be implemented to monitor the effectiveness of the best management practices and other water quality protection efforts, and to ultimately lead to improvements to water quality. The WQPP is organized in this manner to make the best management practices volume a more compact and practical resource for managers of ORNL facilities and others who are involved in activities that have a potential to impact water quality. The WQPP will be fully implemented in 2009.

5.5.1.2 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 weekly, semimonthly, or quarterly. Numerous outfalls with no 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 1.2 gram per day action level specified in the permit.

Compliance with the action level is calculated by multiplying the instantaneously measured concentration by the instantaneous flow rate of the outfall.

UT-Battelle monitored 192 measurable dry-weather discharges during 2008 at 31 ORNL outfalls. The action level was exceeded a total of 15 times across five outfalls. A report detailing monitoring results, corrective actions, and proposed modifications is submitted to TDEC annually.

5.5.1.3 Storm Water Pollution Prevention

The ORNL NPDES Permit requires an SWP3 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 revised in 2008 but due to the reissuance of the ORNL NDPES Permit, which became effective August 1, 2008, SWP3 activities have been significantly revised since then and included in the WQPP, which was implemented on January 1, 2009. Information on the WQPP and associated monitoring activities will be included in the *ORR Annual Site Environmental Report for 2009*.

Under the SWP3, storm water outfalls were grouped into four broad categories based on common land uses or pollutant sources and storm water pollutant potential. The four groups were further subdivided based on permit categorizations that have different monitoring schedule requirements. The former permit required 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 sampled in 2008 were chosen to represent a group or were considered to be more vulnerable to runoff pollution. Other factors considered in selecting representative outfalls from each group included interest in a particular runoff quality at an outfall and ease of obtaining a representative sample. A rotation of representative outfalls occurred each sampling period as directed by the permit. The results of the storm water outfall effluent sampling are provided in Attachment 5.0 of the SWP3. Various water-quality reference values were used to compare to ORNL storm water data collected under this SWP3 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 included report levels adopted by the TDEC Multi-Sector General Storm Water Permit for Industrial Activities, which are developed specifically for “sectors” or classifications of industrial activity. ORNL storm water data have been consistently lower than TDEC report levels for applicable sectors.

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 because 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 U.S. urban areas. Urban storm-water 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. A formal National Storm Water Quality Database (Version 1.1) was published in February 2004. This latest publication includes industrial median values that target land use components typical of industry. In a comparison of ORNL storm water data with data from the Nationwide Storm Water Quality Database, most values for the conventional storm water quality constituents measured are well below the Industrial EMCs. Patterns of values exceeding the industrial

EMCs can be generalized by elevations of copper, nitrate/nitrite, or zinc. Copper is natural 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 (e.g., fertilizers, organic decay). Zinc can be attributed to vehicular degradation. There were also a few elevated levels of suspended solids that can probably be attributed to the numerous and ongoing construction projects in and around the main ORNL campus.

5.5.1.4 Radiological Monitoring Plan

In 2008, UT-Battelle monitored specific radiological constituents at NPDES outfalls identified as having the potential to discharge radioactivity and at instream monitoring stations under the *Radiological Monitoring Plan*, which was implemented on November 1, 1999, per the ORNL NPDES Permit. Table 5.19 details the monitoring frequency and target analyses for 27 category outfalls (dry-weather component of discharge), 3 treatment facility outfalls, and 3 instream monitoring locations.

Category outfalls are outfalls that discharge effluents with relatively minor constituent levels and that receive little or no treatment prior to discharge. Dry-weather discharges from category outfalls are primarily cooling water, groundwater, and condensate. In 2008, dry-weather grab samples were collected at 19 of the 27 category outfalls. The remaining eight outfalls were not sampled due to various factors, including the absence of flow or discharge or the discontinued use of the outfall The three treatment facilities monitored in 2008 in conjunction with the *Radiological Monitoring Plan* included the Sewage Treatment Plant (STP), the SPWTF (formerly known as the Coal Yard Runoff Treatment Facility), and the Process Waste Treatment Complex (PWTC). Three instream monitoring locations were: X13 on Melton Branch, X14 on WOC, and X15 at WOD (Fig. 5.17). At each of the treatment facilities and instream monitoring stations, monthly flow-proportional composite samples were collected using dedicated automatic water samplers.

Expressing radioactivity concentrations as percentage of DOE DCG values is used in this section to compare different radiological contaminants and concentrations measured at NPDES sampling points. Annual average concentrations are compared with DCG values where applicable (there are no DCGs for gross alpha and gross beta activities) and when at least one measurement was greater than or equal to the minimum detectable activity (MDA). When analytical procedures 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. DCGs, which are intended to be used as thresholds for effluent discharges and not for instream comparisons, are nonetheless useful as a frame of reference for instream radiological constituent levels. In this section effluent and instream concentrations are compared to DCGs for human exposure to radiological contaminants via ingestion of water, but in practice ORNL effluents or ambient waters are not sources of drinking water.

In 2008, measured annual average concentrations of radioactivity exceeded 100% of DCG concentrations at one outfall -- outfall 302. The annual average $^{89/90}$Sr concentration was 1,400 pCi/L, or 1.4 times the DCG for ^{90}Sr. The annual average concentration of $^{233/234}$U was also notable at 120 pCi/L, or 24% of the DCG for ^{233}U and ^{234}U (the DCGs are the same for both isotopes). Elevated concentrations were first measured in the grab sample collected on February 7, 2008. In the February sample, the concentration of $^{89/90}$Sr was 11,000 pCi/L and the concentration of $^{233/234}$U was 430 pCi/L. The elevated concentrations were the result of a pump failure at Pump Station No. 1. The pump station is part of the process liquid waste management system and is located about ten feet from a portion of the stormwater pipe network that discharges at Outfall 302. Elevated water levels in the pump station vault, as a result of the pump failure, allowed water to escape the vault and seep via groundwater into the storm drain network. The pump was repaired within several days of the discovery of elevated radiological concentrations at the outfall; however, several months were required for concentrations to return to normal.

Table 5.19. 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[c]	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[c]	Annually		X					
Outfall 204	Quarterly	X	X			X		
Outfall 205[c]	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	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[e]	Annually		X	X				
Outfall 383	Annually		X		X			
Sewage Treatment Plant (X01)	Monthly	X	X	X[f]	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		
WOC (X14)	Monthly	X	X	X	X	X		
WOD (X15)	Monthly	X	X	X	X	X		

[a]Isotopic analyses are performed to identify contributors to gross activities when results exceed screening criteria described in the *Radiological Monitoring Plan*, June 1999.
[b]Outfall no longer exists.
[c]No discharge present.
[d]Physically removed in late 2004; eliminated as part of the HFIR ponds remediation project.
[e]No longer discharges (plugged).
[f]Added to the plan in January 2006.

In addition to outfall 302, the annual average concentration of at least one radionuclide exceeded 4% of the relevant DCG concentration in dry-weather discharges from four other NPDES outfalls (X01, X12, 085, and 304) and at instream sampling locations X13 and X15 (Fig. 5.18). 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 only a comparison point, and ORNL effluents and ambient waters are not direct

sources of drinking water). The annual average concentration of $^{89/90}$Sr in the ORNL STP Discharge (outfall X01) was 13% of the DCG. Concentrations of ^{137}Cs and tritium measured in the discharge from the PWTC (outfall X12) were greater than 4% of the DCG: ^{137}Cs (9.1%) and tritium (14%). Measured concentrations of parameters greater than 4% of applicable DCGs were also observed at outfalls 085 and 304. At outfall 085, $^{89/90}$Sr was 9.4% of the DCG; at outfall 304 $^{89/90}$Sr was 38%. At the instream monitoring station on Melton Branch (location X13), $^{89/90}$Sr was measured at 4.3% of the DCG, and at the X15 monitoring station at WOD, $^{89/90}$Sr was measured at 5.2% of the DCG.

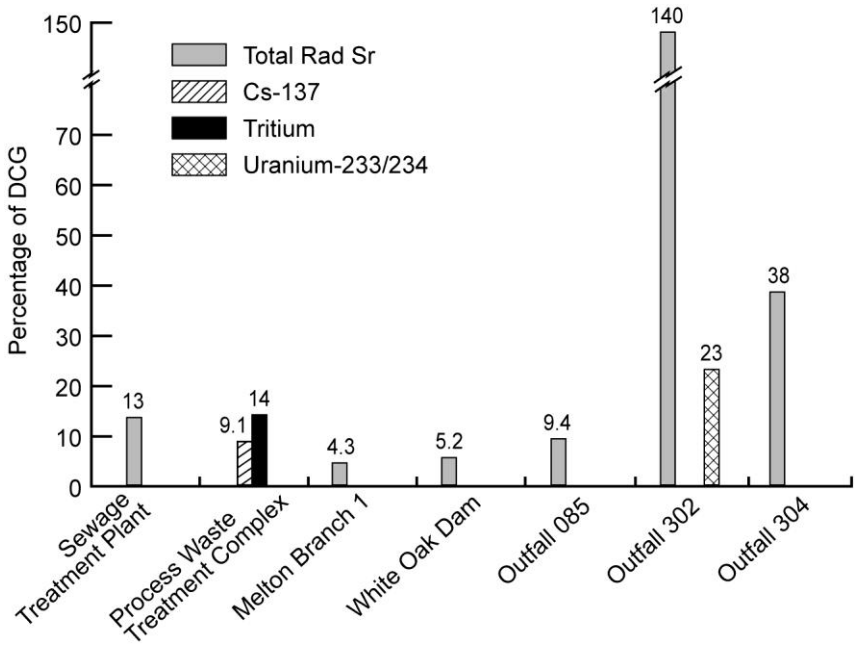


Fig. 5.18. Radionuclides at ORNL sampling sites having average concentrations greater than 4% of the relevant derived concentration guides in 2008

The total annual discharges of radioactivity measured in stream water at WOD, the final monitoring point on WOC before the stream flow leaves ORNL, were calculated from concentration and flow. Results of those calculations for each of the past 5 years are shown in Figs. 5.19 through 5.23. Discharges at White Oak Dam in 2008 continued to decline in comparison to the years preceding completion of the waste area caps in Melton Valley.

In 2008 the radiological monitoring also included monitoring at category outfalls during storm runoff conditions. A total of 10 storm water outfalls were monitored and analyzed for gross alpha, gross beta, and tritium. A gamma scan analysis was also performed. Additional analyses were performed when the gross alpha and/or gross beta activity levels in a sample indicated that DCG levels could be exceeded. In 2008, additional analyses were performed on samples from outfalls 204 and 341.

Of the 56 individual storm water sample results collected in 2008, 32 (57%) showed no detectable activity (measured activities 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: at outfall 204, $^{89/90}$Sr was measured at 45% of the DCG for ^{90}Sr. At outfall 341, $^{89/90}$Sr was measured at 65% of the DCG for ^{90}Sr, and $^{233/234}$U was measured at 30% of the DCG for ^{233}U and ^{234}U.

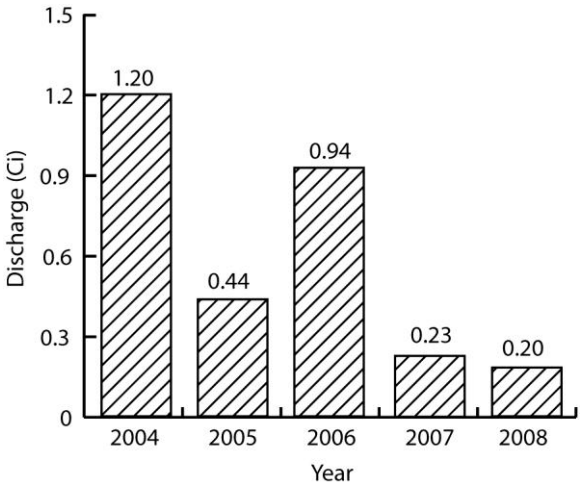


Fig. 5.19. Cesium-137 discharges at White Oak Dam, 2004–2008.

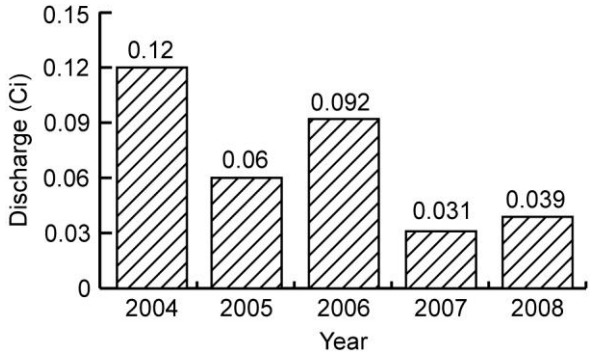


Fig. 5.20. Gross alpha discharges at White Oak Dam, 2004–2008.

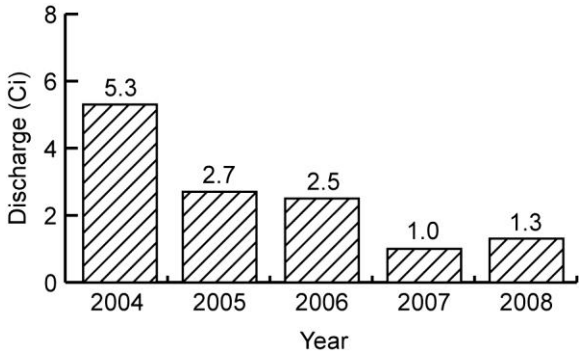


Fig. 5.21. Gross beta discharges at White Oak Dam, 2004–2008.

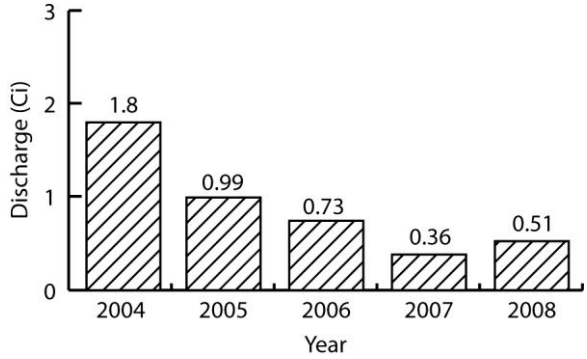


Fig. 5.22. Total radioactive strontium discharges at White Oak Dam, 2004–2008.

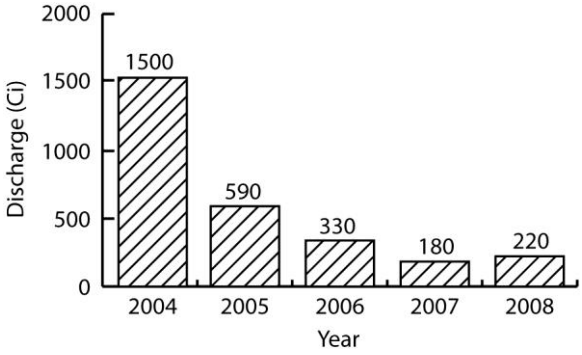


Fig. 5.23. Tritium discharges at White Oak Dam, 2004–2008.

5.5.1.5 Biomonitoring

Wastewaters from the STP, the SPWTF, and the PWTC were evaluated for toxicity during 2008 in accordance with NPDES requirements. The results of these toxicity tests are presented in Table 5.20, which includes the month the test was conducted, the concentration of wastewater that kills 50% of the test organisms (LC_{50}) for fathead minnows (*Pimephales promelas*) and daphnia (*Ceriodaphnia dubia*), the highest concentration that does not significantly reduce survival or growth of fathead minnows or survival or reproduction of *Ceriodaphnia* (the no-observed-effect concentration [NOEC]), and/or as applicable the concentration that inhibits survival, growth, or reproduction by 25% (IC_{25}). The NPDES permits defined the limits for the biomonitoring tests. For the outfall X01 (STP) discharge, toxicity in tests conducted prior to August 2008 (when a new NPDES permit became effective) was demonstrated if more than 50% lethality of the test organisms occurred in 96 h in 41.1% effluent (96 h LC_{50}) or if the NOEC was less than 12.3%. In STP tests conducted after August, toxicity was demonstrated if the 48 h LC_{50} was less than or equal to 69.4% effluent in any of four separate short-term (acute) tests conducted on wastewater samples collected at equal intervals over a 24 h period, or if the IC_{25} in longer-term (chronic) tests was less than or equal to 15.5%. For the outfall X02 discharge (SPWTF), toxicity in tests conducted prior to August was demonstrated if the LC_{50} was less than or equal to 4.2% effluent or if the NOEC was less than 1.3%. Because of the batch mode of discharge at the SPWTF, the limit for the NOEC applied only if the facility discharged for a sufficient length of time. Toxicity testing of the SPWTF was discontinued in the new NPDES permit. For the outfall X12 discharge (PWTC), toxicity in tests conducted prior to August was demonstrated if the 96-h LC_{50} was less than or equal to 100% effluent (LC_{50}) or if the NOEC was less than 30.9%. In PWTC tests conducted after August, toxicity was demonstrated if the 48-h LC_{50} was less than or equal to 100% effluent or if the IC_{25} was less than or equal to 30.5%.

During 2008, the STP and PWTC discharges were each tested for toxicity three times and the SPWTF was tested twice. Numeric biomonitoring limits in the NPDES permits were met in all cases.

5.5.1.6 Biological Monitoring and Abatement Program

The BMAP is a requirement of the ORNL NPDES Permit to assess the condition of aquatic life in WOC, the northwest tributary of WOC, Melton Branch, Fifth Creek, and First Creek. The results for bioaccumulation and macroinvertebrate and fish community studies in the WOC watershed for the BMAP in 2008 are summarized in the following sections.

5.5.1.6.1 Bioaccumulation Studies

The bioaccumulation task for the BMAP addresses two NPDES permit requirements at ORNL: (1) evaluate whether mercury at the site is contributing to a stream so that it will impact fish and aquatic life or violate the recreational criteria (instream water analyses for mercury are part of this activity), and (2) monitor the status of PCB contamination in fish tissue in the WOC watershed.

Mercury in Water. In continuation of a monitoring effort initiated in 1997, bimonthly water samples were collected from WOC at four sites in 2008. Stream conditions were selected to be representative of seasonal base-flow conditions (dry weather, clear flow) based on historical results that indicate higher mercury concentrations under these conditions.

The concentration of mercury in WOC upstream from ORNL was < 5 ng/L in 2008. Long-term trends in waterborne mercury in the WOC system downstream of ORNL are shown in Fig. 5.24. Waterborne mercury downstream of ORNL declined abruptly in 2008 as a result of rerouting highly contaminated sump water in Building 4505 to the Process Waste Treatment Complex (PWTC) in December 2007. The mean (± standard error [SE]) total mercury concentration at White Oak Creek kilometer (WCK) 4.1 was 22.5 ± 2.8 in 2008 compared with 108 ± 33 ng/L in 2007. The decrease was also apparent but less pronounced at WCK 3.4, with mercury averaging 18.4 ± 2.0 ng/L in 2008 vs 49 ± 23 ng/L in 2007. Similarly, the average mercury concentration in the White Oak Lake discharge was 29.9 ± 4.9 ng/L in 2008 compared with 45 ± 17 ng/L in 2007.

Bioaccumulation in Fish. In WOC, mercury and PCB concentrations in fish are at or near human health risk thresholds (e.g., EPA ambient water quality criteria [AWQC], TDEC fish advisory limits).

Mercury concentrations in fish collected in the WOC system (WCK 2.9, WCK 1.5) remained within historical ranges in 2008 (Fig. 5.25). Mercury concentrations in redbreast sunfish at WCK 3.9 (a site collected for the first time in 2007) averaged 0.47 µg/g in 2008. Mean PCB concentrations in fish continued to indicate the presence of upstream sources, with the redbreast sunfish samples from WOC (WCK 3.9) averaging 0.66 ± 0.28 µg/g PCBs, higher than the mean concentration of 0.26 ± 0.03 µg/g observed a kilometer downstream at WCK 2.9 and at WCK 1.5 (0.62 µg/g) for bluegill (Fig. 5.26).

Table 5.20. Toxicity test results of ORNL wastewaters, 2008

Test date	Test species	NOEC[a]/IC_{25}[b]	LC_{50}[c]
Sewage Treatment Plant (outfall X01)			
February	*Ceriodaphnia*	41.1	>41.1
	Fathead minnow	41.1	>41.1
June	*Ceriodaphnia*	41.1	>41.1
	Fathead minnow	41.1	>41.1
September/October	*Ceriodaphnia*	>100	>100
	Fathead minnow	>100	>100
Steam Plant Wastewater Treatment Facility (outfall X02)			
February	*Ceriodaphnia*	NA[d]	>4.2
	Fathead minnow	NA[d]	>4.2
June	*Ceriodaphnia*	NA[d]	>4.2
	Fathead minnow	NA[d]	>4.2
Process Waste Treatment Complex (outfall X12)			
February	*Ceriodaphnia*	100	>100
	Fathead minnow	100	>100
June	*Ceriodaphnia*	100	>100
	Fathead minnow	100	>100
September/October	*Ceriodaphnia*	>100	>100
	Fathead minnow	>100	>100

[a]NOEC 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. The NOEC applies to tests conducted prior to August 2008.

[b]IC_{25} the inhibition concentration causing a 25% reduction in survival, reproduction, or growth of the test organisms. The IC_{25} applies to tests conducted after August 2008.

[c]LC_{50} the concentration (as percentage of full-strength wastewater) that kills 50% of the test species in either 96 hours (tests conducted prior to August 2008) or 48 hours (tests conducted after August 2008).

[d]Insufficient duration of discharge for chronic test and determination of NOEC.

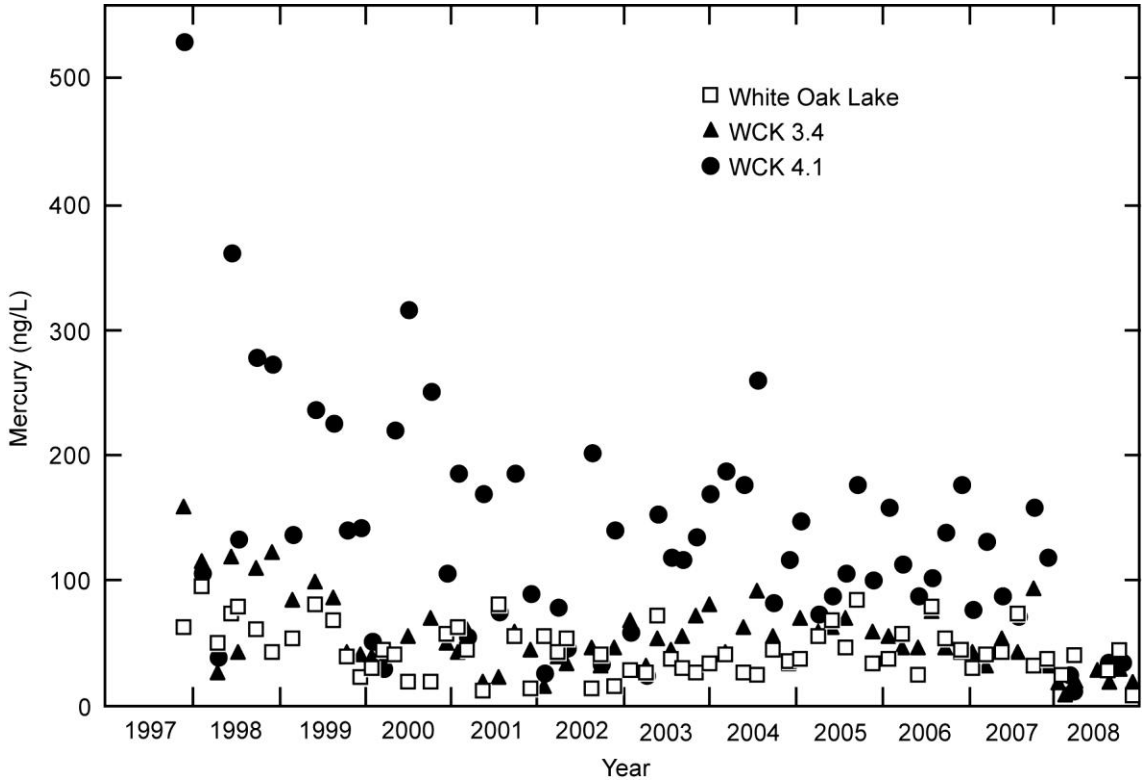


Fig. 5.24. Total aqueous mercury concentrations at sites in White Oak Creek downstream from ORNL, 1998-2008

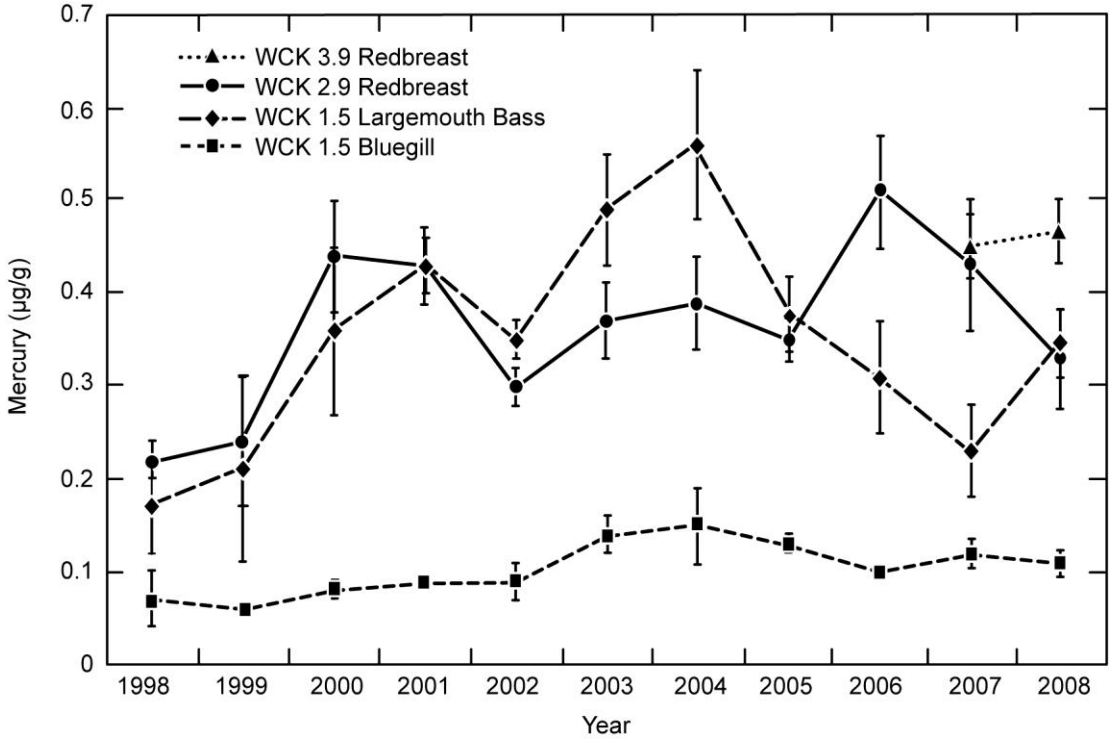


Fig. 5.25. Mean concentrations of mercury (µg/g, ± SE, N 6) in muscle tissue of sunfish and bass from WOC (WCK 2.9) and White Oak Lake (WCK 1.5), 1998–2008.

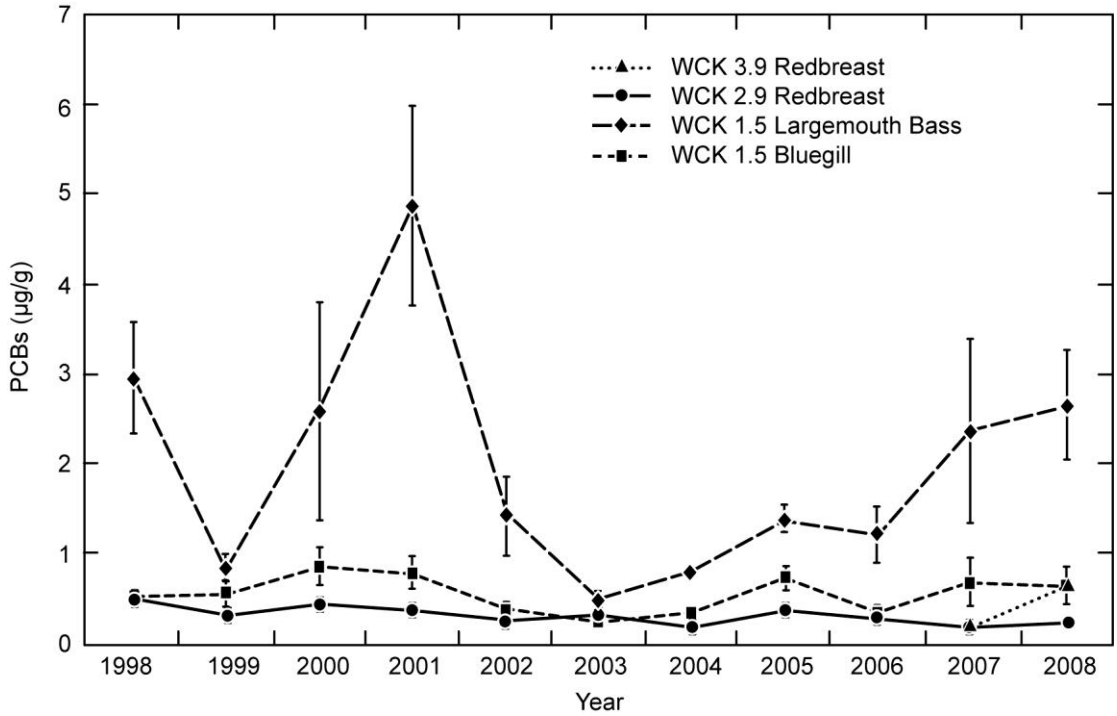


Fig. 5.26. Mean PCB concentrations (µg/g, ± SE N=6) in fish fillet collected from the WOC watershed, 1998–2008. (WCK WOC kilometer.)

Benthic Macroinvertebrate Communities

Monitoring of benthic macroinvertebrate communities in WOC, First Creek, and Fifth Creek continued in 2008. Additionally, monitoring of the macroinvertebrate community in lower Melton Branch continued under the Water Resources Restoration Program. Benthic macroinvertebrate samples are collected at sites upstream and downstream of the influence of ORNL operations; reference sites for WOC, First Creek and Fifth Creek are used as references for the Melton Branch site (Melton Branch kilometer [MEK] 0.6). 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 1987, but community characteristics indicate that ecological impairment remains (Figs. 5.27, 5.28, and 5.29). Total taxonomic richness (i.e., the number of different species per sample) and richness of the pollution-intolerant taxa (i.e., mayflies, stoneflies, and caddisflies or Ephemeroptera, Plectoptera, and Trichoptera [EPT] richness) continue to be lower at sites adjacent to and downstream of the main ORNL campus than at their respective reference sites. Prior to 2008, total and EPT taxa richness at downstream sites remained relatively stable, with the magnitude of annual changes being similar to those at the reference sites. However, the magnitude of reductions in both metrics in lower First Creek (First Creek kilometer [FCK] 0.1, Fig. 5.27) and lower Fifth Creek (FFK 0.2, Fig. 5.28) relative to their reference sites from 2007 and 2008 suggest that an additional stress may have been present. Long-term results from these sites show that changes between years can be considerable. Thus it is possible that the metric reductions in 2008 were just natural fluctuation. However, it is possible that several construction projects in each stream's catchment may be having short-term negative effects on macroinvertebrates through further alterations in storm water runoff and inputs of silt and sediment. Changes in the macroinvertebrate communities in lower WOC (WCK 3.9 and WCK 2.3, Fig. 5.29) and lower Melton Branch (MEK 0.6, Fig. 5.30) suggest that conditions remain stable in these streams. The

benthic macroinvertebrate community in lower Melton Branch (MEK 0.6) continues to show no evidence of discernible degradation based on total and EPT richness. However, abundances of invertebrates at that site are somewhat elevated compared with reference sites (data not shown), which is a common characteristic of streams with elevated concentrations of nutrients (i.e., nitrogen and phosphorus), either from direct (e.g., from effluent discharges or stormwater runoff from fertilized land) or indirect (e.g., inputs from nutrients naturally present in freshly disturbed soils).

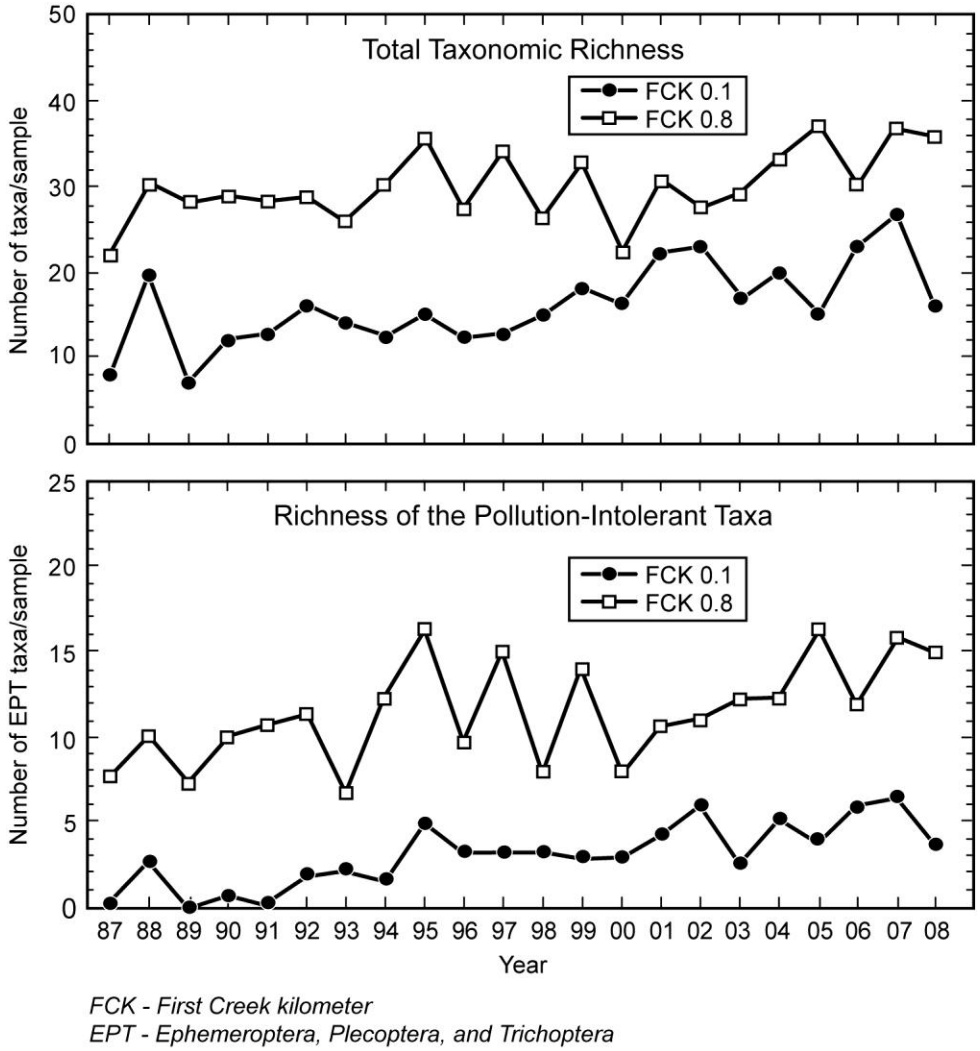
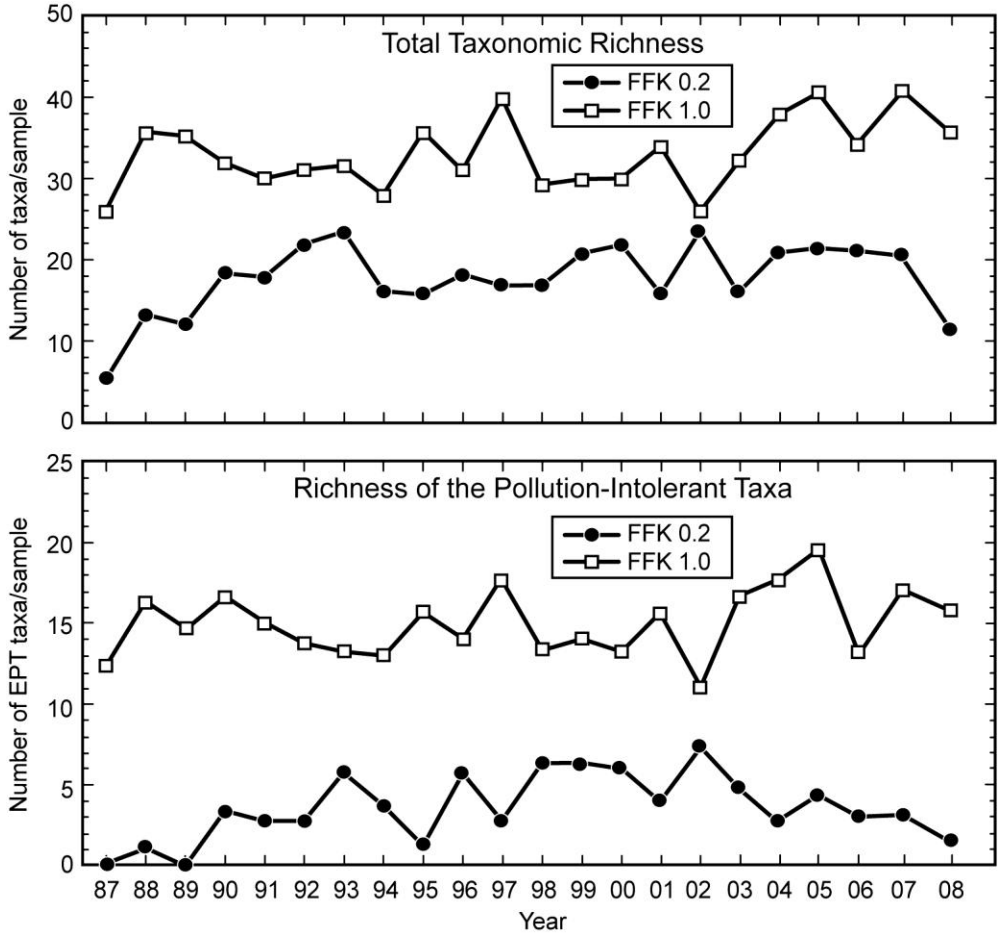
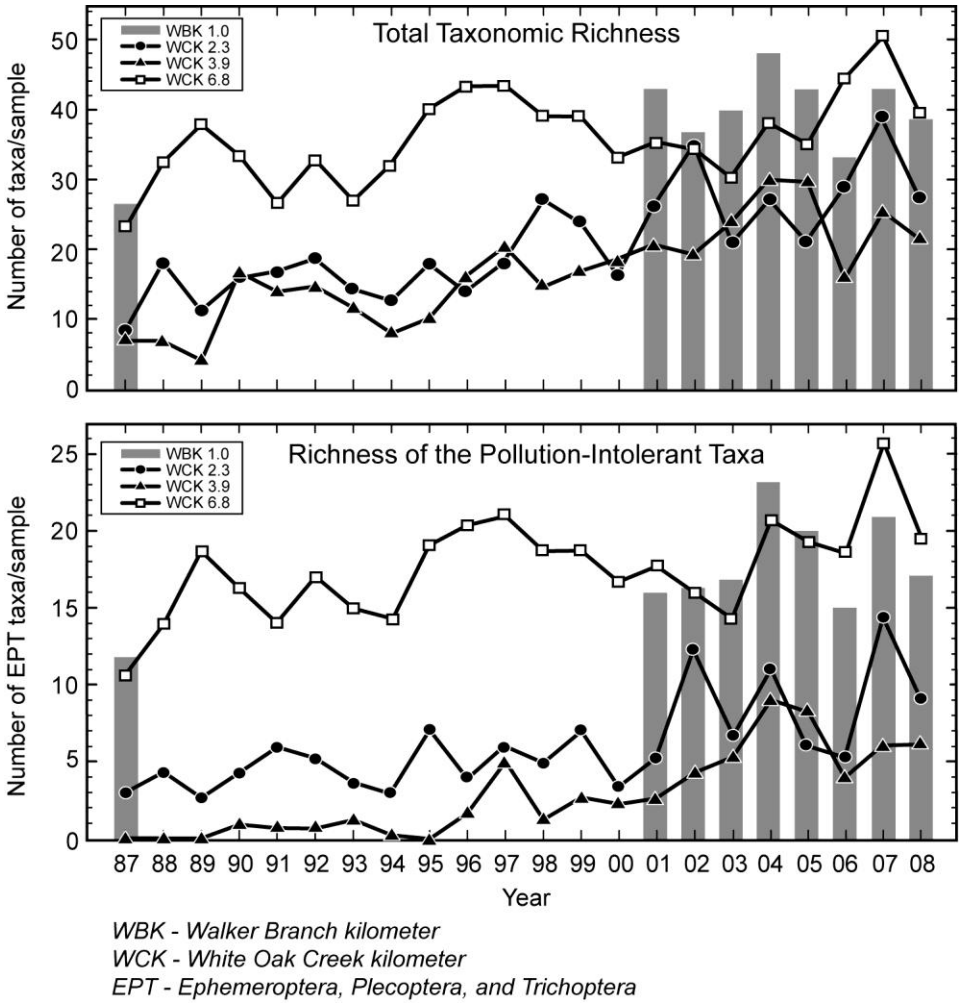


Fig. 5.27. Taxonomic richness (top) and richness of the pollution-intolerant taxa (bottom) of the benthic macroinvertebrate community in First Creek, April sampling periods, 1987−2008. FCK 0.8 is the reference site.
FCK First Creek kilometer
EPT Ephemeroptera, Plecoptera, and Trichoptera



FFK - Fifth Creek kilometer
EPT - Ephemeroptera, Plecoptera, and Trichoptera

Fig. 5.28. Taxonomic richness (top) and richness of the pollution-intolerant taxa (bottom) of the benthic macroinvertebrate community in Fifth Creek, April sampling periods, 1987−2008. FFK 1.0 is the reference site.



WBK - Walker Branch kilometer
WCK - White Oak Creek kilometer
EPT - Ephemeroptera, Plecoptera, and Trichoptera

Fig. 5.29. Taxonomic richness (top) and richness of the pollution-intolerant taxa (bottom) of the benthic macroinvertebrate communities in White Oak Creek, April sampling periods, 1987−2008 WBK 1.0 is the reference site.

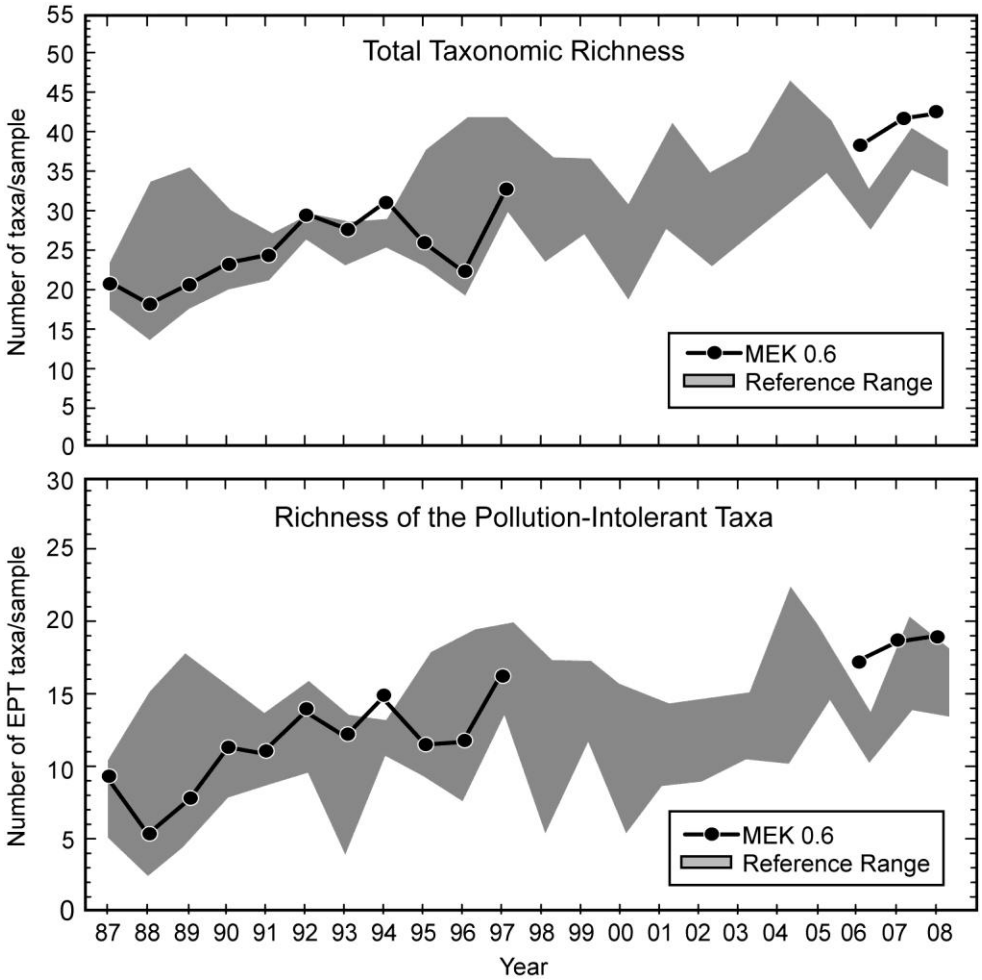


Fig. 5.30. Taxonomic richness (top) and richness of the pollution-intolerant taxa (bottom) of the benthic macroinvertebrate community in lower Melton Branch, April sampling periods, 1987−2008. The reference range delineates the minimum and maximum values for ORNL BMAP reference sites on First Creek, Fifth Creek, Melton Branch (1987–1997), Walker Branch (2001–2008), and White Oak Creek (1987–-2000).

