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Oak Ridge Reservation Annual Site Environmental Report for 2009

on the World Wide Web
http://www.ornl.gov/sci/env_rpt/

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Acronyms and Abbreviations

AAS	ambient air station
AAS2	Ambient Air Station 2
AAS8	Ambient Air Station 8
ABC	Aluminum Beverage Can
ACGIH	American Conference of Governmental Industrial Hygienists
ACM	Asbestos-containing Material
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
AOEC	Agent Operations Eastern Command
ARAP	Aquatic Resource Alteration Permit
ARAR	Applicable or Relevant and Appropriate Requirement
ARRA	American Recovery and Reinvestment Act
ASER	Annual Site Environmental Report
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
ASTM	American Society for Testing and Materials
ATLC	Atomic Trades and Labor Council
ATSDR	Agency for Toxic Substances and Diseases Registry
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
BG	Burial Ground
BJC	Bechtel Jacobs Company LLC
BMAP	Biological Monitoring and Abatement Plan
BOD	Biological Oxygen Demand
BSTS	Big Spring Treatment System
Btu	British Thermal Units
CAA	Clean Air Act
CAP-88	Clean Air Assessment software
CBMH	catch basin manhole
CCC	Complex Command Center
CE	Status due to commercial exploitation
CEMS	Continuous Emission Monitoring System
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	*Code of Federal Regulations*
CH	contact-handled
CHMB	Contact-Handled Marshalling Building
CHSA	Contact-Handled Staging Area
CMTS	Central Mercury Treatment System
CNF	Central Neutralization Facility
CNMS	Center for Nanophase Materials Sciences

CO2e	Carbon Dioxide Equivalent
COD	Chemical Oxygen Demand
COROH	Center for Oak Ridge Oral History
CPU	Central Processing Unit
CRK	Clinch River Kilometer
CROET	Community Reuse Organization of East Tennessee
CRT	Cathode Ray Tube
CSA	Container Storage Area
CWA	Clean Water Act
CX	categorical exclusion
CX	Categorical Exclusion
CY	Calendar Year
CYRTF	Coal Yard Runoff Treatment Facility
D&D	Decontamination and Decommissioning
DAC	Derived Air Concentration
DAC	Derived Air Concentration
DAC	Drum Aging Container
DBCP	1,2-dibromo-3-chloropropane
DCE	dichloroethene
DCG	Derived Concentration Guideline
DES	detailed energy survey
DOE EM	DOE Office of Environmental Management
DOE	U.S. Department of Energy
DOE	U.S. Department of Energy
DOE-ORO	DOE Oak Ridge Operations Office
dps	disintegrations per second
dscf	dry standard cubic foot
dscm	dry standard cubic meter
DVB	Drum Venting Building
DVD	Digital Video Disc
DWI	David Witherspoon, Inc.
E	Endangered
E.O.	Executive Order
EC&P	Environmental Compliance and Protection
ECD	Environmental Compliance Department
ECGR	Experimental Gas-Cooled Reactor
ECM	energy conservation measures
ECR	environmental compliance representative
ED	effective dose
EDE	effective dose equivalent
EERE/FEMP	Energy Efficiency Renewable Energy/Federal Energy Management Program
EFD	east foundation drain
EFK	East Fork Kilometer
EFPC	East Fork Poplar Creek
ELF	Extremely Low Frequency
EM	DOE Office of Environmental Management
EMC	event mean concentration
EMEF	Environmental Management and Enrichment Facilities
EMMIS	Environmental Monitoring Management Information System

EMPO	Emergency Management Planning Organization
EMS	Emergency Management System
EMWMF	Environmental Management 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
EPEAT	Electronic Product Environmental Assessment Tool
EPO	Environmental Protection Officer
EPT	Ephemeroptera, Plecoptera, and Trichoptera (taxa)
ER	Environmental Restoration
ERO	Emergency Response Organization
ES&H	Environment, Safety, and Health
ESCO	energy savings contractor
ESD	Environmental Sciences Division
ESPC	Energy Savings Performance Contract
ESS	Environmental Surveillance System
EStar	Environmental Sustainability
ETCFC	East Tennessee Clean Fuel Coalition
ETTP	East Tennessee Technology Park
FCK	First Creek Kilometer
FEC	Federal Electronics Challenge
FFA	Federal Facility Agreement
FFCA	Federal Facilities Compliance Agreement
FFK	Fifth Creek Kilometer
FGR	Federal Guidance Report
FIRP	Facilities Infrastructure Recapitalization Program
FONSI	finding of no significant impact
FS	feasibility study
FSC	Federal Special Concern
FY	fiscal year
GCK	Grassy Creek Kilometer
GEM-JV	GEM Technologies, Inc./Joint Venture
GET	General Employee Training
GHG	greenhouse gas
gpm	gallons per minute
Gpy	gallons per year
gsf	gross square feet
GW	Groundwater
GWQAR	Groundwater Quality Assurance Report
HC	Hydrocarbons
HCK	Hinds Creek Kilometer
HEPA	High-efficiency Particulate Air
HEUMF	Highly Enriched Uranium Materials Facility
HFIR	High Flux Isotope Reactor
HPSB	High-Performance and Sustainable Buildings

HQ	hazard quotient
HQ	Headquarters
HSS	Health, Safety, and Security
HSWA	Hazardous Solid Waste Amendment
HVAC	Heating, Ventilating and Air Conditioning
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
ICRP	International Commission on Radiological Protection
ID	identification (number)
IDMS	Integrated Document Management System
IFDP	Integrated Facility Disposition Project
IP	initial proposal
IR	Infrared
ISM	Integrated Safety Management
ISMS	Integrated Safety Management System
ISO	International Organization for Standardization
ISOTEK	Isotek Systems LLC
IT	Information Technology
ITER	International Thermonuclear Experimental Reactor
JIBS	Joint Institute for Biological Sciences
JTU	Jackson turbidity unit
K-25	K-25 Gaseous Diffusion Plant
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
LLC	Limited Liability Corporation
LLW	low-level radioactive waste
LOC	Local Oversight Committee
MACT	Maximum Achievable Control Technology
MBK	Mill Branch Kilometer
MC	Species of Management Concern
MCCBK	McCoy Branch Kilometer
MCDC	Multiprogram Computational and Data Center
MCL	Maximum Contaminant Level
MDA	minimum detectable activity
MDL	method detection limit
MEK	Melton Branch Kilometer
MFL	million fibers per liter
mgd	million gallons per day
MIK	Mitchell Branch Kilometer
MLF	Modernization of Laboratory Facilities

MOA	Memorandum of Agreement
MRF	Multiprogram Research Facility
MSDS	Material Safety Data Sheet
MSL	Mean Sea Level
MSRE	Molten Salt Reactor Experiment
MT	Meteorological Tower
MT2	ORNL Wind Tower C
N	Number
N/A	Not available (Table 5.17)
NA	not analyzed
NAAQS	National Ambient Air Quality Standards
ND	Not Detected
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
NOROH	Networking Oak Ridge Oral History
NOT	Notice of Termination
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
NT-3	North Tributary
NTRC	National Transportation Research Center
NTS	Nevada Test Site
NTU	nephelometric turbidity unit
NWTK	Northwest Tributary Kilometer
NZEB	Net Zero Energy Building
ODS	ozone-depleting substance
OFEE	Office of the Federal Environmental Executive
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
ORPS	Occurrence Reporting and Processing System
ORR PCB FFCA	Oak Ridge Reservation Polychlorinated Biphenyl Federal Facilities Compliance Agreement
ORR	Oak Ridge Reservation
ORRL	Oak Ridge Reservation Landfills
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
PCE	perchloroethylene
PCPA	postclosure permit application
PDO	Pacific Decadal Oscillation
PHEV	Plug-in Hybrid Electric Vehicle
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
ppm	parts per million
Ppmv	parts per million by volume
PSS	Plant Shift Superintendent
PWD	process waste drain
PWTC	Process Waste Treatment Complex
QA	quality assurance
QC	quality control
QE	quality evaluation
R&D	research and development
RA	remedial action
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
RDR/RAWP	Remedial Design Report/Remedial Action Work Plan
Recovery Act	American Recovery and Reinvestment Act
RER	Remediation Effectiveness Report
RF	Radio Frequency
RfC	reference concentration
RfD	reference dose
RFID	Radio Frequency Identification
RH	remote handled
RI	species of regional importance
ROD	Record of Decision
RQ	Reportable Quantity
RRD	Research Reactors Division
RsD	Risk Specific Dose
S	Special Concern
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act

SBI	Small Business Initiative
SBMS	Standards-Based Management System
SCK	Scarboro Creek Kilometer
SDWA	Safe Drinking Water Act
SE	standard error
SEP	Supplemental Environmental Project
SF	slope factor
SHPO	state historic preservation officer
SIP	State Implementation Plan
SMS	Safety Management System
SNAP	Significant New Alternatives Program
SNS	Spallation Neutron Source
SOP	Standard Operating Procedure
SPCC	Spill Prevention, Control, and Countermeasures Plan
SPEIS	Supplemental Programmatic Environmental Impact Statement
SPMD	Semi-permeable Membrane Devices
SPWTF	Steam Plant Wastewater Treatment Facility
SS6	Sanitary Sewer Station 6
STP	Sewage Treatment Plant
SWEIS	Site-wide 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
T	Threatened
TBT	Tributyltin
TCA	Trichloroacetic Acid
TCC&I	Tennessee Chamber of Commerce and Industry
TCE	trichloroethene
TDEC	Tennessee Department of Environment and Conservation
TEAM	Transformational Energy Action Management
TEMA	Tennessee Emergency Management Agency
TEQ	Toxic Equivalent for Dioxin
TNDA	Tennessee Department of Agriculture
TNHW	Tennessee Hazardous Waste
TOA	Tennessee Oversight Agreement
TP3	Tennessee Pollution Prevention Partnership
TPH	Total Petroleum Hydrocarbons
TRC	total residual chlorine
TRC	Total Residual Chlorine
TRO	Total Residual Oxidant
TRU	transuranic
TSCA	Toxic Substances Control Act
TSCAI	Toxic Substances Control Act Incinerator
TSS	total suspended solids
TTO	Total Toxic Organics
TVA	Tennessee Valley Authority
TWA	time-weighted average

TWPC	Transuranic Waste Processing Center
TWRA	Tennessee Wildlife Resources Agency
UEFPC	Upper East Fork Poplar Creek
UMC	Unneeded Materials and Chemicals
UPF	Uranium Processing Facility
USDA	U.S. Department of Agriculture
USGBC	U.S. Green Building Council
UST	Underground Storage Tank
UT	University of Tennessee
UT-B	U.T.-Battelle
UTL	Upper Tolerance Limit
UV	Ultraviolet
VIP	Very Important Person
VOC	volatile organic compound
WAG	waste area grouping
WAI	Wastren Advantage Inc
WBK	Walker Branch Kilometer
WCK	White Oak Creek Kilometer
WEMA	West End Mercury Area
WIPP	Waste Isolation Pilot Project
WMin	Waste Minimization
WOC HW	White Oak Creek Headwaters
WOC	White Oak Creek
WOD	White Oak Dam
WOL	White Oak Lake
WPF	Waste Processing Facility (Table 5.9)
WQC	water quality criteria
WQPP	water quality protection plan
WQPP	Water Quality Protection Plan
WRRP	Water Resources Restoration Program
WSR	Waste Services Representative
WWTS	Waste Water Treatment System
X-10	Oak Ridge National Laboratory
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) is a 13,607-ha (33,624-acre) federally owned site located in the counties of Anderson and Roane in eastern Tennessee. The ORR is home to two major U.S. Department of Energy (DOE) operating components, the Oak Ridge National Laboratory (ORNL) and the Y-12 National Security Complex (Y-12 NSC). Also located on the ORR are the East Tennessee Technology Park (ETTP), site of a former gaseous diffusion plant that is undergoing environmental restoration; the Oak Ridge Institute for Science and Education (ORISE) South Campus, which includes training facilities, laboratories, and support facilities; a variety of smaller government-owned, contractor-operated facilities involved in environmental restoration; and the government-owned, government-operated Agent Operations Eastern Command of the Office of Secure Transportation.

The ORR was established in the early 1940s as part of the Manhattan Project for the purposes of enriching uranium and pioneering methods for producing and separating plutonium. The missions of the ORR have evolved over the years, as it continues to adapt to meet the changing basic and applied research and national security needs of the United States.

The *Oak Ridge Reservation Annual Site Environmental Report* and supporting data are available at http://www.ornl.gov/sci/env_rpt.

1.1 Background

The *Oak Ridge Reservation Annual Site Environmental Report* is prepared annually and presents summary environmental data to (1) characterize environmental performance, (2) summarize environmental occurrences reported during the year, (3) confirm compliance with environmental standards and requirements, and (4) highlight significant program activities. The report fulfills the requirement contained in DOE Order 231.1A, *Environment, Safety and Health Reporting* (DOE 2004) that an integrated annual site environmental report be prepared.

The results summarized in this report are based on data collected prior to and through 2009. This report is not intended to nor does it present the results of all environmental monitoring associated with the ORR. 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. Appendix A to this report identifies corrections for the 2008 report. Appendix B contains a glossary of technical terms that may be useful for understanding the terminology 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 points of release to the environment; these measurements allow the quantification and official reporting of contaminant levels, assessment of radiation and chemical exposures to the public, and demonstration of compliance with applicable standards and permit requirements. Environmental surveillance consists of direct measurements and collection and analysis of samples taken from the site and its environs exclusive of effluents; these activities provide information on contaminant concentrations in air, water, groundwater, soil, foods, biota, and other media. Environmental surveillance data support determinations regarding environmental compliance and, when combined with data from effluent monitoring, support chemical and radiation dose and exposure assessments regarding the potential effects of ORR operations, if any, on the local environment.

1.2 History of the Oak Ridge Reservation

The ORR area was first occupied by Native Americans more than 10,000 years ago, and members of the Overhill Cherokee tribe still lived in the East Tennessee region when European settlers arrived in the late 1700s. These settlers lived on farms or in four small communities called Elza, Robertsville, Scarboro, and Wheat. All but Elza were founded shortly after the Revolutionary War. In the early 1940s approximately 1,000 families inhabited the area.

In 1942 the area that was to become the ORR was selected for use in 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. The site's wartime name was "Clinton Engineering Works."

The workers' city, named Oak Ridge, was established on the reservation's northern edge. The city grew to a population of 75,000 and was the fifth largest in Tennessee; however, it was not shown on any map. At the Y-12 NSC, south of the city, the electromagnetic separation method was used to separate uranium-235 (^{235}U) from natural uranium. A gaseous diffusion plant, later known as K-25, was built on the reservation's western edge. Near the reservation's southwest corner, about 16 km (10 miles) from Y-12, was a third facility, known as X-10 (or Clinton Laboratories), where the Graphite Reactor was built. The X-10 facility was a pilot plant for the larger plutonium production facilities built at Hanford, Washington. Two years after World War II ended, Oak Ridge was shifted to civilian control, under the authority of the U.S. Atomic Energy Commission. In 1959 the city was incorporated and a city manager and city council form of government was adopted by the community

Since that time, the missions of these three major installations have continued to evolve and operations adapted to meet the changing defense, energy, and research needs of the United States. Their current missions, as well as the missions of several smaller DOE facilities/activities on the ORR, are described in Sect. 1.4 of this document.

1.3 Site Description

1.3.1 Location and Population

The ORR lies within the Great Valley of East 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 (10 miles) to the northwest; the Great Smoky Mountains are 51 km (31.6 miles) to the southeast. The ORR encompasses about 13,607 ha (33,624 acres) of mostly contiguous land owned by the federal government and under the management of the DOE (Fig. 1.2). 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. Approximately 4,699 ha (11,611.5 acres) of the ORR is situated in Anderson County, and approximately 8,946 ha (22,106 acres) is in Roane County. The population of the 10-county region surrounding the ORR is about 927,200 with about 1.5% of its labor force employed on ORR (Fig. 1.3). Other municipalities within approximately 30 km (18.6 miles) of 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 (25 miles) to the east and has a population of about 183,550. Except for the city of Oak Ridge, the land within 8 km (5 miles) of the ORR is semirural and is used primarily for residences, small farms, and cattle pasture. Fishing, hunting, 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 1980–2009 is 14.7°C (58.5°F). The average temperature for the Oak Ridge area during 2009 was 14.9°C (58.8°F). The coldest month is usually January, with temperatures averaging

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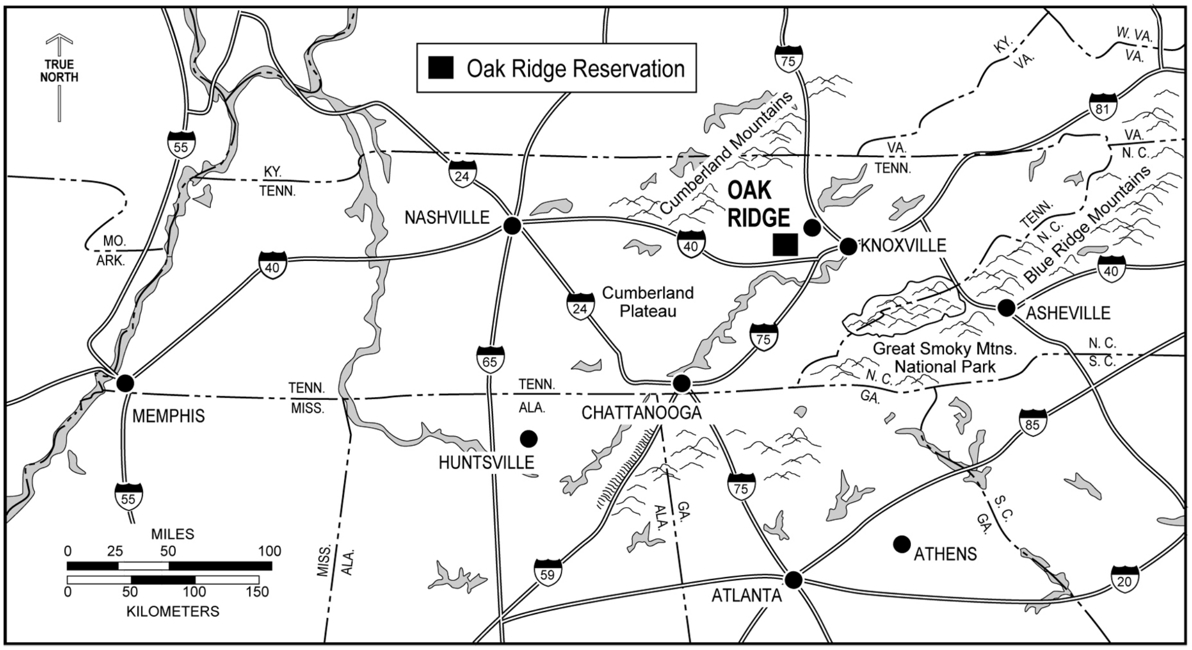

Fig. 1.1. Location of the city of Oak Ridge.

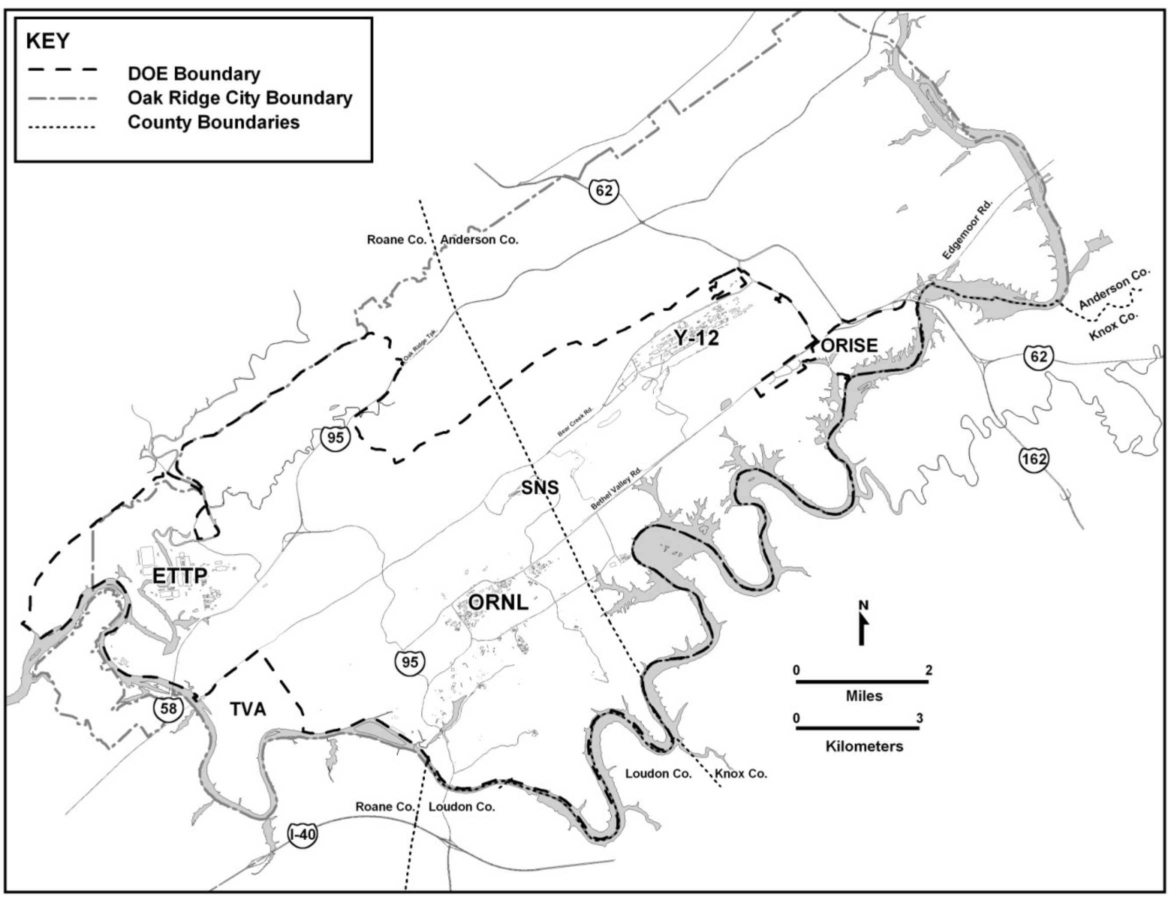

Fig. 1.2. The Oak Ridge Reservation.

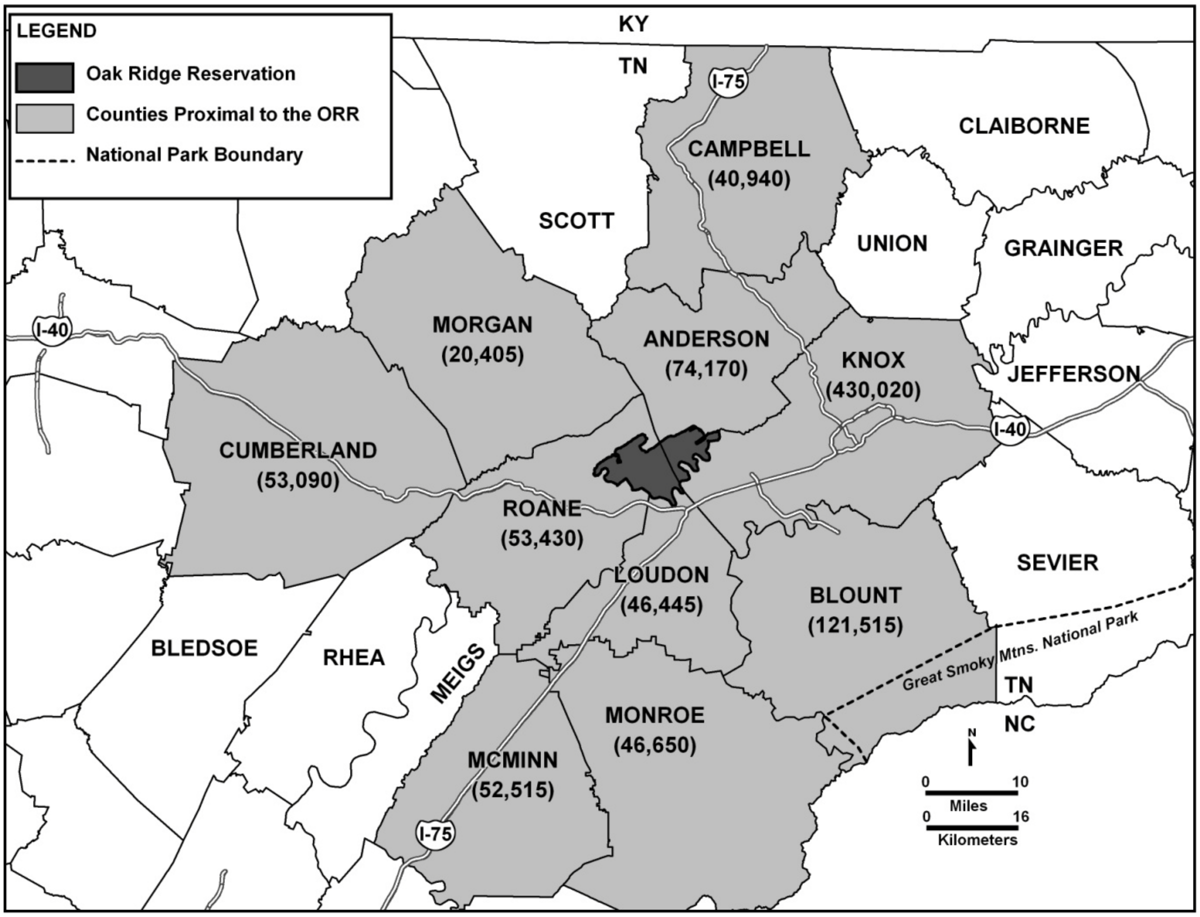

Fig. 1.3. Population by county in the ten-county region surrounding the Oak Ridge Reservation.

about 3.1°C (37.6°F). During 2009, January temperatures averaged near normal at 2.9°C (37.2°F). July tends to be the warmest month, with average temperatures of 25.6°C (78°F). July 2009 temperatures averaged 23.9°C (75°F), significantly below the 30 year mean for July.

Average annual precipitation in the Oak Ridge area for the 30-year period from 1980 to 2009 was 1,312.6 mm (51.68 in.), including about 21.4 cm (8.4 in.) of snowfall annually (NOAA 2010). Total rainfall during 2009 (measured at the Oak Ridge National Weather Service meteorological tower) was 1,544.0 mm (60.8 in.), and total 2009 snowfall was 10.2 cm (4 in.). Precipitation during 2009 was 17.6% above the 30 year average. Monthly summaries of precipitation averages, extremes, and 2009 values are provided in Appendix C, Table C.1.

In 2009, wind speeds at ORNL Tower C (MT2) measured at 10 m (32.8 ft) above ground level averaged 1.2 m/s (3.9 ft/s). This value increased to about 2.9 m/s (9.5 ft/s) for winds at 100 m (328 ft) 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 the ORR towers during 2009 and during precipitation events over the 10 year representative period from 1998–2007 are presented in Appendix C.

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) and in Appendix C of this document.

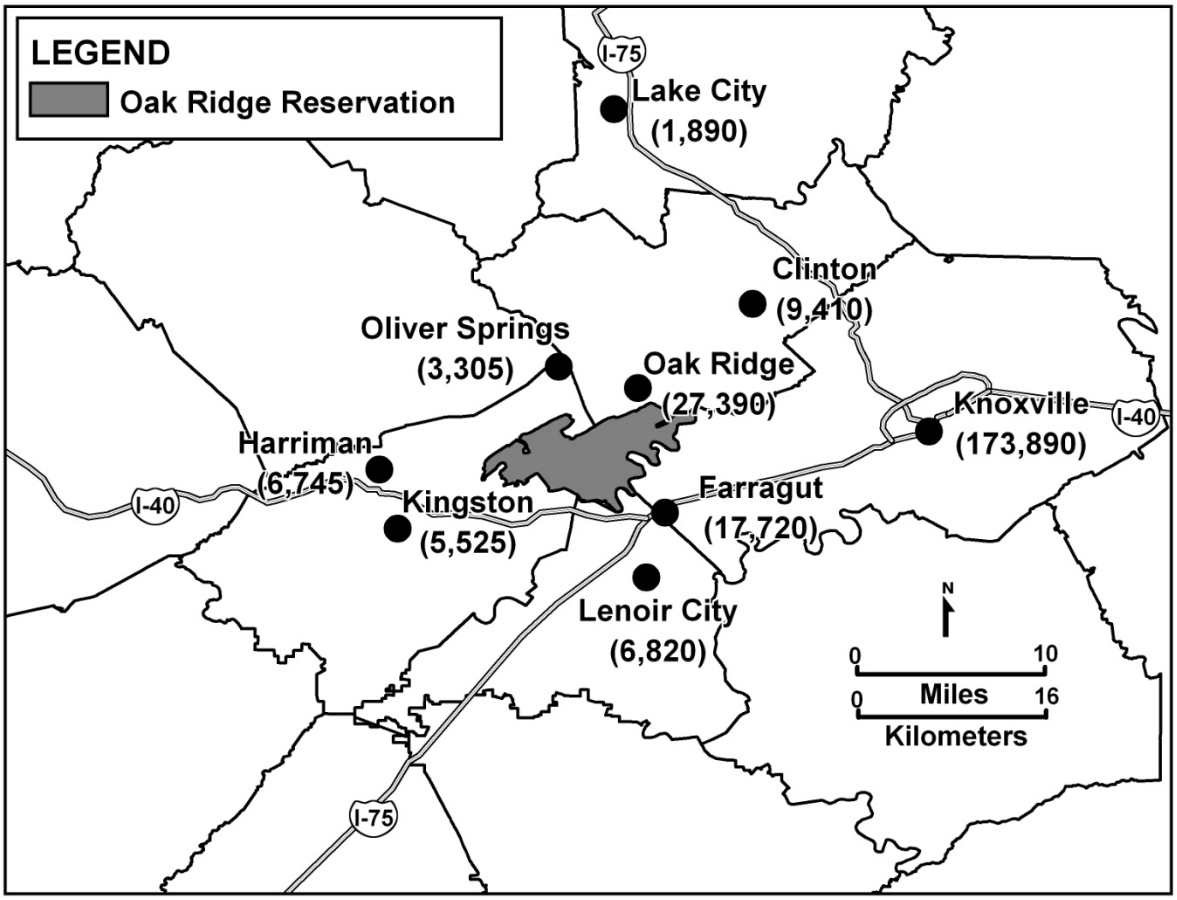

Fig. 1.4. Locations and populations of towns nearest to the Oak Ridge Reservation.

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 fine particulate matter with an aerodynamic 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 hour (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 for $PM_{2.5}$ as well. Air quality in the greater Knoxville and Oak Ridge area is classified as an attainment area with the NAAQS for all other criteria pollutants for which EPA has made attainment designations.

1.3.4 Surface Water

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 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 that, in turn, flows into the Tennessee River.

The largest of the drainage basins is Poplar Creek, which receives drainage from a 352 km^2 (136 $mile^2$) 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 NSC and flows northeast along the south side of the Y-12 Complex. Bear Creek also originates within the Y-12 NSC and 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 (6.4 $mile^2$). 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 (300 to 400 ft) 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 (1,000 gal/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).

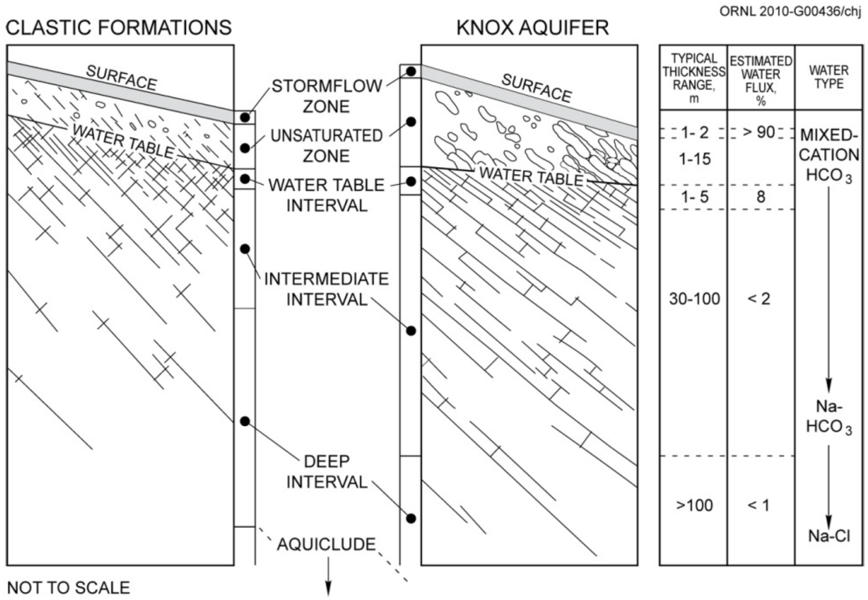

Fig. 1.5. Vertical relationships of flow zones of the Oak Ridge Reservation: estimated thicknesses, water flux, and water types.

1.3.6 Natural, Culftural, 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 these resources.

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 (Fig. 1.6). Wetlands identified to date range in size from several square meters at small seeps and springs to approximately 10 ha (25 acres) 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 references 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 (Fig. 1.6).

Two sites in the Bear Creek watershed were monitored in 2009 as part of wetland and stream mitigation requirements: north tributary 3 (NT-3) and the “Bear Creek Weir” site near Route 95. Both mitigation sites were established as a consequence of wetland and stream disturbances resulting from the implementation of waste disposal requirements in the watershed. In 2009, both mitigation sites were monitored for the growth and survival of planted trees and shrubs, and the general condition of the wetlands relative to jurisdictional wetland criteria.

The construction of a parking structure north of building 4500N at ORNL resulted in impacts to wetland and stream areas. A jurisdictional wetland delineation was conducted on August 4, 2009, prior to major construction activities, and an Aquatic Resources Alteration Permit application was submitted to the Tennessee Department of Environment and Conservation (TDEC) on November 2, 2009. The construction will result in 0.03 ha (0.08 acre) of wetland loss and 67 m (220 ft) of stream loss, which will be mitigated by expanding an existing wetland by 0.02 ha (0.04 acre) and enhancement of 366 m (1,200 ft) of riparian area along White Oak Creek and First Creek. TDEC issued a permit that certified the proposed activity including approval of the mitigation plan on January 15, 2010.