MEK Melton Branch kilometer
EPT Ephemeroptera, Plecoptera, and Trichoptera.

Fish Communities

Monitoring fish communities in WOC and major tributaries continued in 2008. Fish samples were taken at 11 sites in the WOC watershed in the spring and fall. Streams located near or within the city of Oak Ridge were also sampled as reference sites: Mill Branch as a reference for smaller upstream locations within WOC and Brushy Fork as a reference for the larger downstream portions of WOC.

In WOC, the fish community continued to be degraded in 2008 compared with communities in reference streams, 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. Densities at WOC sites have generally stabilized over the past couple of years, with some minor variability. The fish communities in 2008 showed changes in species richness at each site. Historically there has been little change in species richness in the WOC watershed relative to off-site reference locations because of barriers that limit immigration of new species from the Clinch River. A project to introduce some of these missing species

into the watershed was initiated in 2008 and increased richness at 2 of the 3 monitoring sites (Fig. 5.31). The location where species richness declined was affected by episodic fish kills which may have influenced species to temporarily leave that section of the stream. A companion study also evaluated road crossings and in-stream structures within WOC to determine whether fish could openly move within the watershed. The study found there were numerous barriers to upstream fish movement which should be considered when evaluating stream recovery. The initial success of the introductions in WOC suggests that overall water quality has improved in the watershed over the past two decades.

Generally, the fish communities in tributary sites adjacent to and downstream of ORNL outfalls remained impacted in 2008 relative to reference streams or upstream sites (Figs. 5.32, 5.33 and 5.34). Species richness of fish in tributaries to WOC remained slightly lower in 2008 relative to reference streams not in the WOC watershed. The primary difference between these tributaries and reference streams is the absence of pollution-sensitive species, such as darters. The introduction of darters at one locale in Melton Branch as part of the species enhancement project has been successful initially, with survival and reproduction observed. The density of fish communities in First Creek and in Fifth Creek showed decreases in 2008 compared to 2007.

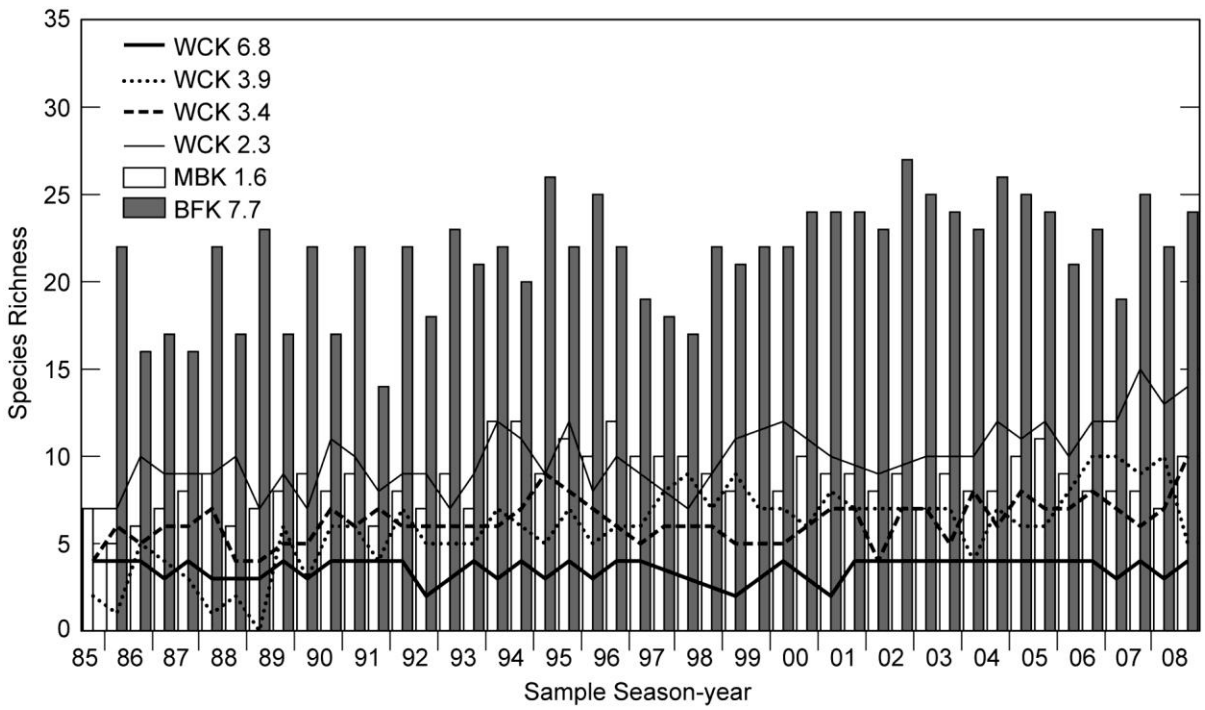


Fig. 5.31. Species richness for fish communities in spring and fall samples from White Oak Creek (WCK), and two reference sites, Mill Branch (MBK 1.6) and Brushy Fork (BFK 7.6), 1985–2008.

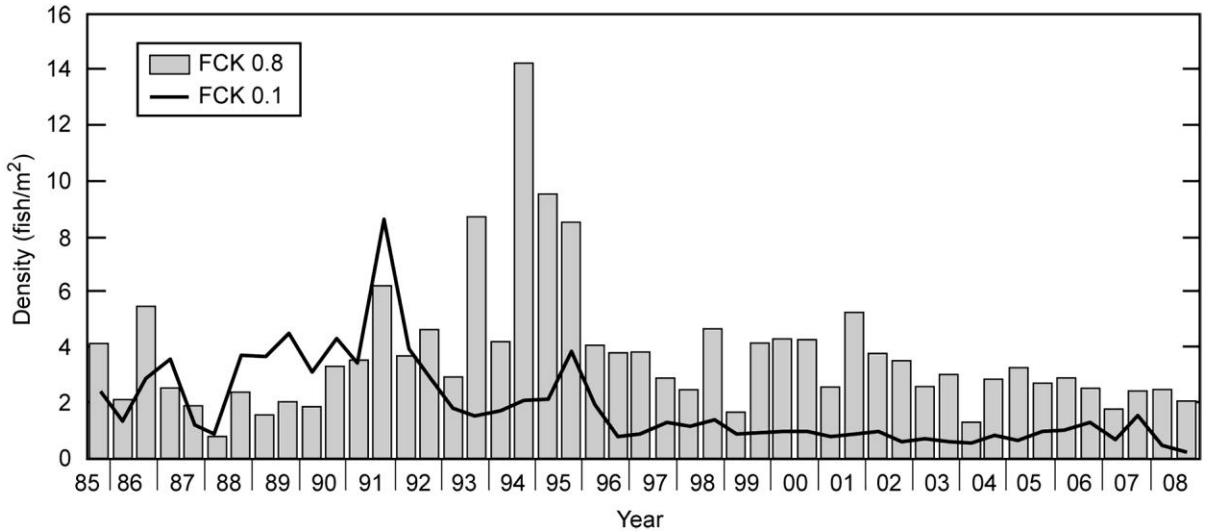


Fig. 5.32. Density (fish/m^2) estimates for fish in spring and fall samples from First Creek, 1985–2008. FCK 0.8 is the reference site.

FCK First Creek kilometer

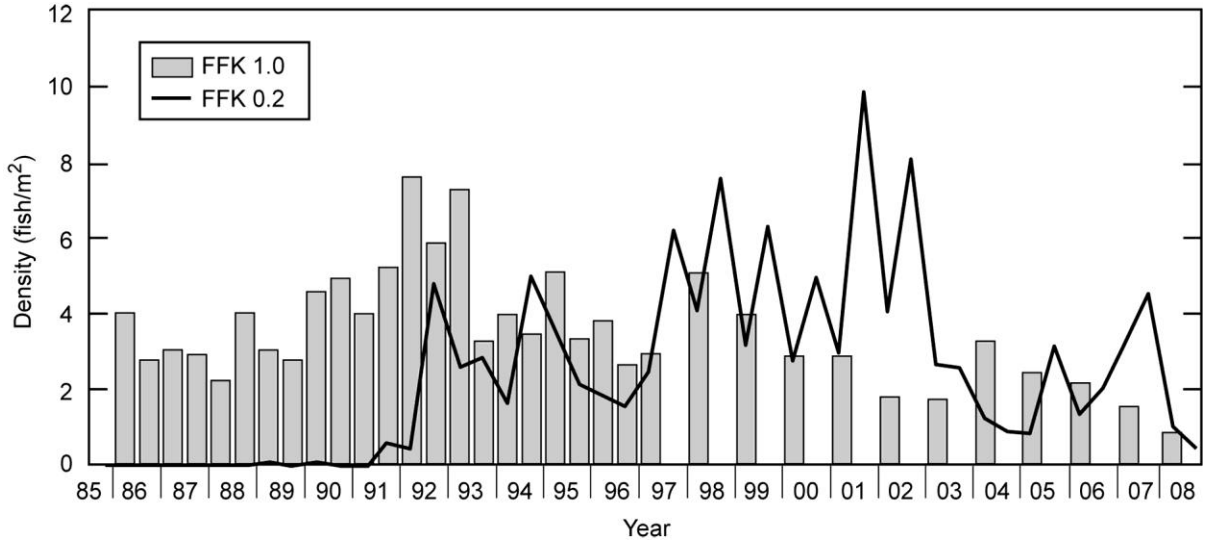


Fig. 5.33. Density (fish/m^2) estimates for fish in spring and fall samples from Fifth Creek, 1985–2008. FFK 1.0 is the reference site.

FFK Fifth Creek kilometer

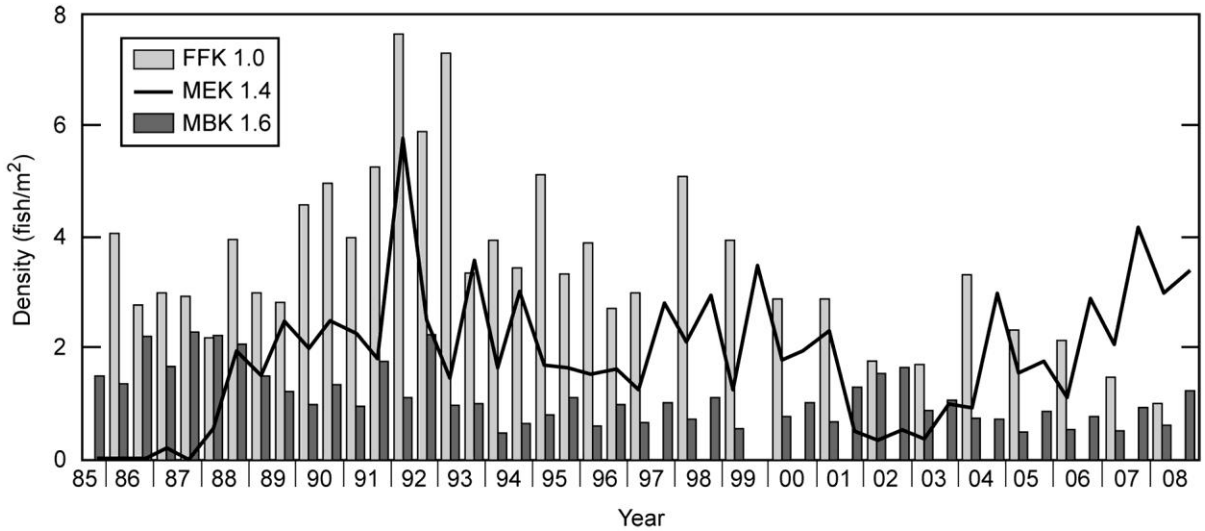


Fig. 5.34. Density (fish/m^2) estimates for fish in spring and fall samples from Melton Branch, 1985–2008. MEK 1.4, FFK 1.0, and MBK 1.6 are reference sites.

MEK Melton Branch kilometer
FFK Upper Fifth Creek kilometer
MBK Mill Branch kilometer

5.5.2 Surface Water Monitoring at NPDES Reference Location

WOC headwaters were monitored in 2008 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 nonradiological surface water quality, Tennessee general water quality criteria (TDEC 2008) 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 in *Environmental Monitoring on the Oak Ridge Reservation: 2008 Results* [DOE 2009b] for surface water analyses.)

5.5.3 Sanitary Wastewater

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 nonhazardous biodegradable wastes, such as scintillation fluids. The effluent stream from the sewage treatment plant is ultimately discharged into WOC through an NPDES-permitted outfall (X-01). 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 2008 because the plant was undergoing an expansion project. During 2008, ORNL's sewage sludge was dried and handled as solid LLW. Shipments of sludge to the city of Oak Ridge may resume in 2009.

TWPC holds a state operating permit for sewage holding tanks, which are emptied and the sanitary wastewater taken for processing at an off-site sewage treatment plant.

5.5.4 Storm Water Protection Permits

Storm water discharges associated with construction activities that disturb 0.4 ha 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 and if appropriate erosion-control measures are identified.

In 2008, ORNL had six 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, the ORNL 24-Inch Water Line Replacement Project, a project to decommission and demolish specific excess buildings, the Pro2Serve Facility construction, and the West Campus Improvement Project.

5.5.5 Aquatic Resources Protection

The Army Corps of Engineers, The Tennessee Valley Authority (TVA), and TDEC conduct permitting programs for projects and activities that could affect aquatic resources, including navigable waters, surface waters (including tributaries), and wetlands. The permits include Corps of Engineers Sect. 404 dredge-and-fill permits, TDEC aquatic resource alteration permits (ARAPs), and TVA 26A approvals.

ORNL had one active ARAP in 2008, for the West Campus Improvements Project, which includes removal of an existing pedestrian bridge and steam pipe over First Creek and replacement of the pedestrian bridge.

5.5.6 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 on the ORR implements a site-specific plan. This section of the CWA was significantly amended by the Oil Pollution Act of 1990, which has a primary objective of improving 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 countermeasures plans (SPCCs), including how the plans are prepared, reviewed, and certified and the information that must be included in the plans. The ORNL SPCC was revised in September 2007, including incorporation of the new EPA requirements. A separate SPCC plan was prepared for the NTRC, an off-site facility in Knox County that now stores sufficient oil to require a plan. The NTRC SPCC plan was put into effect on September 15, 2008.

5.5.7 ORNL Surface Water Surveillance Monitoring

The ORNL surface water monitoring program includes sample collection and analysis from 12 locations at ORNL and around the ORR. This program is conducted in conjunction with the ORR surface water monitoring activities discussed in Sect. 6.4 to enable assessing the impacts of past and current DOE operations on the quality of local surface water. Sampling locations include streams downstream of ORNL waste sources, and reference points on streams and reservoirs upstream of waste sources (see Fig. 5.35).

Sampling frequency and parameters vary by site. Grab samples are collected and analyzed for general water quality parameters and are screened for radioactivity at all locations. Samples are further analyzed for specific radionuclides when general screening levels are exceeded. Samples from WOL at WOD are also checked for VOCs, PCBs, and metals. Table 5.21 lists sampling locations, frequencies and parameters.

Four of the 12 sampling locations are classified by the state of Tennessee for freshwater fish and aquatic life. Tennessee water quality criteria associated with these classifications are used as references where applicable (TDEC 2008). 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.

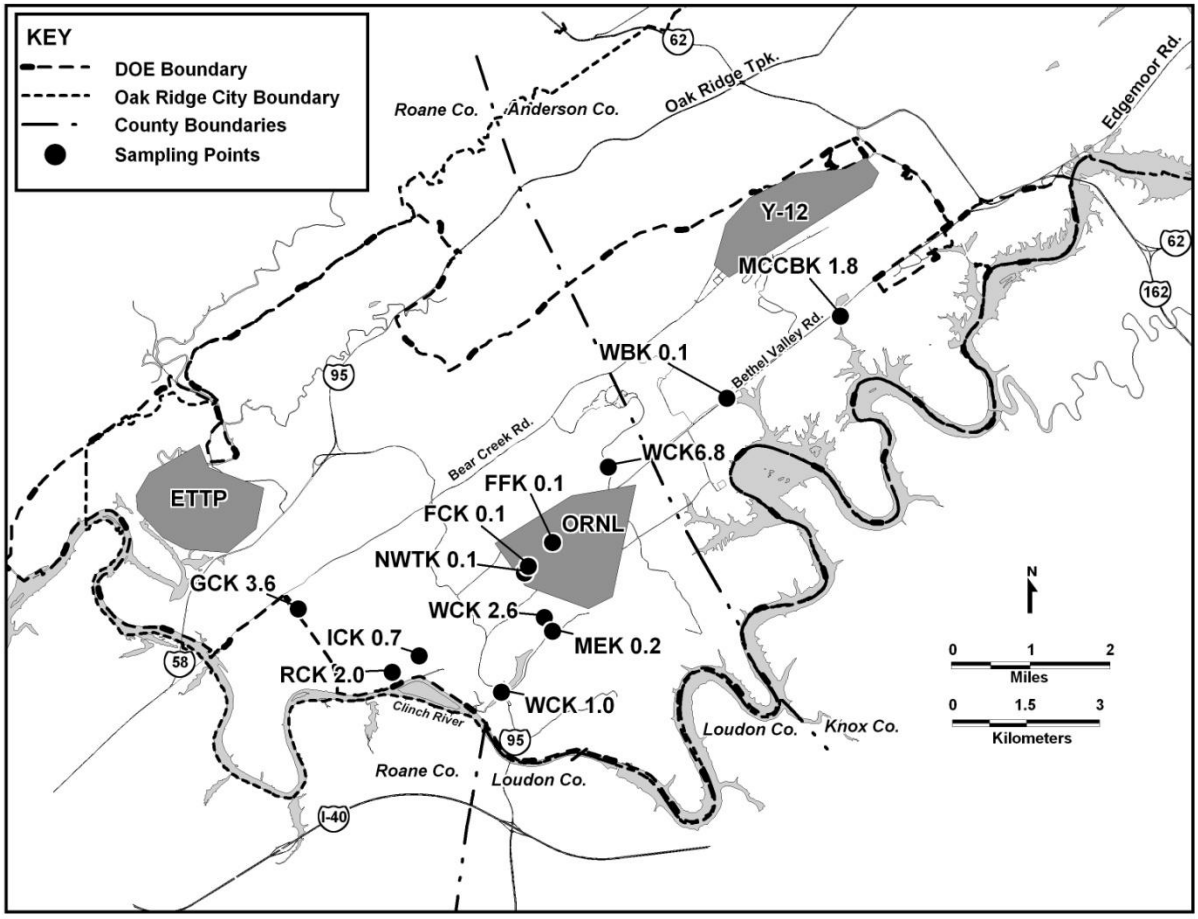


Fig. 5.35. ORNL surface water sampling locations.

Table 5.21. ORNL surface water sampling locations, frequencies, and parameters, 2008

Location[a]	Description	Frequency	Parameters
MEK 0.2	Melton Branch downstream from ORNL	Bimonthly (Jan., March, May, July, Sept., 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 (WOC) downstream from ORNL	Bimonthly (Jan., March, May, July, Sept., Nov.)	Gross alpha, gross beta, gamma scan, total radioactive strontium, ^{3}H, field measurements[b]
WCK 6.8	WOC 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 WOC (ORNL)	Semiannually (April, Oct.)	Gross alpha, gross beta, total radioactive strontium, gamma scan, ^{3}H, field measurements[b]

[a]Locations identify bodies of water and locations on them (e.g., WCK 1.0 1.0 km upstream from the confluence of White Oak Lake and the Clinch River).

FCK First Creek kilometer
FFK Fifth Creek kilometer
GCK Grassy Creek kilometer
ICK Ish Creek kilometer
MCCBK McCoy Branch kilometer
MEK Melton Branch kilometer
NWTK Northwest Tributary kilometer
RCK Racoon Creek kilometer
WBK Walker Branch kilometer
WCK White Oak Creek (WOC) kilometer

[b]Field measurements consist of dissolved oxygen, pH, and temperature.

5.5.7.1 Results

Radionuclides were detected above MDAs at all of the 12 surface water locations in 2008. The locations with the highest radionuclide levels are in the ORNL main plant area or at locations downstream of the main plant. These locations are near or downstream of CERCLA sites. Over the past few years, several remedial actions have been completed within the main plant area, which have resulted in observed decreases in radionuclide concentrations in surface water samples as compared to concentrations observed in mid-1990s; future remedial actions in those areas are planned and, until completion, little change in surface water contaminant conditions is expected (DOE 2008). The results from 2008 sampling at those locations are consistent with historical data and with the processes or legacy activities nearby or upstream from these locations. The VOCs chloroform along with acetone and methylene chloride which are common laboratory contaminants were detected at WOC at WOD in 2008, all at low estimated levels.

Sampling locations west, southwest of ORNL [Raccoon Creek (RCK 2.0), Grassy Creek (GCK 3.6), and Ish Creek (ICK 0.7)] are impacted by contaminated groundwater from Solid Waste Storage Area 3. Future remedial actions should decrease these levels of radionuclides.

5.5.8 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 (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. 5.36). 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. 5.36). These samples are filtered, and the residue (settleable solids) is analyzed for gross alpha, gross beta, and gamma emitters.

5.5.8.1 Results

Potassium-40, a naturally occurring radionuclide, and ^{137}Cs were detected in sediments at all three locations. The ^{137}Cs concentrations at CRK 70 and CRK 16 were higher than in previous sampling events; ^{137}Cs at CRK 32 was lower than either of the other two locations and was lower than previous sampling events at that location. Figure 5.36 shows 5 years of ^{137}Cs results in sediment.

Heavy rain event sampling took place in February and August 2008. Radionuclide concentrations for alpha, beta, and ^{137}Cs were higher at the downstream locations than those observed at the upstream reference location and there was no indication of significant trends in alpha, beta or ^{137}C at any of the locations.

During August 2008, the ^{40}K concentration at WOC headwaters was higher than at any of the other locations and higher than what has been observed historically; no cause was determined for the concentration.

During August 2008, the ^{7}Be concentration at WCK 2.6 was higher than at any of the other locations and higher than what has been observed historically. Beryllium is transferred through precipitation from the atmosphere to earth. It is possible that the higher concentration of ^{7}Be at WCK 2.6 was a result of runoff from a rain event associated with Hurricane Fay.

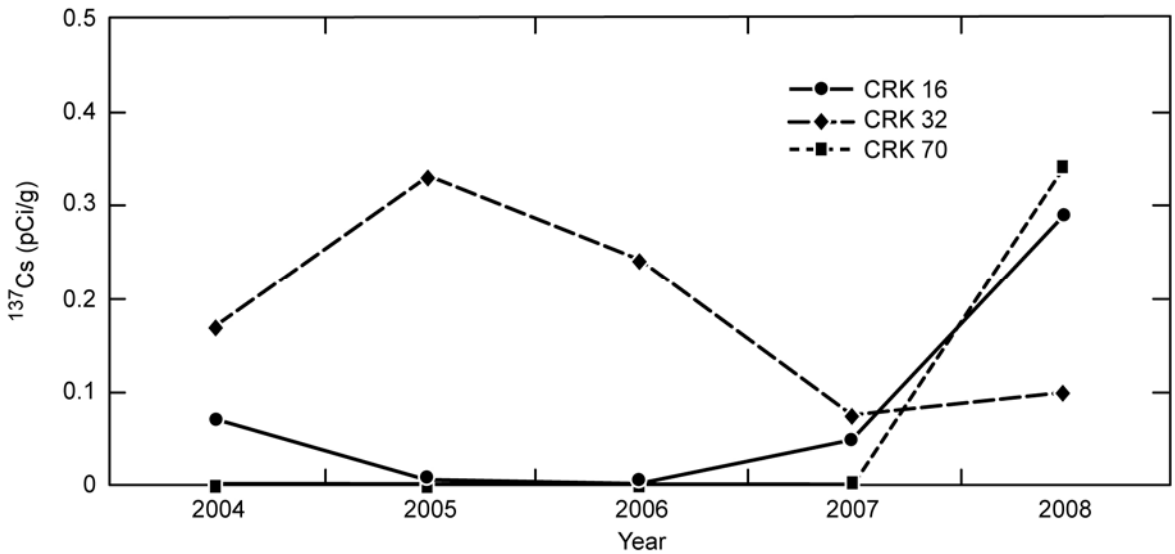


Fig. 5.36. ORNL sediment sampling results for ^{137}Cs, 2004–2008.

5.6 U.S. Department of Agriculture/Tennessee Department of Agriculture

In 2008, ORNL researchers had 13 domestic soil agreements for receipt of or movement of quarantined soils and four soil permits for receipt of or movement of nondomestic soils (from outside the continental United States). Three other researchers held permits or approvals for receipt of other material regulated by the USDA, such as animal or plant viruses or genetically engineered organisms. The domestic soil agreements are jointly issued by the USDA and the Tennessee Department of Agriculture, whereas permits are issued by the USDA.

5.7 Groundwater Protection Program

Groundwater monitoring at ORNL was conducted under two sampling programs in 2008: DOE EM monitoring and DOE Office of Science surveillance monitoring. The EM groundwater monitoring program was performed by cleanup contractor Bechtel Jacobs Company. The Office of Science groundwater monitoring surveillance program was conducted by UT-Battelle.

5.7.1 DOE EM Groundwater Monitoring

Under the EM program, monitoring was performed as part of an ongoing comprehensive cleanup effort in Bethel and Melton Valleys at ORNL, the two watersheds defined by the Water Resources Restoration Program (WRRP). The WRRP has been managed by Bechtel Jacobs Company for the EM program since its inception and is the vehicle for DOE to carry out the monitoring requirements outlined in the Federal Facility Agreement. The scope of the EM monitoring has largely dealt with remediation effectiveness monitoring at contaminated sites undergoing cleanup. In 2007 and in subsequent sampling events, radionuclides were detected in the Melton Valley picket wells located on the Oak Ridge Reservation proximate to the Clinch River. As required by the Melton Valley Interim Record of Decision, DOE is now working with TDEC and EPA to establish an additional network of wells on private property across the Clinch River. To date there has been no direct evidence that contaminated ground water originating from the Melton Valley Burial Grounds has migrated under the Clinch River or otherwise impacted groundwater west of the Clinch River. The monitoring results from EM activities on the ORR in 2008, including information on these picket wells, are presented in the *Remediation Effectiveness Report* (DOE 2009) and are not discussed in this document.

5.7.2 Office of Science Groundwater Monitoring

DOE Order 450.1A is the primary requirement for a site-wide groundwater protection program at ORNL. As part of the program, and to be consistent with UT-Battelle management objectives, a groundwater surveillance monitoring strategy was developed to monitor ORNL groundwater exit pathways and UT-Battelle facilities ("active sites") potentially posing a risk to groundwater resources at ORNL. Results of the DOE Office of Science groundwater surveillance monitoring program are reported in the following sections.

Exit pathway and active sites groundwater surveillance monitoring points sampled during 2008 included seep/spring and surface water monitoring locations in addition to groundwater surveillance monitoring wells. Seep/spring and surface water monitoring locations were used in the absence of monitoring wells located in appropriate groundwater discharge areas.

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 for evaluating sampling results. To provide a basis for evaluating analytical results and for assessment of groundwater quality at locations monitored by UT-Battelle for the Office of Science, federal drinking water standards and Tennessee water quality criteria for domestic water supplies (TDEC 2008) are used as reference standards in the following discussions. Four percent of the DOE DCGs are used if no federal or state standards have been established for a radionuclide. Although drinking water standards and DOE DCGs 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.

5.7.2.1 Exit Pathway Monitoring

During 2008, exit pathway groundwater surveillance monitoring was performed under the guidance of *UT-Battelle Sampling and Analysis Plan for Surveillance Monitoring of Exit Pathway Groundwater at Oak Ridge National Laboratory* (Bonine 2008) (Exit Pathway SAP). Groundwater exit pathways at ORNL include areas from watersheds or subwatersheds 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 process carried out in 2004. One of the original exit pathway zones was split into two zones for the sake of geographic expediency. The Southern Discharge Area Exit Pathway was carved from the East End Discharge Area Exit Pathway. Figure 5.37 shows the locations of the exit pathway monitoring points sampled in 2008.

The five zones include

- the WOC Discharge Area Exit Pathway (wells 857, 858, 1190, 1191, and 1239);
- the 7000/Bearden Creek Watershed Discharge Area Exit Pathway (wells 1198 and 1199 and Spring BC-01);
- the East End Discharge Area Exit Pathway (well 923 and Springs/Surface Water Monitoring Points EE-01 and EE-02);
- the Northwestern Discharge Area Exit Pathway (wells 531, 535, and 4579; see the *Remediation Effectiveness Report* for 4579 results); and
- the Southern Discharge Area Exit Pathway (Springs/Surface Water Monitoring Points S-01 and S-02).

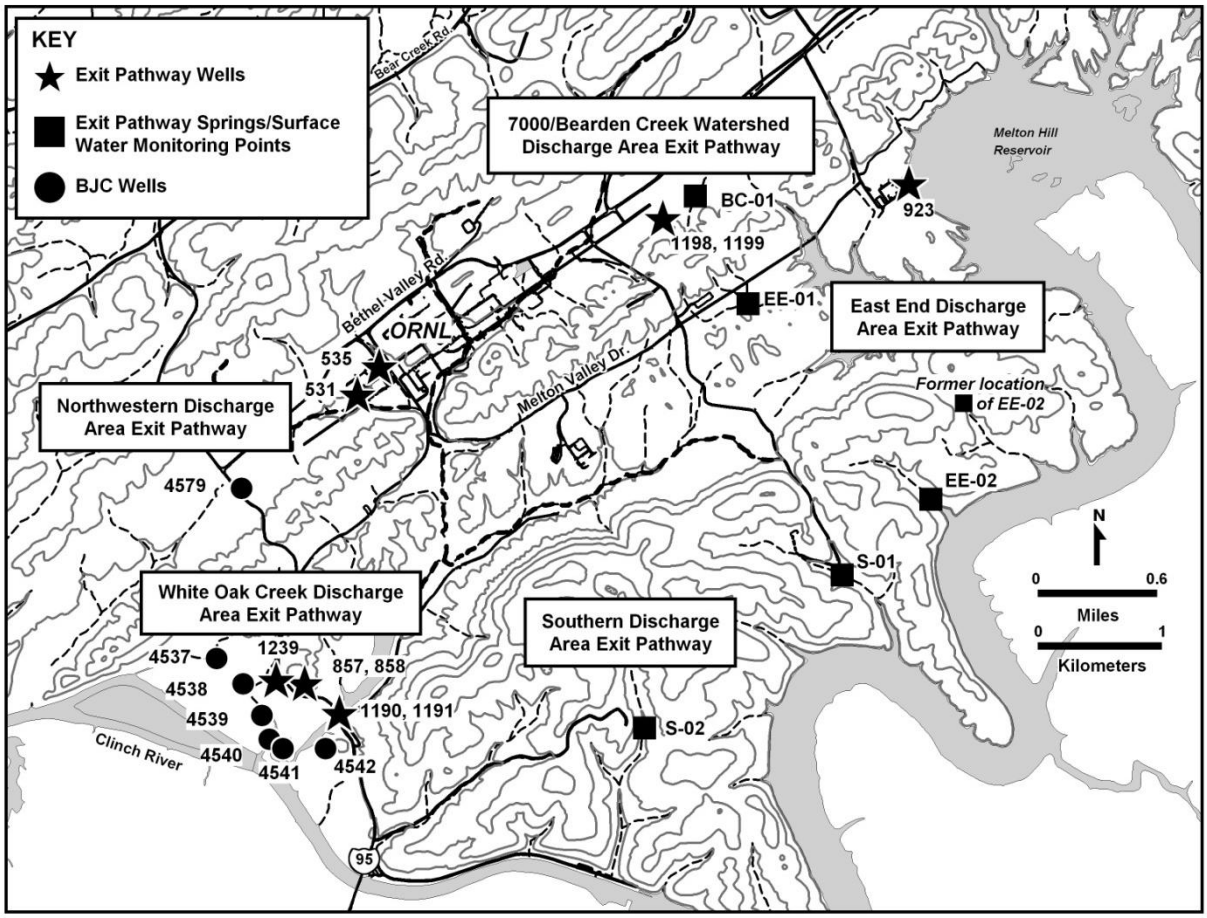


Fig. 5.37. UT-Battelle exit pathway groundwater monitoring locations at ORNL, 2008.

Samples were collected during 2008 from seven multiport monitoring wells (wells 4537, 4538, 4539, 4540, 4541, 4542, and 4579) installed west of the main ORNL campus by Bechtel Jacobs Company. Multiport wells enable multiple shallow to deep water-bearing strata to be monitored. Sampling data generated by the wells were used to supplement the data generated by the WOC Discharge Area Exit Pathway. The data were reviewed by UT-Battelle but are not reported in this document. The multi-port monitoring well analytical data are reported in Sect. 3 of the 2009 *Remediation Effectiveness Report* (DOE 2009) as well as the Oak Ridge Environmental Information System (OREIS).

Samples collected from the UT-Battelle exit pathway groundwater surveillance monitoring points in 2008 were analyzed for VOCs, semivolatile 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 *Sampling and Analysis Plan*, samples were collected semiannually during wet and dry seasons in 2008.

5.7.2.1.1 Exit Pathway Monitoring Results

Trend analyses were performed on exit pathway monitoring data of interest that exceeded reference standards in 2008. Historical time series data collected from the late 1980s through 2008 were used as the bases for the trend analyses. In some cases there was insufficient data density to perform statistical trend analysis, and trending was not performed when concentrations of naturally occurring metals (i.e., aluminum, iron, and manganese) exceeded reference standards because those 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. Moreover, trend analyses were not performed on 2008 monitoring data that were reported as being undetected by the laboratory, even when

minimum detection limits exceeded reference standards (i.e., semivolatile organic compounds atrazine, benzo(a)pyrene, hexachlorobenzene, and pentachlorophenol).

Samples were not collected at BC-01, S-01, or EE-02 during the dry season because of the continuing climate-based moisture deficit affecting east Tennessee during 2008. Drought conditions also impacted sampling at the BC-01 spring; it was dry during the wet season of 2008. In addition, samples were not collected from Well 535 during the dry season due to construction activities proximal to the well. Groundwater sampling results that exceeded reference standards as well as those that were detected in 2008 are found in Table 2.1 ("Constituents detected in exit pathway groundwater at ORNL, 2008") and Table 2.2 ("Constituents detected in SNS groundwater, 2008") in *Environmental Monitoring on the Oak Ridge Reservation: 2008 Results*. DOE/ORO/2298.

WOC Discharge Area Exit Pathway Results

Monitoring wells 857, 858, 1190, 1191, and 1239 were sampled during April and May and again in August 2008. Three radiological constituents continued to be detected in two wells at concentrations greater than the reference standards: ^{3}H in well 1190 and gross beta activity, total radioactive strontium, and ^{3}H in well 1191. No other radionuclides exceeded reference standards in WOC discharge area wells. A statistically significant downward trend exists for all three radiological constituents at both sampling locations. The following radionuclides were detected in WOC discharge area wells: gross alpha in Well 1239; gross beta activity in wells 857, 858, 1190, and 1239; and ^{3}H in well 857. Lead exceeded the associated reference standard in well 858, but trend analyses indicate a statistically significant downward trend in well 858 lead concentrations. Several other metals (iron, manganese, and aluminum) exceeded their reference standards during 2008, but they are routinely found in the soil, rock, and groundwater at ORNL. A number of other metals were detected at low concentrations in groundwater samples collected from WOC Discharge Area wells; among them were arsenic, barium, cadmium, chromium, lead, silver, sodium, and uranium.

Detection limits for several undetected semivolatile organic compounds exceeded reference standards in samples collected from WOC Discharge Area monitoring points. No other organic compounds were present in concentrations above reference standards in samples collected from WOC Discharge Area wells; however, a common plasticizer [bis(2-ethylhexyl) phthalate] was detected at low, estimated concentrations in wells 858 and 1190 and was detected in wells 1191 and 1239. Diethyl phthalate was also detected in low, estimated concentrations in a sample collected from well 1190 in 2008. Methylene chloride was found at low, estimated concentrations in a sample collected from well 1239, but was also detected in the lab blank indicating that the field sample was probably contaminated by laboratory staff during analysis.

7000/Bearden Creek Watershed Discharge Area Exit Pathway Results

Wells 1198 and 1199 were sampled by UT-Battelle in April and August 2008. Spring/seep BC-01 was not sampled during the wet or dry seasons due to prevailing drought conditions during 2008. No radionuclides exceeded their reference standards during the monitoring period. Tritium was detected in samples collected from both wells. Additionally, gross beta activity was detected in both wells. Iron was found to exceed its reference standard in samples collected from well 1198. Lead was found to exceed its reference standard in one sample collected from well 1199. No trending was performed on lead data for well 1199 due to a lack of data density. Other metals detected at low concentrations in samples collected at monitoring points within the 7000/Bearden Creek Discharge Area include barium, chromium, lead, silver, and uranium.

As noted in Sect. 5.8.1, detection limits for several undetected semi-volatile organic compounds exceeded reference standards. No other organic compounds were detected above reference standards; however, acetone was detected at a low concentration in well 1199. Chloroform and methylene chloride were also detected in wel1 1199 at estimated concentrations.

East End Discharge Area Exit Pathway Results

Well 923 was sampled in May and August 2008. EE-01 was sampled in April and August 2008. EE-02 was sampled once in 2008 during the wet season (May) because there was no flow at that monitoring point during the dry season. No radiological constituents were present above reference standards in samples collected from East End Discharge Area monitoring points, however low concentrations of gross beta activity were detected in the samples collected from EE-01 and well 923 in 2008. Aluminum, iron, and manganese exceeded reference standards in EE-01 and EE-02, and iron and manganese exceeded reference standards in well 923, but those metals are relatively common in the soil, rock, and groundwater at ORNL. Other metals detected at low concentrations in samples collected at monitoring points within the East End Discharge Area include arsenic, barium, cadmium, chromium, lead, and uranium.

As mentioned in Sect. 5.8.1, detection limits for several undetected semivolatile organic compounds exceeded reference standards. Bis(2-ethylhexyl) phthalate and acetone (estimated concentrations) were detected in well 923 in 2008. Plastic well casing materials used in the construction of the well may explain the presence of the phthalate in the sample. Acetone was also found in the trip blank that accompanied the sample collected from well 923. In addition, 2-butanone was detected at a low, estimated concentration in EE-01 during the monitoring period.

Northwestern Discharge Area Exit Pathway Results

Well 531 was sampled in May and August 2008. Due to access restrictions associated with construction activities related to ORNL campus upgrades, well 535 was sampled only once in 2008 (in May). The concentration of gross beta activity exceeded its reference standard at wells 531 and 535 in 2008. A statistically insignificant slight upward trend is observable in the historical gross beta data set for well 531. Detection of gross beta activity in the sample collected from Well 535 in 2008 increased significantly when compared to 2007 results. Despite the increase, a statistically downward trend is observable in the historical gross beta data set for well 535. No other radionuclides exceeded their reference standards at Northwestern Discharge Area monitoring points; however, ^{3}H was detected in a sample collected from well 535 during the wet season. The concentration of lead exceeded its reference standard in a sample collected from well 535. Lead exhibits a statistically significant upward trend in that well. Lead was also reported exceeding its reference standard in well 535 in 2006 and 2007. Aluminum, iron, and manganese exceeded reference standards in the sample collected from well 535, but those metals are common in groundwater at ORNL. Barium and chromium were detected in samples collected from well 531, and arsenic, barium, cadmium, chromium, and uranium were detected in the sample collected from well 535.

Detection limits for several undetected semivolatile organic compounds exceeded reference standards. No other organic compounds were present above reference levels in samples collected from Northwestern Discharge Area monitoring points. Acetone was detected at a low, estimated concentration in a sample collected from well 531. Acetone was also found in the trip blank that accompanied the sample collected from well 531. The plasticizer diethyl phthalate was found in a low, estimated concentration in a sample collected from well 535 during 2008. Plastic well casing materials used in the construction of the well may explain the presence of the phthalate in the sample. In addition, benzoic acid was detected at low, estimated value in a sample collected from well 535.

Southern Discharge Area Exit Pathway Results

Monitoring point S-01 was sampled by UT-Battelle in April 2008, but no samples were collected during the dry season sampling event (August 2008) because the monitoring point was dry. Monitoring point S-02 was sampled in April and August 2008. Aluminum, iron, manganese, and lead exceeded reference standards at S-02. Lead exhibits a statistically significant upward trend in S-02. Those metals are common constituents of earth materials at ORNL. No radiological constituents or organic compounds were present above detection limits in samples collected from Southern Discharge Area monitoring points. Detection limits for several undetected semivolatile organic compounds exceeded reference

standards. Barium and uranium were detected in samples collected from S-01. Arsenic, barium, cadmium, chromium, and uranium were detected in samples collected from S-02.

5.7.2.2 Active Sites Monitoring

5.7.2.2.1 Active Sites Monitoring—HFIR

Routine groundwater monitoring at the HFIR site, which had been conducted by the ORNL Research Reactor Division, was discontinued in 2007. The decision to discontinue routine groundwater monitoring was based on a 6 year history of zero detectable subsurface releases of ^{3}H from the reactor's process waste drain system and observations of tritium concentration reductions in samples collected from monitoring wells located downgradient of the release site. It is expected that tritium concentrations should continue to decrease with the possibility of additional precipitation-driven concentration spikes or drought-induced tritium concentration stagnation. The main mass of the tritium plume was observed to continue in its movement from the release area to the south-southeast toward a tributary to Melton Branch and Melton Branch, itself. Tritium release detection at HFIR has continued under the auspices of the *NPDES Radiological Monitoring Plan*. See Sect. 5.5.1.4 for 2008 results. All wells used in the RRD groundwater monitoring program are being maintained for future use as needed.

5.7.2.2.2 Active Sites Monitoring—SNS

Active sites groundwater surveillance monitoring was performed in 2008 at the SNS site. The SNS site was monitored based on the potential for adverse impact on groundwater resources at ORNL should a release occur. Monitoring at the SNS site was performed in 2008 under the draft, biennial (2006–2008) *Operational Groundwater Monitoring Plan for the Spallation Neutron Source Site* (Operational Monitoring Plan) (Bonine, Ketelle, and Trotter, 2007). Operational monitoring was initiated following a 2 year (2004–2006) baseline monitoring program. Operational monitoring will continue throughout the duration of SNS operations.

The SNS site is located atop Chestnut Ridge northeast of the main ORNL facilities. The site slopes to the north and south, and small stream valleys, populated by springs and seeps, lie on the ridge flanks. Surface water drainage from the site flows into Bear Creek, to the north, and into WOC, to the south.

The SNS site is a hydrologic recharge area underlain by geologic formations that form karst geologic features. Groundwater flow directions at the site are based on the generally observed tendency for groundwater to flow parallel to geologic strike (parallel to the orientation of the rock beds) and via karst conduits which breakout at the surface in springs and seeps located down gradient of the SNS site. A sizable fraction of infiltrating precipitation (groundwater recharge) flows to springs and seeps via the karst conduits.

SNS operations have the potential for introducing radioactivity (via 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 complicated by multiple uncertainties resulting from a variety of factors, including hydraulic conductivity differences in earth materials found at depth, the distribution of water-bearing zones, the fate and transport characteristics of neutron activation products produced, diffusion and advection, and the presence of karst geomorphic features found on the SNS site. These uncertainties led to the initiation of the groundwater surveillance monitoring program at the SNS site. Objectives of the groundwater monitoring program outlined in the *Operational Monitoring Plan* include (1) determine compliance with applicable environmental quality standards and public exposure limits outlined in DOE Orders 450.1A and 5400.5, respectively, and (2) provide uninterrupted monitoring of the SNS site.

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 2008. Locations were chosen based on hydrogeological factors and

proximity to the beam line. Figure 5.38 shows the locations of the specific monitoring points sampled during 2008.

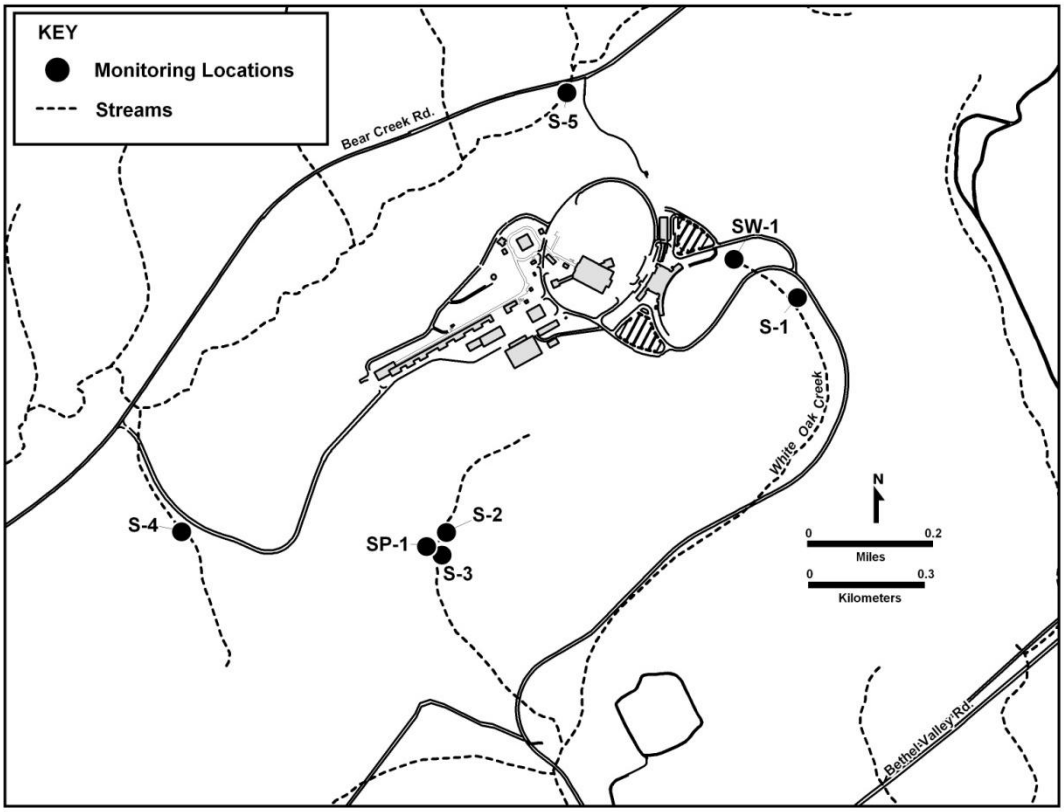


Fig. 5.38. Groundwater monitoring locations at the Spallation Neutron Source, 2008.