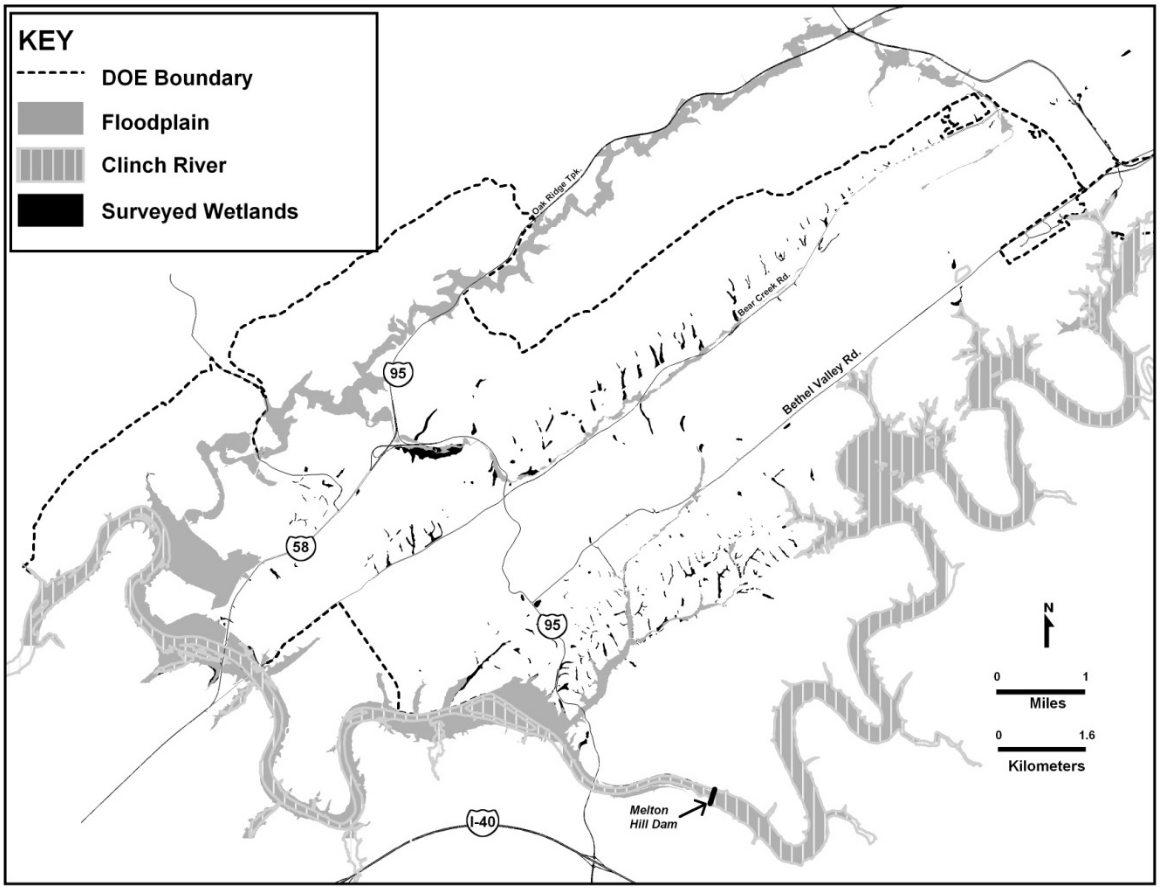

Fig. 1.6. Oak Ridge Reservation wetlands.

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 listed along with their status in Table 1.1. The list illustrates the diversity of avian species 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).

Birds, fish, and aquatic invertebrates are the most thoroughly surveyed animal groups on the ORR. The only federally listed animal species that has been observed on the ORR in recent years 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 uncommon migrants or visitors to the reservation; however, the little blue heron is believed to be 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 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

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	
Zapus hudsonius	Meadow jumping mouse		**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			
Megaceryle 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 traillii	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 vermivorum	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.

management, has been sighted once on the reservation. Barn owls have been known to nest on the reservation in the past.

One species of fish, 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 may be present on the ORR. The Tennessee dace, listed by the state as being in need of management, has been found in Bear Creek watershed, tributaries to lower East Fork watershed, and Ish Creek, and may occur in some sections of Grassy Creek (upstream of Scientific Ecology Group, Inc., and International Technology Corporation at Clinch River Kilometer 23).

1.3.6.3 Threatened and Endangered Plants

There are 23 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, were removed from the state list November 17, 1999. The big-tooth aspen was found on the ORR; it was removed from the state list at the January 2007 meeting of the Tennessee Heritage Program Scientific Advisory Committee. Four species (spreading false-foxglove, Appalachian bugbane, tall larkspur, and butternut) have been under review for listing at the federal level and were listed under the formerly used "C2" candidate designation. These species are now informally referred to as "special concern" species by the U.S. Fish and Wildlife Service.

Two additional species listed by the state, the Michigan lily and the hairy sharp-scaled sedge, were identified in the past on the ORR; however, they have not been found in recent years. Several state-listed plant species currently found on adjacent lands may be present on the ORR, although they have not been observed (Table 1.2).

During botanical surveys in 2009, an addition to the ORR list of state-protected plants (Table 1.2) was found. This plant, American barberry, is listed as a species of special concern by the state. The Tennessee Heritage Program scientific advisory committee met in 2009 to revise the state list, but its changes to the state list are not yet official. These changes are expected to add one species to the ORR list while deleting two. In addition, the ORR list (Table 1.2) reflects changes made by the state to the scientific names used for plants.

1.3.6.4 Historical and Cultural Resources

Efforts continue to preserve the rich prehistoric and historic cultural resources of the ORR. The reservation contains more than 45 known prehistoric sites (primarily burial mounds and archeological evidence of former structures), more than 250 historic pre-World War II structures, 31 cemeteries, and several historically significant Manhattan Project–era structures. Six historic ORR properties are individually listed in the *National Register of Historic Places*:

- Freels Bend Cabin,
- Graphite Reactor,
- New Bethel Baptist Church and Cemetery,
- Oak Ridge Turnpike Checking Station,
- George Jones Memorial Baptist Church and Cemetery, and
- Scarboro Road Checking Station.

Although not yet listed in the *National Register*, an area known as the Wheat Community African Burial Grounds was dedicated in June 2000, and a memorial monument was erected.

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 and establish a management strategy.

Table 1.2. Vascular plant species listed by state or federal agencies, 2009

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
Berberis canadensis	American barberry	Rocky bluff, creek bank	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
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 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 DOE Oak Ridge Office (ORO) is rich in history, dating back to World War II, when the organization played a major role in the production of enriched uranium and development of processes for production and separation of plutonium for the Manhattan Project. Since then, the ORO has expanded far beyond those first missions and today is responsible for managing major DOE programs in science, environmental management, energy efficiency, nuclear fuel supply, reindustrialization, and national security and for providing support to science laboratories and facilities operated by DOE throughout the United States. ORO also provides support to national security activities managed by the National Nuclear Security Administration (NNSA). The FY 2009 budget for all DOE programs in Oak Ridge was $4.063 billion ($1.180 billion, American Recovery and Reinvestment Act–related Energy and Water appropriations; $2.253 billion, FY 2009 Energy and Water appropriations).

1.4.2 The National Nuclear Security Administration Y-12 Site Office

The National Nuclear Security Administration (NNSA) is a semiautonomous agency within DOE that works in partnership with the U.S. Department of Defense, and the other components of the NNSA National Security Enterprise, to perform routine maintenance and repair of nuclear weapons components, dismantlement of retired nuclear weapons, and refurbishment of nuclear warheads and to maintain the capability to design, manufacture, and certify new nuclear warheads.

The NNSA Y-12 Site Office (YSO), located on the Y-12 NSC, is responsible for operation of the Y-12 NSC. YSO employees perform contract and program management oversight, contract and administrative management, and technical evaluation and assessment.

1.4.3 Oak Ridge National Laboratory

Oak Ridge National Laboratory is DOE's largest science and energy laboratory (Fig. 1.7). Managed since April 2000 by a partnership of the University of Tennessee and Battelle, ORNL was established in 1943 as a part of the Manhattan Project to pioneer a method for producing and separating plutonium. During the 1950s and 1960s, ORNL became an international center for the study of nuclear energy and related research in the physical and life sciences. With the creation of DOE in the 1970s, ORNL's mission broadened to include a variety of energy technologies and strategies. Today the laboratory supports the nation with a peacetime science and technology mission.

Fig. 1.7. The Oak Ridge National Laboratory.

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 fusion experiment and the BioEnergy Science Center, which is sponsored by the DOE Office of Science.

The Transuranic (TRU) Waste Processing Center (TWPC) is managed by Wastren Advantage, Inc. (WAI) for DOE. In late 2009, WAI was awarded the contract to operate the TWPC. Until that contract was awarded, the TWPC was operated by EnergX TN LLC. The TWPC's mission is to receive TRU wastes from ORNL for processing, treatment, repackaging, and shipment to designated facilities for final disposal. Processed TRU waste is shipped to the Waste Isolation Pilot Plant (WIPP) for disposal. Waste that is determined to be non-TRU (e.g., low-level radioactive waste, mixed low-level waste) is shipped to the Nevada Test Site or other approved facility.

Isotek Systems LLC (Isotek) manages activities at ORNL's Building 3019 Complex for DOE and is responsible for activities associated with processing, down-blending, and packaging the DOE inventory of ^{233}U stored in the Building 3019 Complex.

1.4.4 The Y-12 National Security Complex

The original Y-12 Complex (Fig. 1.8) was constructed as part of the World War II Manhattan Project and began operations in November 1943. 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.

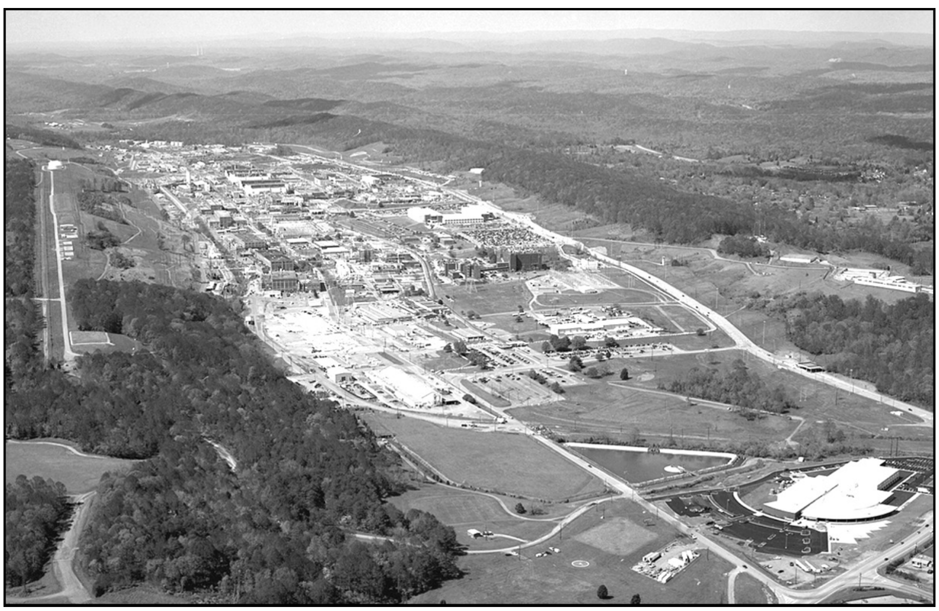

Fig. 1.8. Y-12 National Security Complex.

Today, as part of the NNSA Nuclear Security Enterprise, Y-12 performs critical roles in strengthening national security and reducing the global threat from weapons of mass destruction through work in support of the nation's nuclear weapons stockpile, nuclear nonproliferation, and naval reactors. Y-12 also provides unique and highly specialized manufacturing and software technologies to other federal agencies through the DOE Work for Others program.

1.4.5 East Tennessee Technology Park

What is now known as the ETTP site was originally named the K-25 site, on which was located the nation's first gaseous diffusion plant for enriching uranium (Fig. 1.9), as part of the Manhattan Project.

In the postwar years, additional uranium enrichment facilities were built adjacent to K-25, forming a complex officially known as the Oak Ridge Gaseous Diffusion Plant. Uranium enrichment operations at the site ceased in 1987. The site was renamed 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, disposition of wastes, and reindustrialization are the major activities at the site.

ORNL 2010-G00441/chj

Fig. 1.9. East Tennessee Technology Park.

1.4.6. Environmental Management Waste Management Facility

The EMWMF is located in eastern Bear Creek Valley near the Y-12 NSC and is operated by Bechtel Jacobs Inc. LLC. The EMWMF was built for disposal of waste resulting from the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) cleanup actions on the ORR. The original design was for the construction, operation, and closure of a projected 1.3 million m^3 (1.7 million yd^3) disposal facility. The approved capacity was subsequently increased to 1.8 million m^3 (2.4 million yd^3) to maximize utilization of the footprint designated in a 1999 record of decision. The facility currently consists of four disposal cells. A fifth cell, under construction will be completed in 2010.

EMWMF is an engineered landfill that accepts LLW and hazardous wastes from DOE sites on the ORR that meet specific waste acceptance criteria developed in accordance with the agreements with state and federal regulators. Waste types that qualify for disposal include soil, dried sludge and sediment, solidified wastes, stabilized waste, building debris, scrap equipment, and secondary waste such as personal protective equipment, all of which must meet the land disposal restrictions. In addition to the solid waste disposal facility, EMWMF operates a leachate collection system. The leachate is treated at the ORNL Liquids and Gaseous Treatment Facility (LGTF), which is operated by UT-Battelle.

1.4.7 Oak Ridge National Environmental Research Park

In 1980, DOE established the Oak Ridge National Environmental Research Park (Fig. 1.10), which by congressional action was designated a protected outdoor research reserve in 1990. Consisting of about 8,000 ha (19,760 acres), 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. It contains large blocks of forest and diverse communities of vegetation that offer unparalleled resources for ecosystem-level and large-scale research. Major national and international collaborative research initiatives use it to address issues such as multiple stress interactions, biodiversity, sustainable development, tropospheric air quality, global climate change, innovative power conductors, solar radiation monitoring, ecological recovery, and monitoring and remediation.

ORNL 2010-G00440/chj

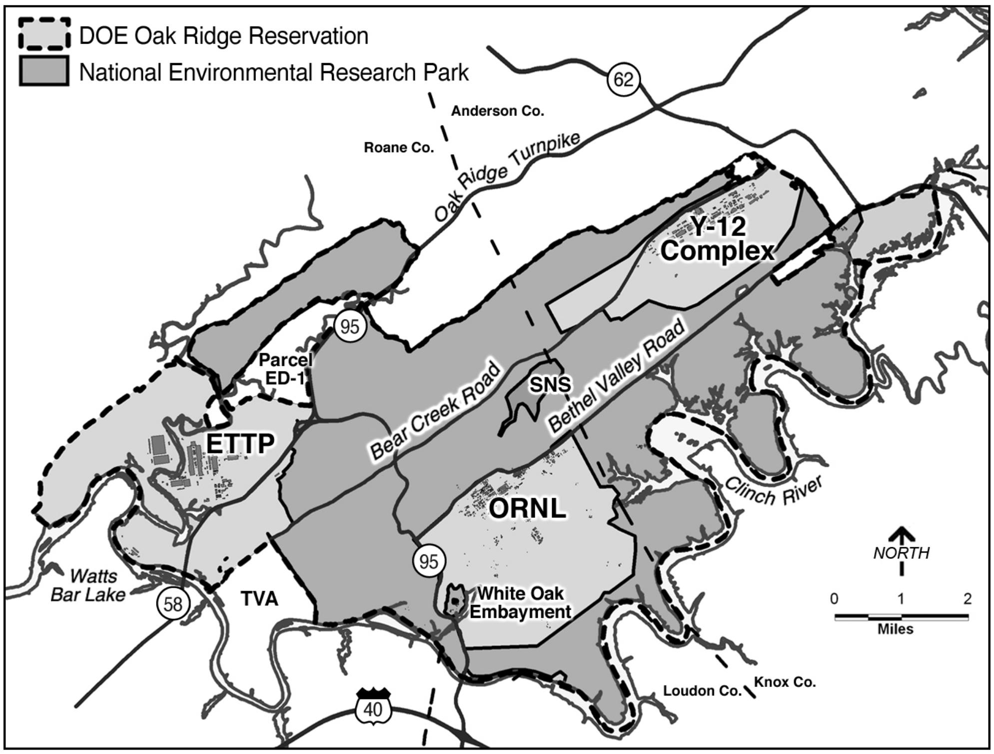

Fig. 1.10. The Oak Ridge National Environmental Research Park covers about 8,094 ha (20,000 ac) on the reservation.

Field sites at the Research Park provide maintenance and support facilities that permit sophisticated and well-instrumented environmental experiments. These facilities include elaborate monitoring systems that enable users to precisely and accurately measure environmental factors for extended periods of time. Because the park is under the jurisdiction of the federal government, public access is restricted, and experimental sites and associated equipment are, therefore, not disturbed.

National recognition of the value of the Research Park has led to its use as a component of both regional- and continental-scale research projects. Various Research Park sites offer opportunities for aquatic and terrestrial ecosystem analyses of topics such as biogeochemical cycling of pollutants resulting from energy production, landscape alterations, ecosystem restoration, wetlands mitigation, and forest and wildlife management.

1.4.8 Oak Ridge Institute for Science and Education

The Oak Ridge Institute for Science and Education (ORISE) is a DOE institute, which is managed by Oak Ridge Associated Universities (ORAU). ORISE addresses national needs in assessing and analyzing environmental and health effects of radiation, beryllium, and other hazardous materials; developing and operating medical and national security radiation emergency management and response capabilities; and managing education programs to help ensure a robust supply of scientists, engineers, and technicians to meet future science and technology needs. ORISE creates opportunities for collaboration through partnerships with other DOE facilities, federal agencies, academia, and industry in a manner consistent with DOE objectives and the ORISE mission.

ORISE includes a 94-ha (232-acre) 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 site houses offices, laboratories, and storage areas for the ORISE program offices and support departments.

1.4.9 The National Nuclear Security Administration Office of Secure Transportation Agent Operations Eastern Command

Since 1947, DOE and its predecessor agencies have moved nuclear weapons, weapons components, special nuclear materials, and other important national security assets by commercial and government transportation modes. In the late 1960s, worldwide terrorism and acts of violence prompted a review of procedures for safeguarding these materials. As a result, a comprehensive new series of regulations and equipment was developed to enhance the safety and security of these materials in transit. Thus, modified and redesigned transport equipment to incorporate features that more effectively enhance self-protection and that deny unauthorized access to the materials was established. Also during this time, the use of commercial transportation systems was abandoned, and a totally federal operation was implemented. The organization within DOE/NNSA responsible for this mission is the Office of Secure Transportation (OST).

The NNSA OST Agent Operations Eastern Command (AOEC) Secure Transportation Center and Training Facility is located on the ORR. The NNSA OST AOEC is situated on approximately 485 ha (1,198 acres) on the ORR and operates under a user permit agreement with DOE ORO. The NNSA OST AOEC implements its assigned mission transportation operations, maintains applicable fleet and escort vehicles, and continues extensive training activities for its federal agents.

1.5 References

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2. Compliance Summary and Community Involvement

DOE 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 2009 status for DOE operations on the ORR. A number of facilities at the East Tennessee Technology Park (ETTP) site have been leased to private entities over the past several years through the DOE Reindustrialization Program. The compliance status of these lessee 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 2009 status, and references to the report sections that provide more detailed information.

2.2 Release of Property

DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, 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. The Transuranic Waste Processing Center (TWPC) and Isotek return all government material, equipment, and property from nonradiological areas, other than what is outlined below, to UT-Battelle for appropriate management. 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 (nonradioactive items or materials received at the TWPC can be returned or recycled even if they are not immediately determined to be 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.

Table 2.1. Applicable laws/regulations and 2009 status

Regulatory program description	2009 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 ORR has been on the U.S. Environmental Protection Agency (EPA) National Priorities List (NPL) since 1989. The ORR Federal Facility Agreement was initiated in 1992 among EPA, the Tennessee Department of Environment and Conservation (TDEC), and the Department of Energy (DOE). The Federal Facility Agreement 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 2009, UT-Battelle, Bechtel Jacobs Company (BJC), B&W Y-12, activities of Wastren Advantage, Inc. (WAI), Isotek Systems, and Oak Ridge Associated Universities/Oak Ridge Institute for Science and Education on the ORR were in full compliance with NEPA requirements.	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. Activities on the ORR were in compliance with NHPA requirements during 2009.	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. Greenhouse gas emissions inventory tracking and reporting are regulated by EPA.	In 2009, all three major ORR sites operated in conformance to the CAA Title V Operating Permit Program. TWPC operated in conformance to the CAA Standard Operating Permit. All ORR activities were conducted in compliance with CAA requirements in 2009.	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 2009.	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 ETTP, the Y-12 National Security Complex (Y-12 Complex), to the Oak Ridge Institute for Science and Education, and to ORNL.	3.3 4.3.5 5.3.7

Table 2.1 (continued)

Regulatory program description	2009 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 were in full compliance with emergency planning and reporting requirements. There were no releases of hazardous substances exceeding reportable quantities in 2009.	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 2009 each site, including the TWPC, operated in accordance with the RCRA permits that govern waste treatment, storage, and disposal units. In August 2009, TDEC and DOE entered into a RCRA Compliance Agreement concerning previously corrected issues at Y-12 and ETTP that were the result of inspections in 2005 and 2006, respectively.	2.5 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 continues to provide a mechanism to addresses legacy PCB-use issues across the ORR. The agreement 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 Federal Facilities Compliance Agreement. There were no issues related to TSCA-related issues reported to regulators in 2009.	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

Table 2.1 (continued)

Regulatory program description	2009 Status	Report sections
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 was implemented through each site's NEPA program, and surveys for the presence of wetlands were 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 were protected in accordance with this Act.	1.3.6.2
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 ORR Annual Site Environmental Report is prepared to summarize ORR environmental activities during 2009 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, BJC, WAI, Isotek, and Oak Ridge Associated Universities/Oak Ridge Institute for Science and Education all generate radioactive waste and have implemented waste certification programs that are protective of workers, the public and the environment to ensure compliance with this Act.	3.8.1 4.2.3.4 5.11
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, WAI, 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 and to ensure compliance with this DOE order.	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 2009 dose to a hypothetically exposed member of the public from all ORR sources could have been about [TBD] 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

Items originating from nonradiological areas within the sites' controlled areas not in the listed categories are surveyed prior to release to the public, or a process knowledge evaluation is conducted to ensure that material has not been exposed to radioactive material or beams of radiation capable of creating radioactive material. In some cases both a radiological survey and a process knowledge evaluation are performed (e.g., a radiological survey is conducted on the outside of the item, and a process knowledge form is signed by the custodian for inaccessible surfaces). When the process knowledge approach is employed, the item's custodian is required to sign a statement that specifies the history of the material and 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 post experiment 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 2009 and are summarized in Table 2.2. This table does not include internal DOE prime contractor assessments for 2009.

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/.

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

Date	Reviewer	Subject	Issues
		ORNL	
May 11–14	TDEC, RCRA	TDEC Annual RCRA Inspection	0
July 23	USDA/TNDA	USDA Compliance Inspection	0
September 22	TDEC	CWA NPDES Inspection	0
September 25	TDEC	RATA for Predictive Emissions	0
November 3	TDEC	Annual RCRA inspection at Y-12 Complex	0
December 17	TDEC	Annual CAA Inspection	0
		ETTP	
February 9–11	TDEC	Annual RCRA Compliance Inspection	0
February 13	TDEC	NPDES Permitting — new permit discussions	0
April 16–17	TDEC	NPDES Permitting — new permit discussions	0
May 14	TDEC	NPDES Permitting — new permit discussions	0
August 6	TDEC	NPDES Permitting — new permit discussions	0
September 24	TDEC	NPDES Compliance Evaluation Inspection	0
October 7	TDEC	TSCA Incinerator — RCRA	0
October 8	EPA/TDEC	TSCA Incinerator — PCB Inspection	0
Monthly (Jan–Dec)	TDEC Div. of Solid Waste	Active Y-12 Landfill inspection	0
Semiannual	TDEC Div. of Solid Waste	Inactive Y-12 Landfill inspection	0
		Y-12 Complex	
January 14	City of Oak Ridge	Semi-Annual Industrial Pretreatment Compliance Inspection	1[a]
January 21–22	TDEC	TDEC Annual Clean Air Compliance Inspection	0
August 4	TDEC	Underground Storage Tank Compliance Inspection	0
September 14	City of Oak Ridge	Semi-Annual Industrial Pretreatment Compliance Inspection	0
November 2–5	TDEC	TDEC Annual RCRA Inspection	0
		TWPC (WAI)	
May 14	TDEC	TDEC Annual RCRA Inspection	0
		Isotek	
		Not applicable	

[a]The City of Oak Ridge requested an action plan to address inflow/infiltration into the sanitary sewer system.

Abbreviations

CAA	Clean Air Act
CWA	Clean Water Act
EPA	Environmental Protection Agency
NPDES	National Pollutant Discharge Elimination System
PCB	polychlorinated biphenyl
RATA	Relative Accuracy Test Audit
RCRA	Resource Conservation and Recovery Act
TDEC	Tennessee Department of Environment and Conservation
TNDA	Tennessee Department of Agriculture
USDA	United States Department of Agriculture

2.4 Emergency Reporting of Spills and Releases

There were no releases of hazardous substances exceeding reportable quantities on the ORR during 2009.

There were two reportable releases at the Y-12 National Security Complex in 2009. On June 22, 2009, a hydraulic line on a construction crane failed, resulting in a leak of approximately 371 L (98 gal) of hydraulic fluid. Some hydraulic fluid reached a storm drain system inlet to East Fork Poplar Creek, resulting in an oil sheen and prompting reporting to the National Response Center, the Tennessee Emergency Management Agency, and the Local Emergency Planning Committee. There were no observed effects to fish and aquatic conditions as result of this event.

On September 2, 2009, while performing cleanup activities and operating heavy equipment at the 9720-58 yard, a pressurized acetylene cylinder was inadvertently punctured resulting in a release of asbestos material on the ground that exceeded the reportable quantity. The work site was inspected by hand prior to restart of activities. This activity included hand removal of bulky items, wearing the proper personal protective equipment, as well as clearing and combing through overgrown areas in an attempt to reveal any items which may have been hidden.

There were no reportable releases to the environment at ORNL in 2009.

2.5 Notices of Violations and Penalties

In August 2009, TDEC and DOE entered into a RCRA Compliance Agreement. The purpose of the Compliance Agreement was to formally resolve notices of violation (NOVs) that were issued by TDEC as a result of RCRA compliance inspection at the Y-12 Complex and ETTP in December 2005 and February 2006, respectively. Although the specific violations identified during the 2005 and 2006 inspections had been previously corrected, the Compliance Agreement provides the framework by which DOE and BJC will avoid future violations associated with the storage of newly discovered hazardous waste. Specifically, the Compliance Agreement requires BJC to provide periodic reports to TDEC on the status of waste characterization and disposal activities and requires all characterization activities to be completed by June 30, 2011.

Concurrent with the RCRA Compliance Agreement, DOE and TDEC signed a Settlement Agreement that provided for a Supplemental Environmental Project (SEP) in lieu of stipulated penalties for missing an Federal Facility Agreement milestone for the construction start of the ETTP Ponds Project as well as for the 2005 and 2006 NOVs at the Y-12 Complex and ETTP, respectively. In choosing the SEP, TDEC sought to utilize DOE's expertise and capabilities in handling radioactively contaminated materials. The SEP involves the pickup and disposition of certain radioactive objects from several locations in Tennessee.

There were no NOVs, penalties, or consent orders issued to Y-12 activities in 2009.

A NOV was issued by TDEC to BJC on November 5, 2009, when the concentration of 1,1 dichloroethene (1,1 DCE) observed in a downgradient groundwater monitoring well at an ORR Landfill exceeded the drinking water MCL for that constituent. The 1,1 DCE has been closely monitored by DOE and TDEC since it first appeared in 1997, and due to its very slow migration and the extensive distance from the site boundary, it is not considered to be a threat to off-site groundwater resources. Corrective action, including a more aggressive Phase III Assessment Monitoring Plan, was implemented in accordance with TDEC requirements.

- No NOVs or penalties were issued to UT-Battelle during 2009.
- No NOVs or penalties were issued to TWPC, WAI, EnergX, or Isotek during 2009.

2.6 Community Involvement

2.6.1 Public Comments Solicited

Public input and comments were solicited on a variety of significant proposed actions, documents, and plans in 2009 including the following.

- An Aquatic Resource Alteration Permit application and Wetland Notice of Involvement for an ORNL vehicle-parking structure project
- Draft Global Nuclear Energy Partnership Programmatic Environmental Impact Statement, which provides an analysis of the potential environmental consequences of the reasonable alternatives to support expansion of domestic and international nuclear energy production
- Proposed approval of the radioactive, remote-handled transuranic waste characterization program implemented by the Central Characterization Project in Oak Ridge
- Revision of DOE's Freedom of Information Act regulations, which streamlines DOE's procedures for determining the release of information and updates the requirement for reproduction of the documents
- Proposal for major modifications to the Federal Facility Agreement that would add new Integrated Facility Disposition Program work scope and extend the EM cleanup completion time frame
- Parcel ED-8 Covenant Deferral Request, which addresses the transfer of approximately 37 ha (91 acres) located in the southern portion of ETTP to Heritage Center LLC
- Tennessee Air Pollution Control Regulations permit request for Building 3019 at ORNL
- National Resource Damage Assessment Evaluation of Contaminant-Related Losses in Watts Bar Reservoir and Gains from the Black Oak Ridge Conservation Easement
- K-792 Switchyard Covenant Deferral Request, which addresses the transfer of the switchyard to Heritage Center LLC
- Request for Proposal to sell approximately 13,900,000 kg (15,300 tons) of radiologically contaminated nickel scrap recovered from enrichment operations in Oak Ridge and Paducah, Kentucky
- Environmental Impact Statement for the long-term management and storage of elemental mercury, which will evaluate alternatives for a storage facility

To keep the public informed about comment periods and other matters related to cleanup activities on the ORR, DOE publishes a monthly newsletter, *Public Involvement News (see* (http://www.oakridge.doe.gov/external/). DOE also keeps the public informed by publishing notices in local newspapers and conducting public meetings.

2.6.2 Oak Ridge Site Specific Advisory Board

The Oak Ridge Site Specific Advisory Board (ORSSAB) is an independent, volunteer, federally appointed citizens' advisory panel charged with providing DOE Oak Ridge with advice and recommendations on its environmental cleanup operations on the ORR. It has been actively involved in that role since the board's inception in 1995.

In 2009, the ORSSAB was actively involved in two major programs that had significant impact on the Oak Ridge EM program: the Integrated Facility Disposition Program (IFDP), which will add more than 200 facilities at the Y-12 Complex and ORNL to the existing EM baseline; and the American Recovery and Reinvestment Act (ARRA) Implementation of the IFDP-required modifications to the Federal Facility Agreement, which guides the process for cleaning up the Reservation. In February 2009 the ORSSAB and DOE co-hosted a public meeting to explain the changes and allow for comments on those changes. The ORSSAB also provided detailed briefings to the public in March, April, and May, to explain how ARRA funding would augment Oak Ridge EM budgets for 2009–2011.

The ORSSAB continued to be involved in the development of Oak Ridge oral histories during 2009, including the development of the Networking Oak Ridge Oral History (NOROH) task team to support the existing Center for Oak Ridge Oral History (COROH). The COROH was established to consolidate existing publicly available oral histories about activities on the reservation and to collect additional information. The newly created NOROH is a four-agency Federal program task team formed to support the COROH. This team will ensure that Federal and contractor technical/scientific oral histories will be captured and made available to COROH for public access when possible or kept and maintained when currently classified information is recorded.

Other ORSSAB activities in 2009 included extensive efforts to inform and involve the public in the Oak Ridge EM program including the following.

- monthly board meetings, which are open to the public and broadcasted on local cable channels
- an outreach program that included meetings with reporters and editors from six area newspapers to discuss strategies for keeping the public informed of ORSSAB and DOE EM programs
- plans for developing new interactive displays at the American Museum of Science and Energy which will use touch-screen kiosks
- participation in Earth Day and Secret City festivals
- an educational outreach program that includes inviting two high school students to serve as members of the Board, presentations to high school classes, and reservation tours
- participation in decisions and recommendations on approaches for preserving the historical significance of the K-25 Building at ETTP

2.6.3 DOE Information Center

The DOE Information Center, located at 475 Oak Ridge Turnpike, Oak Ridge, Tennessee, is a one-stop information facility that maintains a collection of more than 40,000 documents describing environmental activities in Oak Ridge. The center is open Monday through Friday, 8 a.m. to 5 p.m. The DOE ORO web site (www.oakridge.doe.gov) includes a Public Activities tab, which describes DOE program activities for the general public. The Online Catalog tab, under the Information Center tab of Public Activities, can be used to search for DOE documents by author, title, date, and other fields. The recently added New Documents tab provides links to recently published documents.

2.6.3.1 Telephone Contacts

- DOE Information Center: (865) 241-4780; toll free 1-800-382-6938 (option 6)
- DOE Public Affairs Office: (865) 576-0885
- DOE-ORO Public Information Line: 1-800-382-6938
- Oak Ridge Site Specific Advisory Board: (865) 241-4583, (865) 241-4584, 1-800-382-6938
- Tennessee Department of Environment and Conservation, DOE Oversight Division: (865) 481-0995
- U.S. Environmental Protection Agency Region IV: 1-800-241-1754
- Agency for Toxic Substances and Disease Registry: 1-800-232-4636

2.6.3.2 Internet Sites

- DOE Main Web Site: www.energy.gov
- DOE-ORO Home Page: www.oakridge.doe.gov
- DOE-ORO Environmental Management Program: www.oakridge.doe.gov/external (Click on “Programs” then select “Environmental Management”)
- Oak Ridge Site Specific Advisory Board: www.oakridge.doe.gov/em/ssab
- Agency for Toxic Substances and Disease Registry: www.atsdr.cdc.gov
- U.S. Environmental Protection Agency: www.epa.gov/region4/
- Tennessee Department of Environment and Conservation: www.state.tn.us/environment/
- Tennessee Department of Environment and Conservation, DOE Oversight Division: http://www.state.tn.us/environment/doeo/
- DOE Information Center: www.oakridge.doe.gov/info_cntr
- American Recovery and Reinvestment Act: www.recovery.gov and www.energy.gov/recovery

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.