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. Three grab samples were collected from each seep/spring: one sample to represent base flow and two samples to represent 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). Each monitoring point was sampled on a quarterly basis. Given their fate and transport characteristics, ^{3}H and ^{14}C are the principal groundwater constituents of concern at the SNS site. In 2008, samples were collected on a quarterly basis for ^{3}H and ^{14}C analyses. Additionally, samples were collected during wet season base flow conditions for gross activity (alpha and beta) and for selected gamma spectroscopic parameters.

SNS Site Results

Wet season sampling occurred in February, March, and December 2008. Dry season sampling occurred in June and August 2008. The results of the 2008 SNS monitoring effort were compared to reference standards. Gross alpha activity was detected in samples collected during the February 2008 base flow sampling event at monitoring points S-2, S-5 (both regular and duplicate samples collected), and SW-1. The gross alpha concentration reported for the field duplicate sample collected at S-5, 16.5 pCi/L, exceeded the reference standard (15 pCi/L). No other radionuclides exceeded reference standards during the 2008 monitoring period. Gross beta activity was detected in samples collected during the base flow sampling event in February 2008 at monitoring points S-1, S-2, S-3, S-5 (regular sample and field duplicate samples), and SW-1. Bismuth-214 was detected at S-3 during the base flow sampling event in

February 2008. Carbon-14 was detected in a sample collected at monitoring point S-2 during the falling limb sampling event in June 2008 and at monitoring points S-5 (field duplicate sample), SP-1, and SW-1 during the rising limb sampling event in February 2008. Tritium was detected in samples collected at monitoring points S-2 and S-5 (field duplicate sample) in the March 2008 during the falling limb sampling event. The levels reported for ^{14}C and ^{3}H in 2008 were at levels well below their respective reference standards.

Historical SNS ^{14}C and ^{3}H monitoring data (samples collected April 2004–December 2008) were reviewed to gain an insight into whether SNS operations have had an effect on groundwater quality on the SNS site. The vast majority of the ^{14}C and ^{3}H data are "censored" (i.e., below the analytical method limit of detection). However, review of the historical data set revealed that the count of detected ^{14}C and ^{3}H data increased slightly after initiation of SNS operations. Given the number of censored data in the historical data set, a 2×2 contingency table was used along with Fisher's Exact Method to test whether the proportion of detected data is that same based on the operational start date of the SNS facility. The statistical analysis incorporated each flow regime (base flow, rising limb, and falling limb). The results of the analysis indicate that the proportion of detected ^{14}C and ^{3}H data is statistically similar (at a level of significance, α, of 0.05) prior to and after the start-up of the SNS. The results of the statistical analysis and occurrence of very low concentrations of ^{14}C and ^{3}H in groundwater samples collected at the SNS site suggest that the operation of the SNS has had little impact on site groundwater quality.

Review and analysis of the data collected under the *Operations Monitoring Plan* are performed periodically, and modifications to the monitoring protocol are made as needed. The SNS staff is committed to performing groundwater monitoring throughout the duration of its operation.

5.8 Quality Assurance Program

The application of quality assurance (QA)/quality control (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 and record keeping must address and meet applicable quality standards. The activities associated with administration, sampling, data management, and reporting for ORNL environmental programs are performed by the UT-Battelle Environmental Protection and Waste Services Division (EP&WSD).

UT-Battelle utilizes the SBMS to provide a systematic approach for integrating quality assurance, environmental, and safety considerations into every aspect of ORNL environmental monitoring. SBMS is a web-based system that provides a single point of access to all the requirements necessary for staff to safely and effectively perform work. SBMS translates laws, orders, directives, policies, and best management practices into Laboratory-wide subject areas and procedures.

5.8.1 Work/Project Planning and Control

UT-Battelle's Work/Project Planning and Control directives establish the processes and requirements for executing work activities at ORNL. All environmental sampling tasks are performed following the four steps required in the work control subject areas:

- define scope of work,
- work planning: analyzing hazards and defining controls,
- work execution, and
- provide feedback.

In addition, EP&WSD has approved project specific standard operating procedures for all activities which are controlled and maintained through the ORNL Integrated Document directives.

Environmental sampling standard operating procedures developed for ORNL environmental sampling programs provide detailed instructions on maintaining chain of custody, sample identification, sample collection and handling, sample preservation, equipment decontamination, and collection of quality control samples such as field and trip blanks, duplicates, and equipment rinses.

5.8.2 Personnel Training and Qualifications

The UT-Battelle Training and Qualification Management System provides employees and nonemployee staff of UT-Battelle, with the knowledge and skills necessary to perform their jobs safely, effectively, and efficiently with minimal supervision. This capability is accomplished by establishing site-level procedures and guidance for training program implementation with an infrastructure of supporting systems, services, and processes.

5.8.3 Equipment and Instrumentation

5.8.3.1 Calibration

The UT-Battelle Quality Management System includes subject area directives that require all ORNL staff to use equipment of known accuracy based on appropriate calibration requirements that are traceable to an authority standard. The UT-Battelle Facilities and Operations Instrumentation and Control Technical Support tracks all equipment used in ORR environmental monitoring programs through a maintenance recall program to ensure that equipment is functioning properly and within defined tolerance ranges. The determination of calibration schedules and frequencies is based on a graded approach at the activity planning level. EP&WSD environmental monitoring programs follow rigorous calibration schedules to eliminate gross drift and the need for data adjustments. Instrument tolerances, functions, ranges, and calibration frequencies are established based on manufacturer specifications, program requirements, actual operating environment and conditions, and budget considerations.

5.8.3.2 Standardization

EP&WSD sampling procedures, maintained in IDMS, include requirements and instructions for the proper standardization and use of monitoring equipment. Requirements include the use of traceable standards and measurements, performance of routine, before-use equipment standardizations, and actions to follow when standardization steps do not produce required values. Sampling SOPs also include instructions for designating nonconforming instruments as “out-of-service” and initiating requests for maintenance.

5.8.3.3 Visual Inspection, Housekeeping, and Grounds Maintenance

EP&WSD environmental sampling personnel conduct routine visual inspections of all sampling instrumentation and sampling locations. These inspections identify and address any safety, grounds keeping, general maintenance, and housekeeping issues or needs.

5.8.4 Assessment

Independent audits, surveillance, and internal management assessments are performed to verify that requirements have been accurately specified and that activities have been performed conform to expectations and requirements. External assessments are scheduled based on requests from auditing agencies. EP&WSD also conducts internal management assessments of ORNL environmental monitoring procedural compliance, safety performance, and work planning and control. Surveillance results, recommendations, and completion of corrective actions, if required, are also documented and tracked in the Assessment and Commitment Tracking System.

5.8.5 Analytical Quality Assurance

The contract laboratories that perform analyses of environmental samples from the ORR environmental monitoring programs are required to have documented QA/QC programs, trained and qualified staff, appropriately maintained equipment and facilities, and applicable certifications. A competitive award system is used by UT-Battelle to select laboratories that are contracted under basic ordering agreements to perform analytical work to characterize ORNL environmental samples. Oversight

of subcontracted commercial laboratories is performed by the DOE Environmental Management Consolidated Audit Program. This program, administered by DOE and subcontractors from across the DOE complex, establishes required internal and external laboratory control and performance evaluation programs and conducts on-site laboratory reviews which monitor the performance of all subcontracted laboratories and verifies all quality requirements are met.

A statement of work for each project specifies any additional QA/QC requirements and includes detailed information on data deliverables, turnaround times, and required methods and detection limits. Blank and duplicate samples are routinely submitted along with ORR environmental samples to provide an additional check on analytical laboratory performance.

5.8.6 Data Management and Reporting

ORNL environmental surveillance and monitoring data management is accomplished using the Environmental Surveillance System (ESS), a web interface data management tool. A software QA plan for ESS has been developed to document ESS user access rules; verification and validation methods; configuration and change management rules; release history; software registration information; and the employed methods, standards, practices, and tools.

Field measurements and sample information are entered into ESS, and an independent verification is performed on all records to ensure accurate data entry. Sample results and associated information are loaded into ESS from electronic files provided by analytical laboratories. An automated compliance screening is performed to ensure that all required analyses were performed, appropriate analytical methods were employed, holding times were met, and specified detection levels were achieved.

Following the compliance screening, a series of checks is performed to determine whether results are consistent with expected outcomes and historical data. QC sample results (i.e., blanks and duplicates) are reviewed to check for potential sample contamination and to confirm repeatability of analytical methods within required limits. More in-depth investigations are conducted to explain results that are questionable or problematic.

5.8.7 Records Management

The UT-Battelle Records Management System provides the requirements for managing all ORNL records. Requirements include creating and identifying record material, scheduling, protecting, and record storage in both office areas and the ORNL Inactive Records Center and destroying records.

The TWPC maintains all of the records specific to the project and the records management program includes the requirements for creating and identifying record material, protecting and storing records in applicable areas, and destroying records.

5.9 Environmental Management Activities

Environmental Management (EM) is the largest DOE program in Oak Ridge, with cleanup programs under way to correct the legacies remaining from years of energy research and weapons production.

ORNL includes facilities located primarily within the Bethel and Melton Valley Watersheds and on the Chestnut Ridge. Historical processes, programs, and waste management practices associated with the mission of the Laboratory have led to environmental contamination in both Bethel and Melton Valleys, and separate RODs have been negotiated and signed by the EPA, TDEC, and DOE to define the selected remedial actions for each watershed.

The main ORNL operations center, located in Bethel Valley, includes key research facilities, primary administrative offices and various waste sites. Bethel Valley is defined by the upper drainage area of White Oak Creek and its tributaries and also includes the neighboring Raccoon Creek watershed and a small portion of Bearden Creek. Portions of Bethel Valley have been contaminated by laboratory-related chemicals and radionuclides through a number of release mechanisms (chemical spills, leaking lines, landfills, pits and sumps below buildings, basins, and burn pits). Mobile contaminants primarily leave the Bethel Valley Watershed via White Oak Creek. These contaminants travel from the Bethel Valley

Watershed to the Melton Valley Watershed, where further contaminants may enter White Oak Creek. Discharges to White Oak Creek are then released over White Oak Dam and into the Clinch River.

The Bethel Valley ROD specifies a variety of different remedies for waste areas, including decontamination and decommissioning buildings, capping buried waste areas, removing contaminated sediments and soils, removing or remediating contaminated tanks and pipelines, and addressing areas of contaminated groundwater. The ultimate goals are to protect human health and to reduce the amount of contaminants in White Oak Creek to acceptable levels.

The Melton Valley watershed occupies approximately 405 ha in the southern portion of the ORNL. Waste management was historically the principal activity that took place in Melton Valley, but research and development for two nuclear reactors also occurred there. In addition, the watershed was used in the 1950s and 1960s as the Atomic Energy Commission's Southeastern Regional Burial Ground for radioactive wastes from more than 50 other facilities. Portions of the watershed have been contaminated with a variety of wastes, including liquid and solid LLW through past disposal practices.

The *Melton Valley Remedial Action Report*, which documents remediation activity completion, was approved in September 2007 as described in the *Oak Ridge Reservation Annual Site Environmental Report 2007* (DOE 2008a). The site is now subject to routine monitoring and maintenance to ensure the remediation actions remain effective.

5.10 2008 ORNL Environmental Management Program Activities

5.10.1 Remedial Action Work Plan for Activities in Bethel Valley

In FY 2008, a Remedial Action Work Plan was submitted to regulators to describe soil and sediment characterization activities in Bethel Valley as set forth in the Bethel Valley ROD. The primary objectives of the plan are to define the scope of remediation, identify the controls that will be implemented to protect workers and the environment, and describe the methods of accomplishment to be used to execute the work. The plan further proposes a statistically based soil characterization strategy to acquire additional data, following remedial actions, to ensure that the remedial action objective requirements are met.

5.10.1.1 Waste Handling Plan

The *Waste Handling Plan* was prepared in FY 2008 as a primary document to support requirements under the Federal Facility Agreement. The plan presents the methods that will be used to manage and dispose of waste materials generated.

5.10.1.2 Molten Salt Reactor Experiment Fuel Removal

Nuclear fuel removal from a storage tank at the Molten Salt Reactor Experiment (MSRE) facility was completed in FY 2008. The MSRE facility operated from 1965 to 1969 and was fueled by molten salt that flowed through the reactor chamber, where the nuclear chain reaction produced heat. When the reactor was shut down, the molten salt and the flush salt were drained into three fuel storage tanks located in an underground, concrete-shielded drain tank cell adjacent to the reactor cell.

More detailed information on these 2008 Environmental Management activities is available in the *Clean Up Progress Report for 2008* (DOE 2009x).

5.10.2 Project to Resolve Safety and Security Issues in Building 3019

The goal of the Building 3019 Project at ORNL is to resolve legacy safety and security issues associated with ^{233}U stored in the building. In CY 2007, an environmental assessment for the project was completed and a Finding of No Significant Impact under the NEPA process was issued. During CY 2008, Isotek was active in planning for the design and construction of the operations and facilities needed to accomplish project objectives.

5.11 ORNL Waste Management

5.11.1 ORNL Wastewater Treatment

At ORNL, approximately 120 million gal of wastewater were treated and released at the PWTC in 2008. In addition, the liquid LLW evaporator at ORNL treated 125,000 gal of waste, and a total of 2.3 billion m^3 of gaseous waste were treated at the ORNL 3039 Stack facility. The waste treatment activities supported both EM and Office of Science mission activities in a safe and compliant manner.

5.11.2 Transfer of ORNL Newly Generated Waste Responsibilities

Since the late 1990s, waste management responsibilities at ORNL have been a shared responsibility between the DOE Office of Science (and its prime contractor, UT-Battelle) and DOE EM (and its prime Contractor, Bechtel Jacobs Company). UT-Battelle was responsible for taking appropriate steps in planning for waste generation in its research, development, and operational activities (termed "newly generated" waste), including characterizing and packaging the waste in accordance with requirements from the DOE Environmental Management Program. UT-Battelle was also responsible for completing the required waste documentation and turning the documentation over to Bechtel Jacobs Company for review and acceptance. After completing the waste acceptance step, Bechtel Jacobs was then responsible for picking the waste up from ORNL, transporting it to an appropriate waste storage facility, and arranging appropriate treatment and disposition of the waste in accordance with regulatory requirements.

In recent years, DOE has been changing the division of waste management roles and responsibilities at many of its sites, moving to a process where the waste generator has "cradle to grave" responsibility of the waste it generates. This change is intended to fully incentivize waste generators in finding new ways of doing business to eliminate and/or reduce waste generation. If the waste-generating organization is fully responsible for managing the waste it generates, it can also experience the full benefit in making investments in new technology and equipment to eliminate the generation of waste streams.

In 2008, the DOE decided to begin to transition the shared responsibility at ORNL and to make the DOE Office of Science and UT-Battelle fully responsible for the management of hazardous, low-level radioactive, and mixed hazardous and radioactive wastes they generate. The transition of responsibility was set to conclude October 1, 2008 (the start of FY 2009). After that date, UT-Battelle would be fully responsible for managing its waste streams, including off-site transport, treatment, and disposal of the waste it generates.

In order to manage the transition process, UT-Battelle, Bechtel Jacobs, and DOE jointly developed a detailed transition plan that listed and scheduled the actions that would be needed to accomplish the noted transfer of responsibility. Transition managers and support staff were identified to perform the work, a process that took about 9 months to complete. As scheduled, the transfer of responsibility happened on October 1, 2008. Transfer of the ORNL Hazardous Waste Management Area did not happen until about a month later, in order to allow time for changes to be made in associated permits; it had no adverse effect on the transfer process.

Beginning October 1, 2008, UT-Battelle is now fully responsible for management of the hazardous, low-level radioactive, and mixed wastes that it generates in performing research, development, and operational activities at ORNL. Only specialized waste streams, such as transuranic wastes or wastewaters that can be treated by on-site wastewater treatment facilities (which are jointly used by the different DOE programs at ORNL and are operated by DOE EM) are still handed off to Bechtel Jacobs Company for disposal.

5.11.3 Transuranic Waste Processing Center

TRU waste-processing activities carried out for DOE by EnergX address the three remaining waste streams stored at ORNL—contact-handled (CH) solids/debris, remote-handled (RH) solids/debris, and RH sludge—and involve processing, treatment, repackaging, and off-site transportation and disposal at either the Nevada Test Site or the Waste Isolation Pilot Plant in New Mexico.

The TWPC was designed and constructed to treat and dispose 900 m^3 of RH sludge, 550 m^3 of RH-TRU/alpha LLW solids, 1,600 m^3 of RH LLW supernate, and 1,000 m^3 of CH TRU/alpha LLW solids currently stored in Melton Valley. The forecast for waste quantities to be processed at the TWPC has been updated to include the latest estimates: 2,000 m^3 of RH sludge, 700 m^3 of RH-TRU solids, and 1,500 m^3 of CH-TRU solids. CH-TRU processing started December 2005 and RH-TRU processing started in May 2008. During 2008, 224.1 m^3 of CH-TRU waste was processed and 8.6 m^3 of RH-TRU waste was processed.

5.12 References

ANSI. 1969. *Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities*. ANSI N13.1-1969R. American National Standards Institute, Washington, D.C.

ANSI. 1999. *Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities.* American National Standards Institute, New York, N.Y. 1999.

Bonine, Ketelle, and Trotter. 2007. *Operational Groundwater Monitoring Plan for the Spallation Neutron Source Site* (unpublished).

Bonine. 2008. *UT-Battelle Sampling and Analysis Plan for Surveillance Monitoring of Exit Pathway Groundwater at Oak Ridge National Laboratory* (unpublished).

DOE 2009x. *FY 2008 Cleanup Progress: Annual Report to the Oak Ridge Community*. DOE/ORO/2286.

Cultural Resource Management Plan, DOE Oak Ridge Reservation, Anderson and Roane Counties, Tennessee. DOE/ORO 2085. U.S. Department of Energy, Washington, D.C.

DOE. 2006. *Guidance for Electric Metering in Federal Buildings.* DOE/EE-0312. U.S. Department of Energy, Energy Efficiency and Renewable Energy, Washington, D.C. February 3, 2006.

DOE. 2006a. *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/OR/01-2289&D3. U.S. Department of Energy, Washington, D. C.

DOE. 2008. DOE. 2008. *2008 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee, Volume 2: Data and Evaluations.* DOE/OR/01-2366&D/|V2. U.S. Department of Energy, Washington, D. C.

DOE. 2008. *Oak Ridge National Laboratory Modernization Initiative*. DOE/EA-1618. July 2008.

DOE. 2008a. *Oak Ridge Reservation Annual Site Environmental Report for 2007*. DOE/ORO/2261. U.S. Department of Energy, Oak Ridge, Tennessee. U.S. Department of Energy Oak Ridge Office, Oak Ridge, Tennessee. Oak Ridge National Laboratory (UT-Battelle LLC), Oak Ridge Y-12 National Security Complex (BWXT Y-12, L.L.C.), and East Tennessee Technology Park (Bechtel Jacobs Company LLC), Oak Ridge, Tennessee.

DOE. 2009a. 2009 *Remediation Effectiveness Report/Second Reservation-wide CERCLA Five Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee*. U.S. Department of Energy, Washington, D. C.

DOE. 2009b. *Environmental Monitoring on the Oak Ridge Reservation: 2008 Results*. DOE/ORO/2298. U.S. Department of Energy Oak Ridge Office, Oak Ridge, Tennessee. Oak Ridge National Laboratory (UT-Battelle LLC), Oak Ridge Y-12 National Security Complex (BWXT Y-12, L.L.C.), and East Tennessee Technology Park (Bechtel Jacobs Company LLC), Oak Ridge, Tennessee.

ISO. 2004. *Environmental Management Systems—Requirements with Guidance for Use*. ISO 14001:2004. International Organization for Standardization. http://www.iso.org.

Melton Valley Remedial Action Report.

Palko. 2008. *Oak Ridge National Laboratory Executable Plan.*

TDEC. 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.

6. 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. 7.

6.1 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.

6.1.1 Description

The eight meteorological towers on the ORR are described in Table 6.1 and depicted in Fig. 6.1. The "MT" name format for the meteorological towers is used in this document; however, other commonly used names for the sites are provided in Table 6.1. Meteorological data are collected at different altitudes (2, 10, 15, 30, 33, 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 (associated with the local ridge-and-valley terrain as well as the Great Valley; see Appendix C) can significantly affect the movement of a plume after a facility release (Bowen et al. 2000). Data are collected at the 10 m level at all towers except Tower Y, where data are collected at 15 and 33 m. Additionally, at selected towers, data are collected 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 MT9). Precipitation is measured at MT6 and MT9 at the Y-12 Complex, at MT1 and MT7 at the ETTP, and at MT2 at ORNL. Solar radiation is measured at MT6 and MT9 at the Y-12 Complex, at MT1 and MT7 at the ETTP, and at MT2 at ORNL. Data are collected at 1, 15, and 60 min intervals. General quarterly calibrations of the instruments are managed by UT-Battelle and B&W Y-12.

Data are collected in real time at 15 min and hourly intervals for emergency-response purposes, such as for input to dispersion models. Data from the eight ORR meteorological towers are distributed to dispersion models at the ORNL and Y-12 Emergency Operations Centers.

Annual dose estimates are calculated using the archived hourly data. Data quality is checked continuously against predetermined data constraints, and out-of-range parameters are marked invalid and are excluded from compliance modeling. Quality assurance records of data problems and errors are routinely kept for all eight tower sites.

6.1.2 Meteorological Impacts on Modeling Results

Prevailing winds are generally up-valley from the southwest and west-southwest or down-valley from the northeast and east-northeast. This pattern is the result of the channeling effect of the ridges flanking the 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 (resulting in slightly more varied flow).

Table 6.1. Oak Ridge Reservation meteorological towers

Tower	Alternate tower names	Location lat., long.	Altitude (m MSL)[a]	Measurement heights (m)
		ETTP		
MT1	"K," 1208	35.93317N, 84.38833W	253	10, 60
MT7	"L," 1209	35.92522N, 84.39414W	233	10, 30
		ORNL		
MT2	"C," 1057	35.92559N, 84.32379W	261	10, 30, 100
MT3	"B," 6555	35.93273N, 84.30254W	256	10, 30
MT4	"A," 7571	35.92185N, 84.30470W	263	10, 30
MT10	"M," 208A	35.90947N, 84.38796W	237	10
		Y-12 Complex		
MT6	"W," West	35.98467N, 84.26550W	326	2, 10, 30, 60
MT9	"Y," PSS Tower	35.98745N, 84.25363W	290	15, 33

[a]Mean sea level.

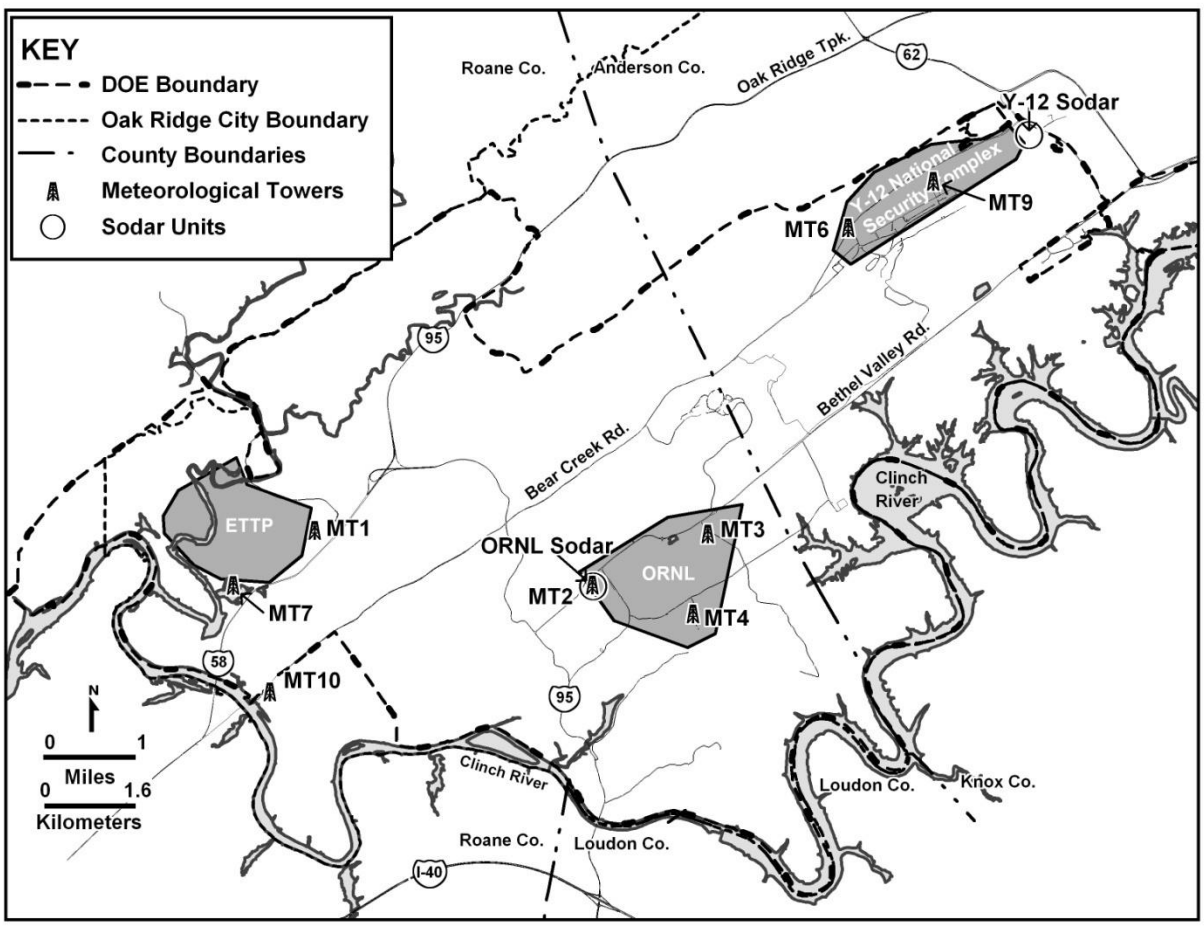


Fig. 6.1. The ORR meteorological monitoring network. (Sodar: sonic detection and ranging wind profiler.)

On the ORR, low-speed winds dominate near the surface. This characteristic is typical of most near-surface measurements (as influenced by nearby ridges). Winds sometimes accelerate at ridgetop level, particularly when winds are not parallel to the ridges (see Appendix C).

The atmosphere over the ORR 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 increased turbulence (atmospheric mixing). These features are captured in the data input to the dispersion models and are reflected in the modeling studies conducted for each facility.

Precipitation data from Tower MT2 are used in stream-flow modeling and in certain research efforts. The data indicate the variability of regional precipitation: the high winter rainfall resulting from frontal systems and the uneven, but occasionally intense, summer rainfall associated with thunderstorms. The total precipitation in 2008 (1,184 mm) was about 12% below the long-term average of 1,340 mm. This marks the fifth consecutive year of below-average precipitation. Precipitation wind roses for Tower MT2 during the previous 10 years (1998 through 2007) are provided in Appendix C (Figs. C.18 thru C.21).

The average data recovery rate minimums (a measure of acceptable data) across locations used for modeling during 2008 were greater than 96.9% for ORNL sites (Towers MT2, MT3, MT4, and MT10), greater than 98.6% for ETTP sites (Towers MT1 and MT7), and 99.5% for Y-12 sites (Towers MT6 and MT9). All data recovery well exceeded the required 90% per quarter recovery rate.

6.2 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 identifying the development of significant trends.

6.2.1 Data Collection and Analysis

External gamma measurements (exposure rates) are recorded weekly at six ambient air stations from resident external gross gamma monitors (Fig. 6.2). 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.

6.2.2 Results

Table 6.2 summarizes the data collected at each station during the year. The mean observed exposure rate for the reservation network for 2008 was 5.4 μR/h, and the average at the reference location was 4.5 μR/h. Exposure rates from background sources in Tennessee range from 2.9 to 11 μR/h. The average 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.

6.3 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.

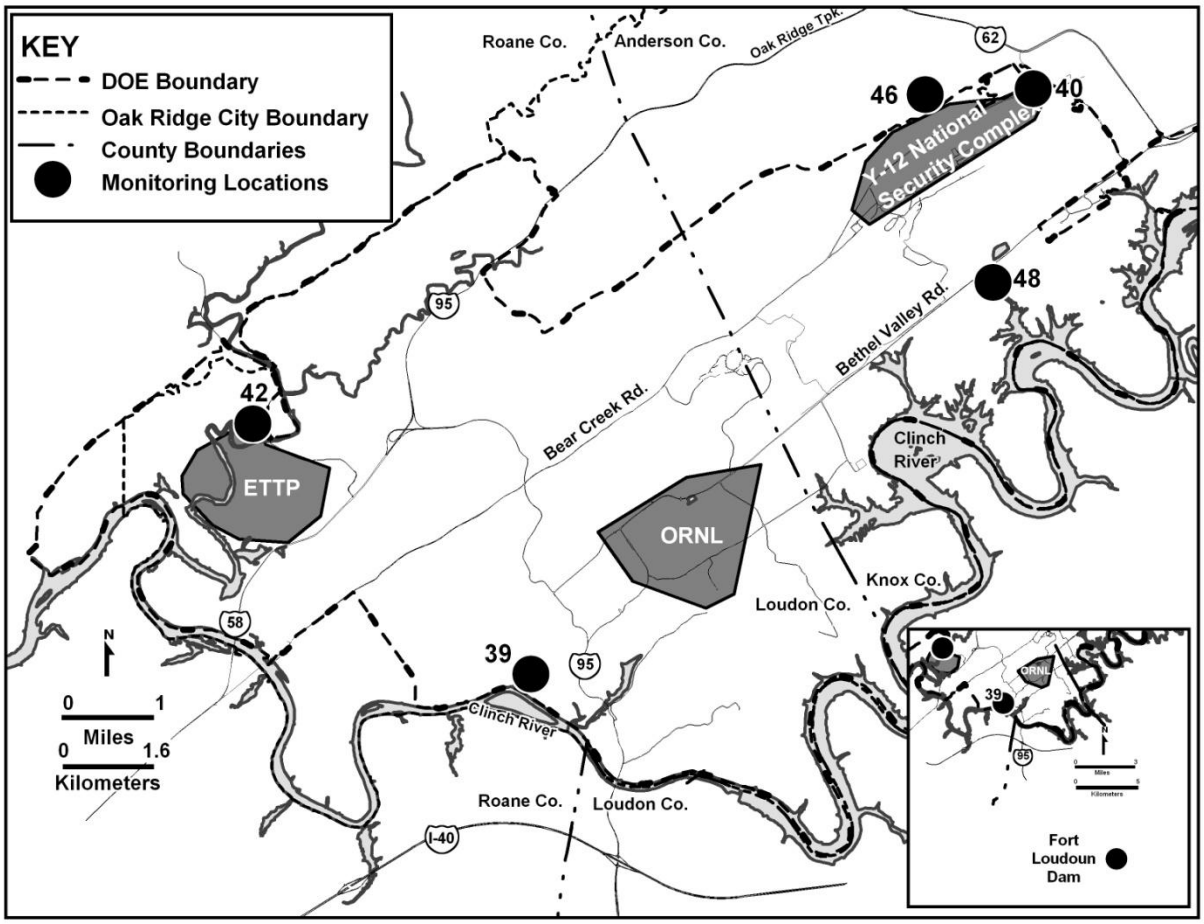


Fig. 6.2. External gamma radiation monitoring locations on the ORR.

Table 6.2. External gamma averages for the ORR, 2008

Monitoring location	Number of data values collected	Measurement (μR/h)[a]		
		Min	Max	Mean
39	53	6.1	6.7	6.4
40	53	4.0	5.8	5.1
42	53	4.2	5.3	4.8
46	53	6.1	6.7	6.3
48	53	4.4	5.3	4.6
52	49	4.2	4.8	4.5

[a]To convert microroentgens per hour (μR/h) to milliroentgens per year, multiply by 8,760.

6.3.1 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. 6.3). Reference samples are collected from Station 52 (Fort Loudoun Dam). Sampling was conducted at each ORR station during 2008 to quantify levels of alpha-, beta-, and gamma-emitting radionuclides and ^{3}H.

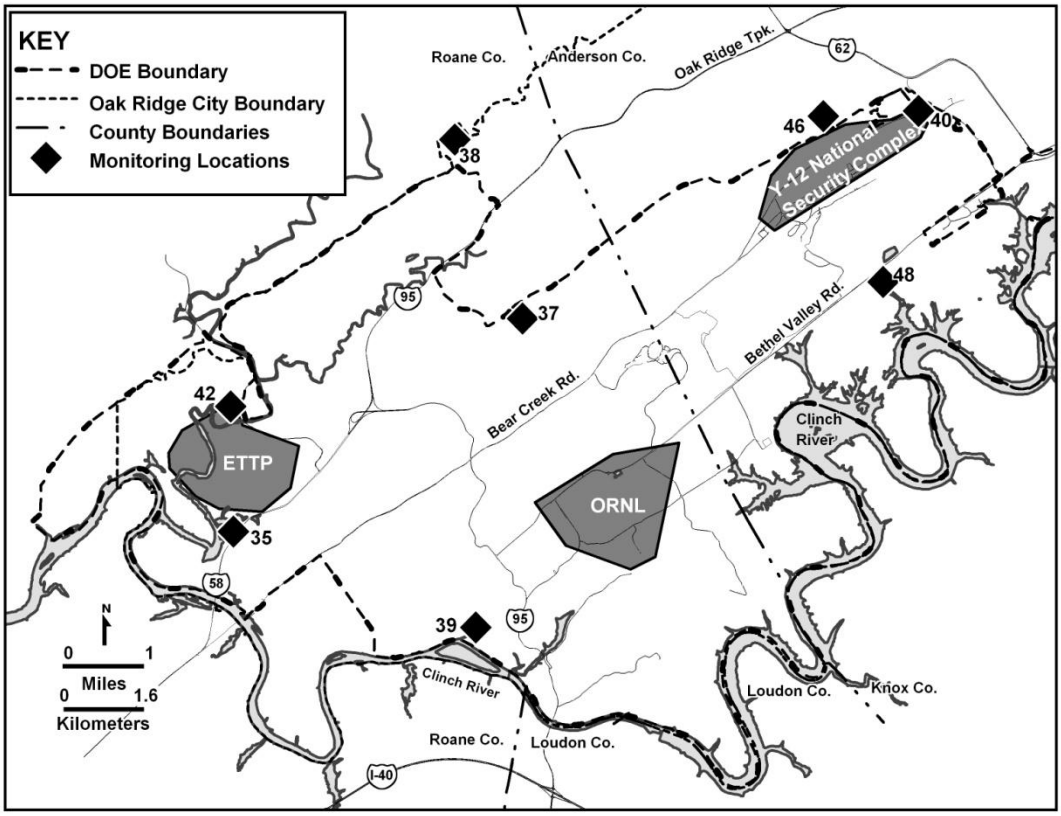


Fig. 6.3. Locations of ORR perimeter air monitoring stations.

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.

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 an analytical laboratory for isotopic analysis. The second system is designed to collect tritiated water vapor. The sampler consists of a prefilter followed by an adsorbent trap consisting of indicating silica gel. The samples are collected weekly or biweekly, composited quarterly, and then submitted to an analytical laboratory for ^{3}H analysis.

The ORR ambient air network (Fig. 6.3) provides appropriate monitoring for all facilities 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 operations. 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.

6.3.2 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 derived concentration guides (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 6.3. Table 6.4 represents the average concentration of three isotopes of uranium at each station for the sampling years 2004 through 2008.

6.4 Surface Water Monitoring

6.4.1 ORR Surface Water Monitoring

The ORR surface water monitoring program consists of sample collection and analysis from five locations on the Clinch River, including public water intakes (Fig. 6.4). 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.

Grab samples are collected quarterly at all five locations and are analyzed for general water quality parameters, screened for radioactivity, and analyzed for mercury and specific radionuclides when appropriate. Table 6.5 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 2008). 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.

6.4.2 Results

Comparison of 2008 surface water sample results from locations upstream of DOE inputs with results from surface water samples obtained downstream of DOE inputs shows a statistically significant difference for gross beta. None of the radionuclides, including gross beta, were detected above 4% of the respective DCG or the 4 mrem dose limit at any location.

6.5 Food

Vegetation samples are collected from areas that could be affected by activities on the reservation. Analysis of the samples enables the evaluation of potential radiation doses received by people who consume local food crops. Food crop monitoring data are also used to monitor trends in environmental contamination and possible long-term accumulation of radionuclides.

6.5.1 Hay

Hay monitoring on the ORR was not conducted in 2008. An evaluation of data from the past 16 years demonstrates that activities on the reservation are not having a significant impact on the radionuclide concentrations in hay grown nearby, and extensive effluent monitoring programs conducted at each of the three major facilities and for the reservation continue to enable quantifying potential impacts on hay.

Table 6.3. Average radionuclide concentrations at ORR perimeter air monitoring stations, 2008

Parameter	No. detected/ no. total	Concentration (pCi/mL)[a]		
		Average	Minimum	Maximum
		Station 35		
Be-7	4/4	3.69E-08	2.26E-08	5.11E-08
K-40	0/4	2.20E-10	-1.41E-10	5.79E-10
Tritium	0/4	2.66E-06	-8.95E-07	6.28E-06
U-234	4/4	6.58E-12	2.76E-12	1.08E-11
U-235	2/4	3.85E-13	0	8.44E-13
U-238	4/4	8.29E-12	1.54E-12	1.86E-11
		Station 37		
Be-7	4/4	3.71E-08	1.68E-08	6.07E-08
K-40	0/4	2.57E-10	-8.80E-11	8.85E-10
Tritium	0/4	-4.27E-08	-1.80E-06	1.69E-06
U-234	4/4	3.81E-12	1.30E-12	5.64E-12
U-235	1/4	3.37E-13	1.99E-13	4.24E-13
U-238	4/4	4.34E-12	1.03E-12	7.04E-12
		Station 38		
Be-7	4/4	4.11E-08	1.99E-08	7.03E-08
K-40	0/4	1.91E-10	-2.27E-10	6.38E-10
Tritium	0/4	1.02E-06	2.73E-07	1.91E-06
U-234	4/4	3.50E-12	2.24E-12	5.89E-12
U-235	2/4	4.38E-13	1.90E-13	8.22E-13
U-238	4/4	3.57E-12	1.33E-12	5.76E-12
		Station 39		
Be-7	4/4	3.67E-08	2.66E-08	5.00E-08
K-40	0/4	3.51E-10	6.31E-11	4.96E-10
Tritium	0/4	4.32E-07	-1.88E-06	2.89E-06
U-234	4/4	2.76E-12	1.61E-12	4.55E-12
U-235	2/4	1.66E-13	1.24E-14	2.62E-13
U-238	4/4	2.88E-12	1.76E-12	4.10E-12
		Station 40		
Be-7	4/4	4.20E-08	3.14E-08	6.24E-08
K-40	0/4	7.91E-11	-5.10E-10	4.60E-10
Tritium	0/4	3.82E-07	-2.12E-06	2.24E-06
U-234	4/4	1.68E-11	9.13E-12	2.07E-11
U-235	4/4	9.24E-13	6.09E-13	1.08E-12
U-238	4/4	5.79E-12	3.93E-12	8.32E-12
		Station 42		
Be-7	4/4	2.79E-08	2.05E-08	4.24E-08
K-40	0/4	9.03E-11	-1.36E-10	2.67E-10
Tritium	0/4	2.00E-06	7.09E-07	2.82E-06
U-234	4/4	4.25E-12	3.00E-12	6.01E-12
U-235	2/4	4.13E-13	2.22E-13	8.36E-13
U-238	4/4	3.72E-12	1.55E-12	6.07E-12

Table 6.3. (Continued)

Parameter	No. detected/ no. total	Concentration (pCi/mL)[a]		
		Average	Minimum	Maximum
		Station 46		
Be-7	4/4	4.07E-08	2.00E-08	6.90E-08
K-40	0/4	-1.49E-10	-3.15E-10	9.84E-11
Tritium	0/4	2.90E-06	8.72E-07	5.10E-06
U-234	4/4	9.39E-12	4.86E-12	1.65E-11
U-235	2/4	5.68E-13	2.07E-13	8.63E-13
U-238	4/4	6.35E-12	2.23E-12	1.02E-11
		Station 48		
Be-7	4/4	3.37E-08	1.57E-08	4.90E-08
K-40	0/4	4.35E-11	-7.42E-11	1.06E-10
Tritium	0/4	3.11E-07	-6.05E-07	1.90E-06
U-234	4/4	4.08E-12	1.68E-12	6.06E-12
U-235	1/4	2.70E-13	5.49E-14	6.93E-13
U-238	4/4	3.60E-12	2.10E-12	6.64E-12
		Station 52		
Be-7	4/4	3.37E-08	1.84E-08	5.59E-08
K-40	0/4	2.13E-11	-4.56E-10	3.34E-10
Tritium	0/4	3.40E-07	-5.73E-07	1.32E-06
U-234	4/4	2.86E-12	1.97E-12	3.73E-12
U-235	1/4	3.20E-13	5.40E-14	7.34E-13
U-238	4/4	2.40E-12	1.29E-12	4.08E-12

[a]1 pCi = 3.7×10^{-2} Bq.

6.5.2 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.

6.5.2.1 Results

Samples were analyzed for gross alpha, gross beta, gamma emitters, and uranium isotopes. No gamma-emitting radionuclides were detected above the minimum detectable activity (MDA), with the exception of the naturally occurring radionuclide ^{40}K. Concentrations of radionuclides detected above MDA are shown in Table 6.6.

6.5.3 Milk

In 2008, local dairies in areas of potential impact could not be located for milk sampling. Periodic surveys of agricultural information in those areas are conducted, and if dairy operations in affected areas are identified, sampling will be conducted to confirm that concentrations of radionuclides from ORR operations are not significantly impacting the quality of milk produced in the vicinity of the ORR.

6.6 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

Table 6.4. Uranium concentrations in ambient air on the ORR

Isotope	Concentration (pCi/mL)[a]				
	2004	2005	2006	2007	2008
			Station 35		
^{234}U	2.38E–11	1.24E–11	1.43E–11	1.28E–11	6.58E-12
^{235}U	1.36E–12	1.10E–12	1.09E–12	6.88E–13	3.85E-13
^{238}U	1.56E–11	2.16E–11	1.94E–11	1.87E–11	8.29E-12
			Station 37		
^{234}U	1.24E–11	8.01E–12	4.52E–12	6.02E–12	3.81E-12
^{235}U	5.40E–13	9.22E–13	5.83E–13	5.09E–13	3.37E-13
^{238}U	7.90E–12	1.01E–11	6.84E–12	1.28E–11	4.34E-12
			Station 38		
^{234}U	9.47E–12	6.21E–12	5.69E–12	6.93E–12	3.5E-12
^{235}U	6.17E–13	5.72E–13	4.72E–13	4.74E–13	4.38E-13
^{238}U	8.50E–12	7.50E–12	8.28E–12	1.41E–11	3.57E-12
			Station 39		
^{234}U	4.84E–12	4.58E–12	4.46E–12	4.05E–12	2.76E-12
^{235}U	4.36E–13	5.74E–13	4.08E–13	3.86E–13	1.66E-13
^{238}U	4.03E–12	4.40E–12	4.51E–12	4.44E–12	2.88E-12
			Station 40		
^{234}U	3.83E–11	2.85E–11	2.07E–11	2.25E–11	1.68E-11
^{235}U	1.43E–12	1.43E–12	1.22E–12	1.01E–12	9.24E-13
^{238}U	7.74E–12	8.73E–12	6.65E–12	1.15E–11	5.79E-12
			Station 42		
^{234}U	2.00E–11	7.51E–12	1.01E–11	6.57E–12	4.25E-12
^{235}U	1.06E–12	4.58E–13	3.55E–13	4.66E–13	4.13E-13
^{238}U	1.31E–11	1.03E–11	9.68E–12	1.18E–11	3.72E-12
			Station 46		
^{234}U	2.09E–11	1.82E–11	1.07E–11	1.12E–11	9.39E-12
^{235}U	1.47E–12	1.10E–12	4.14E–13	7.18E–13	5.68E-13
^{238}U	9.88E–12	1.04E–11	7.01E–12	1.24E–11	6.35E-12
			Station 48		
^{234}U	7.31E–12	7.63E–12	5.50E–12	7.84E–12	4.08E-12
^{235}U	6.15E–13	5.01E–13	2.49E–13	5.53E–13	2.7E-13
^{238}U	5.93E–12	6.60E–12	4.15E–12	9.84E–12	3.6E-12
			Station 52		
^{234}U	5.00E–12	5.03E–12	3.52E–12	3.74E–12	2.86E-12
^{235}U	3.72E–13	5.31E–12	–6.54E–14	7.20E–14	3.2E-13
^{238}U	4.26E–12	3.95E–12	3.69E–12	3.94E–12	2.4E-12

[a]1 pCi = 3.7×10^{-2} Bq.

from three locations on the Clinch River annually and analyzing edible fish flesh. The locations are as follows (Fig. 6.5):

- Clinch River upstream from all DOE ORR inputs (Clinch River kilometer [CRK] 70),
- Clinch River downstream from ORNL (CRK 32), and
- Clinch River downstream from all DOE ORR inputs (CRK 16).