DOE. 1990. “Radiation Protection of the Public and the Environment.” DOE Order 5400.5. February 8.

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 LLC (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 2009, 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 (Fig. 3.1). The plant's original mission was the production of enriched uranium for nuclear weapons. Enrichment was initially carried out in the S-50 thermal diffusion process facility that operated for one year and the K-25 and K-27 gaseous diffusion process buildings. 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. Following the war years the site became officially known as the Oak Ridge Gaseous Diffusion Plant (ORGDP).

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 the production of only low enriched uranium to be fabricated into fuel elements for 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, the 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 renamed the "East Tennessee Technology Park" to reflect its new mission.

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.

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

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Fig. 3.1. East Tennessee Technology Park.

(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.

Bechtel Jacobs Company LLC (BJC) is the environmental management contractor for ETTP. BJC also supports DOE in the reindustrialization program that transferred three building and two land parcels to the CROET as it continued its effort to transform ETTP into a private sector industrial park. In 2009, eleven buildings and five land parcels at ETTP have been transferred to private companies. Construction was also started on speculative buildings on two of the parcels. Unless otherwise noted, information on non-DOE entities located on the ETTP site is not provided in this document.

3.2 Environmental Management System

As required by DOE Order 450.1A, the BJC Environmental Management System (EMS) is integrated into the Integrated Safety Management System (ISMS). BJC's EMS is based on a graded approach for a closure and remediation contract and reflects the elements and framework of ISO 14001:2004. BJC is committed to incorporating sound environmental management, protection, and sustainability practices in all its work processes and activities that are part of the DOE environmental management (EM) program in Oak Ridge, Tennessee. BJC's Environmental Policy states that "it is inherent in our mission to complete environmental cleanup safely with reduced risks to the public, workers, and the environment." In order to achieve this, BJC's Environmental Policy adheres to the following principles:

- **Management Commitment**—Integrate responsible environmental practices into project operations.
- **Environmental Compliance and Protection**—Comply with all environmental regulations and standards.
- **Sustainable Environmental Stewardship**—Minimize the effects of our operations on the environment through a combination of source reduction, recycling, and reuse; sound waste management practices; and pollution prevention (P2).

- **Partnership/Stakeholder Involvement**—Maintain partnerships through effective two-way communications with our customer and other stakeholders.

3.2.1 Environmental Stewardship Scorecard

The Environmental Stewardship Scorecard is used to track and measure site-level progress in EMS progress, performance, and successes. BJC continues to receive green scores for their EMS performance and 2009 Pollution Prevention Performance Measures. Figure 3.2 shows BJC's recycling data by types and quantities for 2009.

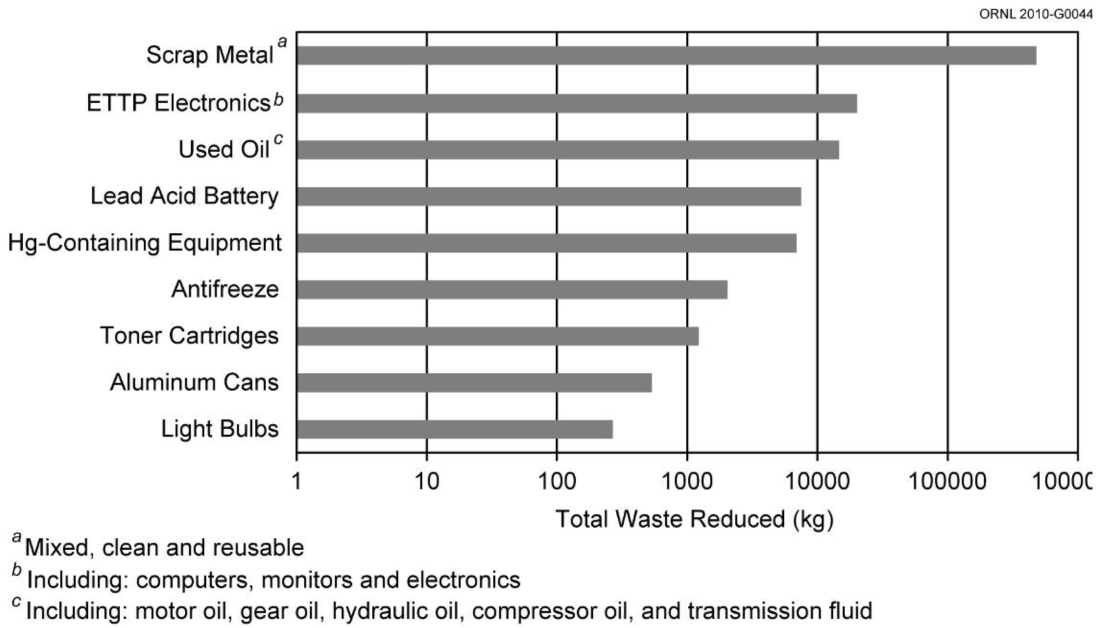

Fig. 3.2. P2 recycling activities at ETTP related to solid waste reduction.

3.2.2 Environmental Compliance

BJC maintains various layers of oversight to ensure compliance with legal and other requirements. The methods of evaluations ranges from independent assessments by outside parties, management assessments conducted by functional or project organizations, and routine field walkdowns conducted by a variety of functional and project personnel. Management and independent assessments are performed in accordance with Management Assessments, BJC-PQ-1420, and Independent Assessments, BJC-PQ-1401. Assessments are scheduled in accordance with BJC-PQ-1420 on the BJC Assessments Share Point Site. Records are maintained for all formal assessments and audits. Issues identified in assessments are handled as described in Sect. 4.5.3.

In addition, external assessments and regulatory inspections are performed by the DOE and regulatory agencies such as the Tennessee Department of Environment and Conservation and the U.S. Environmental Protection Agency.

As required by DOE Order 450.1A, an independent assessment of BJC's EMS in accordance with Independent Assessments, BJC-PQ-1401, will be conducted every three years. In addition, during years when an independent assessment is not conducted, a management assessment of the EMS program will be performed in accordance with Management Assessments, BJC-PQ-1420. Also, routine functional environmental compliance management assessments evaluate the various elements of ISO 14001. Independent and management assessments are scheduled in advance and the schedule is maintained on a SharePoint Site on BJC's intranet.

Results of all assessments are provided to management and CAs are tracked in I/CATS in accordance with Issues Management Program, BJC-PQ-1210 as described in detail in Sect. 4.5.3.

Initial validation of BJC's EMS occurred in December 2005. An internal independent assessment was performed in September 2007; and an evaluation by an outside party, as required by DOE Order 450.1A, was conducted in March 2009. BJC formally declared conformance with EMS requirements contained in DOE Order 450.1A on May 6, 2009.

3.2.3 Environmental Aspects/Impacts

Using a graded approach appropriate for the EMCC, the EMS incorporates these environmental principles and provides a unified strategy for the management, conservation and protection of natural resources, the control and attenuation of risks, and the establishment and attainment of all Environmental, Safety and Health (ES&H) goals. BJC works continuously to improve our EMS in order to reduce the impact from our activities and the effect they have on the environment (i.e., *environmental aspects*) and to communicate and reinforce this policy to our internal and external stakeholders.

At the program/company level, environmental aspects are documented in the *Integrated Safety Management System Description*, BJC-GM-1400. These aspects are reviewed at least annually and updated as necessary. Significant environmental aspects are identified using a systematic process that considers various risk factors (e.g., regulatory risk, environmental risk, mission impact and probability) in determining significance. This process is described in Evaluation of BJC Activities and Ranking of Environmental Aspects/Impacts, EMS-2008-003. BJC's work activities, services, and products were initially reviewed to determine the associated environmental aspects and impacts. These activities, services, and products and the associated environmental aspects and impacts are also reviewed on an ongoing basis as new work activities are initiated.

Continuous improvement opportunities are identified in a number of ways including, but not limited to, ongoing independent and management assessments, external DOE assessments, regulatory inspections, worker feedback, and senior management reviews of BJC's EMS components. Fig. 3.3 provides a model that illustrates the components and key steps of BJC's EMS.

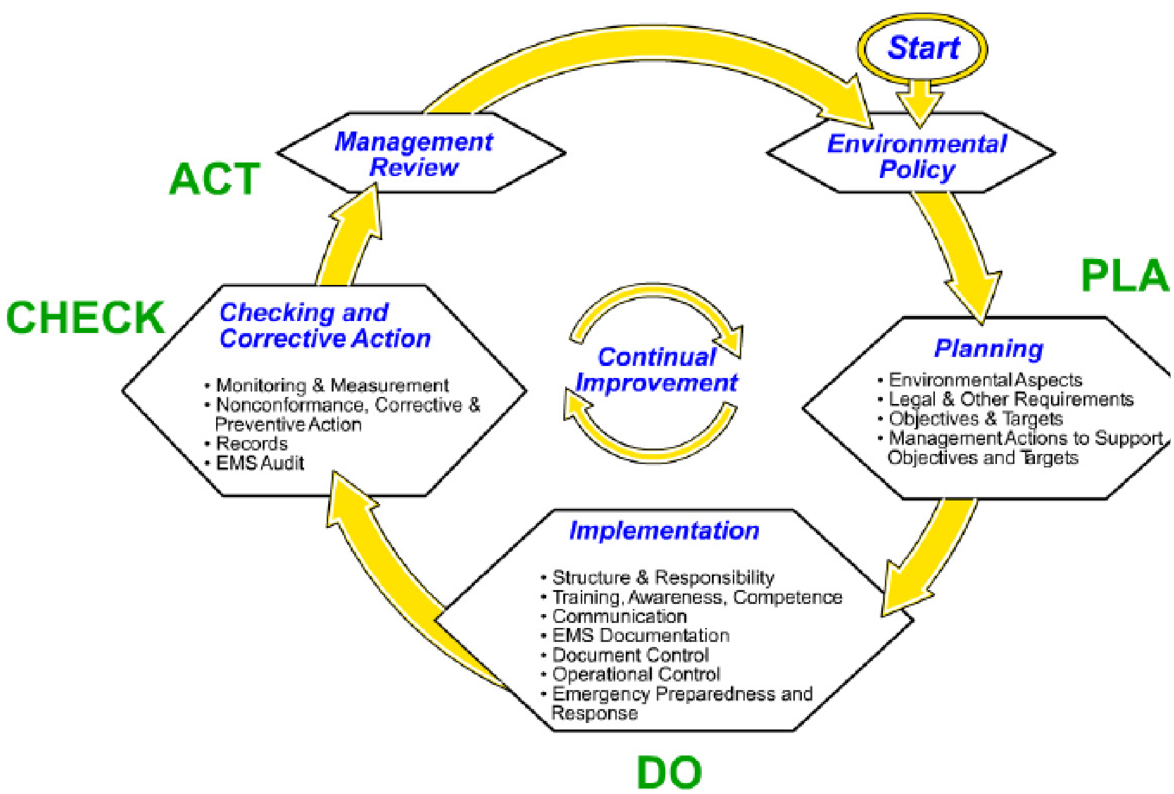

Fig. 3.3. BJC EMS key elements.

The BJC corporate policy emphasizes the company's core values by promoting their commitment to an ISMS. The objective of the ISMS is to systematically integrate 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.

The Environmental Compliance and Protection (EC&P) Oversight Program is an integral part of the BJC 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 P2 and sustainable environmental stewardship goals.

3.2.4 Environmental Performance Objectives and Targets

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.

BJC has established a set of core EMS objectives which remain relevantly unchanged from year-to-year and are included in the Integrated Safety Management System Description, BJC-GM-1400. These objectives are generally applicable to all operations and activities throughout BJC's work scope. The core environmental objectives are based on complying with applicable legal requirements and sustainable environmental practices contained in DOE Order 450.1A and include the following:

- Comply with all environmental regulations, permits and regulatory agreements;
- Encourage the reduction or elimination of the generation and/or toxicity of waste and other pollutants at the source through pollution prevention to reduce waste generation, prevent pollution, and maximize recycle and reuse potential;
- Encourage the reduction or elimination of the acquisition, use, and release of toxic, hazardous, and radioactive materials through acquisition of environmentally preferable products and conduct of operations;
- Reduce degradation and depletion of environmental resources through post–consumer material recycling and energy, fuel, and water conservation efforts; and
- Reduce or eliminate the environmental impact of electronics assets.

In addition to the core objectives listed above, BJC establishes company-level "ad-hoc" objectives and targets each year which are established based on changing priorities, changing legal requirements and other areas of emphasis. The complete list of core and "ad-hoc" environmental objectives and targets are distributed by the BJC President annually for the upcoming calendar year. The list also includes designation of responsibility and timeframes by which actions are to be taken to facilitate achievement of the objectives and targets. The status of objectives and targets are periodically reviewed throughout the year at EC&P Leads meetings and Management Reviews.

Project-specific EMS objectives and targets are developed annually near the beginning of each calendar year and are based on company level objectives and targets taking into consideration significant environmental aspects and legal requirements of their project operations. The status of the environmental objectives and targets at the project-level are reviewed by periodically by the EC&P Lead with project management as well as with the EC&P Program Manager during EC&P Leads meetings.

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). Each ISO element is addressed in BJC's EMS Implementation Description (EMS-2009-005)—*General Requirements, Environmental Policy, Environmental Planning, Implementation and Operations, Checking, and Management Review*. For each element, this document provides the related implementing documents, implementation description, and roles and responsibilities. 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.

3.2.5 Implementation & Operations

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.

3.2.6 P2/Waste Minimization

BJC's work control process requires that source reduction be evaluated for all waste generating activities and product substitution be utilized to produce a less toxic waste when possible. Reuse or recycling of building debris or other waste generated are evaluated in all cases.

BJC recycles office and mixed paper, cardboard, phone books, newspapers, magazines, aluminum cans, antifreeze, engine oils, batteries (lead acid, universal waste, and alkaline), universal waste bulbs, plastic bottles, all types of #1 and #2 plastics, and surplus electronic assets such as computers (CPUs and laptops) and monitors (CRT and LCD). Other recycling opportunities include unique structural steel, stainless steel structural members, transformers, and electrical breakers. Fig. 3.2 shows the P2 recycling activities at ETTP related to solid waste reduction.

BJC's electronic stewardship is award winning. For 2009, the IT's electronic stewardship and life cycle management program won a DOE E.M. "Best in Class" award and a DOE EStar Award for electronic stewardship.

3.2.7 Competence, Training, and Awareness

The BJC training and qualification process assures that needed skills for the workforce are identified and developed, and documents knowledge, experience, abilities, and competencies of the workforce for key positions requiring qualification. This process is described in procedure BJC-HR-0702, Training Program. Completion and documentation of training, including required reading, is managed by the Local Education Administration Requirements Network (LEARN).

A number of training modules and awareness tools have been developed and used to increase general knowledge and awareness of BJC's environmental policy and to communicate roles and responsibilities for all employees. For example, the following training modules contain specific information regarding BJC's environmental policy and EMS:

- Consolidated Annual Training (Module #28307)
- EMS Delta Briefing (Module #28848)
- ISMS EMS Leadership Workshop Training (Module #26930)
- PWT3 Park Worker Training (Module #21221)

Additionally, employees and subcontractors involved in a work activity that may have a significant impact on the environment are provided additional information through review of work packages, procedures, pre-job briefings, and review of Safety Task Analysis Risk Reduction Talk (STARRT) Cards which address potential environmental issues and concerns.

In addition to the formal training modules and project-specific work briefings, BJC uses a number of tools and mechanisms to constantly reinforce awareness and knowledge of BJC's EMS. Some examples of these tools include the following:

- "Green Light" on EMS
- BJC Notes
- Employee Information Monitors
- EMS Brochures
- EMS Crossword Puzzle
- EMS Fact Sheets
- Environmental Pagers
- Internal BJC EMS Website
- Internal BJC Home Page Web Content
- Meeting Safety Topics
- Safety Pause Meetings

3.2.8 Communication

BJC has a written communication plan that addresses both internal and external communication of important company information, including information related to EMS.

BJC has decided to communicate externally regarding environmental aspects on the BJC public website. The public BJC EMS website includes a summary environmental policy statement and a list of environmental aspects as well as a link to Integrated Safety Management System Description, BJC-GM-1400. A number of other documents and reports are also published and made available to the public that address environmental aspects and clean-up progress (e.g., Annual Site Environmental Report, Annual Clean-Up Progress Report). BJC participates in a number of public meetings related to environmental activities at the site (e.g., Site Specific Advisory Board Meetings, Permit Review Public Meetings, and CERCLA Decision Document Public Meetings). Written communications from external parties are tracked using the weekly Open Action Report.

3.2.9 Benefits and Successes of EMS Implementation

BJC utilizes EMS objectives and targets, P2 Recognition Program, Environmentally Preferable Purchasing, work control process and recycle program to meet sustainability and stewardship goals and requirements. The approach is outlined in BJC's P2/Waste Minimization (WMin) Program Plan (BJC/OR-1890/R2).

BJC has initiated energy conservation measures that saved money, energy, and, subsequently, pollution from power generation or vehicle emissions as follows:

- Reindustrialization organization—in the process of purchasing and installing sensors that will automatically turn lights off when people are not present, as well as reminding personnel to turn off lights when leaving a room.
- Energy Star appliances—purchased whenever possible because the appliances meet strict energy efficient guidelines set by the EPA and DOE and because Energy Star is an international standard for energy efficient consumer products.
- Information Technology (IT) department—purchases only EPEAT (Electronic Product Environmental Assessment Tool) silver or gold certified computers and monitors. EPEAT is an easy-to-use, online tool that helps institutional purchasers evaluate, compare, and select electronic products based on their environmental attributes. Additionally, the IT department is creating awareness and is in the process of implementing desktop energy-saving measures for computers, monitors, printers, and copiers.
- Space Consolidation/Utilization Project—implemented during FY 2009 that eliminated 45 facility/trailer types resulting in 805,000 kW/hr energy use avoidance.
- Radio Frequency Identification (RFID) Shipping Project—implemented during FY 2009 that avoided the use of 10,332 gallons of diesel fuel due to a significant decrease in idling time, in addition to improving the truck loading process of the K-1070-B burial ground project and saving 1,667 gallons of diesel fuel.
- General Maintenance—purchases WaterSense replacement parts when performing repairs. WaterSense is an EPA program designed to encourage water efficiency through the use of a special label on consumer products such as toilets, flushing urinals, bathroom sink faucets and accessories.
- Garage personnel—use recycled content coolant (ethylene glycol) that is a 50/50 blend of recycled/new coolant and several biobased products including oils and cleaners which result in less toxic or non-toxic waste generation.

3.2.10 Management Review

Senior management review of the EMS is performed at several layers and frequencies. A formal annual review/presentation with BJC senior management is conducted at least once per year that addresses the requirement elements contained in this section. BJC Senior Management includes the President/General Manager, Vice President/Deputy General Manager, and Manager of Safety Systems Integration. At least two of the senior managers shall be present for management reviews. Also, as part of the ISMS annual report, a narrative report of the EMS and its effectiveness is published that addresses each requirement element. Integrated Safety Management System Description, BJC-GM-1400 is updated annually and signed by the BJC President to address improvements, lessons learned, and to update objectives and targets as necessary. The environmental policy is also reviewed during the management review annually and revised as necessary.

In addition to the formal annual reviews, monthly review of key DOE metrics are submitted to DOE and discussed with senior management in the monthly Zero Accident Council meeting. These metrics relate to the compliance-based EMS objectives and targets.

On a periodic basis, the status of EMS objectives and targets are reviewed at the monthly EC&P Leads meetings and project meetings as appropriate.

The following is a summary of performance measures against 2009 Objectives and Targets that were presented at the Management Review conducted March 2010:

- Seventeen (17) Environmental Targets Achieved
  - Zero un-permitted discharges
  - Zero reportable releases to the environment
  - Increase recycling of plastic containers by 10%
  - Initiate recycling of alkaline batteries
  - Purchase 100% of EPEAT Silver or Gold certified computer equipment

- Replace 50 CRT computer monitors with energy-efficient units
- Declare compliance with new DOE Order 450.1A

- Four (4) Targets Not Achieved
  - Zero Notices of Violations
  - Zero NPDES permit noncompliances
  - Increase environmentally preferable purchases by 10 %
  - Reduce hazardous waste generation by 10%

3.3 Compliance Programs and Status

3.3.1 Environmental Permits

Table 3.1 contains a list of environmental permits that were effective in 2009 at ETTP.

3.3.2 Notices of Violations and Penalties

ETTP did not receive any notices of violations or penalties from regulators during 2009. However, an NOV was issued to BJC on November 5, 2009. This is discussed in greater detail in Sect. 2.5.

3.3.3 Audits and Oversight

Table 3.2 presents a summary of environmental audits conducted at ETTP in 2009.

3.3.4 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. ETTP 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.

During 2009, ETTP continued to operate under site-level, site-specific procedures that provides requirements for project reviews and NEPA compliance. These procedures call 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 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. 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 2009, no CXs were issued, and 13 review reports (for reindustrialization projects) were prepared.

Compliance with National Historic Preservation Act (NHPA) at ETTP is achieved and maintained in conjunction with NEPA compliance. The scope of proposed actions is reviewed in accordance with the *Cultural Resource Management Plan* (DOE 2001) On the ETTP, there are 135 facilities eligible for inclusion on the *National Register of Historic Places*. A memorandum of agreement (MOA) states that two of these facilities will be maintained (i.e. the north end of K-25 and Portal 4). The other facilities are scheduled to be demolished as part of the site-wide remediation project. To date, over 200 facilities 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.

Table 3.1. Permit actions at East Tennessee Technology Park

Regulatory driver	Permit title/description	Permit No.	Issue date	Expiration date	Owner	Operator	Responsible contractor
CAA	Operating Permit—Tennessee Air Quality Act for K-1407-U VOC Air Stripper.	045253P	06-20-96	10-01-00	DOE	BJC	BJC
CAA	Operating Permit—Tennessee Air Quality Act for K-1425 Waste Oil/Solvent Storage Tank Farm	029895P	09-21-90	10-01-95	DOE	BJC	BJC
CAA	Operating Permit—Tennessee Air Quality Act for K-1435-C Liquid Waste Tank Farm	037460P	03-31-94	10-18-98	DOE	BJC	BJC
CAA	Permit to Construct—Tennessee Air Quality Act for K-1423 TSCA Solids Waste Repack Facility	958435P	10-10-05	10-10-06	DOE	BJC	BJC
CAA	Permit to Construct—Tennessee Air Quality Act for TSCA Incinerator	957808I	01-25-05	03-31-10	DOE	BJC	BJC
CWA	National Pollutant Discharge Elimination System Permit (NPDES) for the Central Neutralization Facility Wastewater Treatment System	TN0074225	10-01-03	09-30-08	DOE	BJC	BJC
CWA	NPDES Permit for treated liquid effluent	TN0002950	03-01-04	03-31-08	DOE	DOE	BJC
CWA	State Operating Permit—Waste Transportation Project. Blair Road and Portal 6 Sewage Pump and Haul Permit	SOP-05068	02-28-06	02-28-09	DOE	URS	URS
CWA	State Operating Permit—K-1310-DF and K-1310-HG Trailers	SOP-99033	04-29-05	04-29-10	DOE	BJC	BJC

Table 3.1 (continued)

Regulatory driver	Permit title/description	Permit No.	Issue date	Expiration date	Owner	Operator	Responsible contractor
CWA	State Operating Permit—K-1065 Facility. Trailer K-1310-BS added in March 2009	SOP-01042	11-30-06	05-31-10	DOE	BJC	BJC
CWA	State Operating Permit—EMWMF. 5000 Gallon Holding Tank and Trailers 998T-74 and 998T-75	SOP-01043	07-31-07	07-31-12	DOE	BJC	BJC
CWA	TSCA Incinerator PCB Treatment Authorization	Not applicable	05-27-08	Ongoing	DOE	BJC	BJC
CWA	Authorized/Certified Underground Storage Tanks. USTs at K-1414 Garage	Customer ID 30166 Facility ID 073008	03-20-89	Ongoing	DOE	BJC	BJC
RCRA	TSCA Incinerator	TNHW-015	09-28-87	09-28-97	DOE	BJC	BJC
RCRA	Container and Tank Storage and Treatment Units	TNHW-133	09-28-07	09-28-17	DOE	BJC	BJC
RCRA	Container Storage and Treatment.	TNHW-117	09-30-04	09-30-14	DOE	BJC	BJC
RCRA	Hazardous Waste Corrective Action Permit. Encompasses the entire ORR	TNHW-121	09-28-04	09-28-14	DOE	DOE/All[a]	DOE/All[a]

[a] DOE and all Oak Ridge Reservation co-operators of hazardous waste permits.

Table 3.2. Regulatory oversight, assessments, inspections, site visits at East Tennessee Technology Park, 2009

Date	Reviewer	Subject	Issues
February 9–1	TDEC	Annual RCRA Storage Area	0
February 13	TDEC-Nashville	NPDES Permitting—new permit discussions	0
April 16–7	TDEC-Nashville	NPDES Permitting—new permit discussions	0
May 14	TDEC-Nashville	NPDES Permitting—new permit discussions	0
August 6	TDEC-Nashville	NPDES Permitting—new permit discussions	0
September 24	TDEC-Knoxville	NPDES Compliance Evaluation Inspection	0
October 7	TDEC	TSCA Incinerator - RCRA	0
October 8	EPA/TDEC	TSCA Incinerator - PCB Inspection	0
Monthly (Jan–Dec)	TDEC—Division of Solid Waste	Active Y-12 Landfill inspection	0
Semiannual	TDEC—Division of Solid Waste	Inactive Y-12 Landfill inspection	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

3.3.5 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.

In 2009, there was one source requiring continuous monitoring of criteria pollutants, two major radionuclide sources with continuous sampling systems, five minor radionuclide sources, and numerous demonstrations of compliance with generally applicable air quality protection requirements (asbestos, stratospheric ozone, etc.). In 2009, TDEC personnel did not perform an inspection of ETTP. In summary, there were no ETTP CAA violations or exceedances in 2009. Section 3.4 provides detailed information on 2009 ETTP activities conducted in support of the CAA.

3.3.6 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.

ETTP discharges to the waters of the state of Tennessee under two individual NPDES permits: NPDES Permit No. TN0002950 which regulates storm water discharges and NPDES Permit No. TN0074225 which regulates industrial discharges from CNF.

In 2009, compliance with the ETTP NPDES storm water permit was determined by approximately 835 laboratory analyses and field measurements. The NPDES permit compliance rate for all discharge points for 2009 was nearly 100% with only one measurement exceeding numeric NPDES storm water permit limits. The noncompliance occurred on January 6, 2009 at storm water outfall 340 where a measured value of 9.1 Standard Units (SU) exceeded the maximum pH limit of 9.0 SU. No harm to aquatic species was seen during investigation of the incident. The exceedance did not result in any discernable ecological impact. Section 3.5 contains detailed information on the activities and programs carried out at 2009 by ETTP in support of the CWA.

In 2009, compliance with the ETTP NPDES permit for industrial wastewater from CNF was determined by more than 2000 laboratory analyses and field measurements. The CNF NPDES permit compliance rate for 2009 was 100% with no occurrences of noncompliances.

3.3.7 Safe Drinking Water Act Compliance Status

ETTP'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 ETTP water distribution system and meets all regulatory requirements for drinking water. The water treatment plant, located on the ORR, southwest of the ETTP, is owned and operated by the city of Oak Ridge.

In 2009, sampling results for ETTP's water system chlorine residual levels, bacterial constituents, disinfectant by-products, lead and copper were all within acceptable limits.

3.3.8 Resource Conservation and Recovery Act Compliance Status

ETTP 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 2009, ETTP had approximately nine generator accumulation areas for hazardous or mixed waste.

ETTP 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 ETTP is managed as universal waste.

Additionally, some batteries are managed according to 40 CFR Part 266.80. This applies to the management of spent lead-acid batteries that are being reclaimed.

ETTP is registered as a large-quantity generator under EPA ID No. TN 0890090004 and is permitted to transport hazardous wastes and to operate RCRA-permitted hazardous waste treatment and storage units. During 2009, 20 units operated as permitted units.

ETTP's RCRA storage and treatment facilities (or units) operate under three permits: TNHW-117, TNHW-133, and TNHW-015. The permits are modified when necessary. One permit modification was approved by TDEC in 2009.

3.3.9 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.

ETTP has two USTs registered with TDEC under Facility ID Number 0730088.

3.3.10 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. Decontamination and decommissioning of surplus facilities is the prime mission of ETTP. 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. 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.

3.3.10.1 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.

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 ETTP 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.

3.3.11 Toxic Substances Control Act Compliance Status

3.3.11.1 Polychlorinated Biphenyls

As required by 40 CFR 761.205, Department of Energy (DOE) notified the U.S. Environmental Protection Agency (EPA) Headquarters on April 3, 1990, that the East Tennessee Technology Park (ETTP) is a generator with on-site storage, a transporter, and an approved disposer of PCB wastes.

PCB waste generation, transportation, disposal, and storage at ETTP is regulated under the EPA ID number TN0890090004. In 2009, ETTP operated approximately 35 PCB waste storage areas in generator buildings and RCRA-permitted storage buildings at ETTP for longer-term storage of PCB/radioactive wastes when necessary. The continued use of authorized PCBs in electrical systems and/or equipment (e.g., transformers, capacitors, rectifiers) is regulated at ETTP. The majority of equipment at ETTP that is regulated under the Toxic Substances Control Act (TSCA) has been disposed. However, some of the ETTP facilities continue to use (or store for future reuse) PCB-contaminated equipment (i.e., transformers).

Because of the age of many of the ETTP facilities and the varied uses for PCBs in gaskets, grease, building materials and equipment, DOE self-disclosed unauthorized use of PCBs to EPA in the late 1980s. As a result the DOE Oak Ridge Office and the EPA Region 4 consummated a major compliance agreement known as the Oak Ridge Reservation Polychlorinated Biphenyl Federal Facilities Compliance Agreement which became effective on December 16, 1996. The agreement specifically addresses the unauthorized use of PCBs in ventilation ducts and gaskets, lubricants, hydraulic systems, heat transfer systems, and other unauthorized uses; storage for disposal; disposal; cleanup and/or decontamination of PCBs and PCB items including PCBs mixed with radioactive materials; and records and reporting requirements at the ORR. A major focus of the agreement is the disposal of PCB waste. As a result of that agreement, DOE and BJC continue to notify EPA when additional unauthorized uses of PCBs, such as PCBs in paint, adhesives, electrical wiring, or floor tile are identified at the ETTP.

ETTP is home to the TSCA Incinerator. On December 2, 2009, the TSCA Incinerator ceased operations as a waste incinerator and shifted into a facility closure and decommissioning mode.

3.3.12 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. ETTP complied with these requirements in 2009 through the submittal of reports under EPCRA Sections 302, 303, 311, and 312.

ETTP had no releases of extremely hazardous substances, as defined by EPCRA, in 2009.

3.3.12.1 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 2009 on the ORR, eleven were located at ETTP.

Private-sector lessees associated with the reindustrialization effort were not included in the 2009 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.

3.3.12.2 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.

3.4 Air Quality Program

The U.S. Environmental Protection Agency (EPA) Mandatory Greenhouse Gas (GHG) Reporting Rule was enacted September 30, 2009 under 40 Code of Federal Regulations (CFR) Part 98.2. According to the EPA rule, in general, the emissions threshold for reporting requirement is 25,000 metric tons or more of carbon dioxide equivalent (CO2e) per year. A review was performed of ETTP processes and equipment categorically identified under 40 CFR 98.2 whose emissions must be included as part of a facility annual GHG report starting with the calendar year 2010 reporting period. On December 2, 2009, the K-1435 Toxic Substances Control Act (TSCA) Incinerator (Fig. 3.4) ceased operations as a waste incinerator and shifted into a Facility Closure and decommissioning mode. Based on projected GHG

Fig. 3.4. TSCA Incinerator.

emissions from all remaining sources not to exceed the annual threshold limit, ETTP would not be subject to mandatory annual reporting under the GHG Rule beginning with the 2010 calendar year.

Prior to December 2, 2009, and the subsequent ceasing of operations, ETTP airborne discharges from the TSCA Incinerator were generated while treating solid and liquid wastes 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 was the TSCA Incinerator which was 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 was 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.

Characterization of the impact on public health of radionuclides released to the atmosphere from ETTP operations was accomplished by conservatively estimating the dose to the maximally exposed member of the public. The dose calculations were 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. Source emissions used to calculate the dose are determined using EPA approved methods ranging from continuous stack sampling systems to conservative estimations based on process and waste characteristics. Continuous sampling systems and permitting are required for radionuclide emitting sources that have the potential dose not less than 0.1 mrem per year impact on the most exposed member of the public. The TSCA Incinerator and the K-1423 Solid Waste Repack Facility (K-1423) are the only ETTP sources that have permitted limitations for radionuclide emissions and require continuous sampling systems. ETTP rad NESHAP sources K-1093/K-1094 Waste Sorting Tent, K-1407 Central Neutralization Facility (CNF), K-1423, and the K-2500-H Segmentation Shops A and D are considered minor based on emissions evaluations using EPA approved calculation methods.

The TSCA Incinerator was 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 2009 period of performance, the TSCA Incinerator contributed approximately 8% of the total

ETTP dose to the ETTP-specific most exposed member of the public. Figure 3.5 conservatively illustrates the estimated monthly and annual dose from TSCA Incinerator operations during 2009. During this reporting period, tritium (31%) was the major dose contributor, followed by uranium-238 (22%) and uranium-234 (18%). The total estimated airborne dose for all ETTP rad NESHAP stack emission sources to the most exposed member of the public specific to this facility was only 0.06 mrem/year.