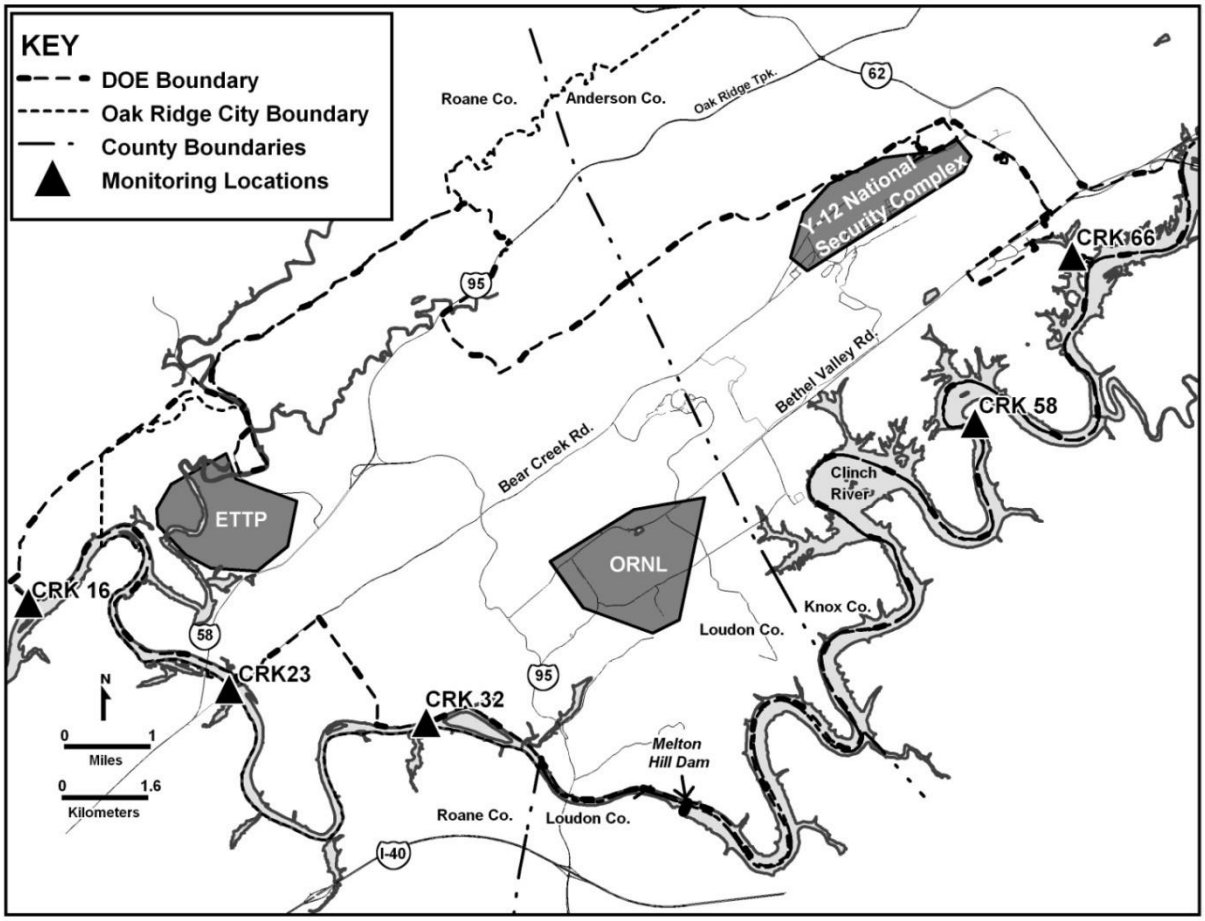


Fig. 6.4. ORR surface water surveillance sampling locations.

Sunfish (*Lepomis macrochirus*, *L. auritus*, and *Ambloplites rupestris*) and catfish (*Ictalurus punctatus*) are collected from each of the three locations, filleted, and frozen. In 2008, one composite sample of flesh from each species at each location was analyzed for selected metals, PCBs, ^{3}H, gross alpha, gross beta, gamma-emitting radionuclides, and total radioactive strontium.

6.6.1 Results

The Tennessee Department of Environment and Conservation (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). These advisories are applicable to atypical consumers, those persons who, because of physiological factors or previous exposures, are more sensitive to specific pollutants; they may include pregnant or nursing women, children, and subsistence fishermen.

In 2008, mercury and radionuclides were detected in both sunfish and catfish at all locations. The 2008 results also show PCBs detected in both species of fish at all locations. PCB-1260 was found in all of the sunfish and catfish composite samples from all of the locations; PCB-1254 was found in all of the catfish composite samples from all of the locations and not in any of the sunfish composite samples. TDEC has issued a fish advisory for the Melton Hill Reservoir in its entirety because of PCB contamination, and the 2008 ORR fish data at upstream and downstream locations are consistent with the advisory.

Table 6.5. ORR surface water sampling locations, frequencies, and parameters, 2008

Location[a]	Description	Frequency	Parameters
CRK 16	Clinch River downstream from all DOE ORR inputs	Quarterly	Mercury, gross alpha, gross beta, gamma scan, ^{3}H, field measurements[b]
CRK 23	Water supply intake for the ETTP	Quarterly	Mercury, gross alpha, gross beta, gamma scan, ^{3}H, field measurements[b]
CRK 32	Clinch River downstream from ORNL	Quarterly	Gross alpha, gross beta, gamma scan, total radioactive strontium, ^{3}H, field measurements[b]
CRK 58	Water supply intake for Knox County	Quarterly	Gross alpha, gross beta, gamma scan, ^{3}H, field measurements[b]
CRK 66	Melton Hill Reservoir above city of Oak Ridge water intake	Quarterly	Mercury, gross alpha, gross beta, gamma scan, total radioactive strontium, ^{3}H, field measurements[b]

[a]Locations indicate bodies of water and distances (e.g., Clinch River kilometer [CRK] 16 = 16 km upstream from the confluence of White Oak Creek and the Clinch River).

[b]Field measurements consist of dissolved oxygen, pH, and temperature.

6.7 White-Tailed Deer

The twenty-third annual deer hunts managed by DOE and the Tennessee Wildlife Resources Agency (TWRA) were held on the ORR during the final quarter of 2008. 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 2008 hunts were held on three weekends. Shotgun/muzzleloader and archery hunts were held November 1–2, November 15–16, and December 6–7. In 2008, there were about 500 shotgun/ muzzleloader-permitted hunters and 600 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; one could be an antlered buck.

The year's total harvest was 483 deer. From the total deer harvest, 284 (58.8%) were bucks and 199 (41.2%) were does. The heaviest buck had eleven antler points and weighed 187 lb. The greatest number of antler points found on one buck was 26. The heaviest doe weighed 118 lb.

Since 1985 10,345 deer have been harvested. Of these only 195 (1.88%) have been retained as a result of potential radiological contamination. The heaviest buck was 218 lb (harvested in 1998); the average weight is 85.8 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.

6.7.1 Results

In the 2008 hunts, 483 deer were harvested on the ORR, and 7 (1.45%) 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 seven retained deer exceeded the limit for beta-particle activity in bone. The average weight of the released deer was 86.7 lb; the maximum weight was 187 lb. The average

^{137}Cs concentration in the released deer was 0.67 pCi/g, and the maximum ^{137}Cs concentration in the released deer was 0.92 pCi/g.

Table 6.6. Concentrations of radionuclides detected in vegetables, 2008 (pCi/kg)[a]

Location	Gross alpha	Gross beta	^{7}Be	^{40}K	^{234}U	^{235}U	^{238}U
			Lettuce				
East of ORR (Claxton vicinity)	0.000030	0.00094	*b*	0.0032	0.0000050	*b*	*b*
North of ETTP	*b*	0.0047	*b*	0.0079	0.0000057	*b*	*b*
Northeast of Y-12, Scarboro #1	0.000023	0.0014	*b*	0.0047	*b*	*b*	*b*
Northeast of Y-12, Scarboro #2	0.000030	0.0020	*b*	0.0046	*b*	*b*	*b*
Southeast of ORNL	0.000080	0.0025	0.00034	0.0049	*b*	*b*	*b*
Southwest of ORNL	0.00014	0.0030	*b*	0.0058	*b*	*b*	*b*
			Tomato				
East of ORR (Claxton vicinity)	0.000048	0.0013	*b*	0.0024	*b*	*b*	*b*
North of ETTP	*b*	0.0017	*b*	0.0026	*b*	*b*	*b*
Northeast of Y-12, Scarboro #1	0.000030	0.0013	*b*	0.0024	*b*	*b*	*b*
Northeast of Y-12, Scarboro #2	*b*	0.0019	*b*	0.0025	*b*	*b*	*b*
Southeast of ORNL	0.00019	0.0014	*b*	0.0027	*b*	*b*	*b*
Southwest of ORNL	0.000018	0.0016	*b*	0.0017	*b*	*b*	*b*
			Turnips				
East of ORR (Claxton vicinity)	0.000051	0.0015	*b*	0.0019	*b*	*b*	*b*
North of ETTP	0.000041	0.0019	*b*	0.0035	*b*	0.0000016	*b*
Northeast of Y-12, Scarboro #1	0.000101	0.0022	*b*	0.003	*b*	*b*	*b*
Northeast of Y-12, Scarboro #2	0.000092	0.0019	*b*	0.0025	*b*	*b*	*b*
Southeast of ORNL	0.000069	0.0015	*b*	0.0024	*b*	*b*	*b*
Southwest of ORNL	0.000085	0.0020	*b*	0.0024	*b*	*b*	*b*

[a]Detected radionuclides are those detected at or above minimum detectable activity. 1 pCi = 3.7×10^{-2} Bq.
[b]Value was not detected above minimum detectable activity.

It is assumed that 55% of the field weight is edible meat; therefore, the average deer would yield 47.7 lb of meat. The total harvest of edible meat (476 released deer) is estimated to be 22,701 lb.

6.8 Fowl

6.8.1 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 on the

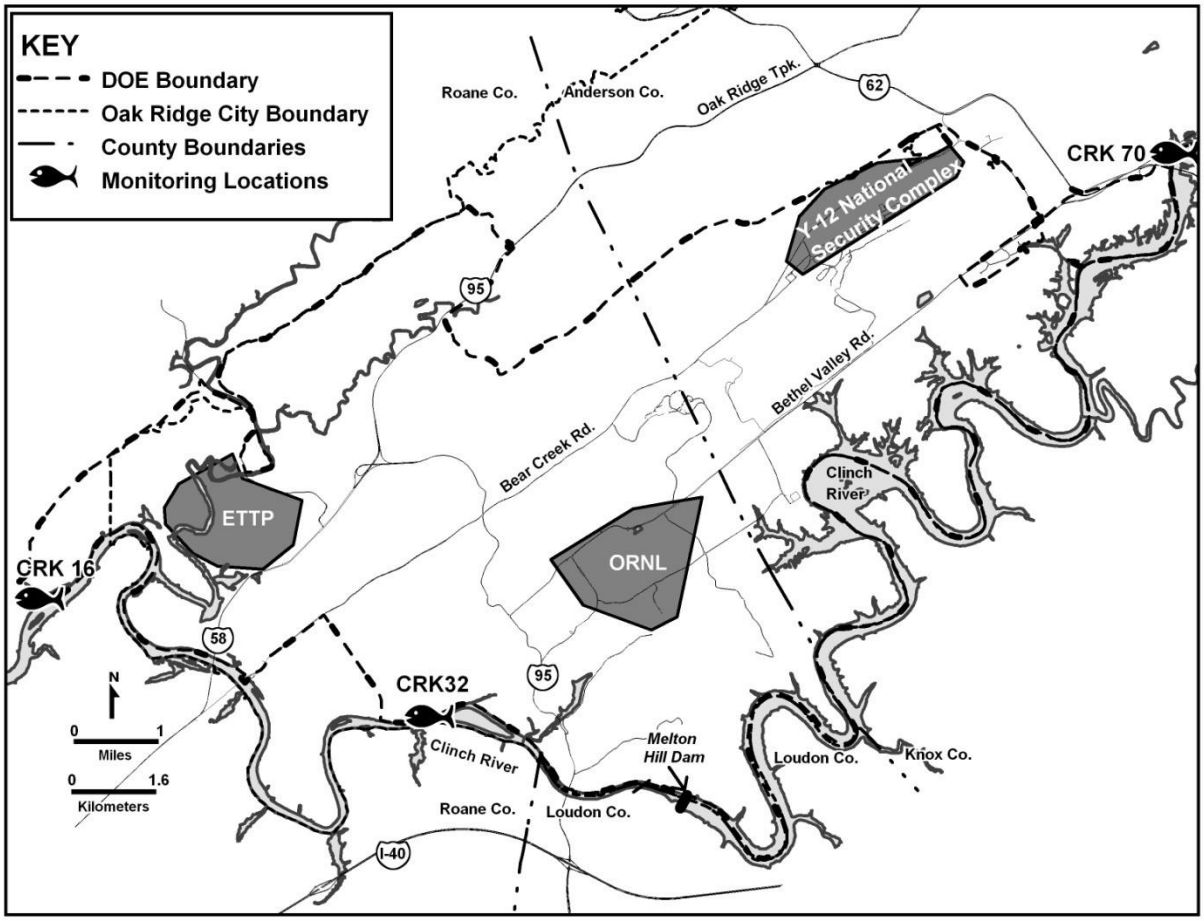


Fig. 6.5. Fish sampling locations for the ORR.

ORR and in counties adjacent to the reservation 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, 227 geese were subjected to live whole-body gamma scans. The geese were collected from ETTP/ORNL (136), Y-12 (28), and Lagoon Road/Clark Center Park (63). None exceeded the administrative release limits.

6.8.1.1 Results

The average ^{137}Cs concentration in the released geese was about 0.26 pCi/g. However, most of the ^{137}Cs concentrations were less than the minimum detection level. The maximum ^{137}Cs concentration in the released geese was about 0.63 pCi/g. The average weight of the geese screened during the roundup was 8.2 lb, and the maximum goose weight was 11.5 lb. No geese were sacrificed for radiological analyses in 2008.

6.8.2 Turkey Monitoring

Two wild turkey hunts managed by DOE and TWRA were held on the reservation (April 5 and 6, and April 12 and 13, 2008). Hunting was open for both shotguns and archery. Twenty-one turkeys were harvested, of which 2 (9.5%) were juveniles and 19 (90.5%) were adults. The average turkey weight was about 19.9 lb. The largest tom weighed 23.3 lb. The longest beard was 11.5 inches, and the average was 9.9 inches. The longest spur was 1.3 inches and the average was 1.0 inches.

Since 1997, 510 turkeys have been harvested. Of these, only three (0.59 %) have been retained because of potential radiological contamination. The heaviest turkey was 24.6 lb; the average weight is 18.7 lb. 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.). For additional information, see the ORNL wildlife webpage: http://www.ornl.gov/rmal/huntinfo.htm.

6.8.2.1 Results

In 2008, none of the 21 birds harvested exceeded the administrative release limits established for radiological contamination. The average ^{137}Cs concentration in the released turkeys was 0.1 pCi/g, and the maximum ^{137}Cs concentration in the released birds was 0.15 pCi/g. Most of the ^{137}Cs concentrations were less than the minimum detection level. It is assumed that about 50% of the field weight is edible meat; therefore, the average turkey would yield about 9.9 lb of meat. Based on the individual weights, the total harvest of edible meat (21 released birds) is estimated to be about 208.8 lb. No turkeys were sacrificed for radiological analyses in 2008.

6.9 Quality Assurance

The activities associated with administration, sampling, data management, and reporting for the ORR environmental surveillance programs are performed by the UT-Battelle Environmental Protection and Waste Services Division. Project scope is established by a task team composed of members representing DOE and each of the three major ORR facilities. UT-Battelle integrates quality assurance, environmental, and safety considerations into every aspect of ORR environmental monitoring. See Sect. 5.8 for a discussion of UT-Battelle quality assurance program elements for environmental monitoring and surveillance activities.

6.10 References

Bowen, B. M., J. A. Baars, and G. L. Stone. 2000. “Nocturnal Wind Shear and its Potential Impact on Pollutant Transport.” Journal of Applied Meteorology 39 (3), 437–45.

TDEC. 2002. The Status of Water Quality in Tennessee. 305b Report. Tennessee Department of Environment and Conservation, Division of Water Pollution Control, Nashville, Tennessee.

TDEC. 2008. 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 June 2008).

7. 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 (ED) of about 0.4 mrem from radionuclides emitted to the atmosphere from all of the sources on the ORR in 2008; 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 ED of about 1 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 ED of about 0.7 mrem, an individual who consumed an average-weight goose containing the average ^{137}Cs concentration could have received 0.2 mrem, and an individual who consumed an average-weight turkey containing the average ^{137}Cs concentration could have received 0.02 mrem. If a hypothetical person consumed one deer, one turkey, and two geese (containing the maximum ^{137}Cs concentration and maximum weights), that person could have received an ED of approximately 2 mrem. This calculation is conducted to provide an estimated upper-bound ED from consuming wildlife harvested from the ORR.

7.1 Radiation Dose

Small quantities of radionuclides were released to the environment from operations at the ORR facilities during 2008. 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 effective doses, and environmental transport and dosimetry codes that also tend to overestimate the calculated effective doses. 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.

7.1.1 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 F. An important term to understand is “effective dose” (ED). ED is a risk-based equivalent dose 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 ED, 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, EDs are

expressed in millirem (mrem), which is one one-thousandth of a rem. (See Appendix F, Sects. F.5.6 through F.5.12, for a comparison and description of various dose levels.)

7.1.2 Methods of Evaluation

7.1.2.1 Airborne Radionuclides

The radiological consequences of radionuclides released to the atmosphere from ORR operations during 2008 were characterized by calculating, for each major facility and for the entire ORR, EDs to maximally exposed off-site individuals, to on-site members of the public, and to the entire population residing within 50 miles of the center of the ORR. The dose calculations were made using CAP-88PC Version 3, 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. The CAP-88PC package implements a steady-state Gaussian plume atmospheric dispersion model to calculate concentrations of radionuclides in the air and on the ground and uses food-chain models to calculate radionuclide concentrations in foodstuffs (vegetables, meat, and milk) and subsequent intakes by humans.

This is the second year CAP-88PC Version 3 has been used. A major difference between the earlier CAP-88 and the CAP-88 PC Version 3 is the use of dose coefficients from *Federal Guidance Report* (FGR) Number 13 (EPA 1999). The FGR 13 dose coefficients are based on the methods in Publication 72 of the International Commission on Radiological Protection (ICRP 1996). The dose coefficients are used to calculate EDs instead of effective dose equivalents (EDEs), which were calculated in earlier CAP-88 versions. The ED, as was the EDE, is the weighted sum of equivalent dose over specified tissues or organs. For the ED there are tissue-weighting factors for 12 tissues or organs (as well as 1 for remainder organs and tissues), as compared to the EDE, for which there were 6 tissue-weighting factors (and 1 for remainder organs and tissues). In addition to tissue-weighting factor modifications, there have been updates to the lung model, gastrointestinal absorption fractions, and biokinetic models used for selected elements.

A total of 30 emission points on the ORR, each of which includes 1 or more individual sources, were modeled during 2008. The total includes 4 (2 combined) points at the Y-12 Complex, 22 points at ORNL, and 4 points at ETTP. Table 7.1 is a list of the emission-point parameter values and receptor locations used in the dose calculations.

Meteorological data used in the calculations for 2008 were in the form of joint frequency distributions of wind direction, wind speed class, and atmospheric stability category. (See Table 7.2 for a summary of tower locations used to model the various sources.) During 2008, rainfall, as averaged over the four rain gauges located on the ORR, was 127.9 cm. The average air temperature was 14.3°C, and the average mixing-layer height was 588 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 ED estimates, production of beef, milk, and crops within 80 km of the ORR was calculated using production rates provided with CAP-88.

Table 7.1. 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[a]			
					Plant maximum		Oak Ridge Reservation maximum	
X-Lab Hoods								
X-1000 Lab Hoods	15	0.5	0	Ambient	NA		NA	
X-2000 Lab Hoods	15	0.5	0	Ambient	5480	E	5480	E
X-3000 Lab Hoods	15	0.5	0	Ambient	4950	E	4950	E
X-4000 Lab Hoods	15	0.5	0	Ambient	4730	E	4730	E
X-6000 Lab Hoods	15	0.5	0	Ambient	4110	E	4110	E
X-7000 Lab Hoods	15	0.5	0	Ambient	4180	ENE	4180	ENE
X-2026	22.9	1.05	10.31	Ambient	5310	E	5310	E
X-2099	3.66	0.178	16.67	Ambient	5280	E	5280	E
X-2523	7	0.3	0	Ambient	5260	ENE	5260	ENE
X-3018	61	4.11	0.23	Ambient	5080	E	5080	E
X-3020	61	1.22	15.58	Ambient	5150	E	5150	E
X-3039	76.2	2.44	13.05	Ambient	5020	E	5020	E
X-3074 Group	4	0.25	0	Ambient	NA		NA	
X-3544	9.53	0.279	18.47	Ambient	5040	ENE	5040	ENE
X-3608 Air Stripper	10.97	2.44	0.57	Ambient	4880	ENE	4880	ENE
X-3608 Filter Press	8.99	0.36	9.27	Ambient	NA		NA	
X-5505								
X-5505M	11	0.305	2.8	Ambient	NA		NA	
X-5505NS	11	0.96	0	Ambient	4340	E	4340	E
X-7503	30.5	0.91	10.27	Ambient	4180	ENE	4180	ENE
X-7830 Group	4.6	0.248	8.56	Ambient	5530	ENE	5530	ENE
X-7856-CIP	18.29	0.483	12.38	Ambient	5480	ENE	5480	ENE
X-7877	13.9	0.406	13.56	Ambient	5550	ENE	5550	ENE
X-7880	27.7	1.52	0	Ambient	5480	ENE	5480	ENE
X-7911	76.2	1.52	12.69	Ambient	4220	ENE	4220	ENE
X-7966	6.096	0.292	11.58	Ambient	4160	ENE	4160	ENE
X-8915	24.38	1.219	5.67	Ambient	4240	ESE	4240	ESE
X-Decon Areas	15	0.5	0	Ambient	4700	E	47000	E
X-STP	7.6	0.203	10.21	Ambient	5240	ENE	5240	ENE
K-1407-U CNF	7.16	1.22	0.625	Ambient	380	SSW	11340	E
K-1423 SWR	7.62	0.71	12.8	Ambient	500	SE	11830	E
K-1435 Incinerator	30.5	1.37	6.01	78.12	700	WSW	10760	E
K-1435-C Tanks	18.29	0.2	0	Ambient	660	WSW	10790	E
Y-Monitored	20	0.5	0	Ambient	2270	NE	5800	S
Y-Room Exhaust	20	0.5	0	Ambient	2270	NE	5800	S
Y-Unmonitored Processes	20	0.5	0	Ambient	2270	NE	5800	S
Y-Unmonitored Lab Hoods	20	0.5	0	Ambient	2270	NE	5800	S

[a]NA: effective doses (EDs) were calculated to be zero, therefore, distance and direction to maximally exposed individuals could not be determined.

"X" prefix designates Oak Ridge National Laboratory.

"K" prefix designates East Tennessee Technology Park.

"Y" prefix designates Y-12 National Security Complex.

Table 7.2. Summary of Oak Ridge Reservation meteorological towers, sampling heights, and sources

Tower	Height (m)	Source
		Y-12 Complex
MT6	20[a]	All Y-12 sources
MT6	60	Spallation Neutron Source (ORNL)
		East Tennessee Technology Park
MT1	10	K-1435 Tanks
MT1	60	K-1435 Incinerator
MT7	10	K-1407-U, K-1423-SWR
		Oak Ridge National Laboratory
MT4	10	X-7830, X-7966
MT4	30	X-7503, X-7856-CIP, X-7877, X-7880, X-7911, and X-7000 Lab Hoods
MT3	30	X-6000 Lab Hoods
MT2	10	X-2099, X-2523, X-3074, X-3544, X-3608FP, and X-STP
MT2	30	X-2026, X-3608AS, X-5505(NS & M), X-Decon Areas, and X-1000, 2000, 3000, & 4000 Lab Hoods
MT2	100	X-3018, X-3020, and X-3039

[a]Wind speeds adjusted to match conditions at a height of 20 m.

7.1.2.1.1 Results

Calculated EDs from radionuclides emitted to the atmosphere from the ORR are listed in Table 7.3 (maximum individual) and Table 7.4 (collective). The hypothetical maximally exposed individual for the ORR was located about 5,800 m south of the main Y-12 National Security Complex release point, about 4,220 m east-northeast of the 7911 stack at ORNL, and about 10,760 m east of the Toxic Substances Control Act (TSCA) Incinerator (stack K-1435) at the ETTP. This individual could have received an ED of about 0.4 mrem, which is well below the NESHAP standard of 10 mrem and is 0.1 % of the 300 mrem that the average individual receives from natural sources of radiation. The calculated collective ED to the entire population within 80 km of the ORR (about 1,040,041 persons) was about 27 person-rem, which is approximately 0.009 % of the 312,012 person-rem that this population received from natural sources of radiation (based on an individual dose of 300 mrem/year).

The maximally exposed individual for the Y-12 National Security Complex was located at about 2,270 m northeast of the main Y-12 Complex release point. This individual could have received an ED of about 0.1 mrem from Y-12 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 (about 82%) of the dose. The contribution of Y-12 Complex emissions to the 50-year committed collective ED to the population residing within 80 km of the ORR was calculated to be about 1 person-rem, which is approximately 4% of the collective ED for the ORR.

The maximally exposed individual for ORNL was located at a residence about 5,020 m east of the 3039 stack and 4,220 m east-northeast of the 7911 stack. This individual could have received an ED of about 0.36 mrem from ORNL emissions. Radionuclides contributing 1% or more to the dose include ^{41}Ar (61.4%), ^{212}Pb (13.8 %),^{138}Cs (13.6%), ^{125}I (2 %),and ^{88}Kr (1.7 %), ^{89}Kr (1.2 %). The contribution of ORNL emissions to the collective ED to the population residing within 80 km of the ORR was calculated to be about 24 person-rem, approximately 89% of the collective ED for the ORR.

The maximally exposed individual for the ETTP was located at a business about 700 m west-southwest of the TSCA Incinerator stack. The ED received by this individual was calculated to be about 0.05 mrem. About 13 % of the dose is from ingestion and inhalation of uranium radioisotopes, about 79% is from ^{3}H, and 3.9 % is from ^{99}Tc. The contribution of ETTP emissions to the collective ED to the

population residing within 80 km of the ORR was calculated to be about 2 person-rem; approximately 7% of the collective ED for the reservation.

Table 7.3. Calculated radiation doses to maximally exposed off-site individuals from airborne releases, 2008

Plant	Effective dose, mrem (mSv)	
	At plant max	At Oak Ridge Reservation max
Oak Ridge National Laboratory	0.36 (0.0036)[a]	0.36 (0.0036)
East Tennessee Technology Park	0.05 (0.0005)[b]	0.02 (0.0002)
Y-12 National Security Complex	0.1(0.001)[c]	0.007(0.00007)
Entire Oak Ridge Reservation	*d*	0.4(0.004)[e]

[a]The maximally exposed individual was located 5020 m E of X-3039 and 4220 m ENE of X-7911.

[b]The maximally exposed individual was located 700m WSW of K-1435.

[c]The maximally exposed individual is located 2270 m NE of the Y-12 National Security Complex release point.

[d]Not applicable.

[e]The maximally exposed individual for the entire ORR is the ORNL maximally exposed individual.

Table 7.4. Calculated collective effective doses from airborne releases, 2008

Plant	Collective effective dose[a]	
	Person-rem	Person-Sv
Oak Ridge National Laboratory	24	0.24
East Tennessee Technology Park	2	0.02
Y-12 National Security Complex	1	0.01
Entire Oak Ridge Reservation (ORR)	27	0.27

[a]Collective effective dose to the 1,040,041 persons residing within 80 km of the ORR (based on 2000 census data).

The reasonableness of the estimated radiation doses can be inferred by comparing EDs estimated from measured radionuclide air concentrations with EDs estimated from calculated (using CAP-88 and emission data) radionuclide air concentrations at the ORR perimeter air monitoring stations (PAMs) (Table 7.5). Based on measured radionuclide air concentrations that could have been released from operations on the ORR (i.e., excluding naturally occurring ^{7}Be and ^{40}K), hypothetical individuals assumed to reside at the PAMs could have received EDs between 0.0008 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 EDs between 0.06 and 0.4 mrem/year. EDs calculated using CAP-88 tended to be higher than EDs calculated using measured air concentrations (Table 7.5).

An indication of doses from sources other than those on the ORR can be obtained from the ED calculated from measured air concentrations at the background air monitoring station (Station 52), which was 0.001 mrem/year. (The isotopes ^{7}Be and ^{40}K also were not included in the background air monitoring station calculation.) It should be noted that measured air concentrations of ^{7}Be were similar at the PAMs and at the background air monitoring station. No CAP-88 calculations were performed for this 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 located near the maximally exposed individual for the Y-12 Complex. The ED calculated using measured air concentrations was 0.008 mrem/year, which is less than the ED of 0.2 mrem/year calculated at the PAM

40 air monitor station using CAP-88. PAM 39 is located closer in but near one of higher dose locations for ORNL; the ED calculated using measured air concentrations was 0.001 mrem/year, which was considerably less than the 0.4 mrem/year calculated using CAP-88. The K-11 Air Monitoring Station is located near the ETTP maximally exposed individual (at a business); the ED calculated using measured air concentrations was about 0.04 mrem/year, which was approximately the same as the ETTP maximally exposed individual annual dose of 0.05 mrem, estimated using CAP-88.

Table 7.5. Hypothetical effective doses from living at the Oak Ridge Reservation and the East Tennessee Technology Park ambient-air monitoring stations, 2008

Station	Calculated effective doses			
	Using air monitor data		Using CAP-88[a] and emission data	
	mrem/year	mSv/year	mrem/year	mSv/year
35	0.06	0.0006	0.1	0.001
37	0.0008	0.000008	0.1	0.001
38	0.001	0.00001	0.07	0.0007
39	0.001	0.00001	0.4	0.004
40	0.008	0.00008	0.2	0.002
42	0.001	0.00001	0.06	0.0006
46	0.003	0.00003	0.1	0.001
48	0.001	0.00001	0.2	0.002
52	0.001	0.00001	*b*	*b*
K2	0.01	0.0001	0.1	0.0005
K6	0.002	0.00002	0.05	0.0005
K11	0.04	0.0004	0.05	0.0005

[a]CAP-88PC Version 3 software, developed under EPA sponsorship to demonstrate compliance with 40 CFR 61, Subpart H.

[b]Effective dose was not calculated using CAP-88 and emission data at the given ambient air monitoring location.

7.1.2.2 Waterborne Radionuclides

Radionuclides discharged to surface waters from the ORR enter the Tennessee River system by way of the Clinch River (see Sect. 1.3.4 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 Chicamauga 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 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. 6.4 and 6.6). 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, and the possibility that some radionuclides of ORR origin might be present in quantities too low to be measured. 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 ED 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 EDs estimated by both methods, in each of the surface water segments, are provided in Appendix F.

7.1.2.2.1 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 ED. At all locations in 2008, estimated maximum EDs to a person drinking water were calculated using both measured radionuclide concentrations in and measured radionuclide discharges to off-site surface water, excluding naturally occurring radionuclides such as ^{40}K.

Upper Melton Hill Lake above all possible ORR inputs. Based on samples from Melton Hill Lake above possible ORR inputs (at Clinch River kilometer [CRK] 66), EDs to a hypothetical maximally exposed person drinking such water was estimated to be 0.002 mrem. The collective ED to the 30,514 persons who drink water from the city of Oak Ridge water plant could have been 0.03 person-rem. If naturally occurring radionuclides are included, individual and collective EDs could have been 2 mrem and 30 person-rem, respectively.

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 maximally exposed individual could have received an ED of about 0.004 mrem; the collective dose to the 52,706 persons who drink water from this plant could have been 0.1 person-rem. If naturally occurring radionuclides are included, the EDs 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 ED of about 0.2 mrem; the collective dose to the 1,000 workers who drink water from this plant could have been about 0.09 person-rem. If naturally occurring radionuclides are included, the EDs could have been about 2 mrem and 1 person-rem.

Lower Clinch River. There are no known drinking water intake sections in this river segment (from the confluence of Poplar Creek to the confluence of 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 ED of about 0.05 mrem; the collective dose to the 24,165 persons who drink water

from these plants could have been about 0.6 person-rem. If naturally occurring radionuclides are included, the EDs could have been 0.3 mrem and 4 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 EDs greater than about 0.05 mrem calculated for drinking Kingston and Rockwood water. The collective dose to the 296,802 persons who drink water within the lower system could have been about 5 person-rem. If naturally occurring radionuclides are included, the EDs could have been about 0.3 mrem and 40 person-rem.

Poplar Creek. There are no drinking water intake locations on Lower East Fork Poplar Creek or on Poplar Creek.

7.1.2.2.2 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 2008 and that the average person, who is used for collective dose calculations, would have consumed 6.9 kg of fish. The estimated maximum ED 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. The EDs estimated by both methods, in each of the surface water segments, are provided in Appendix F.

Upper Melton Hill Lake above all possible ORR inputs. For reference purposes, a hypothetical avid fish consumer who ate fish caught at CRK 66, which is above all possible ORR inputs, could have received an ED of about 0.002 mrem. The collective ED to the 139 persons who could have eaten such fish could have been 0.00001 person-rem. If naturally occurring radionuclides are included, the EDs could have been 13 mrem and 0.6 person-rem.

Melton Hill Lake. An avid fish consumer who ate fish from Melton Hill Lake could have received an ED of about 0.005 mrem. The collective ED to the 139 persons who could have eaten such fish could be about 0.0003 person-rem. If naturally occurring radionuclides are included, the EDs could have been 24 mrem and 1 person-rem.

Upper Clinch River. An avid fish consumer who ate fish from the Upper Clinch River could have received an ED of about 0.6 mrem. The collective ED to the 732 persons who could have eaten such fish could have been about 0.2 person-rem. If naturally occurring radionuclides are included, the EDs could have been 24 mrem and 6 person-rem.

Lower Clinch River. An avid fish consumer who ate fish from the Lower Clinch River (CRK 16) could have received an ED of about 0.3 mrem. The collective ED to the 1,708 persons who could have eaten such fish could have been about 0.2 person-rem. If naturally occurring radionuclides are included, the EDs could have been 63 mrem and 35 person-rem. These higher than normal EDs are attributed largely to an unusual detection of ^{40}K in a water sample from CRK 16. This detection of ^{40}K affects EDs calculated for naturally occurring radionuclides at all locations downstream of the lower Clinch River.

Upper Watts Bar Lake. An avid fish consumer who ate fish from Upper Watts Bar Lake could have received an ED about 0.09 mrem. The collective ED to the 4,880 persons who could have eaten such fish could be about 0.2 person-rem. If naturally occurring radionuclides are included, the EDs could have been 20 mrem and 28 person-rem.

Lower System. An avid fish consumer who ate fish from Lower System could have received an ED of about 0.09 mrem. The collective ED to the 41,780 persons who could have eaten such fish could have been about 1 person-rem. If naturally occurring radionuclides are included, the EDs could have been 20 mrem and 200 person-rem.

Poplar Creek. An avid fish consumer who ate fish from Lower East Fork Poplar Creek above its confluence with Poplar Creek could have received an ED of about 0.9 mrem. Assuming 100 people could have eaten fish from Poplar Creek, the collective ED is estimated to be about 0.03 person-rem. If naturally occurring radionuclides are included, the EDs could have been 11 mrem and 0.4 person-rem, due largely to excess beta activity in water sampled at K-716.

7.1.2.2.3 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 EDs from these activities. At all locations in 2008, the estimated highly exposed individual EDs were based on measured off-site surface water radionuclide concentrations and exclude naturally occurring radionuclides such as ^{40}K. When compared with EDs from eating fish from the same waters, the EDs from these other uses are relatively insignificant.

Upper Melton Hill Lake above all possible ORR inputs. A highly exposed other user of upper Melton Hill Lake above possible ORR inputs (CRK 66) could have received an ED of about 0.0007 mrem. The collective ED to the 10,412 other users could have been 0.002 person-rem. If naturally occurring radionuclides are included, individual and collective EDs could have been 0.2 mrem and 0.5 person-rem, respectively.

Melton Hill Lake. An individual other user of Melton Hill Lake could have received an ED of about 0.0007 mrem. The collective ED to the 24,294 other users could have been about 0.004 person-rem. If naturally occurring radionuclides are included, the EDs could have been 0.3 mrem and 2 person-rem.

Upper Clinch River. Another user of the upper Clinch River could have received an ED of about 0.1 mrem. The collective ED to the 3,866 other users could have been about 0.02 person-rem. If naturally occurring radionuclides are included, the EDs could have been 0.3 mrem and 0.07 person-rem.

Lower Clinch River. Another user of the lower Clinch River could have received an ED of about 0.2 mrem. The collective ED to the 9,020 other users could have been about 0.6 person-rem. If naturally occurring radionuclides are included, the EDs could have been 0.5 mrem and 2 person-rem.

Upper Watts Bar Lake. Another user of upper Watts Bar Lake could have received an ED of about 0.05 mrem. The collective ED to the 25,772 other users could have been about 0.5 person-rem. If naturally occurring radionuclides are included, the EDs could have been 0.2 mrem and 2 person-rem.

Lower System. Another user of the lower system could have received an ED of about 0.08 mrem. The collective ED to the 356,704 other users could have been about 6 person-rem. If naturally occurring radionuclides are included, the EDs could have been 0.2 mrem and 16 person-rem.

Poplar Creek. Another user of Lower East Fork Poplar Creek, above its confluence with Poplar Creek, could have received an ED of about 0.02 mrem. The collective ED to the 100 other users could have been about 0.002 person-rem. If naturally occurring radionuclides are included, the EDs could have been 0.3 mrem in Poplar Creek and 0.002 person-rem in Lower East Fork Poplar Creek.

7.1.2.2.4 Summary

Table 7.6 is a summary of potential EDs from identified waterborne radionuclides around the ORR. Adding worst-case EDs for all pathways in a water-body segment gives a maximum individual ED of about 0.9 mrem to a person obtaining his or her full annual complement of fish from and participating in other water uses on Lower East Fork Poplar Creek or upper Clinch River. The maximum collective ED to the 50-mile population could be as high as 15 person-rem. These are small percentages of individual and collective doses attributable to natural background radiation, about 0.3% and 0.004%, respectively.

Table 7.6. Summary of annual maximum individual (mrem) and collective (person-rem) effective doses (EDs) from waterborne radionuclides[a,b]

	Drinking water	Eating fish	Other uses	Total[c]
Upstream of all Oak Ridge Reservation discharge locations (Clinch River kilometer [CRK] 66, City of Oak Ridge Water Plant)				
Individual ED	0.002	0.002	0.0007	0.005
Collective ED	0.03	0.00001	0.002	0.03
Melton Hill Lake (CRK 58, Knox County Water Plant)				
Individual ED	0.004	0.005	0.0007	0.01
Collective ED	0.1	0.0003	0.004	0.1
Upper Clinch River (CRK 23, Gallaher Water Plant, CRK 32)				
Individual ED	0.2	0.6	0.1	0.9
Collective ED	0.09	0.2	0.02	0.3
Lower Clinch River (CRK 16)				
Individual ED	NA[d]	0.3	0.2	0.5
Collective ED	NA[d]	0.2	0.6	0.8
Upper Watts Bar Lake, Kingston Municipal Water Plant				
Individual ED	0.05	0.09	0.05	0.2
Collective ED	0.6	0.2	0.5	1
Lower System (Lower Watts Bar Lake and Chickamauga Lake)				
Individual ED	0.05	0.09	0.08	0.2
Collective ED	5	1	6	10
Lower East Fork Poplar Creek and Poplar Creek				
Individual ED	NA[d]	0.9	0.05	0.9
Collective ED	NA[d]	0.04	0.002	0.04

[a]1 mrem = 0.01 mSv.

[b]Doses based on measured radionuclide concentrations in water or estimated from measured discharges and known or estimated stream flows.

[c]Total doses and apparent sums over individual pathway doses may differ due to rounding.

[d]Not at or near drinking water supply locations.

7.1.2.3 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 milk and vegetables, 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.

7.1.2.3.1 Milk

No milk samples were collected in 2008 (See Sect. 6.5.3).

7.1.2.3.2 Food Crops

The food-crop sampling program is described in Sect. 6.5. Samples of tomatoes, lettuce, and turnips were obtained from seven gardens, six local and one distant. 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 ^{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 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 30 kg of homegrown tomatoes, 10 kg of homegrown lettuce, and 20 kg of homegrown turnips. The hypothetical gardener could have received a 50-year committed ED of between 0.01 and 0.06 mrem, depending on garden location. Of this total, between 0 and 0.04 mrem could have come from eating tomatoes, between 0.005 and 0.02 mrem from eating lettuce, and between 0.008 and 0.02 mrem from eating turnips. The highest dose to a gardener could have been about 0.06 mrem from consuming all three types of homegrown vegetables. A person eating food from the distant (background) garden could have received a committed ED of about 0.05 mrem, 0.01 mrem from turnips and 0.03 mrem from lettuce.

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 3 and 5 mrem to the hypothetical home gardener's ED.

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 ED of between 4 and 34 mrem. Of this total, between 0 and 25 mrem could have come from eating tomatoes, between 0.7 and 6 mrem from eating lettuce, and between 4 and 9 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. Similar to last year's sampling results, one tomato sample had an elevated gross alpha result. No explanation of this result could be obtained, other than the laboratories opinion that, based on their experience, most of the alpha activity detected in samples of vegetation is ^{210}Po.

7.1.2.3.3 Hay

No hay samples were collected in 2008 (See Sect. 6.5.1).

7.1.2.3.4 White-Tailed Deer

The Tennessee Wildlife Resources Agency (TWRA) conducted three 2-day deer hunts during 2008 on the Oak Ridge Wildlife Management Area, which is part of the ORR (see Sect. 6.7). During the hunts, 483 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). Seven deer exceeded the limit for beta-particle activity in bone and were confiscated. The remaining 476 deer were released to the hunters.

The average ^{137}Cs concentration in tissue of the 476 released deer, as determined by field counting, was 0.67 pCi/g; the maximum ^{137}Cs concentration in a released deer was 0.93 pCi/g. Many of the ^{137}Cs concentrations were less than minimum detectable levels. The average weight was 86.7 lb, and the maximum weight of the released deer was 187 lb. The EDs attributed to field-measured ^{137}Cs concentrations and actual field weights of the released deer ranged from about 0.001 to 2 mrem.

An individual who consumed one average-weight deer (86.7 lb), assuming 55% field weight is edible meat, containing the 2008 average field-measured concentration of ^{137}Cs (0.67 pCi/g) could have received an ED of about 0.7 mrem. The maximum field-measured ^{137}Cs concentration was 1 pCi/g, and the maximum deer weight was 187 lb. A hunter who consumed a hypothetical deer of maximum weight and ^{137}Cs content could have received an ED of about 2 mrem.

The maximum estimated ED from consuming venison from an actual released deer (based on field ^{137}Cs concentrations and weights) and including the maximum 2008 analytical ^{90}Sr result (0.21pCi/g, which was at the minimum detectable level) is estimated to be about 3 mrem.

Tissue samples collected in 2008 from 22 deer (15 released and 7 retained) were subjected to laboratory analysis. Requested radioisotopic analyses included ^{60}Co, ^{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 with the exception of one retained deer. 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 ^{60}Co, ^{137}Cs and ^{90}Sr (at the minimum detectable levels and excluding ^{40}K, a naturally occurring radionuclide) analytical tissue data and actual deer weights, the estimated doses for the 22 deer (both retained and released) ranged between 0.5 to 1.3 mrem**.**

The maximum ED to an individual consuming venison from two or three deer was also evaluated. There were about 47 hunters who harvested two deer or more from the ORR. Based on ^{137}Cs concentrations determined by field counting and actual field weight, the ED range to a hunter who consumed two or more harvested deer was estimated to range between 0.45 to 2 mrem**.**

The collective ED from eating all the harvested venison from ORR with a 2008 average field-derived ^{137}Cs concentration of 0.67 pCi/g and average weight of 86.7 lb is estimated to be about 0.35 person-rem.

7.1.2.3.5 Canada Geese

During the 2008 goose roundup, 227 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 0.26 pCi/g, with maximum ^{137}Cs concentration in the released geese of 0.63 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 8.2 lb. The maximum goose weight was about 11.5 lb.

The EDs attributed to field-measured ^{137}Cs concentrations and actual field weights of the geese ranged from 0 to 0.03 mrem. However, for bounding purposes, if a person consumed a released goose with an average weight of 8.2 lb and an average ^{137}Cs concentration of 0.26 pCi/g, the estimated ED would be about 0.02 mrem. It is assumed that approximately half the weight of a Canada goose is edible. The maximum estimated ED to an individual who consumed a hypothetical released goose with the maximum ^{137}Cs concentration of 0.63 pCi/g and the maximum weight of 11.5 lb was about 0.08 mrem. Though the actual maximum dose to an individual who could consumed one of the roundup geese was estimated to be 0.03 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 ED of about 0.2 mrem.

No geese tissue samples were analyzed in 2008. In 2007, a muscle sample from a seriously injured goose that had to be euthanized was analyzed for ^{3}H, ^{40}K, ^{137}Cs, ^{90}Sr, thorium (^{228}Th, ^{230}Th, ^{232}Th), uranium ($^{233/234}$U, ^{235}U, ^{238}U), and transuranics (^{241}Am, $^{243/244}$Cm, ^{238}Pu, $^{239/240}$Pu). Many of the analytical results were less than minimum detectable activity (MDA) levels. Assuming MDA levels, excluding ^{40}K concentrations (naturally occurring radionuclide), and average weight from the goose roundup, the estimated dose from consuming this goose would have been about 0.3 mrem.

7.1.2.3.6 Eastern Wild Turkey

Participating hunters are allowed to harvest one turkey from the reservation in a given season unless a harvested turkey is retained, in which case, the hunter is allowed to hunt for another turkey. Two wild turkey hunts were held on the reservation in 2008, one on April 5 and 6 and the other on April 12 and 13. Twenty-one birds were harvested, and none was retained. The average ^{137}Cs concentration measured in the released turkeys was 0.1 pCi/g, and the maximum ^{137}Cs concentration was 0.15 pCi/g. The average weight of the turkeys released was about 19.9 lb. The maximum turkey weight was about 23.3 lb.

If a person consumed a wild turkey with an average weight of 19.9 lb and an average ^{137}Cs concentration of 0.1 pCi/g, the estimated ED would be about 0.02 mrem. The maximum estimated ED 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 23.3 lb was about 0.04 mrem. It is assumed that approximately half the weight of a wild turkey is edible. No tissue samples were analyzed in 2008.

The collective ED from consuming all the harvested wild turkey meat (21 birds) with an average field-derived ^{137}Cs concentration of 0.1 pCi/g and average weight of 19.9 lb is estimated to be about 0.0005 person-rem.

7.1.2.3.7 Direct Radiation

External exposure rates due to background sources in the state of Tennessee average about 6.4 μR/h, and range from 2.9 to 11 μR/h (Myrick 1981). These exposure rates correspond to ED rates between 18 and 69 mrem/year, with an average of 40 mrem/year.

External radiation exposure rates are measured at numerous locations on and off the ORR. Exposure rates measured at five PAMs around the ORR during 2008 averaged about 7.7 μR/h and ranged from 6.5 to 9.0 μR/h. These exposure rates correspond to an average ED rate of about 48 mrem/year and a range of 40 to 57 mrem/year. At the remote PAM, the exposure rate was 6.4 μR/h (approximately 39 mrem/year). All measured exposure rates at or near the ORR boundaries fall within the range of state-wide background levels.

Prior to 1994, a cesium experimental plot was considered a potential source of direct radiation to fishermen on the Clinch River. This plot was remediated in 1994. Prior to remediation, external exposure rate measurements indicated that a hypothetical fisherman who spent 5 h/week (250 h/year) on the river could have received a dose of about 1 mrem above background.

External exposure rate measurements taken over a 3 month period in 2008 on the Clinch River shoreline near the old cesium experimental plot averaged 8.6 μR/h and ranged between 8.2 and 9.2 μR/h. This corresponds to an average annual ED of about 54 mrem with a range between 51 and 57 mrem. These exposure and dose rates fall within the range of measured state-wide background rates and rates measured around the ORR. Based on these measurements and average background values, the hypothetical fisherman should not receive an ED greater than 0.4 mrem above the state-wide average ED from external exposures. This ED falls within the state-wide range of external dose rates and is within and adequately represented by the range of local external doses rates. Therefore, the cesium field is no longer regarded as a significant source of direct radiation to members of the public and this calculation will be discontinued.

Direct radiation monitoring is no longer conducted for locations that were formerly the UF_6 cylinder storage yards and the K-770 Scrap Yard at ETTP. These locations have been remediated and direct dose measurements confirm that they are no longer a source of potential dose to the public above background levels.

7.1.3 Current-Year Summary

A summary of the maximum EDs to individuals by pathway of exposure is given in Table 7.7. In the unlikely event that any person was irradiated by all of those sources and pathways for the duration of 2008, that person could have received a total ED of about 4 mrem. Of that total, 0.4 mrem would have come from airborne emissions and 1 mrem from waterborne emissions, (0.2 mrem from drinking water from the upper Clinch River, 0.9 mrem from consuming fish from Lower East Fork Poplar creek near its confluence with Poplar Creek, and 0.2 mrem from other water uses along the lower Clinch River).

This dose is about 1% of the annual dose (300 mrem) from background radiation. The ED of 4 mrem includes the person who received the highest EDs 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 2 mrem.

Table 7.7. Summary of maximum potential effective doses to an adult by exposure pathway, 2008

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	0.4	0.004	0.4	27	0.27	1,040,041[b]	
Liquid effluents:							
Drinking water	0.2	0.002	0.2	6	0.06	383,487[c]	
Eating fish	0.9	0.009	0.9	2	0.02	49,455[d]	
Other activities	0.2	0.002	2	7	0.07	489,023[d]	
Eating deer	2[e]	0.02	2	0.35	0.0035	476	
Eating geese	0.2[f]	0.002	0.2	*g*	*g*		
Eating turkey	0.04[h]	0.0004	0.04	0.0005	0.000005	21	
Direct radiation	0.4[i]	0.004	0.4				
All pathways	4	0.04	4	42	0.42	1,040,041	312,012

[a]Estimated background population dose is based on 300 mrem/year individual dose and the population within 80 km of the Oak Ridge Reservation.

[b]Population based on 2000 census data.

[c]Population estimates based on community and non-community drinking water supply data from the Tennessee Department of Environment and Conservation, Division of Water.

[d]Population estimates based on population within 80 km and fraction of fish harvested from Melton Hill, Watts Bar, and Chickamauga reservoirs. Melton Hill and Chickamauga recreational use information was obtained from the Tennessee Valley Authority (TVA 2006 and TVA 2007).

[e]From consuming one hypothetical worst-case deer, each a combination of the heaviest deer harvested and the highest measured concentrations of ^{137}Cs in released deer on the ORR in 2008; population dose based on number of hunters that harvested deer.

[f]From consuming two hypothetical worst-case geese, each a combination of the heaviest goose harvested and the highest measured concentrations of ^{137}Cs in released geese.

[g]Population doses were not estimated for the consumption of geese since no geese were brought to checking station during the goose hunt.

[h]From consuming one hypothetical worst-case turkey, a combination of the heaviest turkey harvested and the highest measured concentrations of ^{137}Cs in released turkey. The population dose is based on number of hunters that harvested turkey.

[i]Direct radiation dose estimates were conducted, although exposure rates near the Clinch River were near background levels. In addition, direct radiation monitoring is no longer conducted for locations that were formerly the UF_6 cylinder storage yards and the K-770 Scrap Yard. Direct dose measurements have been taken and have confirmed that there is no longer a source of potential dose to the public above the background levels.

DOE Order 5400.5 limits the ED 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 2008 maximum ED should not have exceeded about 4 mrem, or about 4% of the limit given in DOE Order 5400.5. (For further information, see Sections F.5.6 through F.5.12 in Appendix F, which summarizes dose levels associated with a wide range of activities.)

The total collective ED to the population living within an 80 km radius of the ORR was estimated to be about 27 person-rem. This dose is about 0.009% of the 312,012 person-rem that this population received from natural sources during 2008.

7.1.4 Five-Year Trends

Dose equivalents associated with selected exposure pathways for the years from 2005 to 2008 are given in Table 7.8. The variations in values over the 5 year period likely are not statistically significant.

Table 7.8. Trends in effective dose (mrem)[a] for selected pathways

Pathway	2004	2005	2006	2007	2008
All air	0.4	0.9	0.8	0.3	0.4
Fish consumption (Clinch River)	0.2	0.3	0.7	0.9	0.6
Drinking water (Kingston)	0.04	0.03	0.02	0.04	0.05
Direct radiation (Clinch River)	0.4	0.4	0.5[b,c]	0.4[d]	0.4[d]
Direct radiation (Poplar Creek)	3[b]	1[b]	0.8[b]	NA[d]	NA[d]

[a]1 mrem = 0.01 mSv.

[b]Included gamma and neutron radiation measurement data. In 2006, the Poplar Creek location was near the K-1066E Cylinder Yard.

[c]This location is along the bank of the Clinch River near the K-770 Scrap Yard.

[d] Direct radiation dose estimates were conducted, although exposure rates near the Clinch River were near background levels. In addition, direct radiation monitoring is no longer conducted for locations that were formerly the UF_6 cylinder storage yards and the K-770 Scrap Yard. Direct dose measurements have been taken and confirmed that there is no longer a source of potential dose to the public above the background levels.

7.1.5 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. Seven facilities responded to the DOE request. Based on these responses, no member of the public should have received an ED greater than 2 mrem due to airborne releases from these facilities. A maximally exposed individual dose of about 14.9 mrem/year due to direct radiation was estimated at the boundary of one of the facilities. One facility provided a dose estimate of external radiation; however, the area monitoring station was located in the laboratory.

7.1.6 Doses to Aquatic and Terrestrial Biota

7.1.6.1 Aquatic Biota

DOE Order 5400.5, Chap. II, sets an absorbed dose rate limit of 1 rad/d to native aquatic organisms from exposure to radioactive material in liquid wastes discharged to natural waterways (see Appendix F 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 typically the limiting organisms for the general screening phase of the graded approach for aquatic organisms. The screening conceptual model for generating the media-specific BCGs places both the aquatic and riparian animal at the sediment-water interface. In the screening conceptual model sediment presents an external dose hazard to the aquatic animal, whereas, water presents both an internal and external dose hazard. For riparian animals, sediment and water presents both an internal and external dose hazard. The riparian pathways of exposure combine aspects of both terrestrial and aquatic systems.

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 nine different sampling locations:

- Melton Branch (Melton Branch kilometer [MEK] 0.2),
- White Oak Creek (White Oak Creek kilometer [WCK] 1.0 and 2.6),
- First Creek,
- Fifth Creek,
- Raccoon Creek,
- Northwest Tributary, and
- Clinch River (CRK 32 and 66).

All but one location, WCK 1.0 (White Oak Creek at the dam) passed the initial screening phase (maximum concentrations and using default parameters for BCGs). At WCK 1.0, 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/d at all 12 sampling locations.

At the Y-12 Complex, doses to aquatic organisms were estimated from surface water concentrations at six different sampling locations:

- Surface Water Hydrological Information Support System (SWHISS) Station 9422-1 (Station 17);
- Discharge Point S24, Bear Creek at Bear Creek kilometer (BCK) 9.4;
- Discharge Point S17 (unnamed tributary to the Clinch River);
- Outfall 502 West End Treatment Facility;
- Outfall 512; and
- Central Mercury Treatment Unit (Outfall 551).

All but two locations passed the general screening phase (maximum water concentrations and default parameters for BCGs). Station 17 and SWHISS 9422-2 both passed using average water concentrations and for Station 17, also using site-specific sediment concentrations. This resulted in absorbed dose rates to aquatic organisms below the DOE aquatic dose limit of 1 rad/d at all six Y-12 locations.

At ETTP, doses to aquatic organisms were estimated from surface water concentrations at nine different sampling locations:

- Mitchell Branch at K1700, MIK 0.7, and 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/d at all nine sampling locations.

7.1.6.2 Terrestrial Biota

To evaluate impacts on biota, as per DOE Order 450.1, the terrestrial 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). An absorbed dose rate of 0.1 rad/d is recommended as the limit for terrestrial animal exposure to radioactive material in soils (see Appendix F for definitions of absorbed dose and the rad). As for aquatic and riparian biota, certain terrestrial organisms are more sensitive to ionizing radiation than others and it is generally assumed that protecting the more-sensitive organisms will adequately protect other, less-sensitive organisms. The screening conceptual model for terrestrial animals has the animal (e.g., deer mouse) surrounded by soil, and soil presents both an internal and external dose pathway. The screening conceptual model for terrestrial animals also includes the potential for exposure to contaminated water from soil pore water or by drinking from contaminated ponds or rivers. In this terrestrial biota assessment only site soil data were used.

Soil sampling for terrestrial dose assessment was initiated in 2007. This biota sampling strategy was developed taking into account 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.

The soil sampling focused 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. Soil sampling locations and radionuclide analytes are identified below:

- *White Oak Creek floodplain and upland location*. The sampling locations were located at the confluence of Melton Branch and White Oak Creek, White Oak Creek floodplain upstream of White Oak Lake, and off Burial Ground Road and Seepage Pit Loop. Soil radionuclide analytes included ^{241}Am, ^{244}Cm, ^{60}Co, ^{137}Cs, ^{40}K, ^{239}Pu/^{240}Pu, and ^{90}Sr, ^{234}U, and ^{238}U.
- *Bear Creek Valley floodplain.* The sampling locations were on Bear Creek floodplain below the Bone Yard and near the Environmental Monitoring Waste Management Facility (EMWMF). Soil radionuclide analytes include, ^{241}Am, ^{238}Pu, ^{234}U, and ^{238}U.
- *Mitchell Branch Floodplain*. The sampling locations were Mitchell Branch floodplain near 1407C and the Laydown yard and where Mitchell Branch enters Poplar Creek. Soil radionuclide analytes included ^{239}Pu/^{240}Pu, ^{234}U, and ^{238}U.
- *Background locations*. One sampling location was on Gum Hollow which represents Consauaga soils and the other sampling location was near Bearden Creek which represent Chickamauga soils. Soil radionuclide analytes include ^{241}Am, ^{243}Cm/^{244}Cm, ^{60}Co, ^{137}Cs, ^{40}K, ^{238}Pu, ^{239}Pu/^{240}Pu , ^{90}Sr, ^{234}U, and ^{238}U.

With the exception of samples collected on the White Oak Creek floodplain (for example, samples collected at the confluence of Melton Branch and White Oak Creek and those collected on the White Oak Creek floodplain upstream from White Oak Dam), samples taken at all soil sampling locations passed either the initial-level screening, for which default parameters and maximum soil concentrations are used, or second-level screening, for which default parameters and average soil concentrations are used. Cesium-137 is the primary dose contributor in the soil samples collected on the White Oak Creek floodplain. Radiological risk to wildlife associated with ^{137}Cs on the White Oak Creek floodplain is known and will

be addressed in future CERCLA records of decisions. However, based on the results of the terrestrial biota soil sampling, site-specific sampling of biota on the White Oak floodplain is planned.

7.2 Chemical Dose

7.2.1 Drinking Water Consumption

To evaluate the drinking water pathway, hazard quotients (HQs) were estimated upstream and downstream of the ORR discharge points (Table 7.9). (See Appendix G for a detailed description of the chemical dose methodology.) Chemical analytes were measured in surface water samples collected at CRK 23 and CRK 16. CRK 23 is located near the water intake for ETTP; CRK 16 is located downstream of all DOE discharge points. As shown in Table 7.9, HQs were less than 1 for detected chemical analytes for which there are reference doses or maximum contaminant levels.

Acceptable risk levels for carcinogens typically range from 10^{-4} to 10^{-6}. A risk value greater than 10^{-5} was calculated for the intake of 1,2 Dichloroethane in water collected at CRK 23.

Table 7.9. Chemical hazard quotients and estimated risks for drinking water, 2008

Chemical	Hazard quotient[b]	
	CRK 23[c]	CRK 16[d]
Barium	~ 0.005	~0.006
Beryllium	~0.003	~0.003
Boron	~0.003	~0.004
Cadmium	~0.02	
Carbon disulfide	~0.0001	
Chromium	~0.004	~0.005
Lead	~0.1	~0.1
Manganese	0.008	0.008
Nickel	~0.001	~0.001
Selenium	~0.005	~0.006
Vanadium	~0.003	~0.005
Zinc	0.0008	0.001
Risk for carcinogens		
1,2 Dichloroethane	~3E-05	

Abbreviations
CRK = Clinch River kilometer
[a]A tilde (~) indicates that estimated values were used in the calculation.
[b]Melton Hill Reservoir near the water intake for ETTP.
[c]Clinch River downstream of all U.S. Department of Energy inputs.

7.2.2 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/d (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 G for a detailed description of the chemical dose methodology.)

As shown in Table 7.10, for consumption of sunfish and catfish, HQ values of less than 1 were calculated for the all detected analytes except for Aroclor-1254 and Aroclor-1260. An HQ greater than 1 for Aroclor-1254 and Aroclor-1260 was estimated in catfish at all three locations (CRK 16, 32, and 70).

For carcinogens, risk values greater than 10^{-5} were calculated for the intake of Aroclor-1254 found in catfish collected at all three locations. For both sunfish and catfish, risk values greater than 10^{-5} were also calculated for the intake of Aroclor-1260 collected at all three locations. 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 7.10. Chemical hazard quotients and estimated risks for carcinogens in fish, 2008[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						
Antimony	<0.2	<0.2	0.3	0.2	0.2	<0.2
Barium	0.0008	0.0005	0.0005	<0.00003	0.00003	<0.00003
Beryllium	0.004		0.003	<0.001	<0.001	0.002
Boron	0.0002	0.0003	0.0003	<0.0002	<0.0002	<0.0002
Chromium	0.02	0.03	0.02	0.03	0.02	<0.003
Lead	0.3			<0.3		
Manganese	0.004	0.006	0.008	0.001	0.0009	0.0008
Mercury	0.07	0.07	0.3	0.1	0.3	0.4
Nickel	0.001	0.0008	0.002	0.002	<0.0008	<0.0008
Selenium	0.3	0.3	0.3	0.2	0.2	0.2
Silver	0.003			<0.003		
Strontium	0.002	0.002	0.001	0.0001	0.0001	0.00007
Thallium	0.1	0.1	0.08	0.07	0.05	0.04
Uranium			0.00006	<0.002		<0.00002
Vanadium	0.007		0.001	<0.001		<0.001
Zinc	0.04	0.04	0.04	0.02	0.02	0.02
Hazard quotient for pesticides and Aroclors						
Aroclor-1254				4	7	11
Aroclor-1260	1	J0.6	0.9	7	12	12
Risks for carcinogens						
Aroclor-1254				7E–5	1E–4	2E–4
Aroclor-1260	2E–5	J1E–5	2E–5	1E–4	2E–4	2E–4
PCBs (mixed)[e]	2E–5	J1E–5	2E–5	2E–4	3E–4	4E–4

CRK=Clinch River kilometer

[a]A prefix "J" indicates the value was estimated at or below the analytical detection limit by the laboratory, "<" indicates the value for a parameter was not quantifiable at the analytical detection limit, and a blank space indicates that the parameter was undetected.

[b]Melton Hill Reservoir, above the city of Oak Ridge Water Plant.

[c]Clinch River, downstream of Oak Ridge National Laboratory.

[d]Clinch River, downstream of all U.S. Department of Energy inputs.

[e]Mixed polychlorinated biphenyls (PCBs) consist of the summation of Aroclors detected or estimated.

7.3 References

DOE. 2002. DOE Standard: A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota. DOE-STD-1153-2002. U.S. Department of Energy, Washington, D.C.

EPA. 1989. Risk Assessments Methodology, Environmental Impact Statement, NESHAPs for Radionuclides, Background Information. Vol. 1. EPA/520/1-89-005. U.S. Environmental Protection Agency, Washington, D.C.

EPA. 1997. Exposure Factors Handbook, Vol. II. Food Ingestion Factors, EPA/600/P-95/002Fb, U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C.

EPA. 1999. Cancer Risk Coefficients for Environmental Exposure to Radionuclide: Updates and Supplements. Federal Guidance Report No. 13, updated 2002. www.epa.gov/rpdweb00/federal/techdocs.html#report13

Hamby, D. M. 1991. LADTAP XL: An Improved Electronic Spreadsheet Version of LADTAP II. DE93003179. Westinghouse Savannah River Company, Aiken, South Carolina.

International Commission on Radiological Protection (ICRP). 1996. Age-Dependent Doses to the Members of the Public from Intake of Radionuclides Part 5, Compilation of Ingestion and Inhalation Coefficients. ICRP Publication 72, Elsevier.

Myrick, T. E., et al. 1981. State Background Radiation Levels: Results of Measurements Taken During 1975–1979. ORNL/TM-7343. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

TDEC. 2002. The Status of Water Quality in Tennessee. 305b Report. Tennessee Department of Environment and Conservation, Division of Water Pollution Control, Nashville, Tennessee.

USFWS. 1995. Preliminary Estimates of Waterfowl Harvest and Hunter Activity in the United States. U.S. Fish and Wildlife Service, Washington, D.C.

Appendix A. Errata

Appendix A. Errata

Errata in the *Oak Ridge Reservation Annual Site Environmental Report* for 2007 (DOE/ORO/2261).

In Sect 3.7.1, "Air," p. 3-47, the corrected second full paragraph should read as follows.

Figures 3.22 through 3.27 illustrate the air concentrations of As, Be, Cd, Cr, Pb, and total uranium for the past five years based on quarterly composites of weekly continuous samples. The results are compared against any applicable standards for each pollutant. Due to a laboratory procedure anomaly, duplicate quarterly composite samples for all of 2007 were submitted for analysis. The new analytical results were typically higher than the original results and therefore to assure conservatism, only the data from the duplicate sample analyses based on correct analytical procedures are being reported. The 2007 annualized concentrations of As, Be, Cd, Pb, and U, all show results below the indicated standards. The chromium results are conservatively compared with the standard for hexavalent chromium.

In Sect 3.7.1, "Air," p. 3-47, the corrected third full paragraph should read as follows.

Total uranium metal was measured as a quarterly composite of continuous weekly samples from stations K2, K6, K9, and K11. The total uranium mass for each sample was determined by the inductively coupled plasma-mass spectrometer (ICP-MS) analytical technique. The uranium averages and maximum individual concentration measurements for all sites are presented in Table 3.24. The averaged results ranged from a minimum of approximately 0.000038, up to 0.000280 μg/m3. The highest 12-month average result (0.000280 μg/m3) was measured at Station K2. The annual average value for all stations due to uranium was 0.000113 μg/m3. The ICP-MS results are compared with the DCG for natural uranium. (DCG is based on an annual air concentration exposure that would give a dose of 100 mrem.) The highest annual result (K2) only corresponds to approximately 0.2 % of the DCG. The single sampling location with the highest quarterly concentration (0.000551 μg/m3) was at station K2. If this concentration were extrapolated to a 12 month exposure it would only represent 0.4% of the DCG.

In Sect 3.7.1, "Air," p. 3-49 through 3-51, the corrected Figures 3.22, 3.23, 3.24, 3.25, 3.26, and 3.27 are as follows.

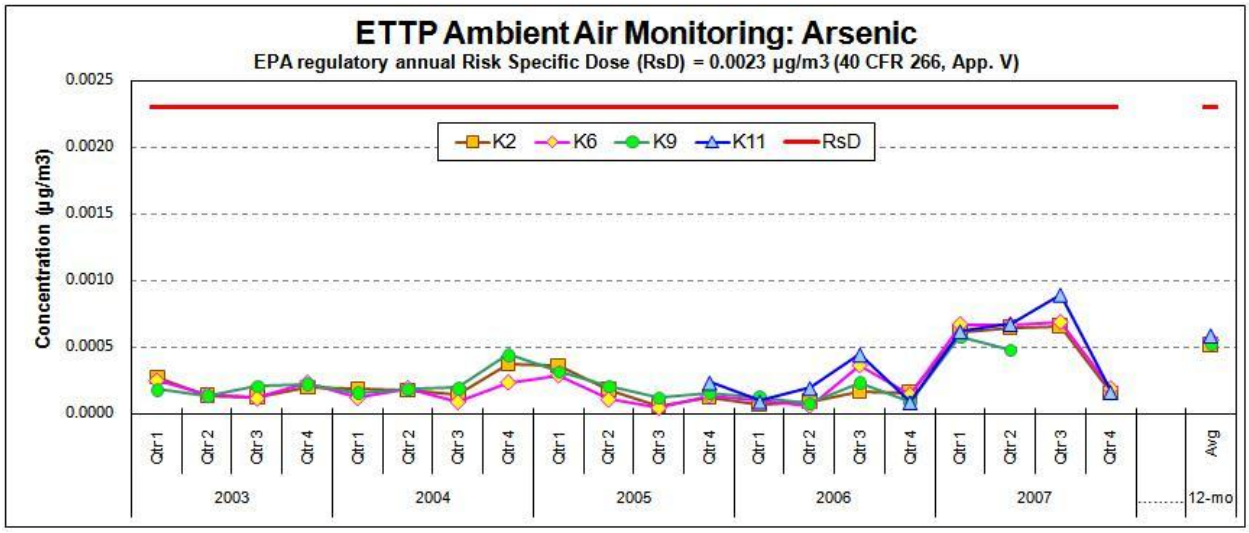


Fig. 3.22. East Tennessee Technology Park ambient air monitoring, 2007: Arsenic.

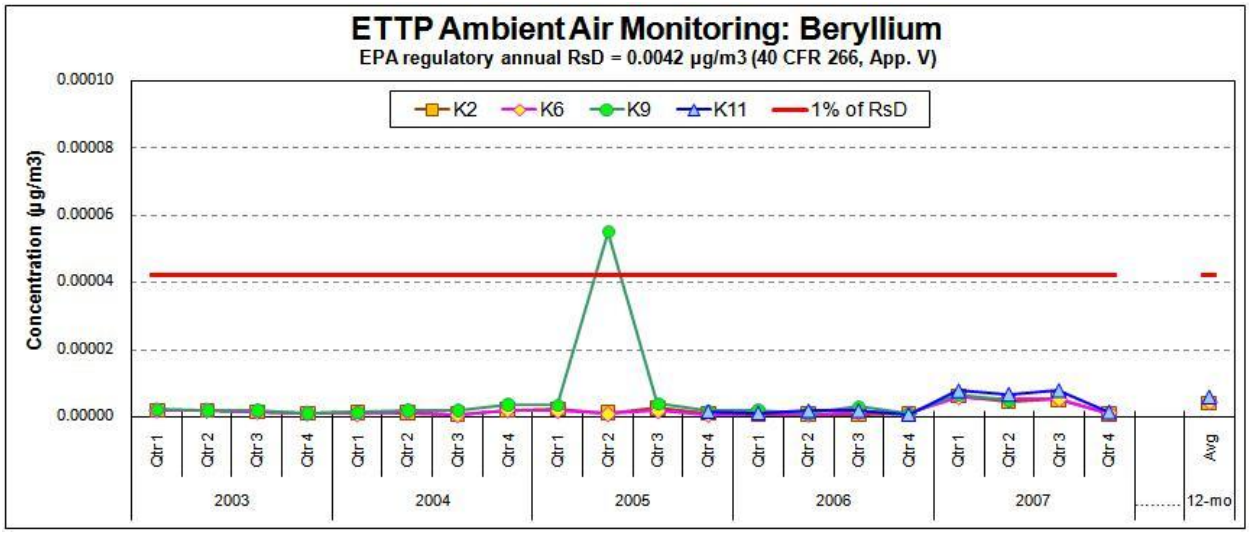


Fig. 3.23. East Tennessee Technology Park ambient air monitoring, 2007: Beryllium.

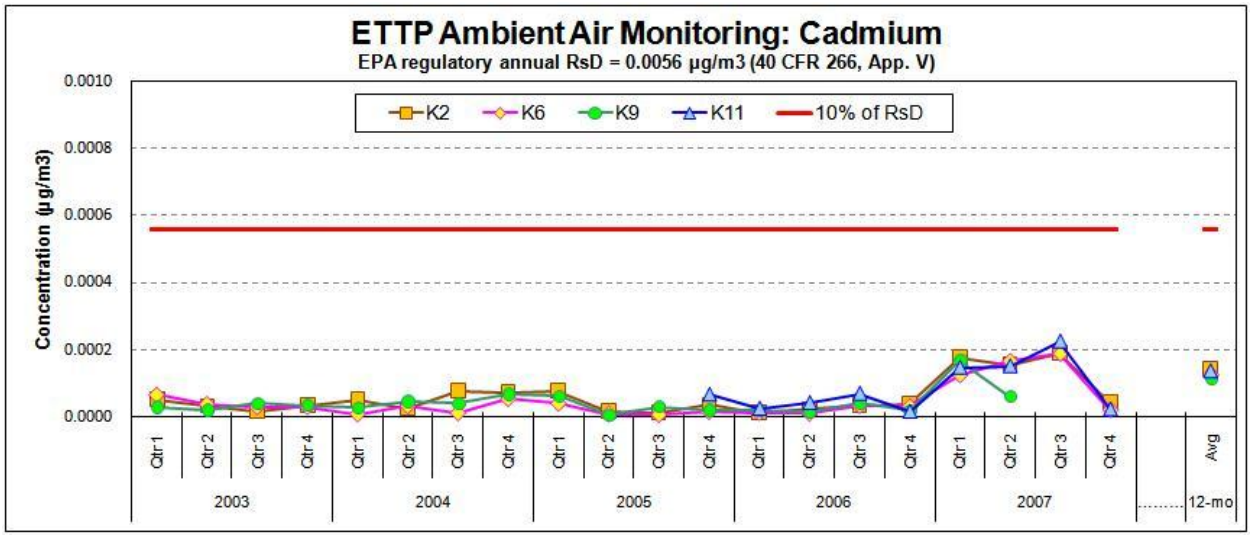


Fig. 3.24. East Tennessee Technology Park ambient air monitoring, 2007: Cadmium.

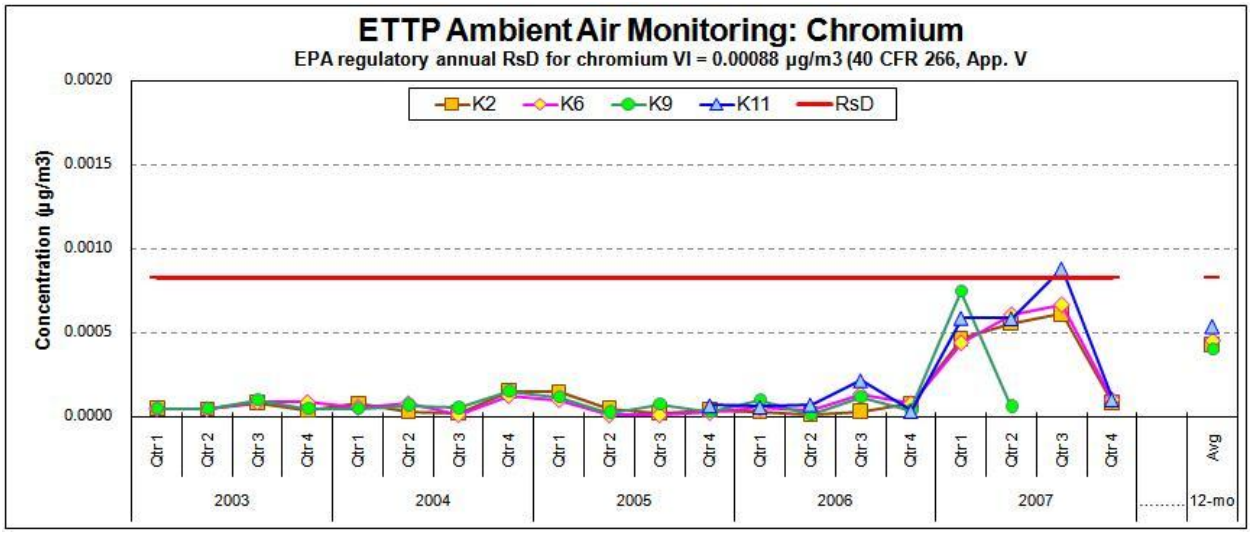


Fig. 3.25. East Tennessee Technology Park ambient air monitoring, 2007: Chromium.

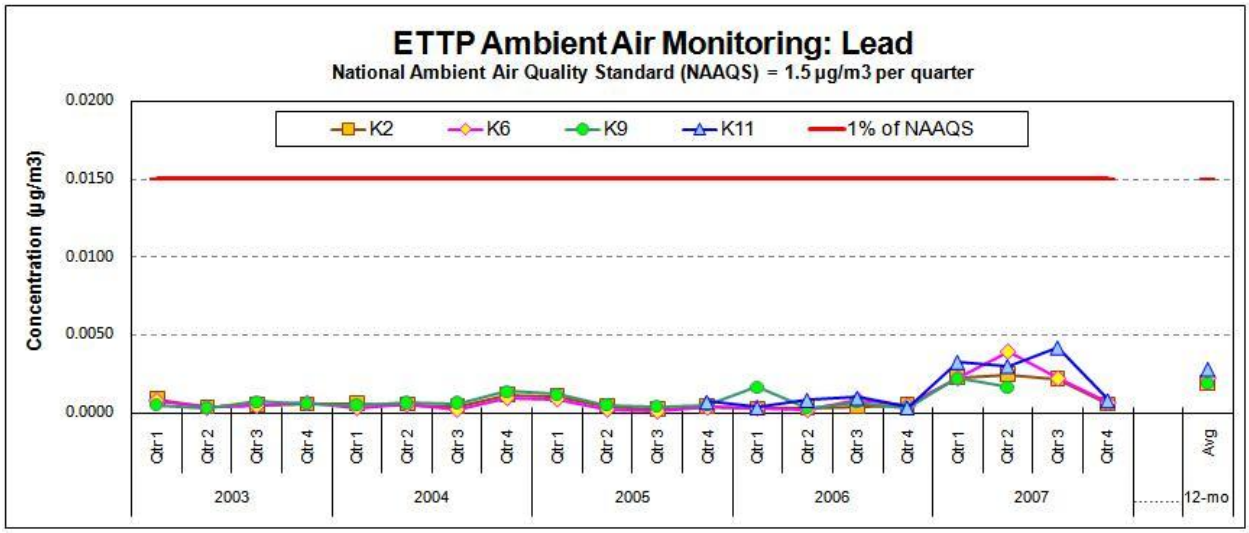


Fig. 3.26. East Tennessee Technology Park ambient air monitoring, 2007: Lead.

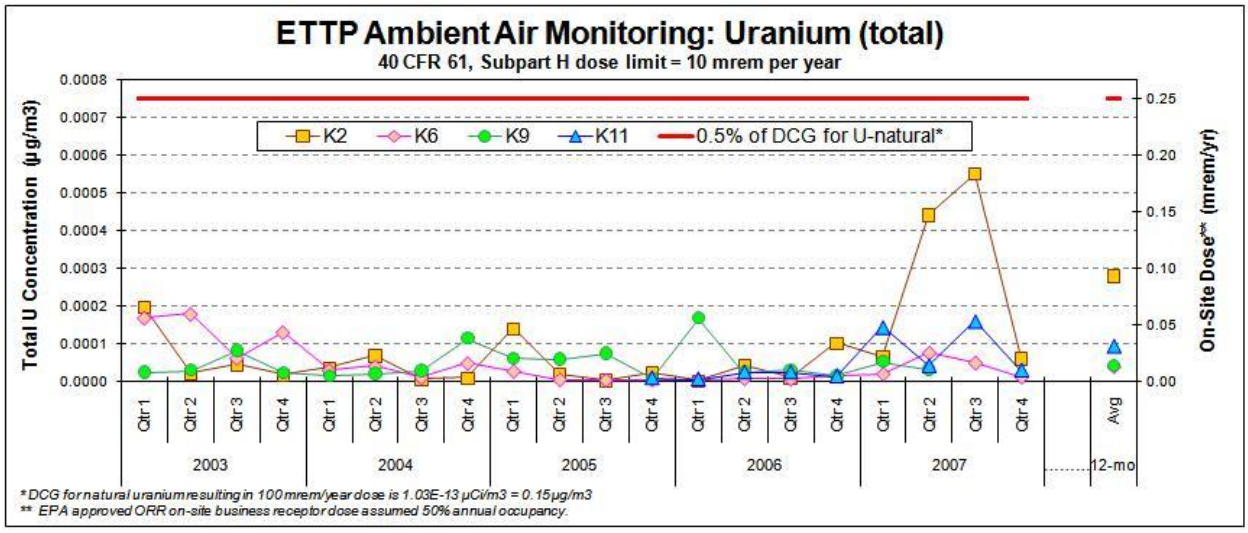


Fig. 3.27. East Tennessee Technology Park ambient air monitoring, 2007: Uranium (total).

In Sect 3.7.1, "Air," p. 3-52, Table 3.24 with the corrected data is as follows.

Table 3.24. 2007 Total uranium in ambient air by inductively coupled plasma analysis at East Tennessee Technology Park

Station	No. of Samples	Concentration[a]				Percentage of DCG[b] (%)	
		μg/m^3		μCi/mL			
		Avg	Max[c]	Avg	Max	Avg	Max
K2	4	0.000280	0.000551	1.87E–16	3.67E–16	0.19	0.37
K6	4	0.000038	0.000075	2.52E–17	4.97E–17	0.03	0.05
K9	2	0.000042	0.000052	2.79E-17	3.48E-17	0.03	0.03
K11	4	0.000093	0.000159	6.21E–17	1.06E–16	0.06	0.11
ETTP total	14	0.000113		7.54E–17		0.08	

[a]Mass-to-curie concentration conversions assume a natural uranium assay of 0.717% ^{235}U.

[b]U.S. Department of Energy (DOE) Order 5400.5 derived concentration guide (DCG) for naturally occurring uranium is an annual concentration of 1E–13 μCi/mL, which is equivalent to a 100 mrem annual dose.

[c]Maximum individual sample analysis result with dose calculations conservatively assuming the value to be an annual concentration.

Appendix B. Glossary

Appendix B. Glossary

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.

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 (µCi)** — 10^{-6} Ci, one-millionth of a curie; 3.7×10^4 disintegrations per second.
>
> **picocurie (pCi)** — 10^{-12} Ci, one-trillionth of a curie; 0.037 disintegrations per second.

DAPC — Division of Air Pollution Control (state of Tennessee).

daughter — A nuclide formed by the radioactive decay of a parent nuclide.

decay, radioactive — The spontaneous transformation of one radionuclide into a different radioactive or nonradioactive nuclide, or into a different energy state of the same radionuclide.

dense nonaqueous phase liquid (DNAPL) — The liquid phase of chlorinated organic solvents. These liquids are denser than water and include commonly used industrial compounds such as tetrachloroethene and trichloroethene.

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.

DRH — Division of Radiological Health (state of Tennessee).

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.

hectare — A metric unit of area equal to 10,000 square meters or 2.47 acres.

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 –38.9ºC 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 × 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 C. Climate Overview for the Oak Ridge Area

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C. 1 Regional Climate

The climate of the Oak Ridge area and its surroundings may be broadly classified as humid subtropical. The term "humid" indicates that the region receives an overall surplus of precipitation compared to the level of evapotranspiration that is normally experienced throughout the year. The "subtropical" nature of the local climate indicates that the region experiences warm to hot summers and cool winters. Such areas typically experience significant changes in temperature between summer and winter.

Local winters are characterized by synoptic weather systems that often produce significant precipitation events every 3 to 5 days. These wet periods are occasionally followed by arctic air outbreaks. Although snow and ice are not associated with many of these systems, occasional snowfall does occur. Winter cloud cover tends to be enhanced by the regional terrain (cold air wedging).

Severe thunderstorms are the most frequent during spring but can occur at any time during the year. The Cumberland Mountains and the Cumberland Plateau often inhibit the intensity of severe systems that traverse the region (due to the downward momentum created as the storms move off of the higher terrain). Summers are characterized by very warm, humid conditions. Occasional frontal systems may produce organized lines of thunderstorms (and rare damaging tornados). More frequently, however, summer precipitation results from "air mass" thundershowers that form as a consequence of daytime heating, rising humid air, and local terrain features. Although adequate precipitation usually occurs during the fall, the months of August through October represent the driest period of the year. The occurrence of precipitation during the fall tends to be less cyclic than during other seasons but is occasionally enhanced by decaying tropical systems moving north from the Gulf of Mexico. During November, winter-type cyclones again begin to dominate the weather and continue to do so until May.

Decadal-scale climate change has recently affected the East Tennessee region. Some of these changes are related to the hemispheric effects caused by the El Niño–Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO), and the Atlantic-Multidecadal Oscillation (AMO). The first two patterns, having cycles of 3 to 7 years and about 40 years, respectively, affect Pacific Ocean sea surface temperatures. The AMO affects Atlantic sea surface temperature (again, having a cycle of about 40 years). All of these patterns can collectively modulate regional temperature and precipitation trends with respect to East Tennessee. The AMO has recently shifted from a cold to warm sea surface temperature phase (mid-1990s) while the PDO appears to be entering a cool sea surface temperature phase (since 2000). Also, the ENSO pattern has more frequently brought about warmer Eastern Pacific sea surface temperatures. Additionally, there is some evidence that human-induced climate change may be affecting the area as well (about +1.7ºC in Oak Ridge during the last 30 years). Little or no additional warming has occurred since 2000. The recent warming appears to have lengthened the growing season (i.e., the period with temperatures above 0ºC) by about 2 to 3 weeks over the last 30 years.

C.2 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 in 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 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 upward displacement.

Figures C.1 thru C.17 display wind roses for each of the eight Oak Ridge Reservation meteorological towers during 2008 (Towers MT1, MT2, MT3, MT4, MT6, MT7, MT9, and MT10). The wind roses represent typical trends and should be used with caution.

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

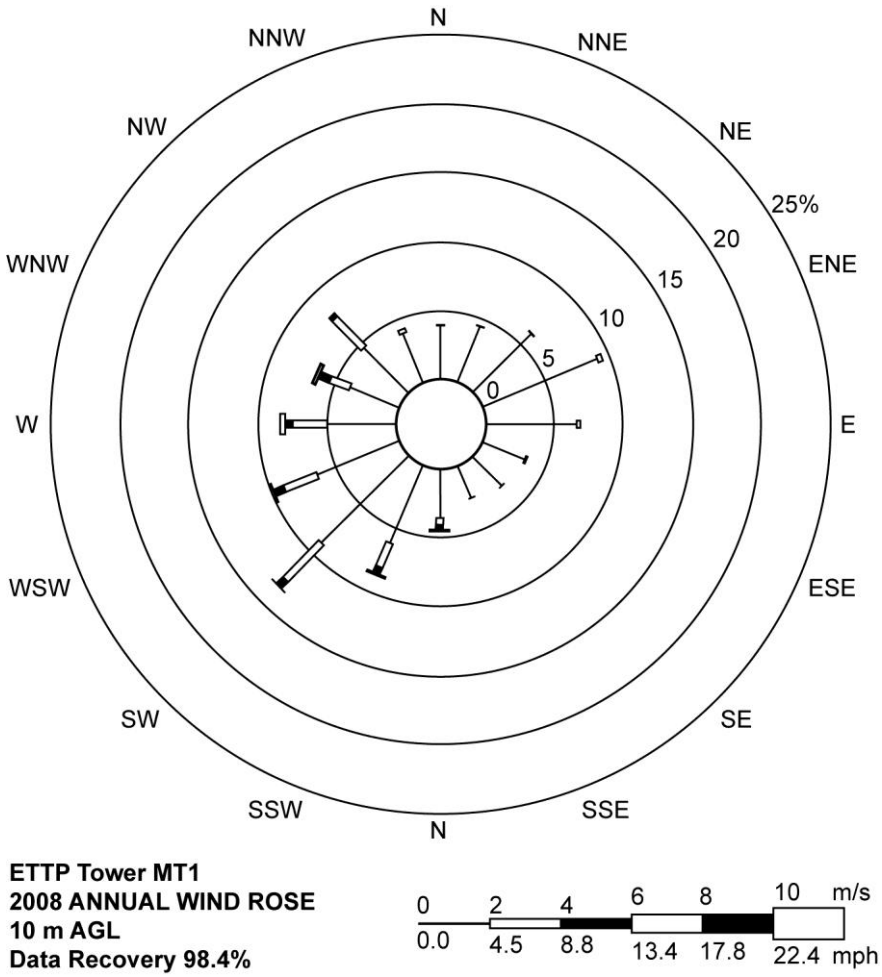


Fig. C.1. Wind rose for ETTP Meteorological Tower 1 for data taken at 10 m above ground level, 2008.