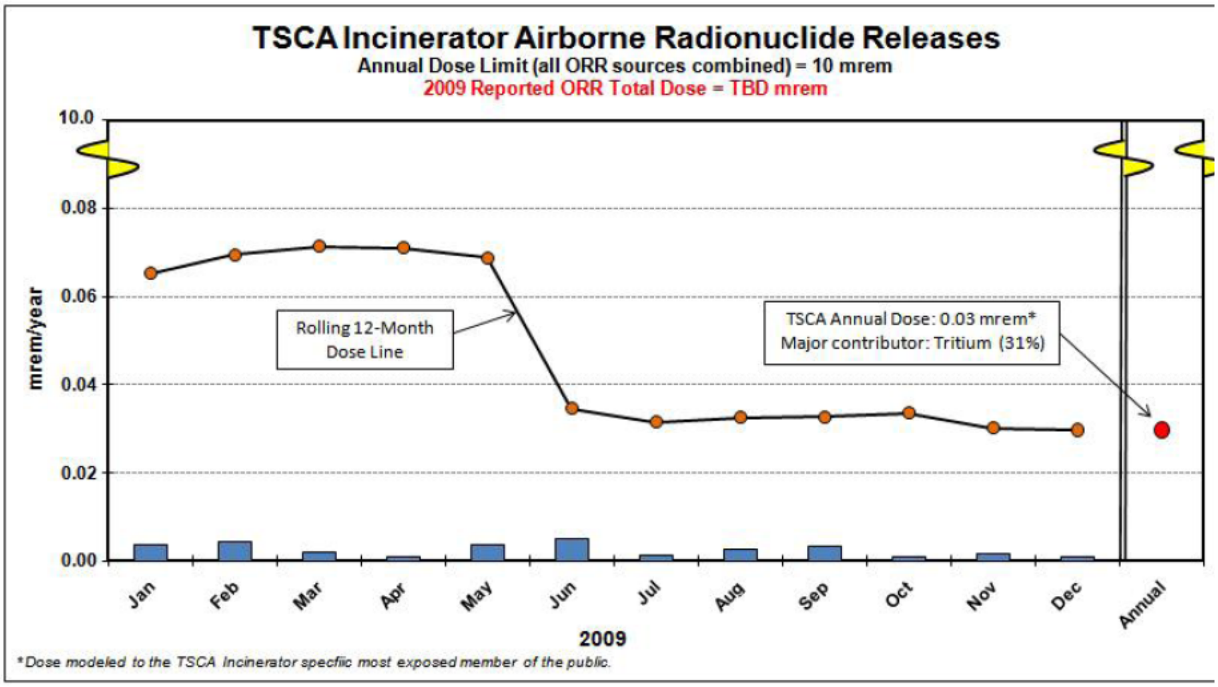

Fig. 3.5. Dose from TSCA Incinerator operations.

CNF was the highest contributor at approximately 70% of the total ETTP specific dose impact. The emissions of radionuclides showed a dose increase as compared to the 2008 reporting period. This result, a lower TSCA Incinerator dose impact, and the close proximity of the public identified CNF as the highest ETTP contributor for 2009.

The K-1423 operation air permit does not require direct monitoring of stack radionuclide emission. Compliance is demonstrated using onsite ambient air environmental sampling for determining the dose impacts on members of the public. The annual dose as measured by environmental sampling at Station K11 was 0.14 mrem. This conservatively represents the exposure of a member of the public if located at this station. The station is conservatively located and collects samples that are potentially impacted by all ETTP sources of radionuclide emissions, including both stack and fugitive emissions, to assure conservative reporting of the estimated dose to an actual onsite member of the public.

Both sources are far below the 10 mrem/year effective dose (ED), which is the rad NESHAP regulatory limit that is the applicable standard for combined radionuclide emissions from all ORR facilities. Emissions from these sources as well as all other ETTP minor stationary sources of radionuclides are included in the annual dose assessment report submitted as required under rad NESHAP regulations.

ETTP operations during 2009 included two stationary sources with permits restricting non-radiological emissions: the TSCA Incinerator and the CNF volatile organic compound (VOC) air stripper. All other stationary sources were evaluated and determined to be below any emission level that would require permitting.

The TSCA Incinerator was the largest permitted operating nonradionuclide air emissions source and the largest source of criteria pollutant emissions such as nitrogen oxides (NOx) and carbon monoxide (CO) for all sources listed in the DOE ETTP Major Source Operating Permit application. Total NOx emissions for 2009 were 15.7 tons (31,347 lb). Total CO emissions were 3.9 tons (7,837 lb). Emissions of all nonradiological regulated air pollutants from TSCA Incinerator operations are noted in Figs. 3.6 through 3.8. In the three categories of data presented, emissions are compared with EPA ambient air quality standards and are identified as criteria pollutants, 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 regulated under Permit No.957808I, as issued by the Tennessee Department of Environment and Conservation (TDEC). Each data point on these figures represents the accumulated pollutant emissions for a continuous 12-

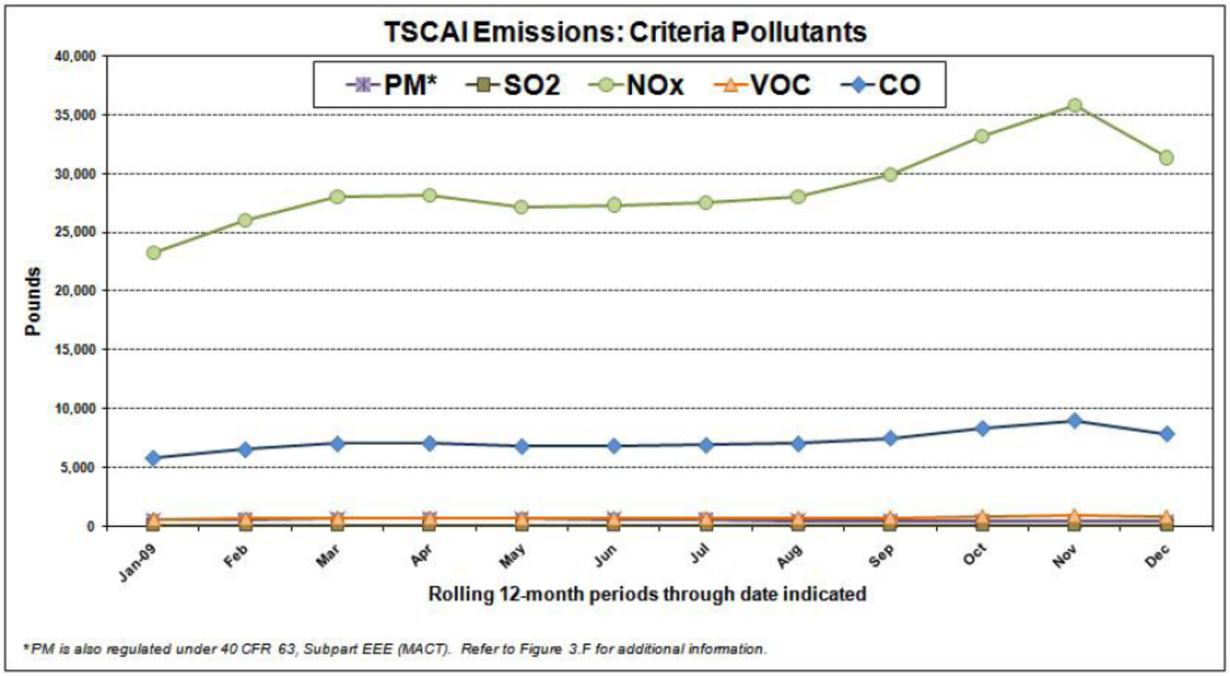

Fig. 3.6. TSCA Incinerator criteria pollutant emissions.

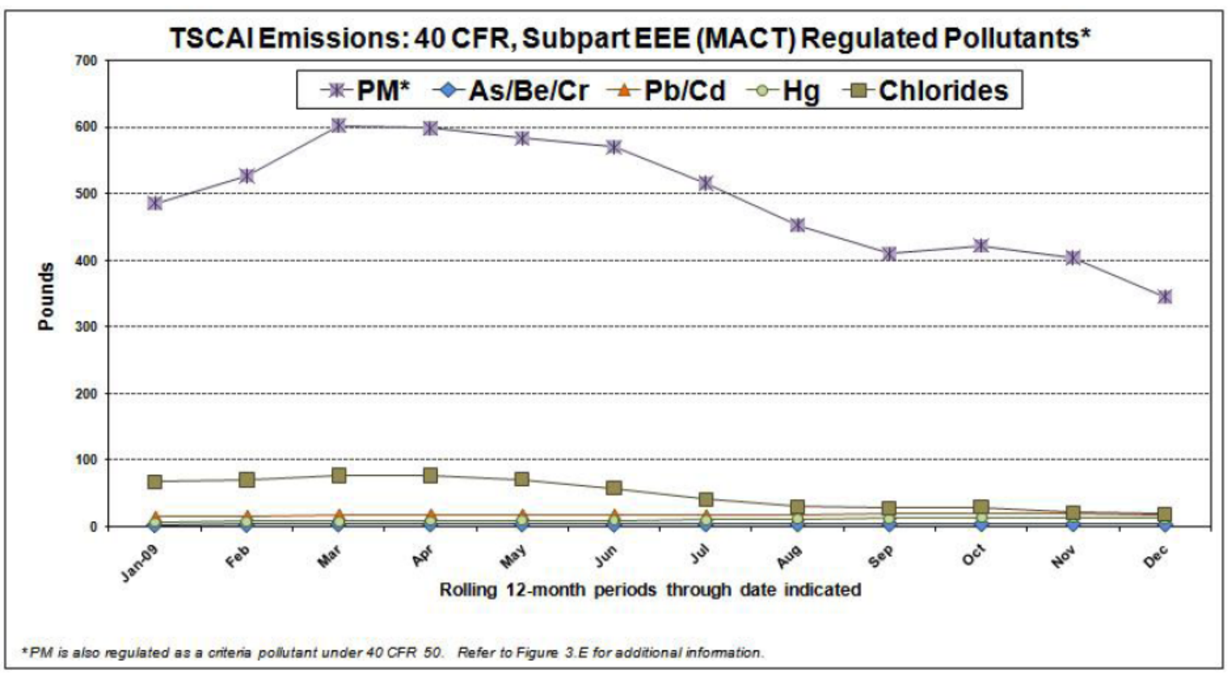

Fig. 3.7. TSCA Incinerator MACT regulated pollutant emissions.

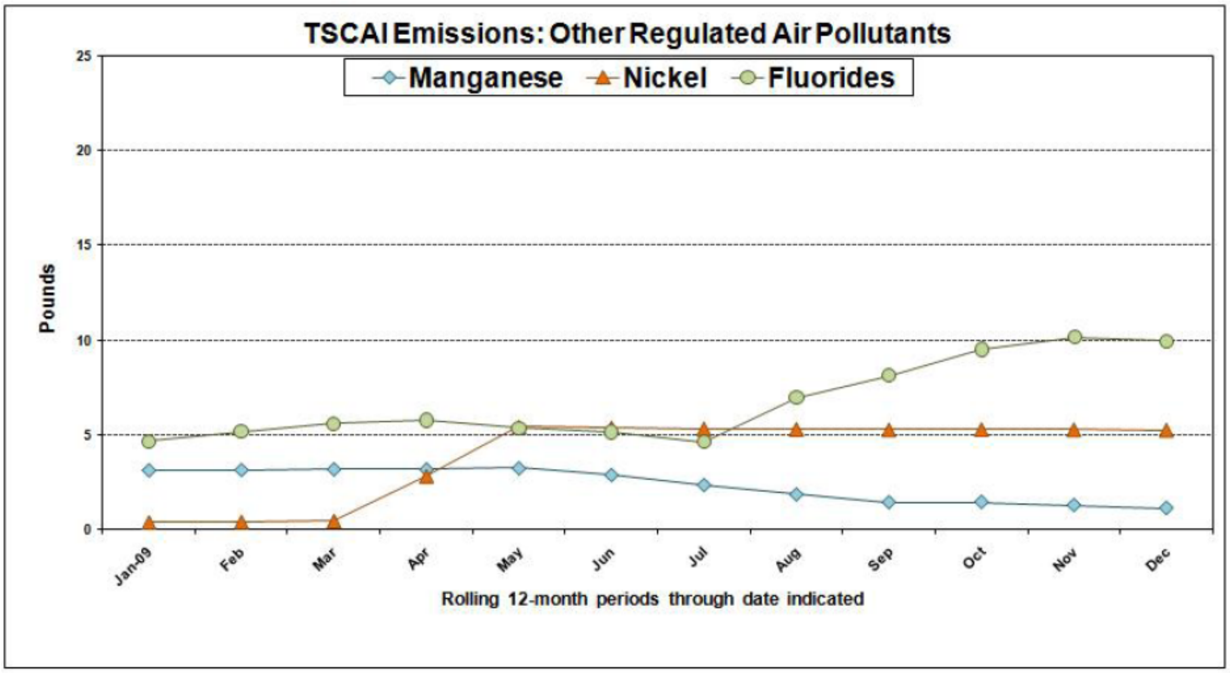

Fig. 3.8. TSCA Incinerator other regulated pollutant emissions.

month period. Table 3.3 lists all TSCA Incinerator emission limits that include those pollutant parameters associated with Figs. 3.6 through 3.8. 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.

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 mercury (Hg) at 29.6%. Emissions of the combination of lead (Pb) and cadmium (Cd) were 23.3% of the permitted limit. The highest emissions result of any other regulated pollutant was for carbon monoxide (CO) at 19.3%.

The CNF air stripper is the only other ETTP air pollutant source under BJC authority that is permitted for non-radionuclide emissions. All process data records and the calculated maximum VOC emission rate for the CNF air stripper were within permitted limits for 2009. The calculated maximum VOC emission rate was only 0.09 lb/hr as compared to the permitted limit of 1.0 lb/hr.

ETTP operations released airborne pollutants from a variety of other minor pollutant emitting sources, such as stacks, vents, and fugitive and diffuse activities. With the exception of the TSCA Incinerator and the CNF air stripper, all other stack and vent emissions are calculated as allowed based on their low emissions to document the verification of their minor source permit exempt status under all applicable state and federal regulations. 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:

- Track long term trends of airborne 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.

Table 3.3. Toxic Substances Control Act Incinerator allowable and actual emissions

Pollutant	Limitation	Annual equivalent	Actual emissions	Percent of Limit
Radionuclides	10 mrem/year—all combined DOE ORR emission sources	10 mrem/year—all DOE ORR emission sources	0.03 mrem/year	0.3
	TSCA administrative limit	7.5 mrem/year		0.4
Particulate matter (PM)	30 mg/dscf	5.0 ton/year	0.17 ton/year	3.1
Sulfur dioxide (SO_2)	8.8 lb/h	38.5 ton/year	0.03 ton/year	0.1
Oxides of nitrogen (NO_x)	Not applicable (N/A)	N/A	15.7 ton/year	N/A
Volatile organic compounds (VOCs)	1.15 lb/h	5.0 ton/year	0.39 ton/year	7.6
Carbon monoxide (CO)/total hydrocarbons (HC)	100 ppmv CO/10 ppmv HC	20.3 ton/year CO/2.03 ton/year HC	3.9 ton/year CO	19.3
Low-volatile metals:	92 µg/dscm combined As-Be-Cr	31.5 lb/year	4.0 lb/year	12.3
Beryllium (normal operations)	0.02 lb/d	7.3 lb/year	0.06 lb/year	0.8
Beryllium (compliance testing)	0.075 lb/d	N/A	N/A	N/A
Semivolatile metals:	230 µg/dscm combined Cd-Pb	76.7 lb/year	17.8 lb/year	22.2
Manganese (Mn)	N/A	N/A	1.1 lb/year	N/A
Nickel (Ni)	N/A	N/A	5.27 lb/year	N/A
Mercury (Hg)	130 µg/dscm	43.1 lb/year	12.8 lb/year	29.0
Hydrogen chloride/chlorine	77 ppmv	6.5 ton/year	0.01 ton/year	0.1
Hydrogen fluoride	0.68 lb/h	5,957 lb/year	3.3 lb/year	0.2
Destruction and removal efficiency	99.99% for each principal organic pollutant/99.9999% for each principal organic hazardous pollutant	N/A	N/A	N/A
Dioxin/furan	0.4 ng/dscm (TEQ)	0.00013 lb/year	N/A	N/A

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

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 utilize samplers specific to a type of potential emissions. Samplers typically include high-volume systems, depending on the source emission evaluation of the project. All base, supplemental, and PAM samplers operate continuously with exposed filters collected weekly. The TSCA stations were only triggered during designated operational upsets at the TSCA Incinerator. Whenever activated, these units would run for no less than four hours to assure any potential plume from an event would be sampled. The TSCA Incinerator ambient air monitors were deactivated when the TSCA Incinerator combustion unit was shut down in December 2009.

The radiological monitoring results of samples collected at the two ETTP area PAM stations were provided by UT-B ORNL staff and are included in the ETTP network for comparative purposes.

Figure 3.9 shows the location of all ambient air sampling stations that were active at some point during this reporting period of CY 2009. Figure 3.10 shows an example of a typical ETTP air monitoring station.