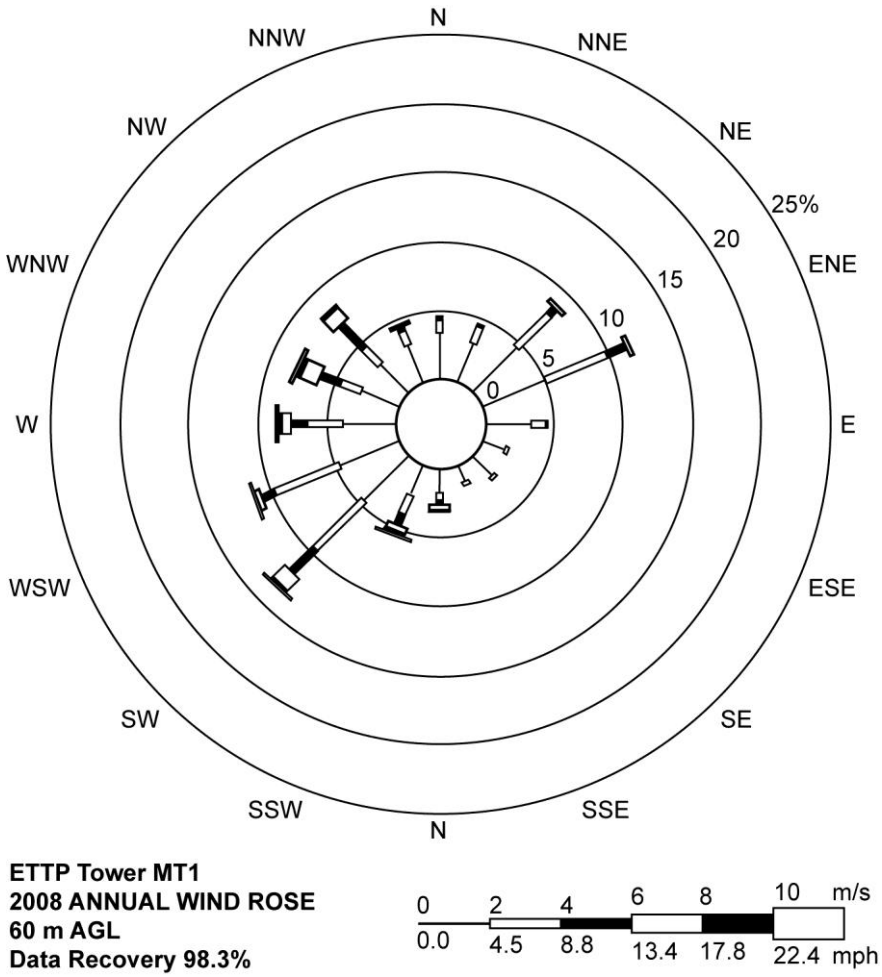


Fig. C.2. Wind rose for ETTP Meteorological Tower 1 for data taken at 60 m above ground level, 2008.

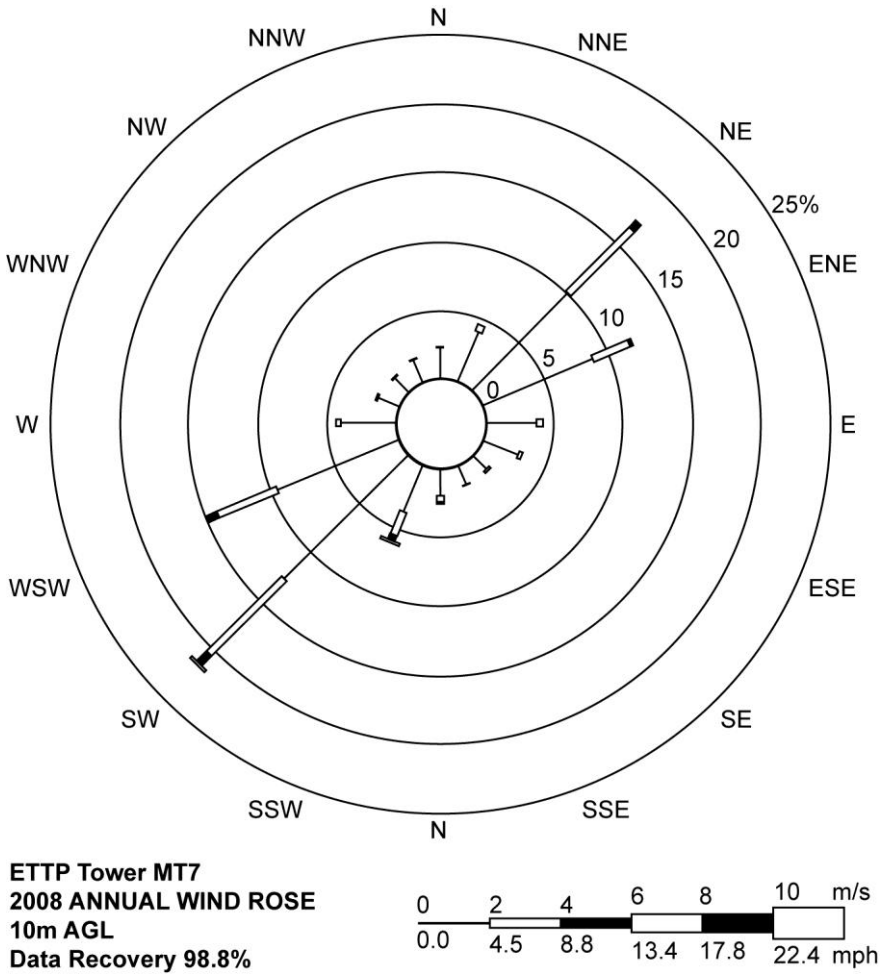


Fig. C.3. Wind rose for ETTP Meteorological Tower 7 for data taken at 10 m above ground level, 2008.

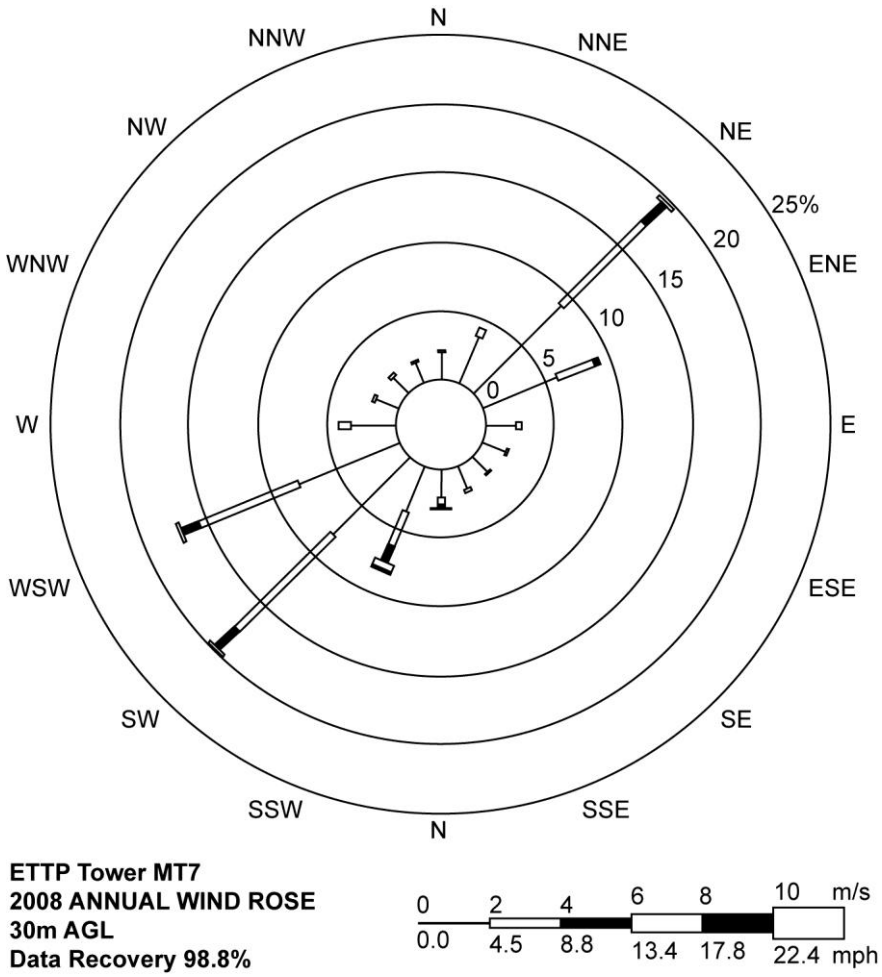


Fig. C.4. Wind rose for ETTP Meteorological Tower 7 for data taken at 30 m above ground level, 2008.

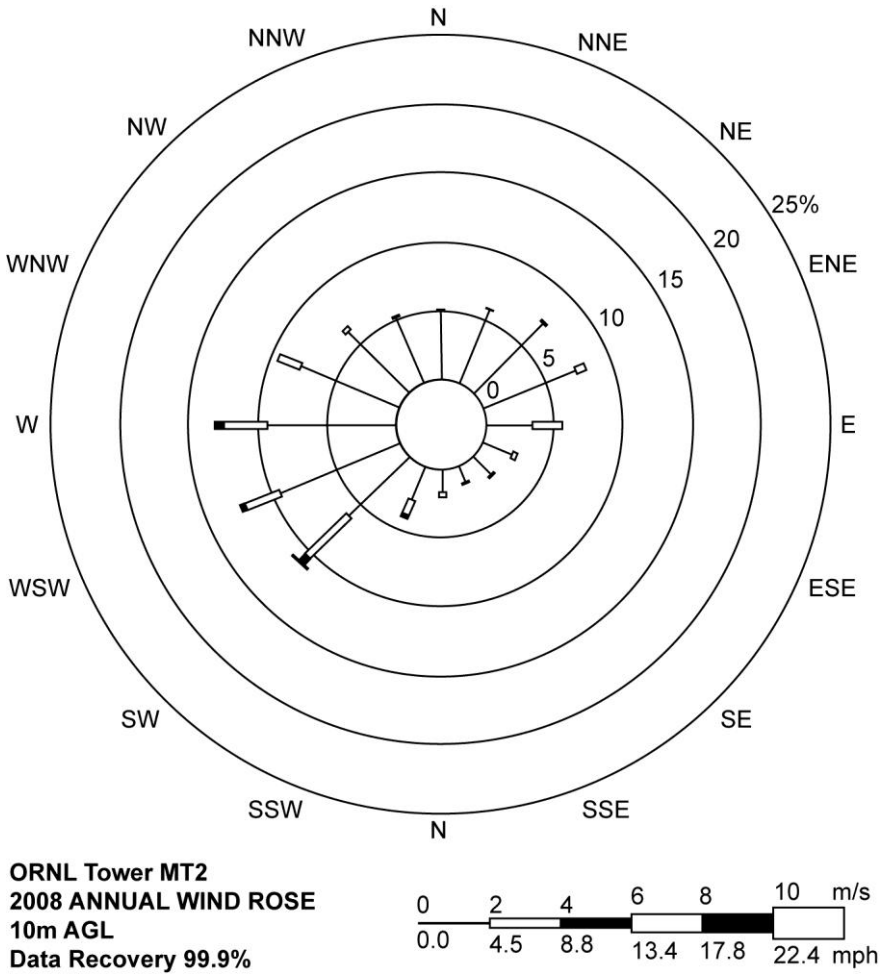


Fig. C.5. Wind rose for ORNL Meteorological Tower 2 for data taken at 10 m above ground level, 2008.

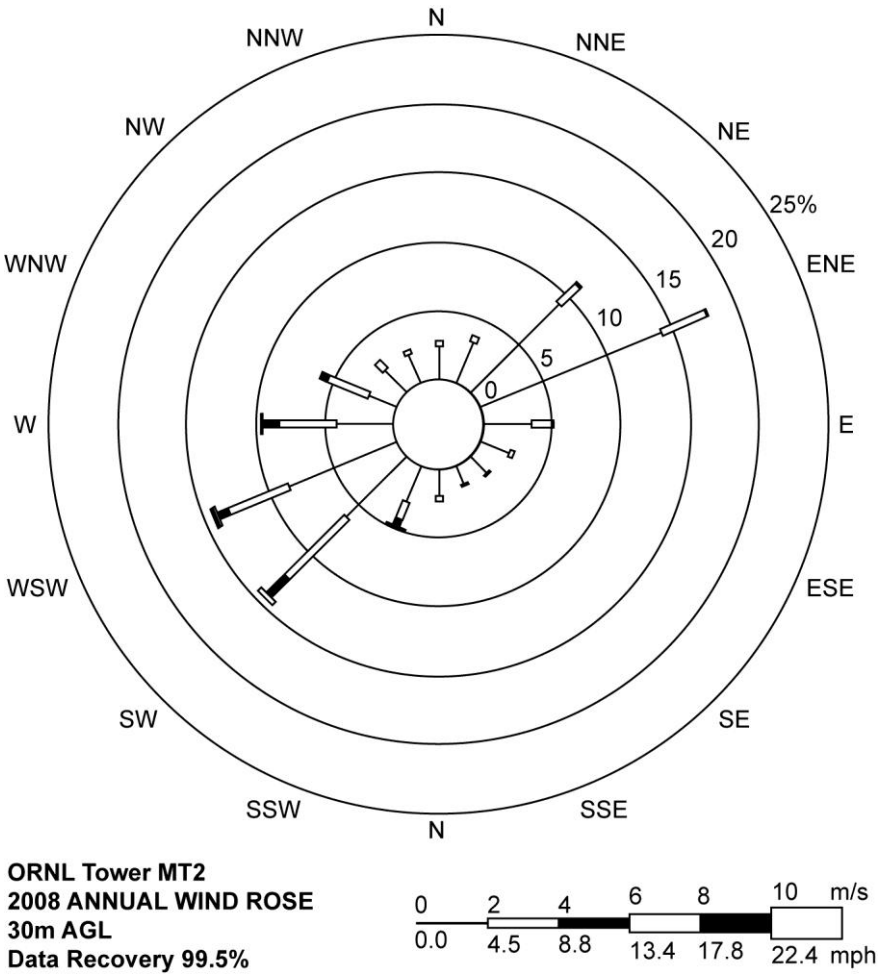


Fig. C.6. Wind rose for ORNL Meteorological Tower 2 for data taken at 30 m above ground level, 2008.

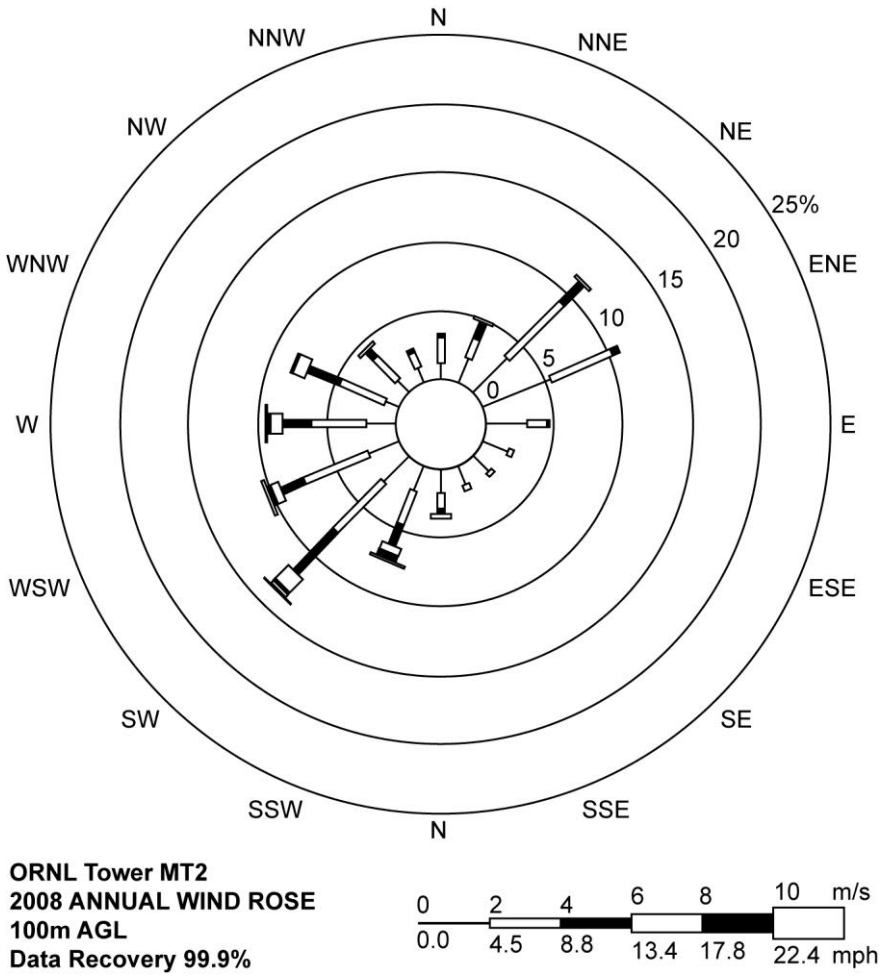


Fig. C.7. Wind rose for ORNL Meteorological Tower 2 for data taken at 100 m above ground level, 2008.

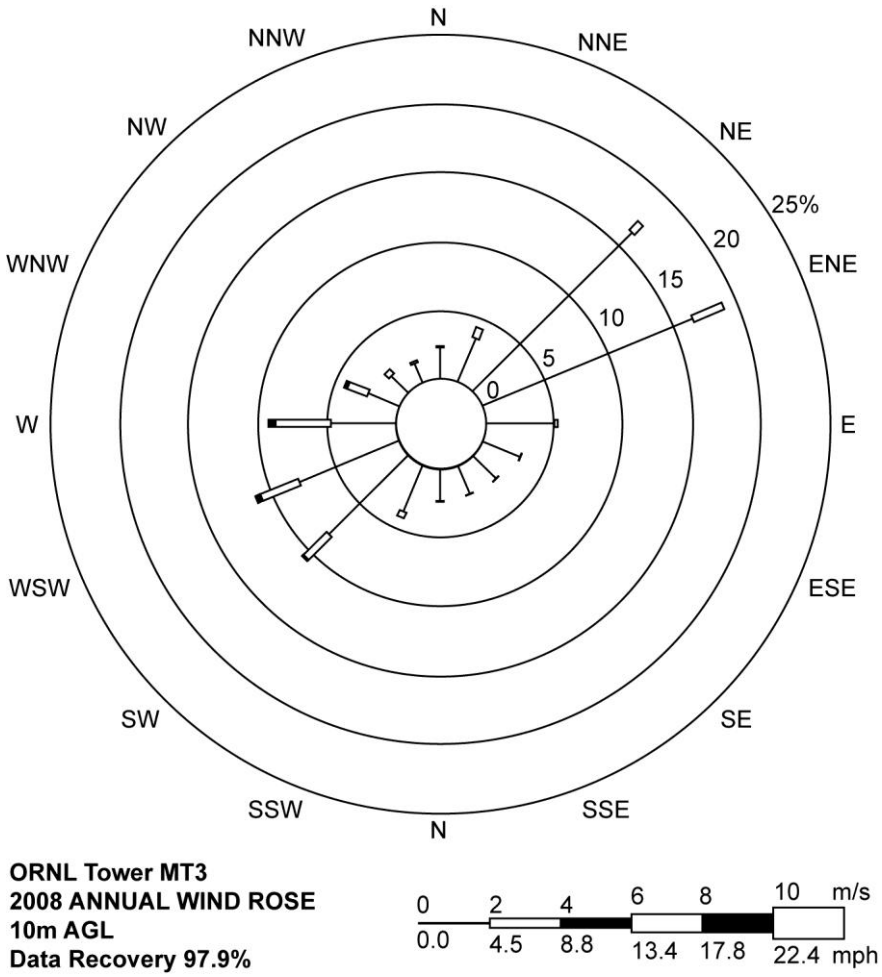


Fig. C.8. Wind rose for ORNL Meteorological Tower 3 for data taken at 10 m above ground level, 2008.

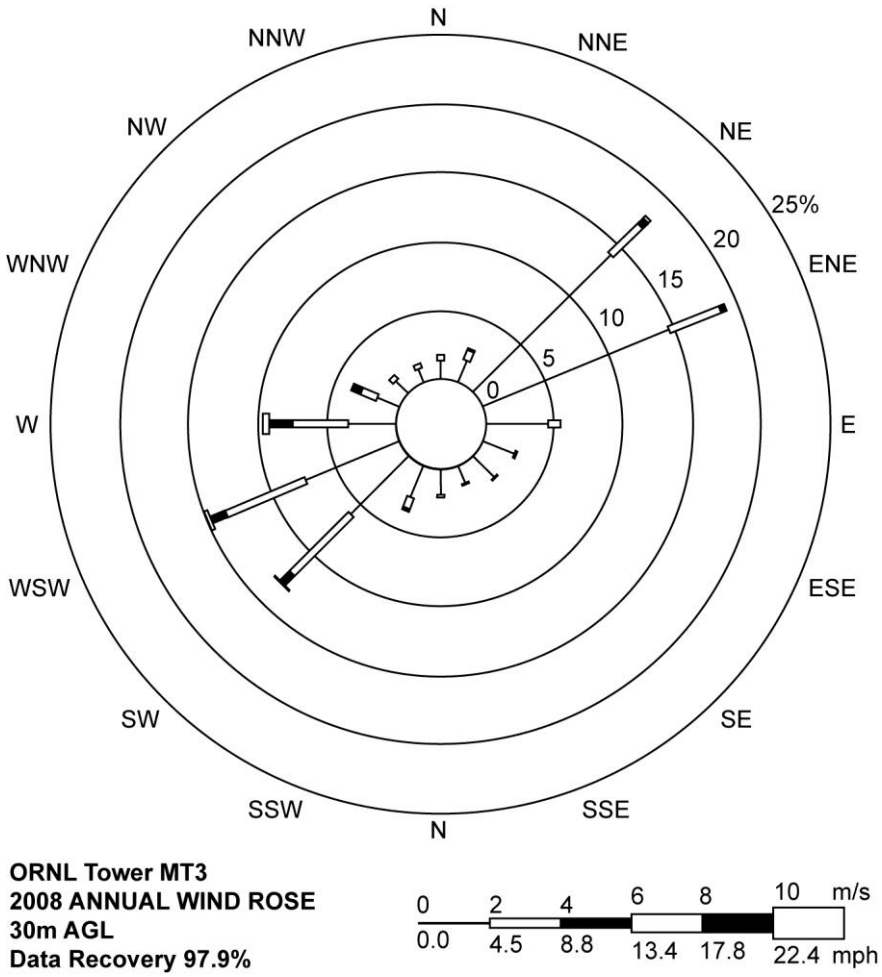


Fig. C.9. Wind rose for ORNL Meteorological Tower 3 for data taken at 30 m above ground level, 2008.

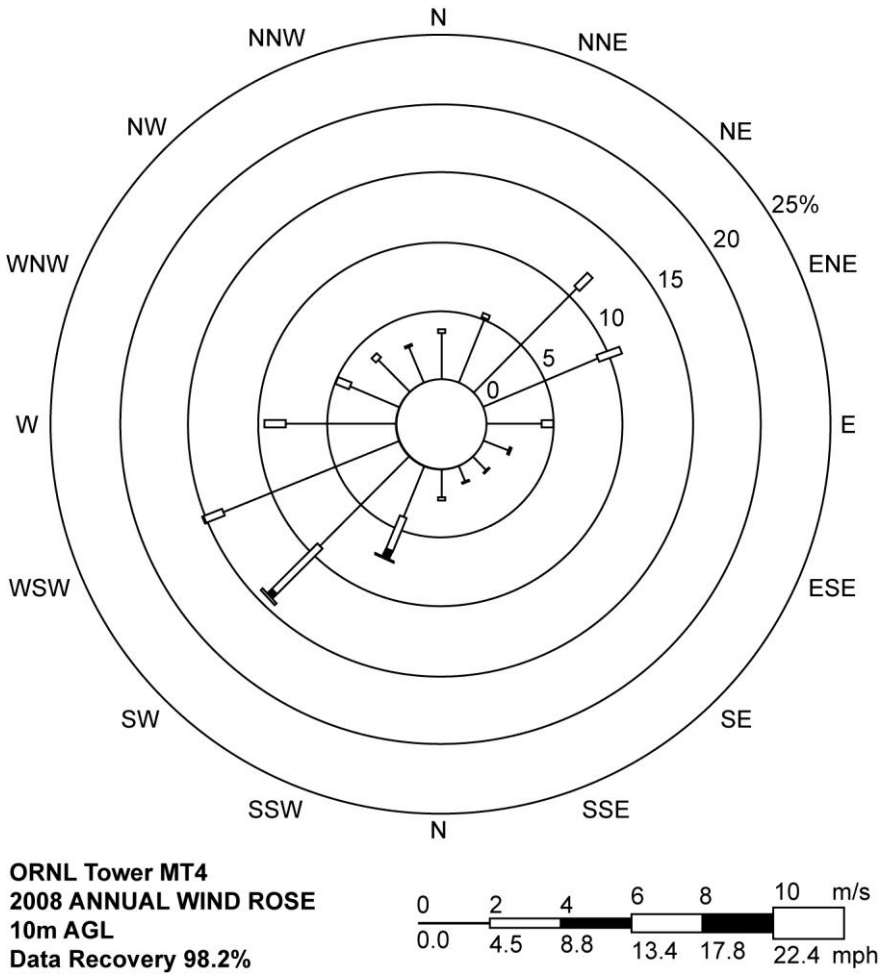


Fig. C.10. Wind rose for ORNL Meteorological Tower 4 for data taken at 10 m above ground level, 2008.

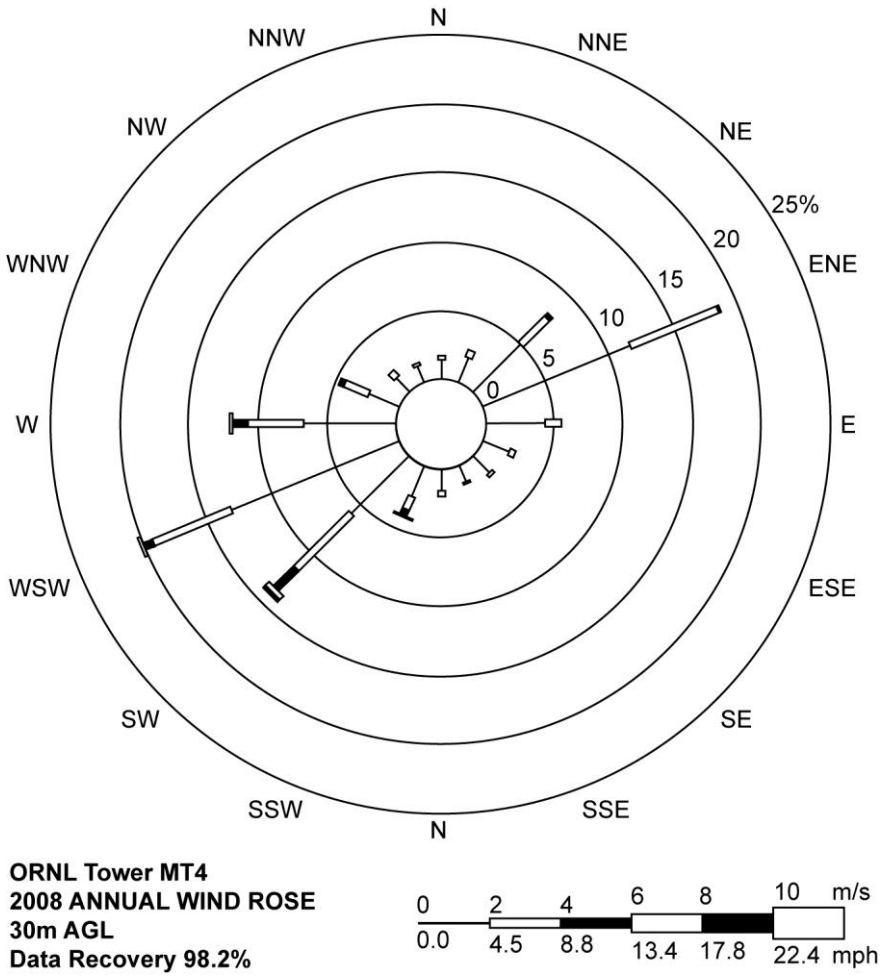


Fig. C.11. Wind rose for ORNL Meteorological Tower 4 for data taken at 30 m above ground level, 2008.

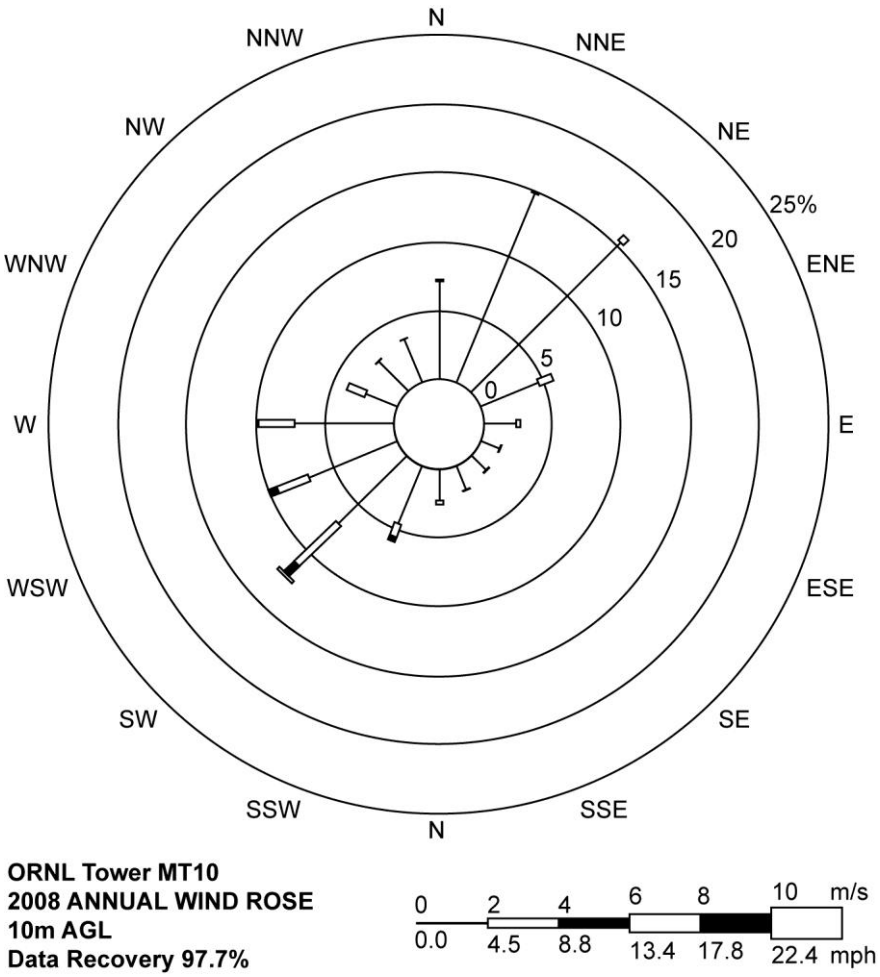


Fig. C.12. Wind rose for ORNL Meteorological Tower 10 for data taken at 10 m above ground level, 2008.

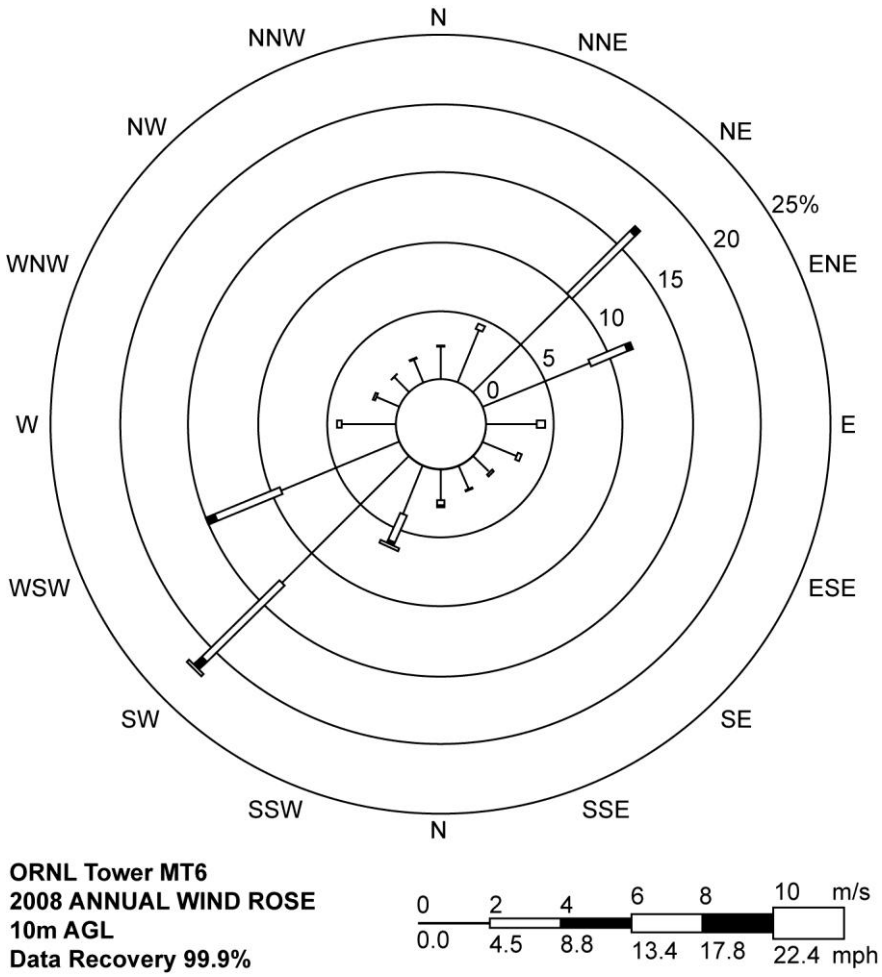


Fig. C.13. Wind rose for ORNL Meteorological Tower 6 for data taken at 10 m above ground level, 2008.

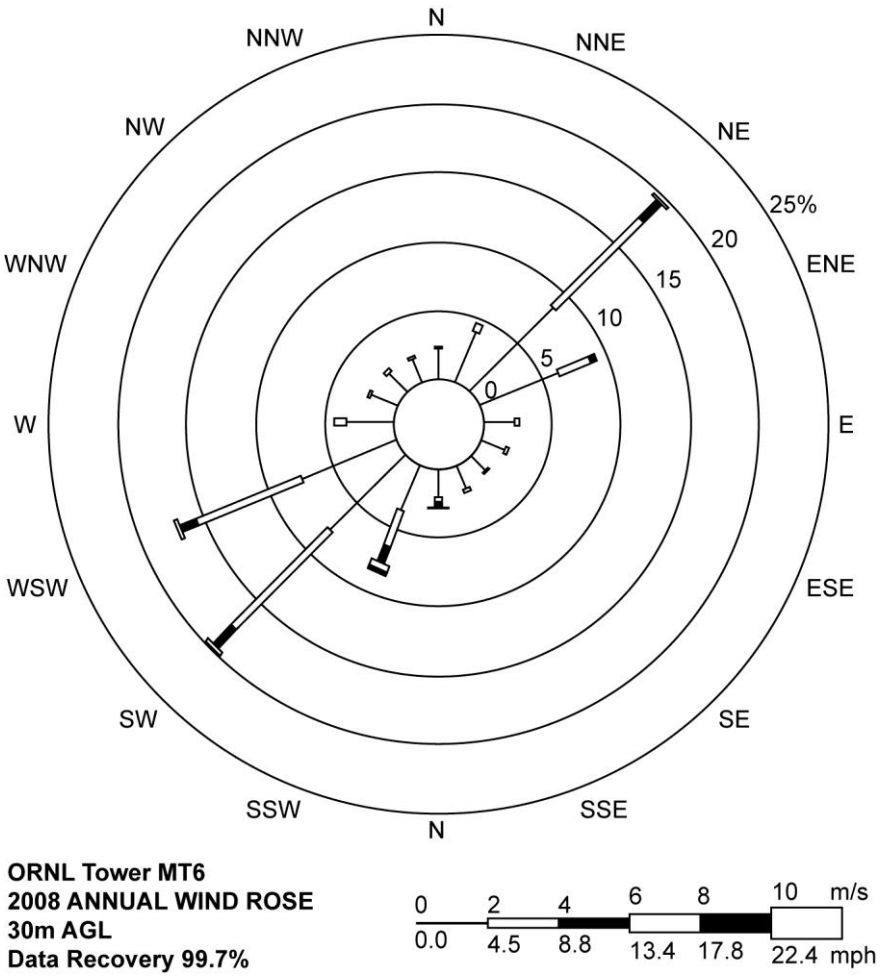


Fig. C.14. Wind rose for ORNL Meteorological Tower 6 for data taken at 30 m above ground level, 2008.

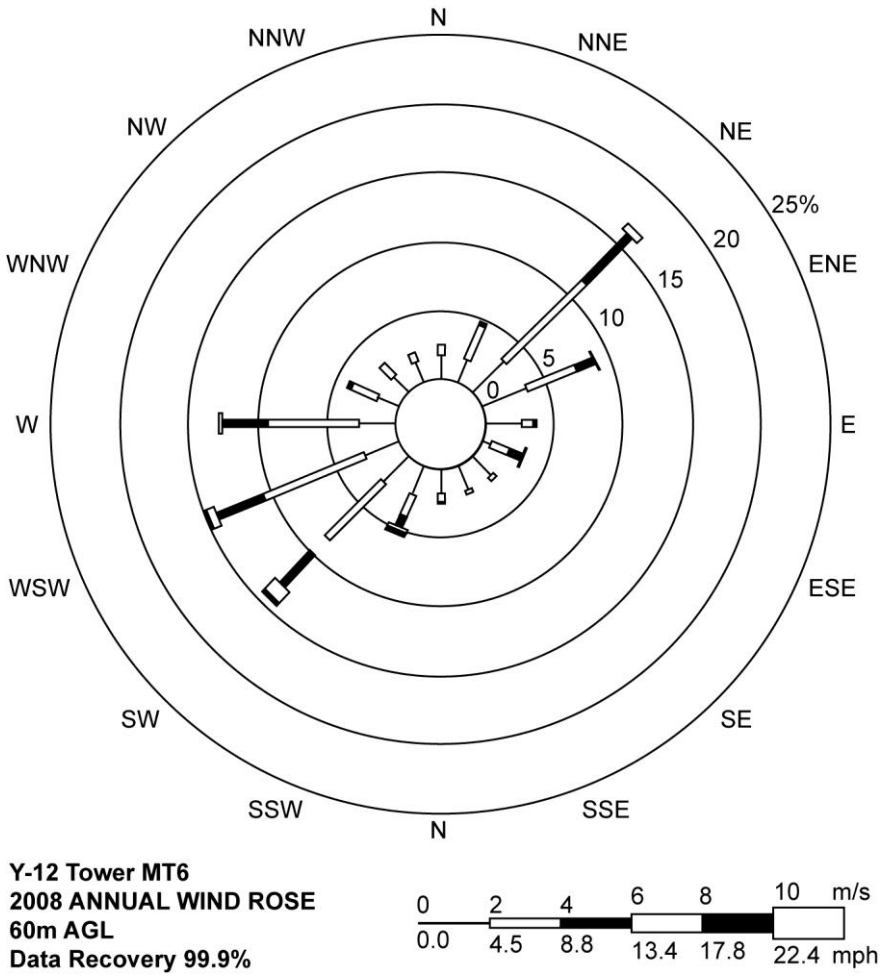


Fig. C.15. Wind rose for Y-12 Meteorological Tower 6 for data taken at 60 m above ground level, 2008.

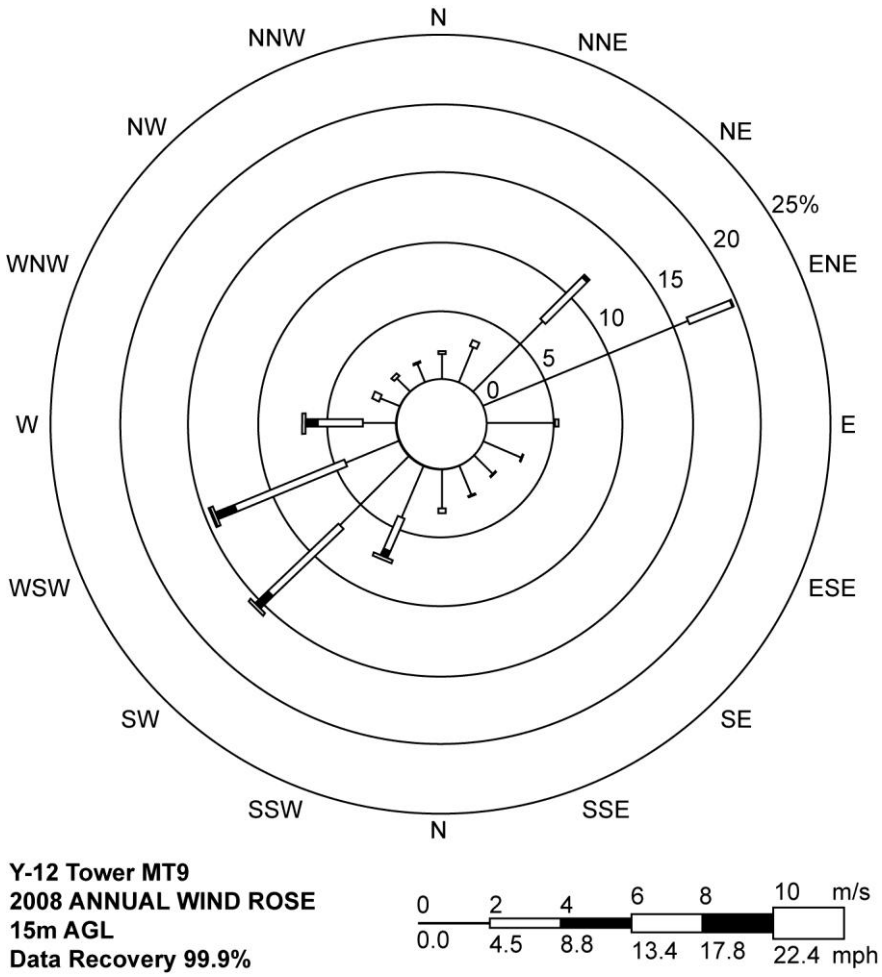


Fig. C.16. Wind rose for Y-12 Meteorological Tower 9 for data taken at 15 m above ground level, 2008.

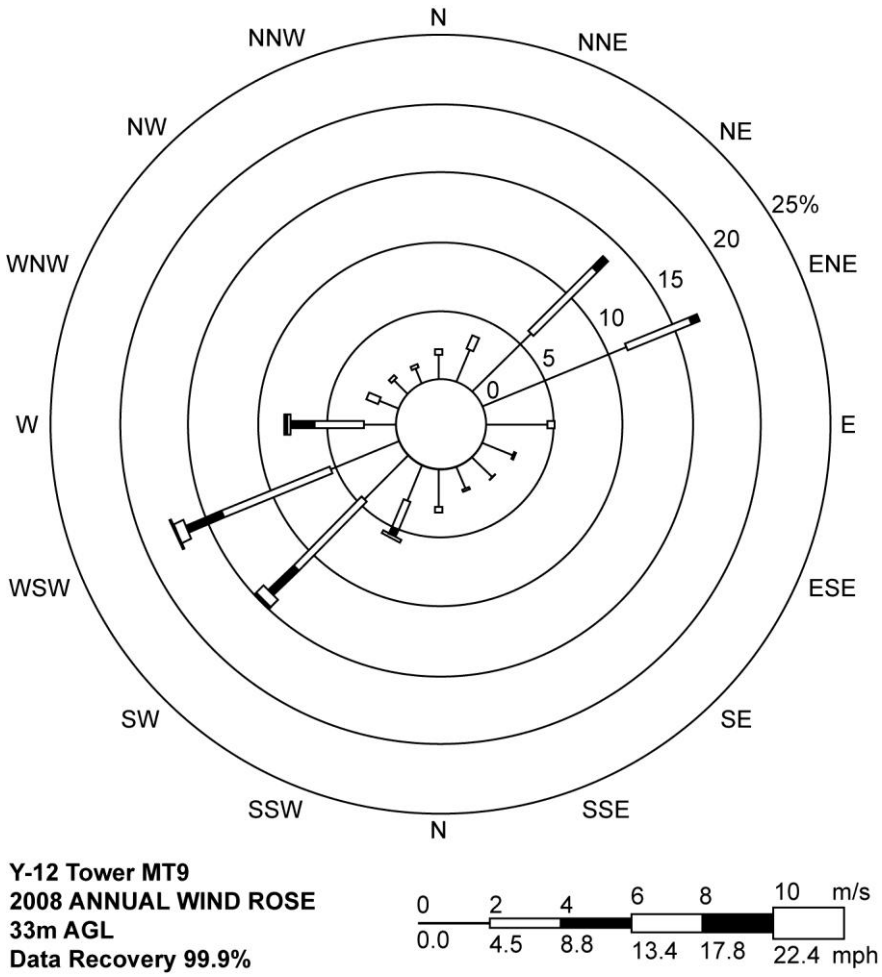


Fig. C.17. Wind rose for Y-12 Meteorological Tower 9 for data taken at 33 m above ground level, 2008.

blow from that direction. The concentric circles represent increasing frequencies from the center outward, given in percent. Precipitation wind roses display similar information except that only hours during which precipitation fell were used. Precipitation events are defined at light (< 0.10 in./h), moderate (0.10–0.30 in./h), and heavy (> 0.30 in./h).

C.3 Temperature and Precipitation

Temperature and precipitation normals (1978–2007) and extremes (1948–2008), and their durations are summarized for the city of Oak Ridge in Table C.1. Decadal temperature and precipitation averages for the decades of 1978 to 1987, 1988 to 1997, and 1998 to 2007 are given in Table C.2. Hourly freeze data (1985–2008) are given in Table C.3.

C.3.1 Recent Climate Change with Respect to Temperature and Precipitation

Table C.2 presents a decadal analysis of temperature patterns over the last 30 years. In general, temperatures in Oak Ridge have risen over the last 30 years but leveled off during the 2000s. Based on average decadal temperatures, temperatures have risen 3.1ºF or 1.8ºC between the decade of 1978 to 1987 as compared to the decade of 1998 to 2007 (from 56.7ºF to 59.8ºF). However, further analysis reveals that the temperature increases have been neither linear nor equal throughout the months or seasons.

January and February average temperatures have seen increases of 7.0ºF and 4.4ºF, respectively. This dramatic increase is probably due to the fact that the Arctic has seen the largest increase in temperatures of anywhere in the Northern Hemisphere over the last 30 years. During the months of January and February, much of the air entering eastern Tennessee comes from the Arctic. As a result, Oak Ridge temperatures have warmed more dramatically during these months. Early spring temperatures (March–April) have risen by about 3ºF whereas most months in the remainder of the calendar year saw temperature increases of about 2.5ºF. The smallest increases, however, are observed for June and July. Average temperatures increased by less than 2ºF during those months and were entirely the result of minimum temperature increases. Overall, annual minimum temperatures seem to have increased more dramatically (by 4.1ºF) than maximum temperatures (by 2.1ºF). Of the summer months, August and September increased the most dramatically (by about 2ºF). For the most recent decade (1998–2007) before 2008, August average temperatures are now about equal to those of July.

Decadal precipitation averages suggest some important changes in precipitation patterns in Oak Ridge over the period of 1978 to 2007. Although overall precipitation has remained within a window of about 48 to 56 in. annually, there have been some recent decadal shifts in the patterns of rainfall on a monthly or seasonal scale. In particular, precipitation has tended to increase during the late winter and early spring (February through April) by about 1 in./month. Conversely, the late summer and early fall months (August through October) have seen slight decreases in precipitation (about 0.50 in./month). Overall, annual precipitation averaged an increase of 4 in. during the 1998–2007 decade vs the 1978–1987 period (see also Table C.2). Despite this average increase in rainfall, 2007 was the driest year on record in Oak Ridge (35.87 in.). This statistic encompasses the period from 1948 to 2008. Next to 2007, the second driest year on record occurred in 1958 (37.43 in.).

The previously discussed increase in winter temperatures has apparently affected monthly and annual snowfall amounts. From 1978 to 1987, snowfall averaged about 13 in. annually in Oak Ridge. However, during the most recent decade (1998–2007), snowfall has averaged only 4 in. This decrease seems to have occurred largely since the mid-1990s. Snowfall during 2008 totaled only 0.8 inches.

Figures C.18 thru C.21 provide typical wind roses for Tower MT2 ("C") during light, moderate, heavy, and all precipitation events (during the previous decade – 1998 to 2007). The precipitation classes are defined by the National Weather Service as follows:

- light: trace to 0.10 in./h
- moderate: 0.11 to 0.30 in./h
- heavy: more than 0.30 in./h

Table C.1. Climate normals (1978–2007) and extremes (1948–2008) for Oak Ridge, Tennessee (Town Site), with 2008 comparisons

Monthly variables	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Temperature, °C (°F)													
30-year average max	8.1 (46.5)	10.8 (51.5)	16.4 (61.5)	21.6 (70.8)	25.8 (78.5)	29.6 (85.3)	31.4 (88.6)	31.2 (88.1)	27.7 (81.9)	21.9 (71.5)	15.5 (59.9)	9.7 (49.4)	20.8 (69.5)
2008 average max	7.9 (46.3)	11.7 (53.1)	16.1 (60.9)	21.2 (70.2)	25.0 (77.0)	31.3 (88.4)	31.4 (88.6)	31.2 (88.2)	28.9 (84.1)	21.7 (71.1)	13.3 (56.0)	10.3 (50.5)	20.9 (69.5)
61-year record max	25 (77)	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	-2.4 (27.7)	-1.0 (30.2)	2.8 (37.0)	7.2 (45.0)	12.3 (54.2)	17.0 (62.6)	19.6 (67.3)	19.1 (66.3)	15.1 (59.2)	8.2 (46.7)	2.9 (37.3)	-1.0 (30.2)	8.3 (47.0)
2008 average min	-2.2 (28.1)	-0.6 (33.1)	2.9 (37.2)	9.2 (48.6)	12.6 (54.7)	17.0 (62.7)	19.1 (66.4)	18.5 (65.3)	16.8 (62.3)	7.9 (46.2)	1.5 (34.7)	0.3 (32.5)	8.8 (47.8)
61-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	2.8 (37.1)	4.9 (40.9)	9.6 (49.3)	14.4 (58.0)	19.1 (66.4)	23.3 (74.0)	25.5 (77.9)	25.1 (77.2)	21.4 (70.6)	15.1 (59.1)	9.2 (48.6)	4.3 (39.8)	14.6 (58.2)
2008 average	2.9 (37.2)	6.2 (43.1)	9.5 (49.1)	15.2 (59.4)	18.8 (65.9)	24.8 (76.6)	25.3 (77.5)	24.9 (76.8)	22.9 (73.2)	14.8 (58.7)	7.4 (45.4)	5.3 (41.5)	14.8 (58.7)
2008 dep from average	0.1 (0.1)	1.2 (2.2)	-0.1 (-0.2)	0.8 (1.4)	-0.3 (-0.5)	1.4 (2.6)	-0.2 (-0.4)	-0.2 (-0.4)	1.4 (2.6)	-0.2 (-0.4)	-1.8 (-3.2)	0.9 (1.7)	0.2 (0.5)
30-year average heating degree days, °C (°F)[a]													
	477 (858)	376 (676)	269 (484)	129 (232)	38 (68)	2 (4)	0	0	14 (26)	114 (206)	271 (487)	430 (774)	2119 (3815)
30-year average cooling degree days, °C (°F)[a]													
	0	0	2 (4)	14 (26)	65 (117)	156 (280)	226 (407)	215 (387)	111 (199)	17 (31)	1 (2)	0	807 (1453)
Precipitation, mm (in.)													
30-year average	122.5 (4.82)	119.7 (4.71)	126.0 (4.96)	114.3 (4.50)	118.1 (4.65)	108.0 (4.25)	137.2 (5.40)	82.8 (3.26)	95.5 (3.76)	69.1 (2.72)	122.2 (4.81)	124.8 (4.91)	1340 (52.75)
2008	114.4 (4.49)	133.4 (5.25)	127.3 (5.01)	91.7 (3.61)	77.5 (3.05)	44.2 (1.74)	124.5 (4.90)	78.3 (3.08)	32.3 (1.27)	51.1 (2.01)	100.6 (3.96)	205.3 (8.08)	1180.2 (46.45)
2008 dep from average	-8.4 (-0.33)	13.7 (0.54)	1.3 (0.05)	-22.6 (-0.89)	-40.7 (-1.60)	-63.8 (-2.51)	-12.7 (-0.50)	-4.6 (-0.18)	-63.3 (-2.49)	-18.0 (-0.71)	-21.6 (-0.85)	80.5 (3.17)	-160.1 (-6.30)
61-year 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)	1939 (76.33)
61-year max 24-hr	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)
61-year 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)	911.4 (35.87)
Snowfall, mm (in.)													
30-year average	96.6 (3.8)	91.5 (3.6)	38.1 (1.5)	7.6 (0.3)	0	0	0	0	0	0	Trace	43.2 (1.7)	276.9 (10.9)
2008 totals	12.7 (0.5)	7.6 (0.3)	Trace	0	0	0	0	0	0	0	Trace	Trace	20.3 (0.8)
61-year max 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)	1052 (41.4)
61-year max 24-hr	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)
Days w/Temp													
30-year max ≥ 32EC	0	0	0	0.1	1.0	5.5	14.7	12.9	4.2	0	0	0	38.4
2008 max ≥ 32E C	0	0	0	0	0	16	16	14	4	3	0	0	53
30-year min ≤ 0EC	21.9	16.4	11.7	2.7	0.1	0	0	0	0	2.0	11.0	19.6	85.4
2008 min ≤ 0EC	22	16	10	0	0	0	0	0	0	0	12	17	77
30-year max ≤ 0EC	2.9	1.3	0.2	0	0	0	0	0	0	0	0.1	1.6	6.1
2008 max ≤ 0EC	2	0	0	0	0	0	0	0	0	0	0	1	3
Days w/Precip													
30-year avg ≥ 0.01 in.	11.5	10.7	11.6	10.4	11.6	11.2	12.5	9.7	9.1	8.1	9.7	11.0	127.1
2008 days ≥ 0.01 in.	12	12	11	8	9	8	12	5	6	7	10	15	115
30-year avg ≥ 1.00 in.	1.3	1.2	1.5	0.8	1.4	1.3	1.4	0.7	1.2	0.7	1.3	1.3	14.1
2008 days ≥ 1.00 in.	1	2	2	1	0	0	1	1	1	1	1	2	13

Table C.2. Decadal climate change (1978–2007) for Oak Ridge, Tennessee (Town Site) with 2008 comparisons

Monthly variables	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Temperature, °C (°F)													
1978-1987 Avg Max	5.7 (42.2)	9.2 (48.6)	15.6 (60.0)	20.9 (69.7)	25.4 (77.8)	29.7 (85.5)	31.3 (88.4)	30.6 (87.0)	27.3 (81.1)	21.5 (70.7)	15.3 (59.6)	9.2 (48.6)	20.1 (68.3)
1988-1997 Avg Max	8.9 (48.0)	11.8 (53.2)	16.9 (62.4)	21.9 (71.5)	25.7 (78.3)	29.5 (85.1)	31.8 (89.2)	31.2 (88.1)	27.6 (81.7)	22.0 (71.6)	14.8 (58.6)	9.5 (49.1)	21.0 (69.7)
1998-2007 Avg Max	9.6 (49.2)	11.4 (52.5)	16.7 (62.1)	21.8 (71.2)	26.3 (79.3)	29.7 (85.4)	31.2 (88.1)	31.8 (89.2)	28.3 (82.9)	22.4 (72.3)	16.4 (61.6)	10.3 (50.5)	21.3 (70.4)
Temp Change (1978-1987 vs. 1998-2007)	3.9 (7.0)	2.2 (3.9)	1.2 (2.1)	0.8 (1.5)	0.8 (1.5)	-0.1 (-0.1)	-0.2 (-0.3)	1.2 (2.2)	1.0 (1.8)	0.9 (1.6)	1.1 (2.0)	1.1 (1.9)	1.2 (2.1)
2008 Avg Max	7.9 (46.3)	11.7 (53.1)	16.1 (60.9)	21.2 (70.2)	25.0 (77.0)	31.3 (88.4)	31.4 (88.6)	31.2 (88.2)	28.9 (84.1)	21.7 (71.1)	13.3 (56.0)	10.3 (50.5)	20.9 (69.5)
1978-1987 Avg Min	-4.7 (23.5)	-2.6 (27.4)	1.4 (34.5)	5.9 (42.7)	11.5 (52.7)	15.9 (60.6)	18.7 (65.6)	18.1 (64.6)	14.3 (57.7)	7.3 (45.2)	2.9 (37.2)	-1.8 (28.7)	7.2 (45.0)
1988-1997 Avg Min	-1.7 (28.9)	-0.8 (30.6)	2.8 (37.1)	6.8 (44.2)	11.8 (53.3)	17.2 (62.9)	19.7 (67.4)	18.9 (66.1)	15.4 (59.7)	7.6 (45.7)	1.8 (35.2)	-1.0 (30.2)	8.2 (46.8)
1998-2007 Avg Min	-0.7 (30.7)	0.3 (32.6)	4.2 (39.5)	8.9 (48.1)	13.7 (56.6)	17.9 (64.3)	20.4 (68.8)	20.1 (68.2)	15.7 (60.2)	9.5 (49.1)	4.2 (39.5)	-0.2 (31.7)	9.5 (49.1)
Temp Change (1978-1987 vs. 1998-2007)	4.0 (7.2)	2.9 (5.2)	2.8 (5.0)	3.0 (5.4)	2.2 (3.9)	2.1 (3.7)	1.8 (3.2)	2.0 (3.6)	1.4 (2.5)	2.2 (3.9)	1.3 (2.3)	1.7 (3.0)	2.3 (4.1)
2008 Avg Min	-2.2 (28.1)	0.6 (33.1)	2.9 (37.2)	9.2 (48.6)	12.6 (54.7)	18.2 (64.8)	19.1 (66.4)	18.5 (65.3)	16.8 (62.3)	7.9 (46.2)	1.5 (34.7)	0.3 (32.5)	8.8 (47.8)
1978-1987 Avg	0.5 (32.9)	3.4 (38.1)	8.5 (47.3)	13.4 (56.2)	18.5 (65.3)	22.8 (73.1)	25.0 (77.0)	24.3 (75.8)	20.9 (69.9)	14.4 (58.0)	9.1 (48.4)	3.7 (38.6)	13.7 (56.7)
1988-1997 Avg	3.6 (38.5)	5.5 (41.9)	9.9 (49.9)	14.3 (57.8)	18.8 (65.8)	23.4 (74.1)	25.7 (78.3)	25.1 (77.1)	21.5 (70.7)	14.8 (58.7)	8.3 (46.9)	4.3 (39.7)	14.6 (58.3)
1998-2007 Avg	4.4 (39.9)	5.8 (42.5)	10.4 (50.8)	15.5 (59.9)	20.0 (68.0)	23.8 (74.9)	25.8 (78.5)	25.9 (78.7)	22.0 (71.6)	15.9 (60.9)	10.3 (50.6)	5.1 (41.2)	15.4 (59.8)
Temp Change (1978-1987 vs. 1998-2007)	3.9 (7.0)	2.4 (4.4)	1.9 (3.5)	2.1 (3.7)	1.5 (2.7)	1.0 (1.8)	0.8 (1.5)	1.6 (2.9)	1.1 (2.0)	1.5 (2.7)	1.2 (2.2)	1.4 (2.6)	1.7 (3.1)
2008 Avg	2.9 (37.2)	6.2 (43.1)	9.5 (49.1)	15.2 (59.4)	18.8 (65.9)	24.8 (76.6)	25.3 (77.5)	24.9 (76.8)	22.9 (73.2)	14.8 (58.7)	7.4 (45.4)	5.3 (41.5)	14.8 (58.7)
Precipitation, mm (in.)													
1978-1987 Avg	103.4 (4.07)	101.4 (3.99)	112.3 (4.42)	94.5 (3.72)	123.5 (4.86)	84.4 (3.32)	137.2 (5.40)	95.0 (3.74)	85.9 (3.38)	74.4 (2.93)	120.4 (4.74)	108.5 (4.27)	1241 (48.83)
1988-1997 Avg	136.7 (5.38)	135.9 (5.35)	146.1 (5.75)	97.1 (3.82)	114.3 (4.50)	122.5 (4.82)	134.4 (5.29)	91.7 (3.61)	101.9 (4.01)	69.1 (2.72)	128.8 (5.07)	157.3 (6.19)	1436 (56.52)
1998-2007 Avg	126.8 (4.99)	122.0 (4.80)	119.7 (4.71)	151.2 (5.95)	116.6 (4.59)	117.4 (4.62)	140.5 (5.53)	61.7 (2.43)	98.3 (3.87)	63.8 (2.51)	117.6 (4.63)	108.7 (4.28)	1344 (52.91)
Precip Change (1978-1987 vs. 1998-2007)	23.4 (0.92)	20.6 (0.81)	7.4 (0.29)	56.7 (2.23)	-6.9 (-0.27)	33.0 (1.30)	3.3 (0.13)	-33.3 (-1.31)	12.4 (0.49)	-10.7 (-0.42)	-2.8 (-0.11)	0.3 (0.01)	103.7 (4.08)
2008 Avg	114.1 (4.49)	133.4 (5.25)	127.3 (5.01)	91.7 (3.61)	77.5 (3.05)	44.2 (1.74)	124.5 (4.90)	78.3 (3.08)	32.3 (1.27)	51.1 (2.01)	100.6 (3.96)	205.3 (8.08)	1180.2(46.45)
Snowfall, mm (in.)													
1978-1987 Avg	117 (4.6)	142 (5.6)	33 (1.3)	23 (0.9)	0	0	0	0	0	8 (0.3)	Trace	28 (1.1)	351 (13.8)
1988-1997 Avg	92 (3.6)	79 (3.1)	69 (2.7)	Trace	0	0	0	0	0	0	3 (0.1)	86 (3.4)	328 (12.9)
1998-2007 Avg	46 (1.8)	46 (1.8)	Trace	Trace	0	0	0	0	0	0	Trace	18 (0.7)	109 (4.3)
Precip Change (1978-1987 vs. 1998-2007)	-71 (-2.8)	-96 (-3.8)	-33 (-1.3)	-23 (-0.9)	0	0	0	0	0	-8 (-0.3)	0	-10 (0.4)	-242 (-9.5)
2008 Avg	12.7 (0.5)	7.6 (0.3)	Trace	0	0	0	0	0	0	0	Trace	Trace	20.3 (0.8)

Table C.3. Hourly freeze data for Oak Ridge, Tennessee, 1985–2008

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
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	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	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	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	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	7	0	100	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	152	2	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	53	1	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	142	3	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	3	0	101	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	6	0	96	10	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	38	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	4	0	41	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	11	0	94	11	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	18	0	28	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	41	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	37	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	9	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	1	0	55	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	15	0	37	0	0	126	41	1	0	461	60	1	0
2007	189	30	5	0	283	70	0	0	29	0	0	32	0	0	0	0	0	60	0	0	83	8	0	0	673	111	5	0
2008	242	86	11	0	114	7	0	0	69	6	0	0	0	0	0	15	0	89	18	0	157	34	5	0	686	151	16	0
Avg.	239	73	16	3	154	37	7	1	69	7	1	12	0	0	0	8	0	72	4	0	205	47	7	1	738	164	31	5

[a]Source: 1985–2007 National Oceanic and Atmospheric Administration Atmospheric Turbulence and Diffusion Division KOQT Station, Automated Surface Observing System.

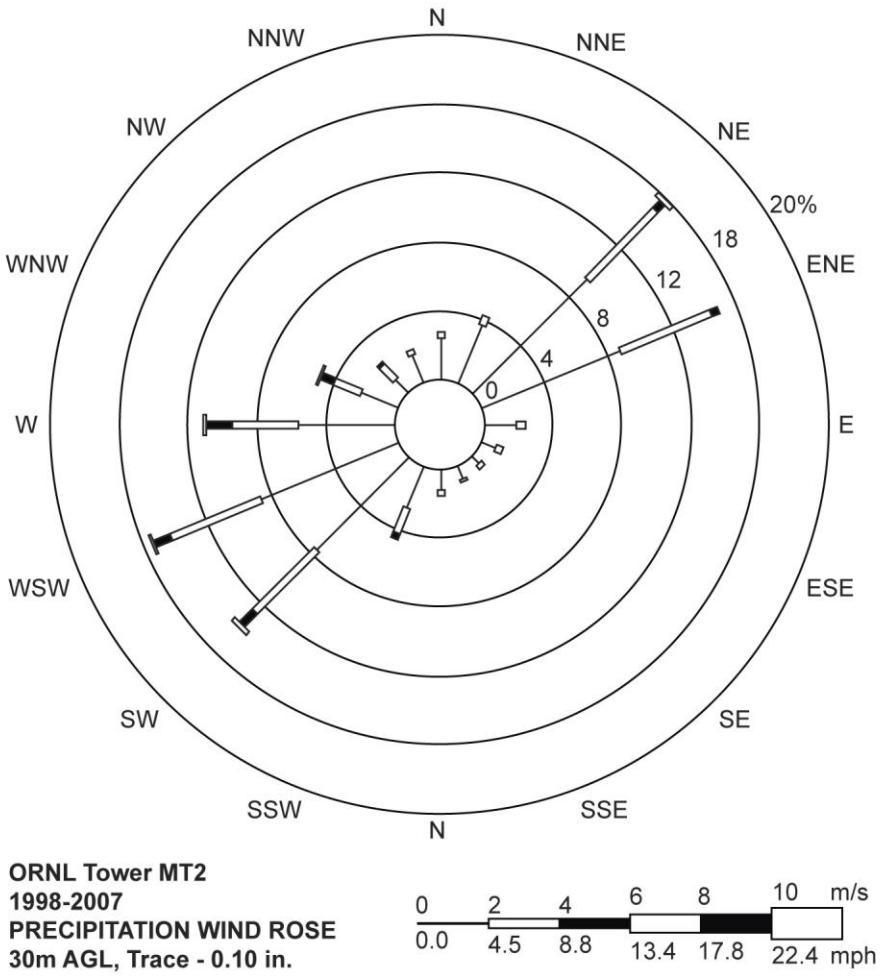


Fig. C.18. Wind rose for ORNL Meteorological Tower 2 for data taken at 30 m above ground level during light precipitation events (trace–0.10 in.), 1998–2007.

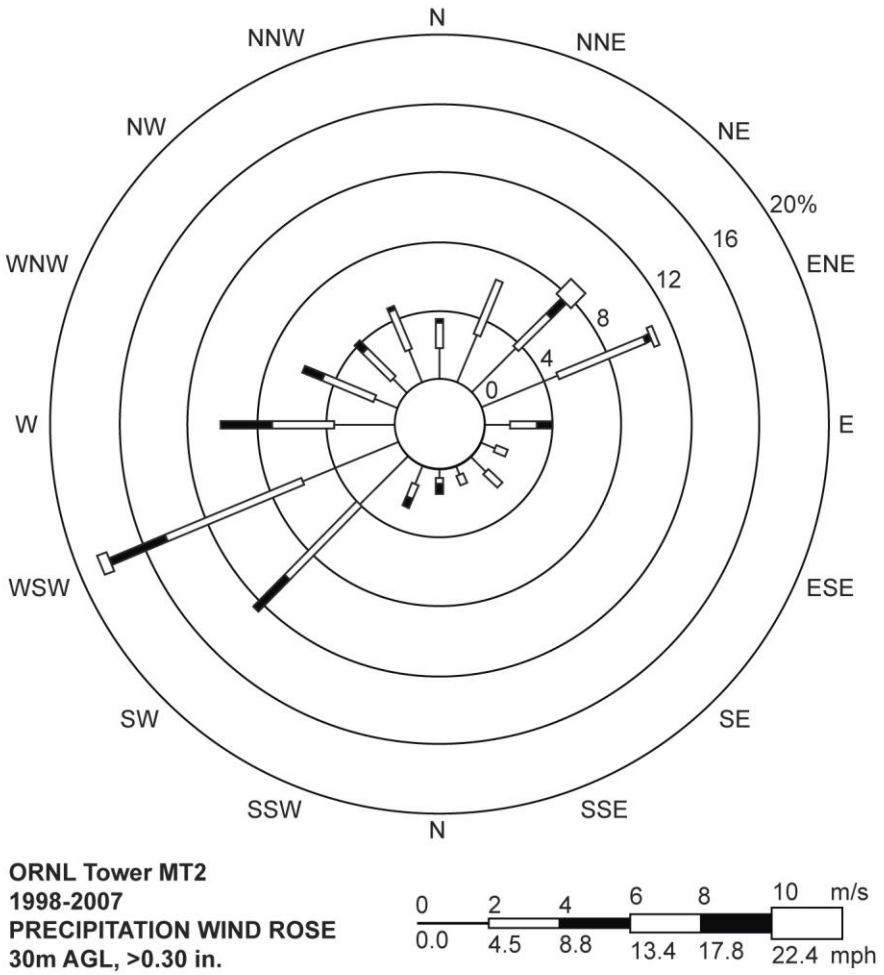


Fig. C.19. Wind rose for ORNL Meteorological Tower 2 for data taken at 30 m above ground level during moderate precipitation events (0.10–0.30 in.), 1998–2007.

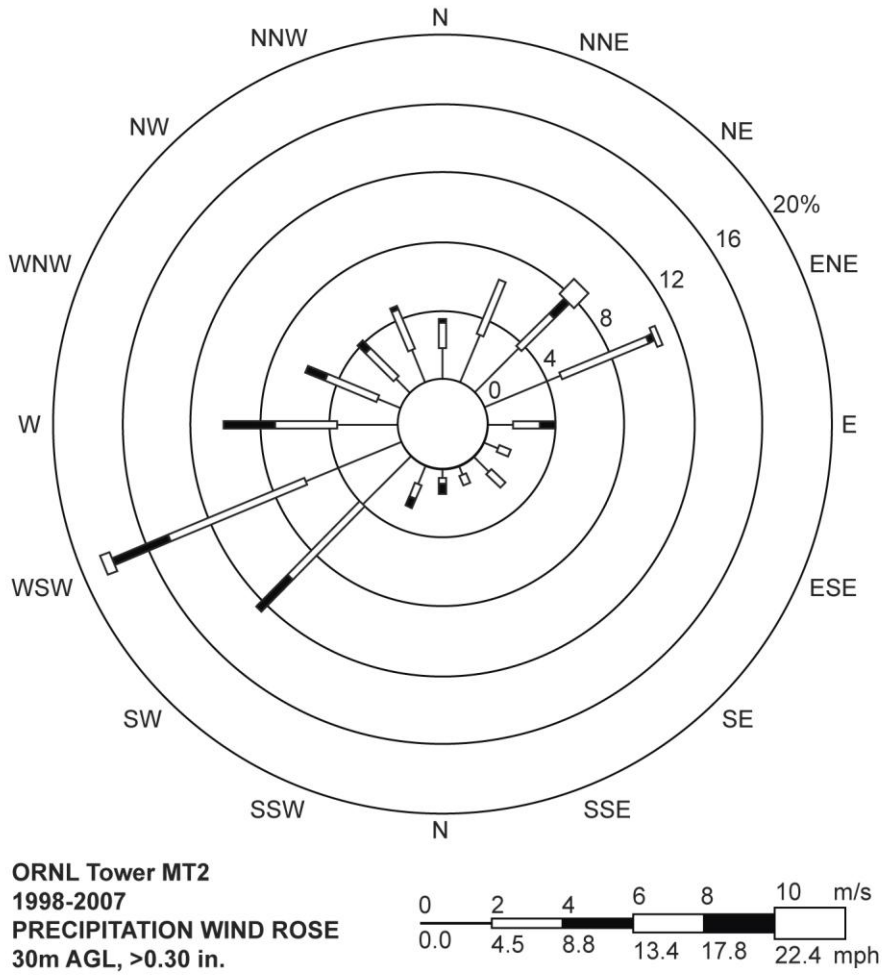


Fig. C.20. Wind rose for ORNL Meteorological Tower 2 for data taken at 30 m above ground level during heavy precipitation events (> 0.30 in.), 1998–2007.

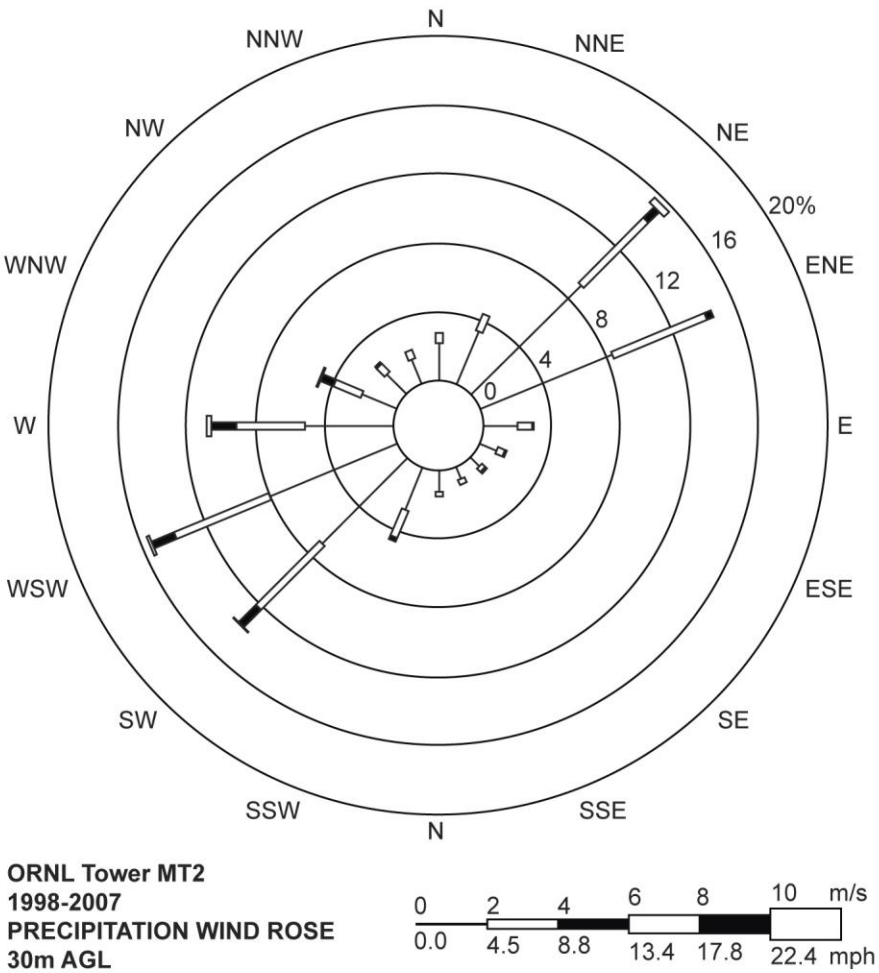


Fig. C.21. Wind rose for ORNL Meteorological Tower 2 for data taken at 30 m above ground level during all precipitation events, 1998–2007.

The meteorological record from ORNL's Tower C was used because it is centrally located within the Oak Ridge Reservation.

Hourly values of subfreezing temperatures in Oak Ridge are presented in Table C.3 for the years 1985 to 2008. During the mid-to-late 1980s, a typical year experienced about 900 to 1000 h of subfreezing temperatures. In recent years, the value has fallen to approximately 620 h.

C.4 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. "Stability" describes the tendency of the atmosphere to 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.

The suppression of vertical motions during stable conditions increases the local terrain's effect on air motion. 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 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 (which 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 fog decks 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 synoptic-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 reintensifies 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.

Figures C.22 thru C.28 provide wind roses for ORNL Tower MT2 at 30 m with respect to Stability A thru G during 2008. Stabilty "A" (unstable) conditions show a strong preference for winds from the south half of the compass. Stability "D" conditions (neutral), which also tend to correspond to higher wind

speed, show a significant preference for winds from the west and west-northwest. During very stable conditions (F and G stability), winds shows a preference for eastnortheast directions (likely down valley "cold air" drainage flow).

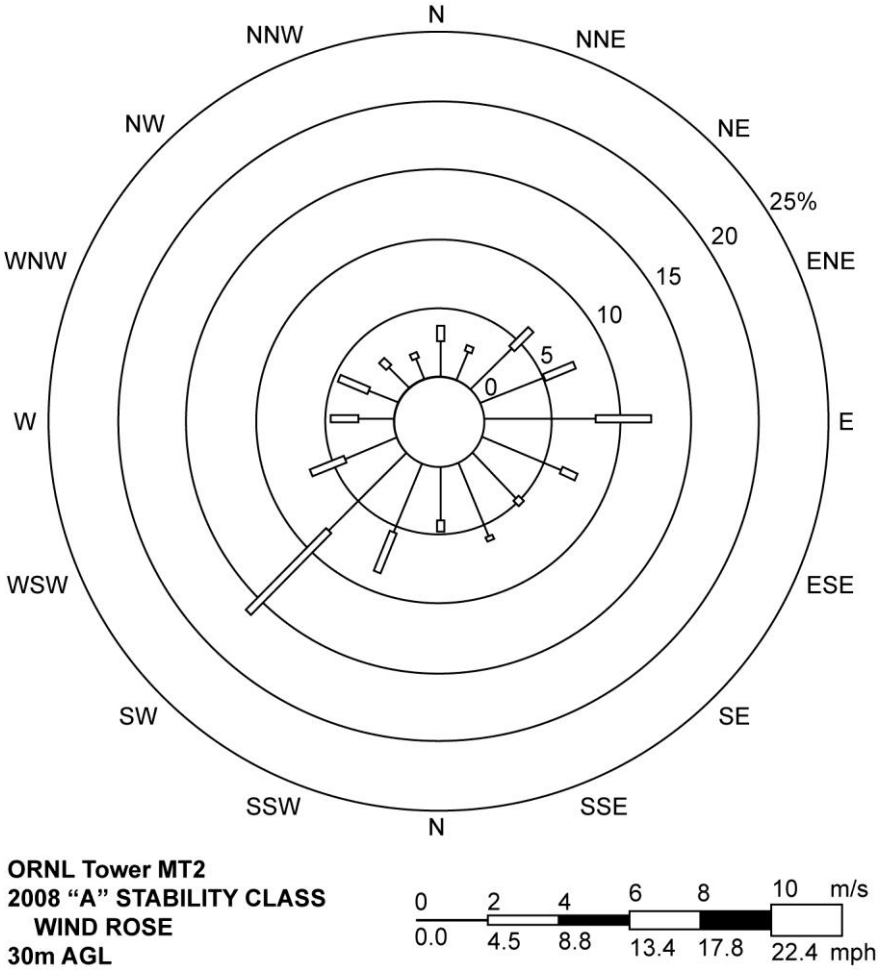


Fig. C.22. Wind rose for ORNL Meteorological Tower 2, stability class A, for data taken at 30 m above ground level, 2008.

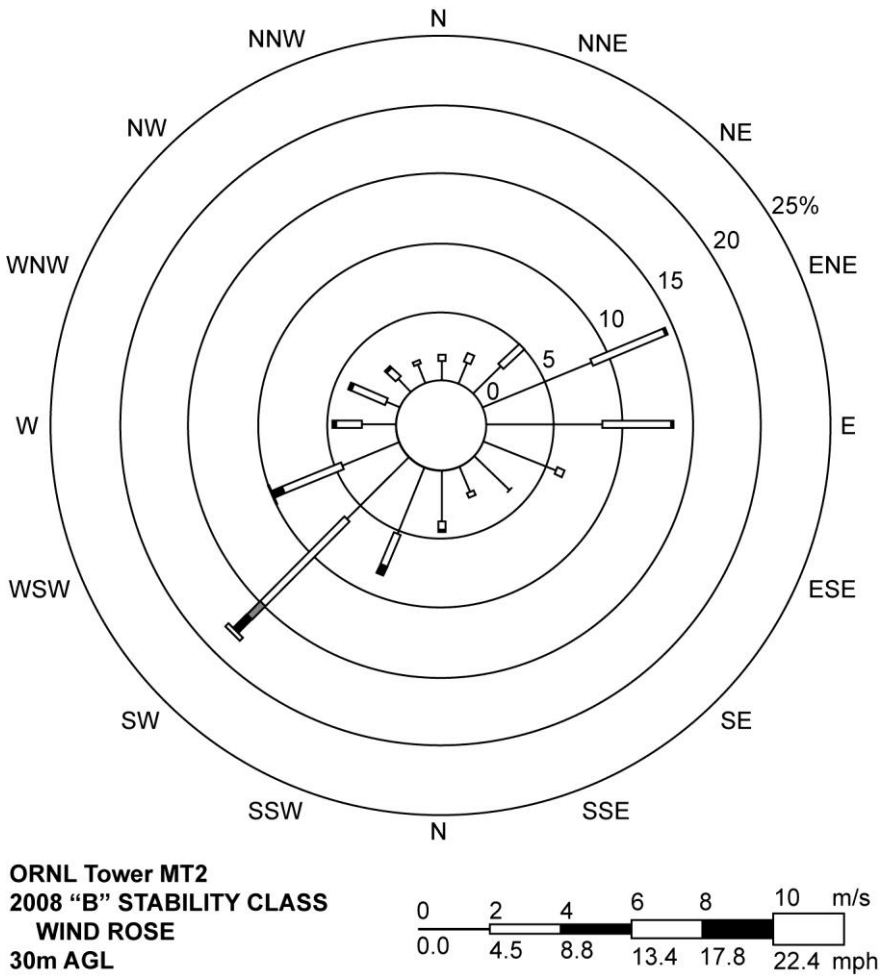


Fig. C.23. Wind rose for ORNL Meteorological Tower 2, stability class B, for data taken at 30 m above ground level, 2008.

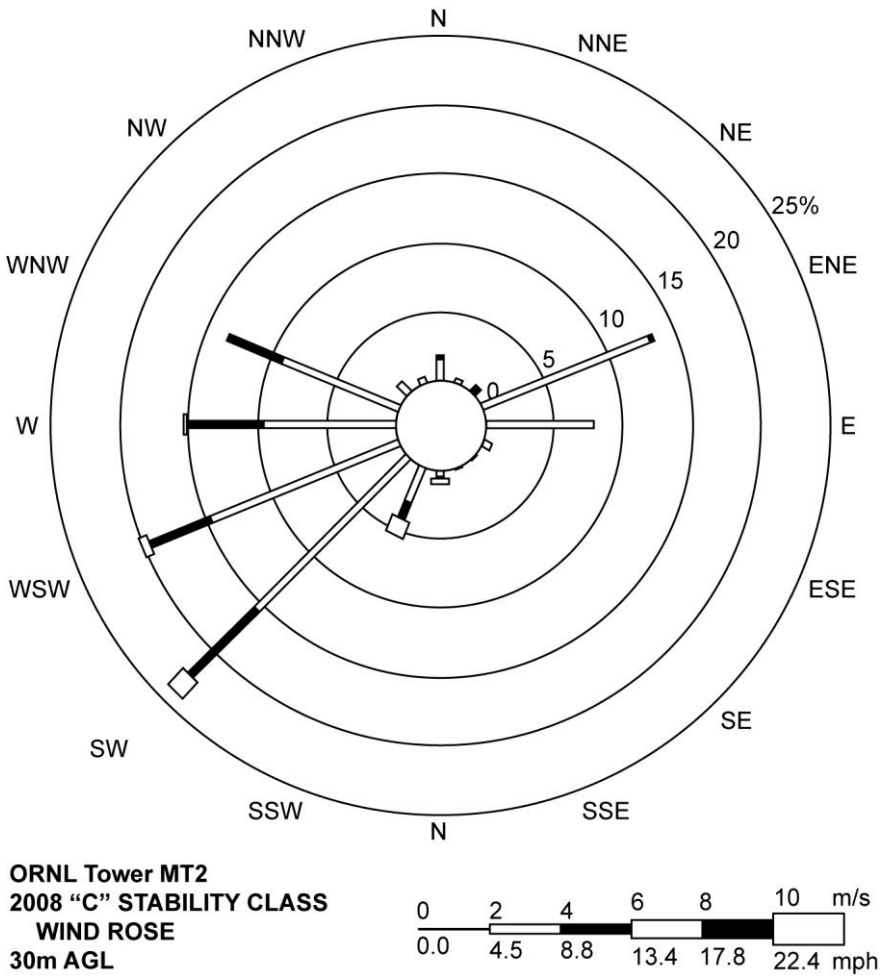


Fig. C.24. Wind rose for ORNL Meteorological Tower 2, stability class C, for data taken at 30 m above ground level, 2008.

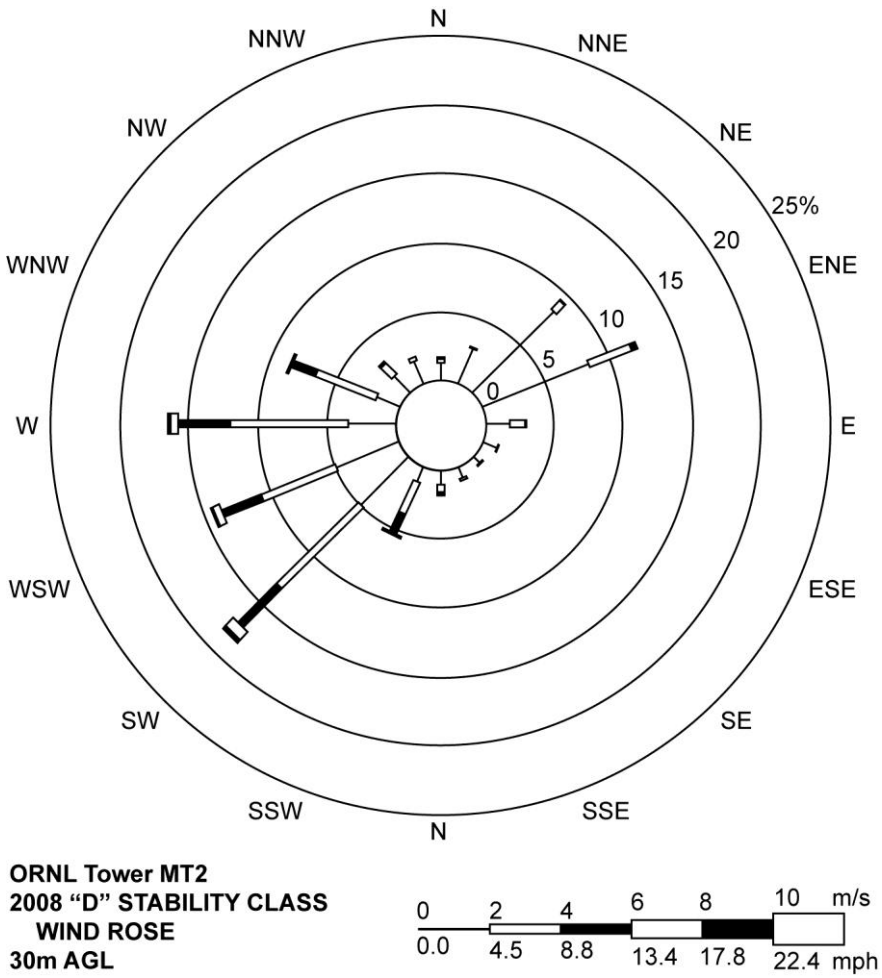


Fig. C.25. Wind rose for ORNL Meteorological Tower 2, stability class D, for data taken at 30 m above ground level, 2008.

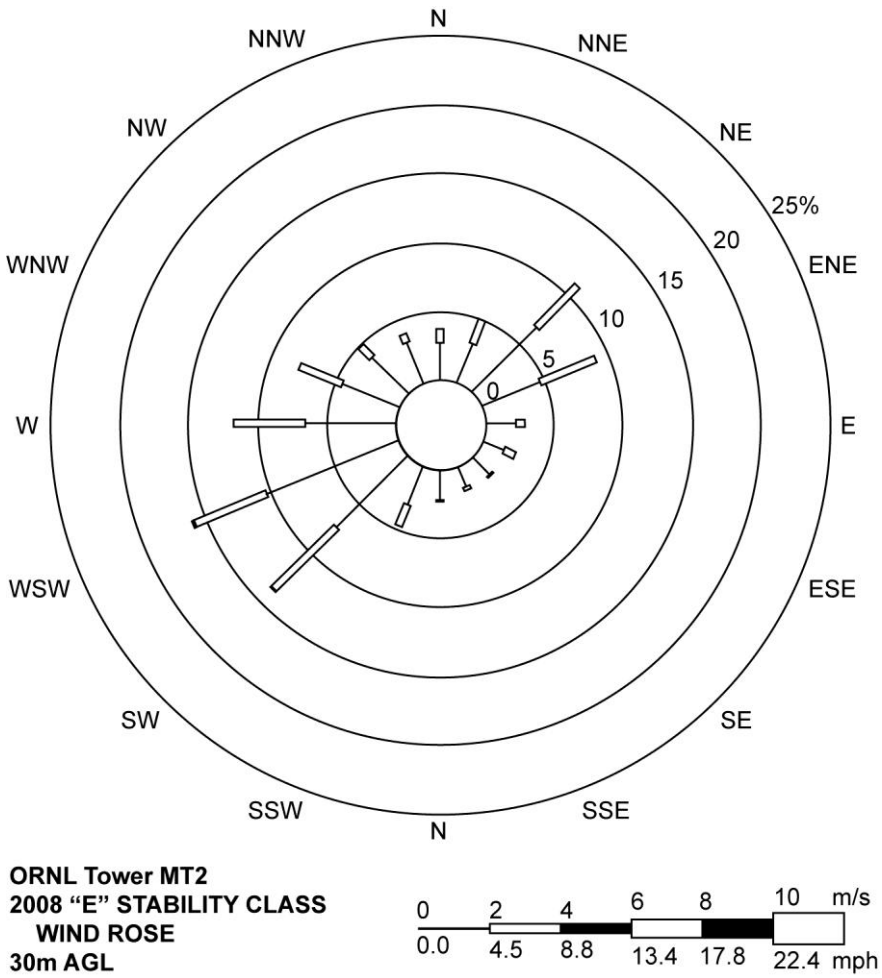


Fig. C.26. Wind rose for ORNL Meteorological Tower 2, stability class E, for data taken at 30 m above ground level, 2008

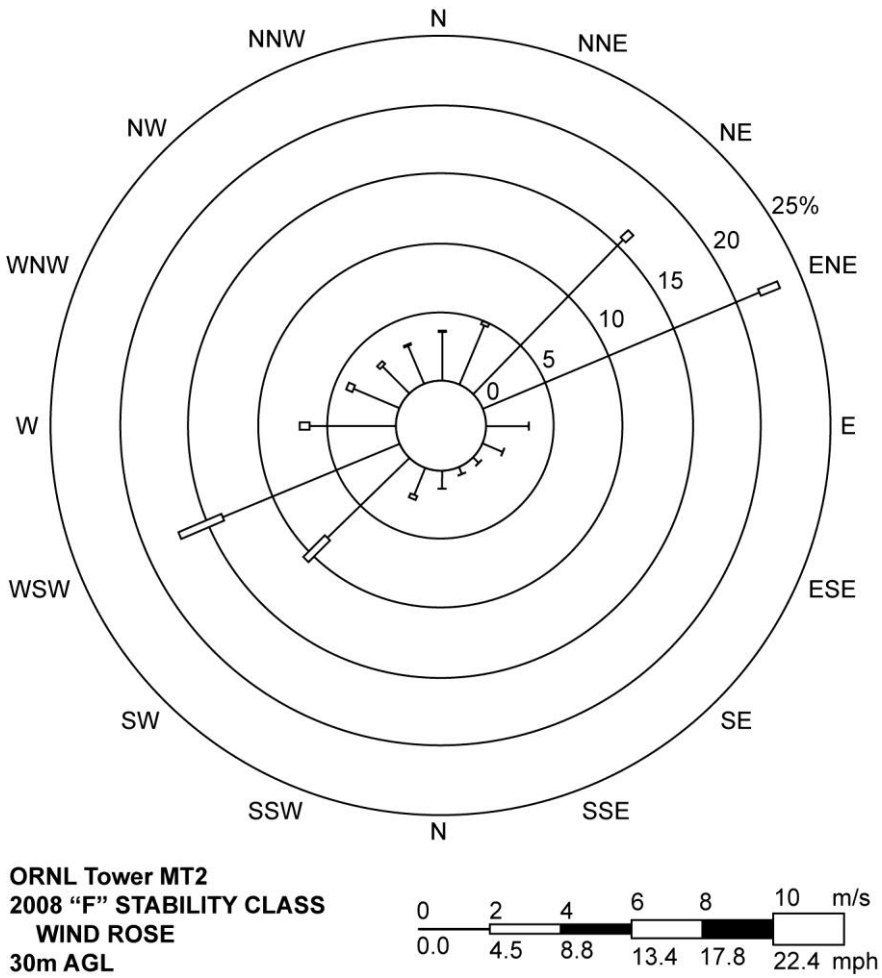


Fig. C.27. Wind rose for ORNL Meteorological Tower 2, stability class F, for data taken at 30 m above ground level, 2008.

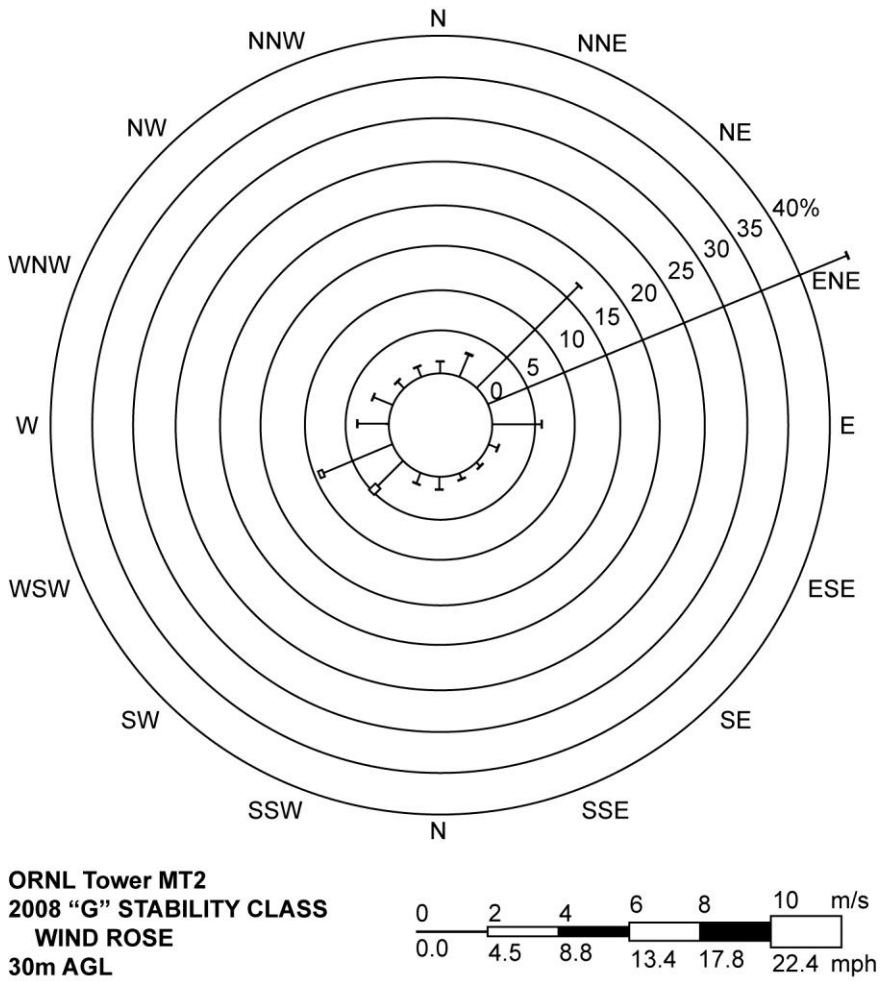


Fig. C.28. Wind rose for ORNL Meteorological Tower 2, stability class G, for data taken at 30 m above ground level, 2008.

C.5 References

Birdwell, K. R. 1996. "A Climatology of Winds over a Ridge and Valley Terrain within the Great Valley of Eastern Tennessee." Master's Thesis, Department of Geosciences, Murray State University, Murray, Kentucky.

Carlson, M. A., and R. B. Stull. 1986. "Subsidence in the Nocturnal Boundary Layer." *Journal of Climate and Applied Meteorology* **25**, 1088–99.

Eckman, R. M. 1998. "Observations and Numerical Simulations of Winds within a Broad Forested Valley." *Journal of Applied Meteorology* **37**, 206–19.

Kossman, M., and A. P. Sturman. 2002. "Pressure Driven Channeling Effects in Bent Valleys." *Journal of Applied Meteorology* **42**, 151–58.

Monti, P., H. J. S. Fernando, M. Princevac, W. C. Chan, T. A. Kowalewski, and E. R. Pardyjak. 2002. "Observations of Flow and Turbulence in the Nocturnal Boundary Layer over a Slope." *Journal of the Atmospheric Sciences* **59**, 2513–34.

Van De Weil, B. J. H., A. F. Moene, R. J. Ronda, H. A. R. De Bruin, and A. A. M. Holtslag. 2002. "Intermittent Turbulence and Oscillations in the Stable Boundary Layer over Land. Part II: A System Dynamics Approach." *Journal of the Atmospheric Sciences* **59**, 2567–81.

Whiteman, C. D. 2000. *Mountain Meteorology: Fundamentals and Applications*. Oxford University Press, New York.

Whiteman, C. D., S. Zhong, W. J. Shaw, J. M. Hubbe, and X. Bian. 2001. "Cold Pools in the Columbia River Basin." *Weather and Forecasting* **16**, 432–47.

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] (:g/L[j])	30	20	500

[a]Only the radionuclides included in the Oak Ridge Reservation monitoring programs are listed. Unless labeled otherwise, units are pCi/L.

[b]40 CFR Part 141, National Primary Drinking Water Regulations Subparts B and G. The drinking water standards are presented strictly for reference purposes and only have regulatory applicability for public water supplies.

[c]Four percent of the derived concentration guide represents the DOE criterion of 4 mrem effective dose equivalent from ingestion of drinking water.

[d]DOE Order 5400.5 Chap. III, "Derived Concentration Guides for Air and Water."

[e]Excludes radon and uranium.

[f]Per 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 ^{3}H and ^{90}Sr 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."

[g]These 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.

[h]Applies to combined ^{226}Ra and ^{228}Ra.

[i]Minimum of uranium isotopes.

[j]Effective December 8, 2003.

Table D.2. TDEC and EPA Nonradiological Water Quality Standards and Criteria (µg/L)

Chemical	TDEC and EPA Drinking Water Standards[a]	TDEC Fish and Aquatic Life Criteria		TDEC Recreation Criteria Water + Organisms, Organisms Only[b]
		Maximum	Continuous	
Acenaphthene				670, 990
Acrolein				190, 290
Acrylonitrile (c)				0.51, 2.5
Alachlor	2 (E1, T)			
Aldrin (c)		3.0	--	0.00049, 0.00050
Aluminum	50 – 200 (E2)			
Anthracene				8300, 40,000
Antimony	6 (E1, T)			5.6, 640
Arsenic (c)	10 (E1, T)			10.0, 10.0
Arsenic (III)		340[c]	150[c]	
Asbestos	7 Million Fibers per Liter (MFL) (E1)			
Atrazine	3 (E1, T)			
Barium	2000 (E1, T)			
Benzene (c)	5 (E1, T)			22, 510
Benzidine (c)				0.00086, 0.0020
Benzo(a)anthracene (c)				0.038, 0.18
Benzo(a)pyrene (c)	0.2 (E1, T)			0.038, 0.18
Benzo(b) fluoranthene (c)				0.038, 0.18
Benzo(k)fluoranthene (c)				0.038, 0.18
Beryllium	4 (E1, T)			
a-BHC (c)				0.026, 0.049
b-BHC (c)				0.091, 0.17
g-BHC (Lindane)	0.2 (E1, T)	0.95	--	0.98, 1.8
Bis(2-chloroethyl)ether (c)				0.30, 5.3
Bis(2-chloro-isopropyl)ether				1400, 65,000
Bis(2-ethylhexyl)phthalate (c)				12, 22
Bromoform (c)				43, 1400
Butylbenzyl phthalate				1500, 1900
Cadmium	5 (E1, T)	2.0[d]	0.25[d]	
Carbofuran	40 (E1, T)			
Carbon tetrachloride (c)	5 (E1, T)			2.3, 16
Chlordane (c)	2 (E1, T)	2.4	0.0043	0.0080, 0.0081
Chloride	250,000 (E2)			
Chlorine (TRC)	4000 (E1)	19	11	
Chlorobenzene	100 (E1, T)			130, 1600
Chlorodibromomethane (c)				4.0, 130
Chloroform (c)				57, 4700
2-Chloronaphthalene				1000, 1600
2-Chlorophenol				81, 150
Chromium (total)	100 (E1, T)			
Chromium (III)		570[d]	74[d]	
Chromium (VI)		16[c]	11[c]	
Chrysene (c)				0.038, 0.18
Coliforms	630/100 mL, E. Coli, geometric mean (T) No more than 5% of samples per month can be positive for Total Coliforms (E1)	2880/100 mL, E. Coli	630/100 mL, E. Coli	126/100 mL, geometric mean, E. Coli 487, maximum lakes/reservoirs, E. Coli 941, maximum, other water bodies, E. Coli

Table D.2. TDEC and EPA Nonradiological Water Quality Standards and Criteria (µg/L)

Chemical	TDEC and EPA Drinking Water Standards[a]	TDEC Fish and Aquatic Life Criteria		TDEC Recreation Criteria Water + Organisms, Organisms Only[b]
		Maximum	Continuous	
Color	15 color units (E2)			
Copper	1000 (E2) 1300 (E1 "Action Level")	13[d]	9.0[d]	
Cyanide (as free cyanide)	200 (E1, T)	22	5.2	140, 140
2,4-D (Dichlorophennoxyacetic acid)	70 (E1, T)			
4,4'-DDT (c)		1.1	0.001	0.0022, 0.0022
4,4'-DDE (c)				0.0022, 0.0022
4,4'-DDD (c)				0.0031, 0.0031
Dalapon	200 (E1, T)			
Dibenz(a,h)anthracene (c)				0.038, 0.18
1,2-dibromo-3-chloropropane (DBCP)	0.2 (E1, T)			
1,2-Dichlorobenzene (*ortho*-)	600 (E1, T)			420, 1300
1,3-Dichlorobenzene(*meta*-)				320, 960
1,4-Dichlorobenzene(*para*-)	75 (E1, T)			63, 190
3,3-Dichlorobenzidine (c)				0.21, 0.28
Dichlorobromomethane (c)				5.5, 170
1,2-Dichloroethane (c)	5 (E1, T)			3.8, 370
1,1-Dichloroethylene	7 (E1, T)			330, 7100
Cis-1,2-Dichloroethylene	70 (E1, T)			
trans 1,2-Dichloroethylene	100 (E1, T)			140, 10,000
Dichloromethane	5 (E1, T)			
2,4-Dichlorophenol				77, 290
1,2-Dichloropropane (c)	5 (E1, T)			5.0, 150
1,3-Dichloropropene (c)				3.4, 210
Dieldrin (c)		0.24	0.056	0.00052, 0.00054
Diethyl phthalate				17,000, 44,000
Di (2-ethylhexyl) adipate	400 (E1, T)			
Di (2-ethylhexyl) phthalate	6 (E1, T)			
Dinoseb	7 (E1, T)			
Dimethyl phthalate				270,000, 1,100,000
2,4-Dimethylphenol				380, 850
Di-n-butyl phthalate				2000, 4500
2,4-Dinitrophenol				69, 5300
2,4-Dinitrotoluene (c)				1.1, 34
Dioxin (2,3,7,8-TCDD) (c)	3 E-5 (E1, T)			0.000001, 0.000001
Diquat	20 (E1, T)			
1,2-Diphenylhydrazine (c)				0.36, 2.0
a-Endosulfan		0.22	0.056	62, 89
b-Endosulfan		0.22	0.056	62, 89
Endosulfan sulfate				62, 89
Endothall	100 (E1, T)			
Endrin	2 (E1, T)	0.086	0.036	0.059, 0.06
Endrin aldehyde				0.29, 0.30
Ethylbenzene	700 (E1, T)			530, 2100
Ethylene Dibromide	0.05 (E1, T)			
Fluoranthene				130, 140
Fluorene				1100, 5300

Table D.2. TDEC and EPA Nonradiological Water Quality Standards and Criteria (µg/L)

Chemical	TDEC and EPA Drinking Water Standards[a]	TDEC Fish and Aquatic Life Criteria		TDEC Recreation Criteria Water + Organisms, Organisms Only[b]
		Maximum	Continuous	
Fluoride	2000 (E2) 4000 (E1)			
Foaming Agents	500 (E2)			
Glycophosate	700 (E1, T)			
Heptachlor (c)	0.4 (E1, T)	0.52	0.0038	0.00079, 0.000790
Heptachlor epoxide (c)	0.2 (E1, T)	0.52	0.0038	0.00039, 0.00039
Hexachlorobenzene (c)	1 (E1, T)			0.0028, 0.0029
Hexachlorobutadiene (c)				4.4, 180
Hexachlorocyclopentadiene	50 (E1, T)			40, 1100
Hexachloroethane (c)				14, 33
Indeno(1,2,3-cd)pyrene (c)				0.038, 0.18
Iron	300 (E2)			
Isophorone (c)				350, 9600
Lead	5 (T) 15 (E1 "Action Level")	65[d]	2.5[d]	
Manganese	50 (E2)			
Mercury (inorganic)	2 (E1, T)	1.4[c]	0.77[c]	0.05, 0.051
Methyl bromide				47, 1500
2-Methyl-4,6-dinitrophenol				13, 260
Methylene chloride (Dichloromethane) (c)				46, 5900
Nickel	100 (T)	470[d]	52[d]	610, 4600
Nitrate as N	10,000 (E1)			
Nitrite as N	1000 (E1)			
Nitrobenzene				17, 690
N-Nitrosodimethylamine (c)				0.0069, 30
N-Nitrosodi-n-propylamine (c)				0.05, 5.1
N-Nitrosodiphenylamine (c)				33, 60
Odor	3 threshold odor number (E2)			
Oxamyl (Vydate)	200 (E1, T)			
Pentachlorophenol (c)	1 (E1, T)	19[e]	15[e]	2.7, 30
pH	6.5 to 8.5 units (E2) 6.0 to 9.0 units (T)		6.0 to 9.0 units, wadeable streams 6.5 to 9.0 units, larger rivers, lakes, etc	6.0 to 9.0 units
Phenol				21,000, 1,700,000
PCBs, total (c)	0.5 (E1, T)	--	0.014	0.00064, 0.00064
Pyrene				830, 4000
Selenium	50 (E1, T)	20	5	
Silver	100 (E2)	3.2[d]	--	
Simazine	4 (E1, T)			
Styrene	100 (E1, T)			
Sulfate	250,000 (E2)			
1,1,2,2-Tetrachloroethane (c)				1.7, 40
Tetrachloroethylene (c)	5 (E1, T)			6.9, 33
Thallium	2 (E1, T)			0.24, 0.47
Toluene	1000 (E1, T)			1300, 15,000

Table D.2. TDEC and EPA Nonradiological Water Quality Standards and Criteria (µg/L)

Chemical	TDEC and EPA Drinking Water Standards[a]	TDEC Fish and Aquatic Life Criteria		TDEC Recreation Criteria Water + Organisms, Organisms Only[b]
		Maximum	Continuous	
Total Dissolved Solids	500,000 (E2)			
Total Trihalomethanes	80 (E1)			
Toxaphene (c)	3 (E1, T)	0.73	0.0002	0.0028, 0.0028
2,4,5-TP (Silvex)	50 (E1, T)			
Tributyltin (TBT)		0.46	0.072	
1,2,4-Trichlorobenzene	70 (E1, T)			35, 70
1,1,1-Trichloroethane	200 (E1, T)			
1,1,2-Trichloroethane (c)	5 (E1, T)			5.9, 160
Trichloroethylene (c)	5 (E1, T)			25, 300
2,4,6-Trichlorophenol (c)				14, 24
Vinyl chloride (c)	2 (E1, T)			0.25, 24
Xylenes (total)	10,000 (E1, T)			
Zinc	5000 (E2)	120[d]	120[d]	

[a]E1 = EPA Primary Drinking Water Standards; E2 = EPA Secondary Drinking Water Standards; T = TDEC domestic water supply criteria.

[b]For each parameter, the first recreational criterion is for "water and organisms" and is applicable on the ORR only to the Clinch River because the Clinch is the only stream on the ORR which is classified for both domestic water supply and for recreation. The second criterion is for "organisms only" and is applicable to the other streams on the ORR. TDEC uses a 10^{-5} risk level for recreational criteria for all carcinogenic pollutants (designated with "(c)" under "Chemical" column). Recreational criteria for noncarcinogenic chemicals are set using a 10^{-6} risk level. [*Note*: All federal recreational criteria are set at a 10^{-6} risk level].

[c]Criteria are expressed as dissolved.

[d]Criteria are expressed as dissolved and are a function of total hardness (mg/L). Criteria displayed correspond to a total hardness of 100 mg/L.

[e]Criteria expressed as a function of pH; values shown correspond to a pH of 7.8.

Appendix E. National Pollutant Discharge Elimination System Noncompliance Summaries for 2008

Appendix E. National Pollutant Discharge Elimination System Noncompliance Summaries for 2008

E.1 Y-12 Complex

The sampling results for Categories 2 and 3 outfalls for the previous six months were reported in the June 2008 Discharge Monitoring Report. A field measurement for total residual chlorine at Outfall 067 was made on January 9, 2008, and a result of 0.68 mg/l was obtained. This value is above the daily maximum concentration of 0.50 mg/l. At the time of the reading there were no observed adverse effects on the receiving stream. Outfall 067 is permitted for cooling water flow, which is basically once-through chlorinated potable water. There are several small, tablet-type dechlorination units located in the area that drain to this outfall. Corrective action was taken by checking operation of the tablet type dechlorination units located upstream. All units were found to be in working order. No problems were found in the drain system, and there was no observed adverse effect on the receiving stream or aquatic life.

E.2 East Tennessee Technology Park

There were no National Pollutant Discharge Elimination System (NPDES) noncompliances at ETTP in 2008.

E.3 Oak Ridge National Laboratory

In 2008, a total of nine NPDES Permit exceedances were reported to TDEC. Six of these non-compliances occurred at the Steam Plant Wastewater Treatment Facility (SPWTF), NPDES Outfall X02 (three exceedances for iron, two for copper, and one for silver). The noncompliances occurred in February and in July 2008. Operational logbooks from the SPWTF indicated normal operation conditions during these months of noncompliance. It was thought that the metals were contained in the sediments within the clay-lined holding ponds that are used as part of the SPWTF process. The metals would have accumulated via runoff from the time when the Steam Plant used coal as its primary fuel. Coal use was eliminated, but the SPWTF still receives regenerant wastewater and boiler blowdown at a low pH from steam plant operations, and still uses the clay-lined ponds as part of the treatment process. The ponds were dredged in July 2008, and a revised NPDES Permit was issued to ORNL and made effective on August 1, 2008. Monitoring requirements in the revised permit have been changed to reflect the current operational status of the treatment facility. The Steam Plant was converted in 2001 to use natural gas with a fuel oil backup. An upgrade to a biomass gasification unit that will use wood chips will be added in late 2010.

In June, a sewer manhole overflowed to an NPDES outfall as a result of power to the associated lift pump being shut off by a non-Utilities staff member. This overflow was reported as a bypass to TDEC. The Facility Use Agreement between the Utilities Division and the building occupants where this electrical switch to the pump was shut off is currently being revised to ensure that this type of situation does not reoccur.

Finally, two fish kills occurred in July and September, resulting in the mortality of ~180 varying species of fish at each incident. The mortalities are believed to be caused by a highly chlorinated discharge from Outfall 227. This outfall conveys cooling tower blowdown, storm drains, and some floor drains. Extensive investigation did not pinpoint an exact source of the toxic discharge. Awareness education to laboratory staff in various job categories continues to occur to dissuade inappropriate disposal of chemicals down storm drains. The existing tablet dechlorinator located on this outfall is checked for operational function twice daily.

Appendix F. Radiation

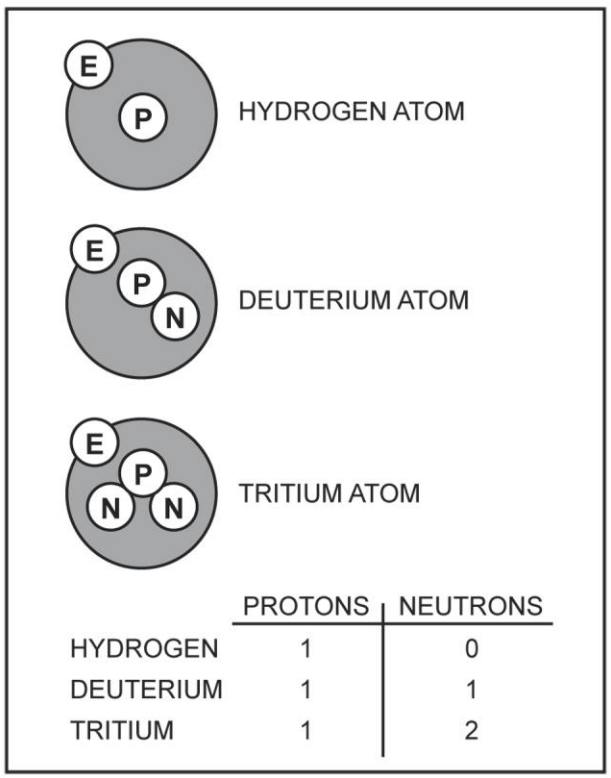
Appendix F. Radiation

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.

F.1 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. F.1).



	PROTONS	NEUTRONS
HYDROGEN	1	0
DEUTERIUM	1	1
TRITIUM	1	2

Fig. F.1. The hydrogen atom and its isotopes.

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 F.1).

Table F.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-234*m*	^{234m}Pa	1.17 minutes
Carbon-14	^{14}C	5.730E+3 years	Radium-226	^{226}Ra	1.6E+3 years
Cerium-141	^{141}Ce	32.50 days	Radium-228	^{228}Ra	5.75 years
Cerium-143	^{143}Ce	1.38 days	Ruthenium-103	^{103}Ru	39.35 days
Cerium-144	^{144}Ce	284.3 days	Ruthenium-106	^{106}Ru	368.2 days
Cesium-134	^{134}Cs	2.062 years	Strontium-89	^{89}Sr	50.55 days
Cesium-137	^{137}Cs	30.17 years	Strontium-90	^{90}Sr	28.6 years
Cesium-138	^{138}Cs	32.2 min	Technetium-99	^{99}Tc	2.13E+5 years
Cobalt-58	^{58}Co	70.80 days	Thorium-228	^{228}Th	1.9132 years
Cobalt-60	^{60}Co	5.271 years	Thorium-230	^{230}Th	7.54E+4 years
Curium-242	^{242}Cm	163.2 days	Thorium-232	^{232}Th	1.405E+10 years
Curium-244	^{244}Cm	18.11 years	Thorium-234	^{234}Th	2.41E+1 day
Iodine-129	^{129}I	157E+7 years	Tritium	^{3}H	12.28 years
Iodine-131	^{131}I	8.04 days	Uranium-234	^{234}U	2.445E+5 years
Krypton-85	^{85}Kr	10.72 years	Uranium-235	^{235}U	7.038E+8 years
Krypton-88	^{88}Kr	2.84 hours	Uranium-236	^{236}U	2.3415E+7 years
Manganese-54	^{54}Mn	312.7 days	Uranium-238	^{238}U	4.468E+9 years
Neptunium-237	^{237}Np	2.14E+6 days	Xenon-133	^{133}Xe	5.245E+9 years
Niobium-95	^{95}Nb	35.06 days	Xenon-135	^{135}Xe	9.11 hours
Osmium-185	^{185}Os	93.6 days	Yttrium-90	^{90}Y	64.1 hours
Phosphorus-32	^{32}P	14.29 days	Zirconium-95	^{95}Zr	64.02 days
Polonium-210	^{210}Po	138.378 days			

Source: DOE 1989. *Radioactive Decay Data Tables: A Handbook of Decay Data for Application to Radioactive Dosimetry and Radiological Assessments*, DOE/TIC-11026.

F.2 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. Examples include alpha and beta particles. Radiation also is characterized as ionizing or non-ionizing because of the way in which it interacts with matter.

F.2.1 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.

F.2.2 Non-ionizing Radiation

Non-ionizing radiation is described as a series of energy waves composed of oscillating electric and magnetic fields traveling at the speed of light. Non-ionizing radiation includes the spectrum of ultraviolet (UV), visible light, infrared (IR), microwave, radio frequency (RF), and extremely low frequency (ELF). Lasers commonly operate in the UV, visible, and IR frequencies. Microwave radiation is absorbed near the skin, while RF radiation may be absorbed throughout the body. At high enough intensities, both will damage tissue through heating. Excessive visible radiation can damage the eyes and skin (Department of Labor, OSHA Safety and Health Topics, www.OSHA.gov). However, in the discussion that follows, the term "radiation" is used to describe ionizing radiation.

F.3 Sources of Radiation

Radiation is everywhere. Most occurs naturally; a small percentage is human-made. Naturally occurring radiation is known as background radiation.

F.3.1 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.

F.3.1.1 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.

F.3.1.2 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.

F.3.1.3 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).

F.3.4 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).

F.3.5 Consumer Products

Some consumer products are sources of radiation. The radiation in some of these products, such as, smoke detectors, radioluminous products, and airport X-ray baggage inspection systems, is essential to the performance of the device. In other products, such as tobacco products, building materials, the radiation occurs incidentally to the product's function (NCRP 1987, NCRP 2009).

F.3.6 Medical Sources

Radiation is an important tool of diagnostic medicine and treatment and is the main source of exposure to the public from human-made radiation. Exposure is deliberate and directly beneficial to the patients exposed. In general, medical exposures from diagnostic or therapeutic X rays result from beams directed to specific areas of the body. Thus, all body organs generally are not irradiated uniformly. Nuclear medicine examinations and treatments involve the internal administration of radioactive compounds, or radiopharmaceuticals, by injection, inhalation, consumption, or insertion. Even then, radionuclides are not distributed uniformly throughout the body. Radiation and radioactive materials also are used in the preparation of medical instruments, including the sterilization of heat-sensitive products such as plastic heart valves.

F.3.7 Other Sources

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.

F.4 Pathways of Radionuclides

People can be exposed to radionuclides in the environment through a number of routes (Fig. F.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.

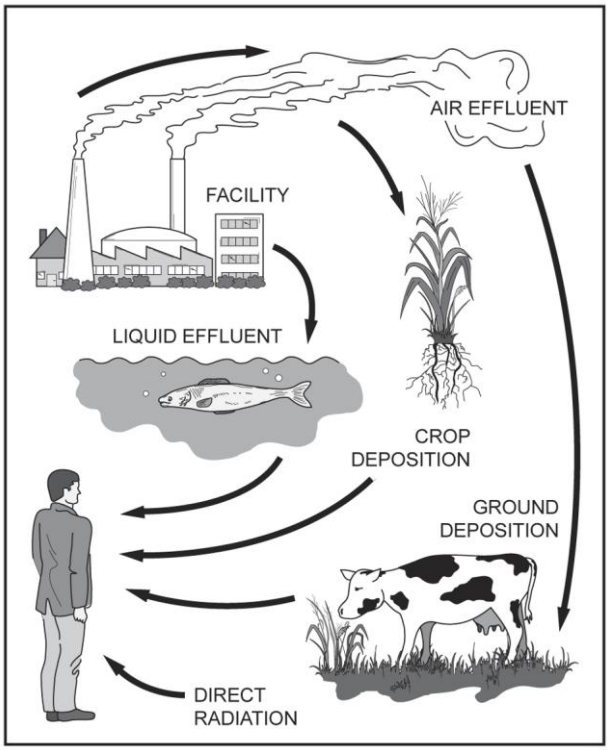


Fig. F.2. Examples of radiation pathways.

F.5 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.

F.5.1 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 H 10^{10} (37,000,000,000) atomic disintegrations per second (dps). In the international system of units, 1 dps equals 1 Becquerel (Bq).

F.5.2 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. 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).

F.5.3 Effective Dose

The measure of potential biological damage to the body caused by exposure to and subsequent absorption of radiation is expressed in a unit of measure known as a rem. For radiation protection purposes, 1 rem of any type of radiation has the same total damaging effect. Because a rem represents a fairly large equivalent dose, it is 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. In previous years, effective dose equivalent (EDE) was the dose unit used in the *Annual Site Environmental Report*; however, beginning in 2007, the dose unit used is effective dose (ED). The ED, as was the EDE, is the weighted sum of equivalent dose over specified tissues or organs. The ED is based on tissue-weighting factors for 12 specific tissues or organs plus 1 for the remainder organs and tissues. The EDE was based on 6 tissue weighting factors plus 1 for the remainder organs and tissues. In addition to tissue-weighting factor modifications, there have been updates to the lung model, gastrointestional absorption fractions, and biokinetic models used for selected elements. Specific types of EDs are defined as follows:

- committed ED: the weight sum of the committed equivalent dose in specified tissues in the human body during the 50-year period following intake; and
- collective ED: the product of the mean ED for a population and the number of persons in the population.

F.5.4 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 effective dose ED, which is the effective dose that will be received during a specified time (50 years) from radionuclides taken into the body in the current year, and the effective dose due to exposure during the year to penetrating radiation from sources external to the body.

F.5.5 Dose Coefficient

A dose coefficient is defined as the effective dose received from exposure to a unit quantity of a radionuclide by way of a specific exposure pathway. There are two types of dose coefficients. One type gives the committed effective dose (rem) resulting from intake (by inhalation and ingestion) of a unit activity (1.0 µCi) of a radionuclide. The second gives the effective dose rate (millirem per year) per unit activity (1.0 µCi) of a radionuclide in a unit (cubic or square centimeters) of an environmental compartment (air volume or ground surface). All dose coefficients used in this report, with Department of Energy concurrence, were approved by the Environmental Protection Agency (EPA 1999).

F.5.6 Comparison of Dose Levels

Figure F.3 gives the 2006 percent contributions of various sources of exposure to total collective dose for the U.S population. As shown the major sources are radon and thoron (37%), computed tomography (24%) and nuclear medicine (12%) (NCRP 2009). Consumer, occupational, and industrial sources contribute about 2% to the total U.S. collective dose. This information is intended to help the reader become familiar with a range of doses that various individuals may receive.

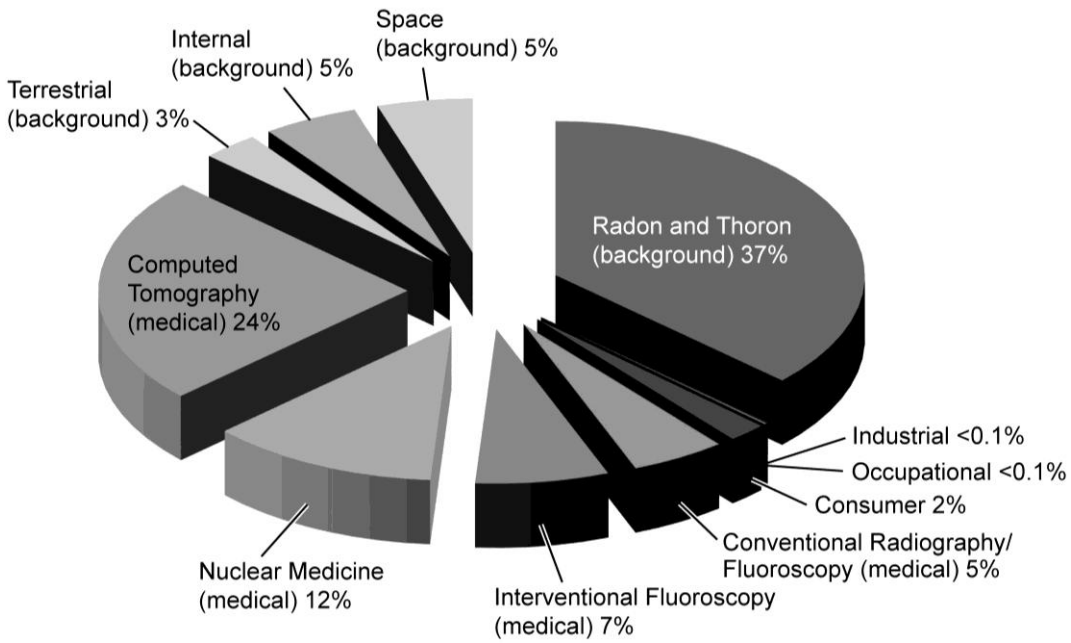


Fig. F.3. All exposure categories collective effective dose (percent) 2006.

F.5.7 Dose from Cosmic Radiation

The average annual dose equivalent to people in the United States from cosmic radiation is about 33 mrem (0.33 mSv) (NCRP 2009). The average dose equivalent caused by cosmic radiation in Tennessee is about 45 mrem per year (0.45 mSv per year) (Tsakeres 1980). When shielding and the time spent indoors are considered, the dose for the surrounding population is reduced to 80%, or about 36 mrem (0.36 mSv) per year.

F.5.8 Dose from Terrestrial Radiation

The average annual dose from terrestrial gamma radiation is about 21 mrem (0.21 mSv) in the United States but varies geographically across the country (NCRP 2009). 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.

F.5.9 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 228 mrem (2.28 mSv) per year. This dose estimate is based on an average radon concentration of about 1 pCi/L (0.037 Bq/L) (NCRP 2009).

The average dose from other internal radionuclides is about 29 mrem (0.29 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 2009).

F.5.10 Dose from Consumer Products and Activities

The U.S. average annual dose to an individual from consumer products and activities is about 13 mrem (0.13 mSv), ranging between 0.1 and 40 mrem (0.001 and 0.4 mSv). Cigarette smoking accounts for about 35% of this dose. Other important sources are building materials (27%), commercial air travel (26%), mining and agriculture (6%), miscellaneous consumer oriented products (3%), combustion of fossil fuels (2%), highway and road construction materials (0.6%), and glass and ceramics (<0.003%). Television and video, sewage sludge and ash, and self-illuminating signs all contribute negligible doses (NCRP 2009).

F.5.11 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 ED, 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 ED from medical examinations is 300 mrem (3 mSv), including 147 mrem (1.47 mSv) from computed tomography scans, 77 mrem (0.77 mSv) from nuclear medicine procedures, 43 mrem (0.43 mSv) from interventional fluoroscopy, and 33 mrem (0.33 mSv) from conventional radiography and fluoroscopy (NCRP 2009). Not everyone receives such exams each year.

F.5.12 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).

F.6 Water Pathway Dose Methodology

People can be exposed to radionuclides in the environment through a number of routes (Fig. F.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 that contain radionuclides taken in from the water. Also, people may swim in or boat on the water or 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. 7.1.2.2.

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. 1.3.4 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 (called water bodies in this appendix):

- 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 Chicamauga 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. 6.4 and 6.6). 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. 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.

F.6.1 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 F.2 is a summary of potential EDs from identified waterborne radionuclides around the ORR and shows the variation in dose based on method used to estimate dose. The ED from ingestion of water is given by

$$D_{E,i,drink} = U_{drink} * C_{w,i} * DC_{i,ing} * EXP(-\lambda_{r,i} * t_{drink}),$$

where $D_{E,i,drink}$ = ED 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 (μCi/L),

$DC_{i,ing}$ = dose coefficient 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 1 day).

F.6.2 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. EDs were calculated from measured radionuclide contents in fish (see Sect. 7.6), measured concentrations of radionuclides in water, and calculated concentrations in water. The ED from consumption of fish containing nuclide *i* is given by

$$D_{E,i,fish} = U_{fish} * C_{w,i} * DC_{i,ing} * B_{i,fish} * EXP(-\lambda_{r,i} * t_{fish}),$$

where $D_{E,i,fish}$ = ED 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 (μCi/L),

$DC_{i,ing}$ = dose coefficient for ingestion of nuclide *i* (mrem/μCi),

$B_{i,fish}$ = bioaccumulation factor (L/kg),

$\lambda_{r,i}$ = radioactive decay constant for nuclide *i* (I/d), and

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.

Table F.2. 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 66				
Water[c]	0.002	0.002	0.0007	0.005
Maximum	0.002	0.002	0.0007	0.005
Melton Hill Lake, CRK 58				
Water[c]	0.003	0.002	0.0007	0.006
Discharge[d]	0.004	0.005	0.0004	0.01
Maximum	0.004	0.005	0.0007	0.01
Upper Clinch River, CRK 23, Gallaher Water Plant, CRK 32				
Fish[b]		0.07		
Water[c]	0.2	0.6	0.1	0.9
Discharge[d]	0.04	0.09	0.01	0.1
Maximum	0.2	0.6	0.1	0.9
Lower Clinch River, CRK 16				
Fish[b]		0.02		
Water[c]	NA[e]	0.3	0.2	0.5
Discharge[d]	NA[e]	0.05	0.006	0.06
Maximum	NA[e]	0.3	0.2	0.5
Upper Watts Bar Lake, Kingston Municipal Water Plant				
Water[c]	0.05	0.09	0.05	0.2
Discharge[d]	0.007	0.02	0.003	0.03
Maximum	0.05	0.09	0.05	0.2
Lower System (Lower Watts Bar Lake and Chickamauga Lake)				
Water[c]	0.05	0.09	0.08	0.2
Discharge[d]	0.007	0.02	0.003	0.03
Maximum	0.05	0.09	0.08	0.2
Poplar Creek				
Water[c]	NA[e]	0.06	0.005	0.07
Discharge[d]	NA[e]	0.9	0.05	0.9
Maximum	NA[e]	0.9	0.05	0.9

[a]1 mrem = 0.01 mSv.
[b]Doses based on measured radionuclide concentrations in fish tissue.
[c]Doses based on measured radionuclide concentrations in water.
[d]Doses based on measured discharges of radionuclides from on-site outfalls.
[e]Not at drinking water supply locations.

F.6.3 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 EDs from these activities.

The ED from swimming in water containing nuclide *i* (except tritium) is given by

$D_{E,i,swim} = 0.142 * C_{w,i} * U_{swim} * DC_{i,WS}$,

where	$D_{E,i,swim}$	=	ED from swimming in water containing nuclide *i* (mrem/year),
	0.142	=	unit conversion factor (1,000 L/m^3 divided by 8,760 h/year),
	U_{swim}	=	time spent swimming (h/year),
	$C_{w,i}$	=	concentration of nuclide *i* in water (µCi/L), and
	$DC_{i.WS}$	=	dose conversion factor for submersion in water containing nuclide *i* (mrem-m^3/year-µCi).

Complete submersion is assumed while swimming. For tritium, the swimming dose equation is

$D_{E,T,swim} = C_{W,T} * U_{swim} * I_T * DC_{T,ing}$,

where	$D_{E,T,swim}$	=	ED from swimming in water containing tritium (mrem/year),
	U_{swim}	=	time spent swimming (h/year),
	$C_{W,T}$	=	concentration of tritium in water (µCi/L),
	I_T	=	absorption factor for tritium via whole body immersion in water (= 0.035 L/h),
	$DC_{T,ing}$	=	dose coefficient for ingestion of tritium (mrem/µCi).

The ED from boating on water containing nuclide *i* (except tritium) is given by

$D_{E,i,boat} = 0.5 * (0.142 * C_{w,i} * U_{boat} * DC_{i,WS})$,

where	$D_{E,i,boat}$	=	ED from boating on water containing nuclide *i* (mrem/year),
	0.5	=	correction factor,
	0.142	=	unit conversion factor (1,000 L/m^3 divided by 8,760 h/year),
	U_{boat}	=	time spent boating (h/year),
	$C_{w,i}$	=	concentration of nuclide *i* in water (µCi/L), and
	$D_{Fi.WS}$	=	dose coefficient 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 ED from using a shoreline containing nuclide *i* is given by

$D_{E,i,shore} = C_{i,shore} * U_{shore} * (G_{shore} / 8760) * DC_{i,soil}$,

where $D_{E,i,shore}$ = ED due to use of shoreline containing nuclide *i* (mrem/year),

$C_{i,shore}$ = annual average concentration of nuclide *i* in shoreline soil (μCi/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

$DC_{i,soil}$ = dose conversion factor for infinitely thick soil containing nuclide (mrem-m^2/μCi-year).

The annual average concentration of nuclide *i* in shoreline soil is obtained by

$$C_{i,shore} = C_{W,i} * F_{i,W\text{-}S} * T_{1/2,i} * (1 - \mathrm{EXP}[-\lambda_{r,i} * 365 * t_{S\text{-}W}]),$$

$C_{W,i}$ = annual average concentration of nuclide i in water (μCi/L),

$F_{i,W\text{-}S}$ = water-to-sediment transfer coefficient nuclide i (= 100 L/m^2-day),

$T_{1/2,i}$ = radioactive half-life of nuclide *i* (d),

$\lambda_{r,I}$ = radioactive decay constant for nuclide *i* (1/d),

$t_{S\text{-}W}$ = 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 have occurred at the current year's rates for the past 50 years.

When compared with EDs from drinking water and eating fish from the same waters, the EDs from these other uses are relatively small. Refer to Table F.2 for a summary of potential EDs from identified waterborne radionuclides around the ORR and shows the variation in dose based on method used to estimate dose.

F.7 References

Alter, H. 1986. A Glossary of Terms in Nuclear Science and Technology, American Nuclear Society, La Grange Park, Illinois.

DOE. 1989. Radioactive Decay Data Tables: A Handbook of Decay Data for Application to Radioactive Dosimetry and Radiological Assessments. DOE/TIC-11026. U.S. Department of Energy, Washington, D.C.

Department of Labor, OSHA Safety and Health Topics, www.OSHA.gov

NCRP. 1987. Ionizing Radiation Exposure of the Population of the United States. NCRP Report No. 93. National Council on Radiation Protection and Measurements, Washington, D.C.

NCRP 2009. Ionizing Radiation Exposure of the Population of the United States. Prepublication Copy. NCRP Report No. 160, National Council on Radiation Protection and Measurements, Bethesda, Maryland, March 3, 2009.

EPA. 1999. Cancer Risk Coefficients for Environmental Exposure to Radionuclide: Updates and Supplements. Federal Guidance Report No. 13, updated 2002. www.epa.gov/rpdweb00/federal/techdocs.html#report13

Tsakeres, F. S. 1980. Radiological Assessment of Residences in the Oak Ridge Area. ORNL/TM-7392/V1. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Appendix G. Chemicals

Appendix G. 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.

G.1 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.

G.2 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, 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.

G.3 Definitions

G.3.1 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.

G.3.2 Dose Terms for Noncarcinogens

G.3.2.1 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 G.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 database, which contains verified reference doses and up-to-date health risk and EPA regulatory information for numerous chemicals.

G.3.2.2 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 G.1.

G.3.3 Dose Term for Carcinogens

G.3.3.1 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 G.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	Heptachlorepoxide	1.3E-05	RfD
Nickel	2.0E–02	RfD		9.1+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			

[a]RfD: reference dose (mg kg^{-1} day^{-1}); SF: slope factor (risk per mg/kg-day).

[b]The RfD for Aroclor-1254 is also used for Aroclor-1260.

[c]The water quality criteria (WQC) are given in units of micrograms per liter. To convert the concentration to an RfD (mg kg^{-1} 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.

[d]This value is based on the 2004 Tennessee WQC for BHC- beta and applied to BHC-Delta for domestic water supplies.

[e]This value is based on the 2004 Tennessee WQC for lead for domestic water supplies.

[f]An 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.

[g]The 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.

[h]This value is based on the 2004 Tennessee WQC for thallium for domestic water supplies, which reflects the maximum contaminant level value (2 µg/L).

G.4 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, there are limits below which they cannot detect chemicals of interest. Concentrations detected below the reported analytical 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.

G.5 Risk Assessment Methodology

G.5.1 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 of water per day directly from the river, which amounts to 730 L 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.

G.5.2 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 × ED) or for carcinogens (365 days/year ×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 × ED) or for carcinogens (365 days/ year × 70 years)

G.5.3 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.

G.6 References

Chan, P. K., G. P. O'Hara, and A. W. Hayes. 1982. "Principles and Methods for Acute and Subchronic Toxicity." Principles *and Methods of Toxicology*. Raven Press, New York.

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