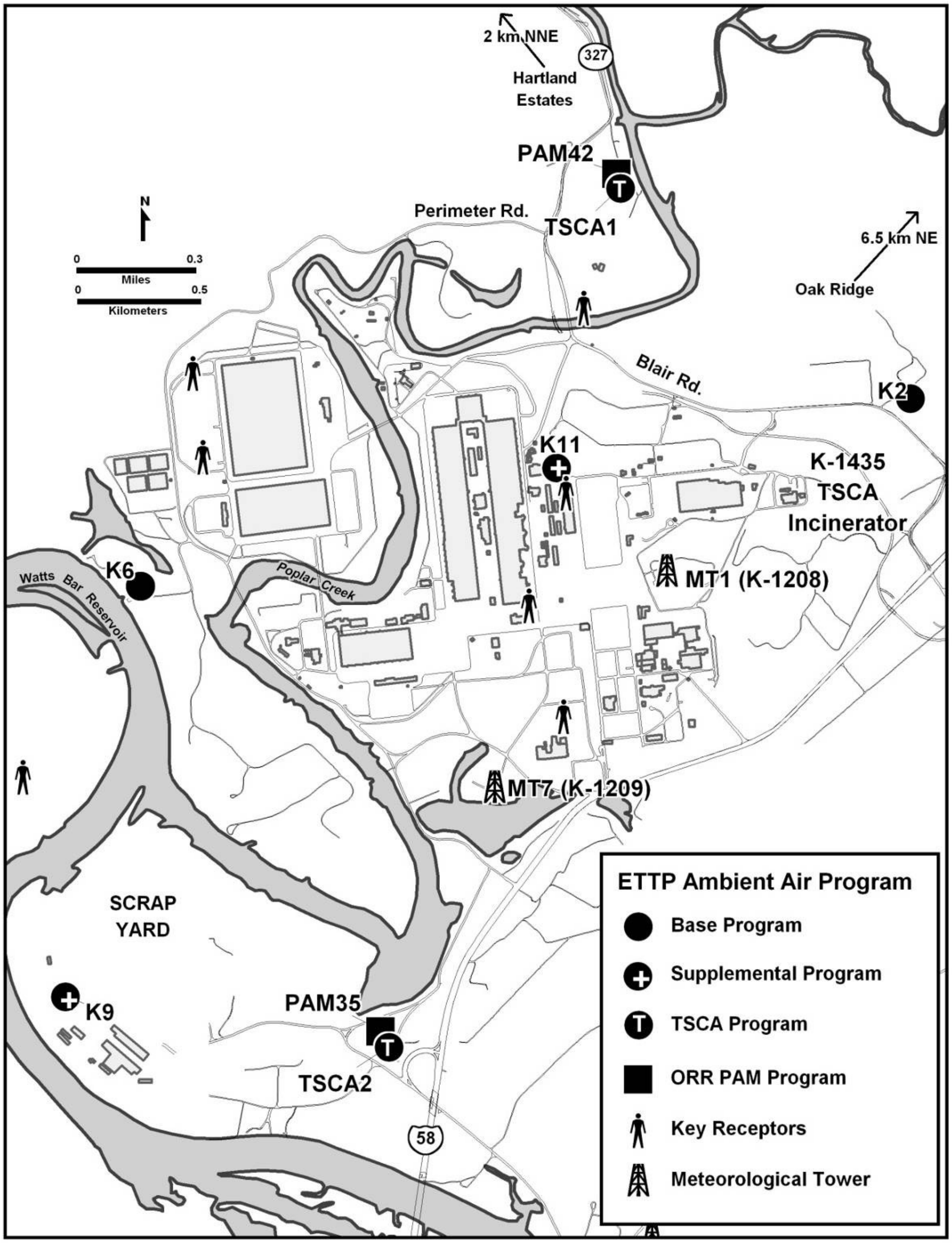

Fig. 3.9. ETTP ambient air monitoring station locations.

Fig. 3.10. Ambient air monitoring station.

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 3.11 through 3.15 illustrate the air concentrations of arsenic (As), beryllium (Be), cadmium (Cd), chromium (Cr), and Pb for the past 5 years, based on quarterly composites of weekly continuous samples. All samples were analyzed by the inductively coupled plasma-mass spectrometer (ICP-MS) analytical technique. The results are compared with any applicable air quality 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 2009 are slightly higher than results reported for 2008 but are within historical trends. The chromium results are conservatively compared with the EPA standard for hexavalent chromium. Lead measurement results indicate that all levels are well within the National Ambient Air Quality Standard (NAAQS) of 0.15 µg/m3.

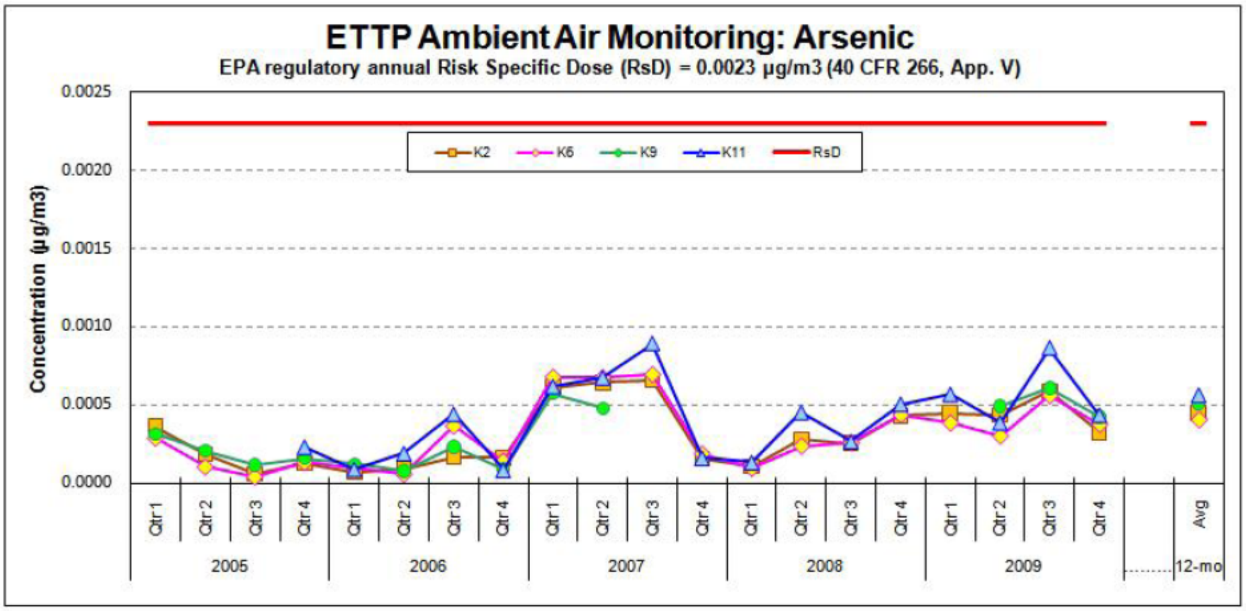

Fig. 3.11. Arsenic monitoring results: 5-year history through 2009.

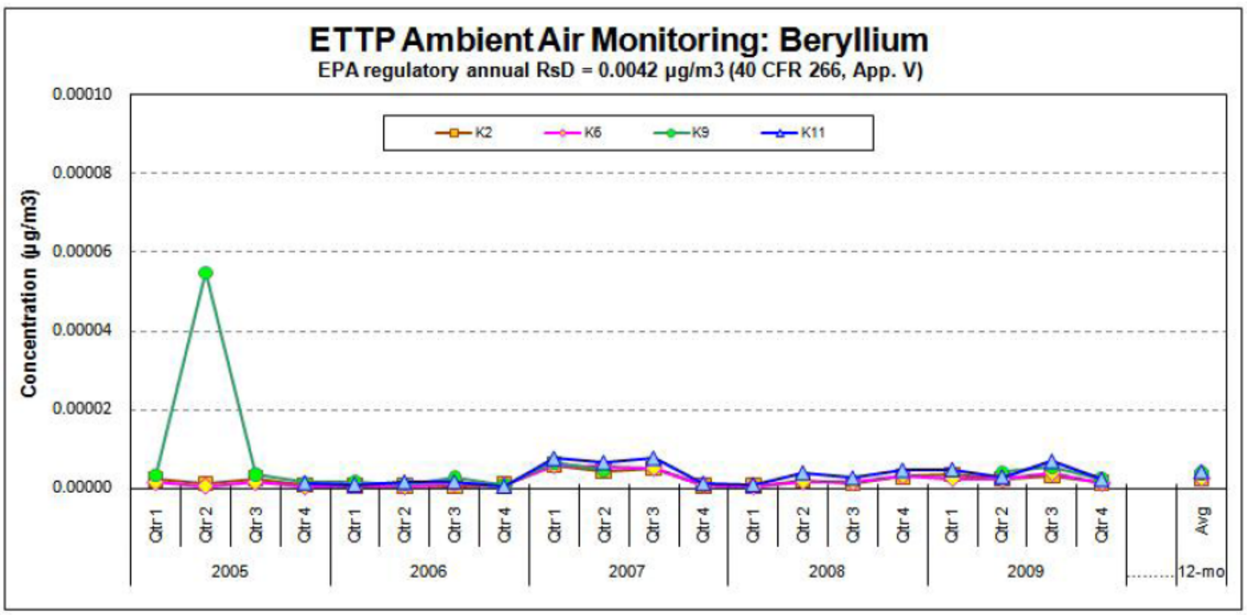

Fig. 3.12. Beryllium monitoring results: 5-year history through 2009.

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 ICP-MS. Figure 3.16 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 3.4. The averaged results ranged from a minimum of approximately 0.000024, up to 0.000122 µg/m3. The highest 12-month average result (0.000122 µg/m3) was measured at Station K2. The annual average value for all stations due to uranium was 0.000074 µg/m3.

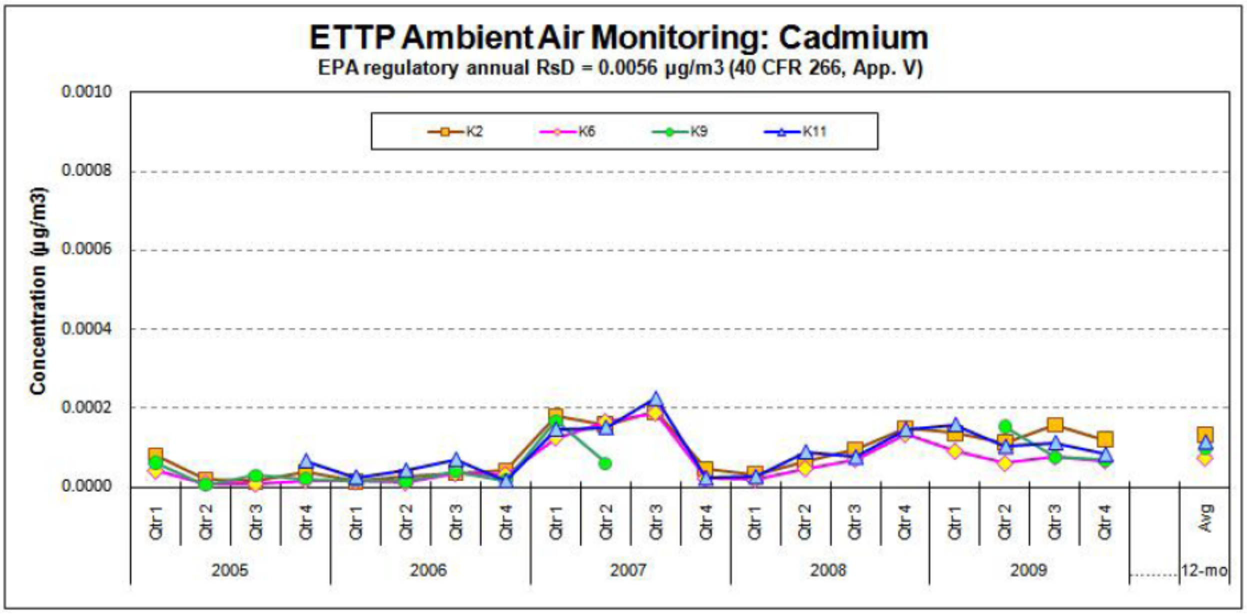

Fig. 3.13. Cadmium monitoring results: 5-year history through 2009.

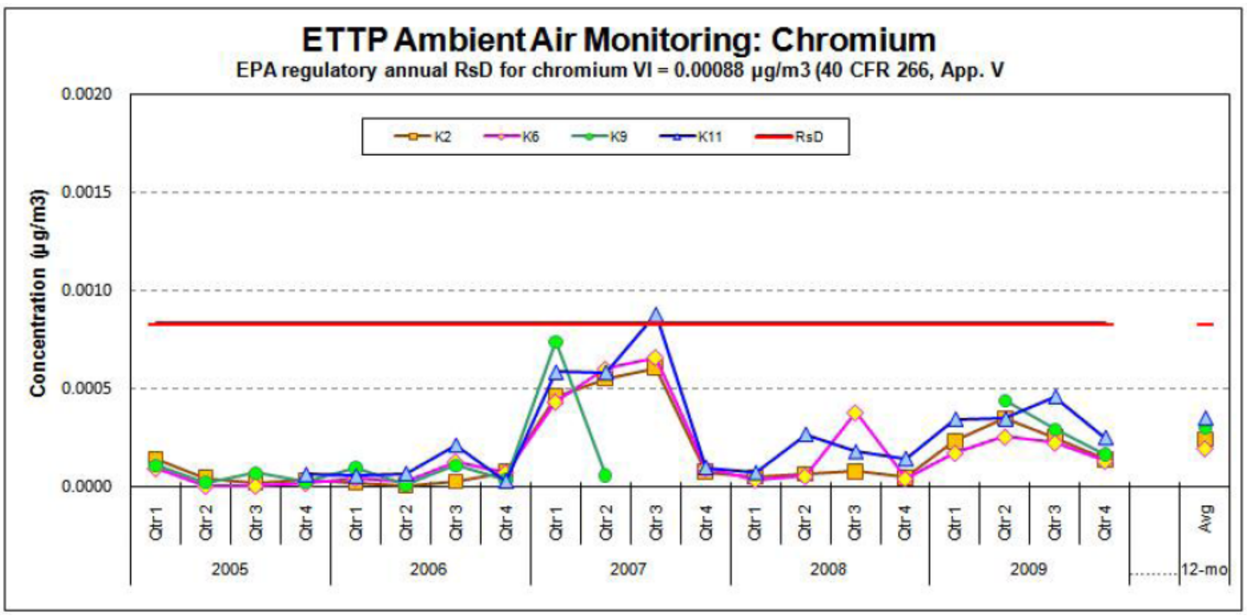

Fig. 3.14. Chromium monitoring results: 5-year history through 2009.

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 0.08% of the DCG. The single sampling location with the highest quarterly concentration (0.000218 µg/m3) was at station K2. If this concentration were extrapolated to a 12 month exposure, it would only represent 0.15% of the DCG. Radiochemical analyses were initiated during CY 2000 on quarterly composite samples collected at all stations. The selected isotopes of interest were 237Np, 238Pu, 239Pu, 99Tc, and isotopic uranium (234U, 235U, 236U, and 238U). The concentration and dose results for each of the nuclides are presented in Table 3.5 for 2009.

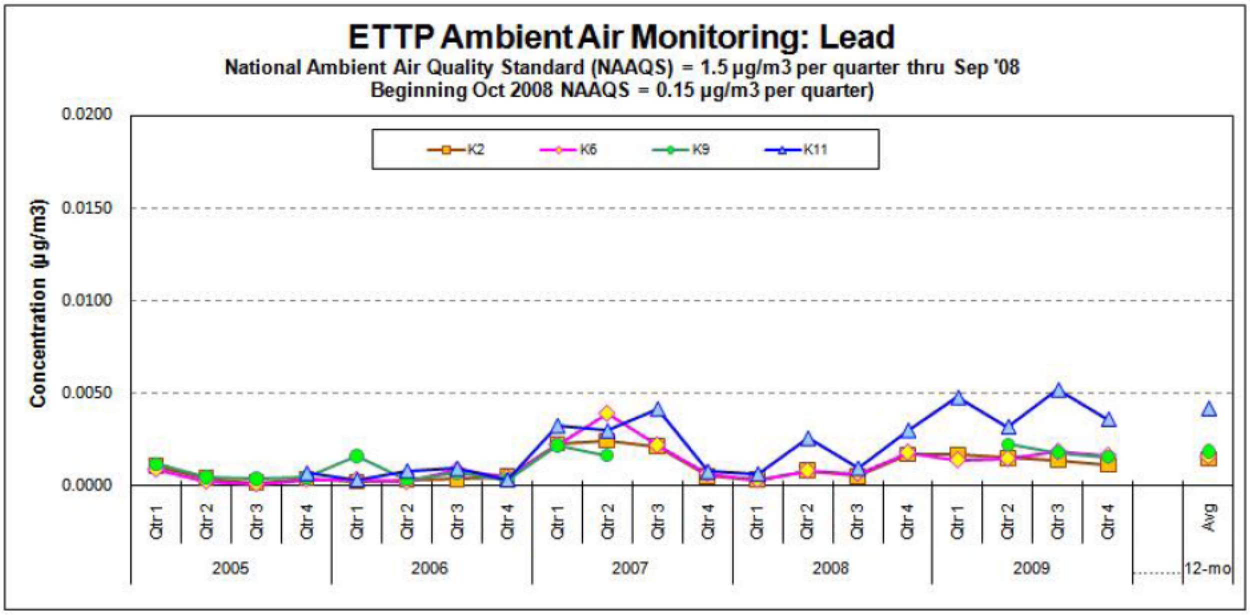

Fig. 3.15. Lead monitoring results: 5-year history through 2009.

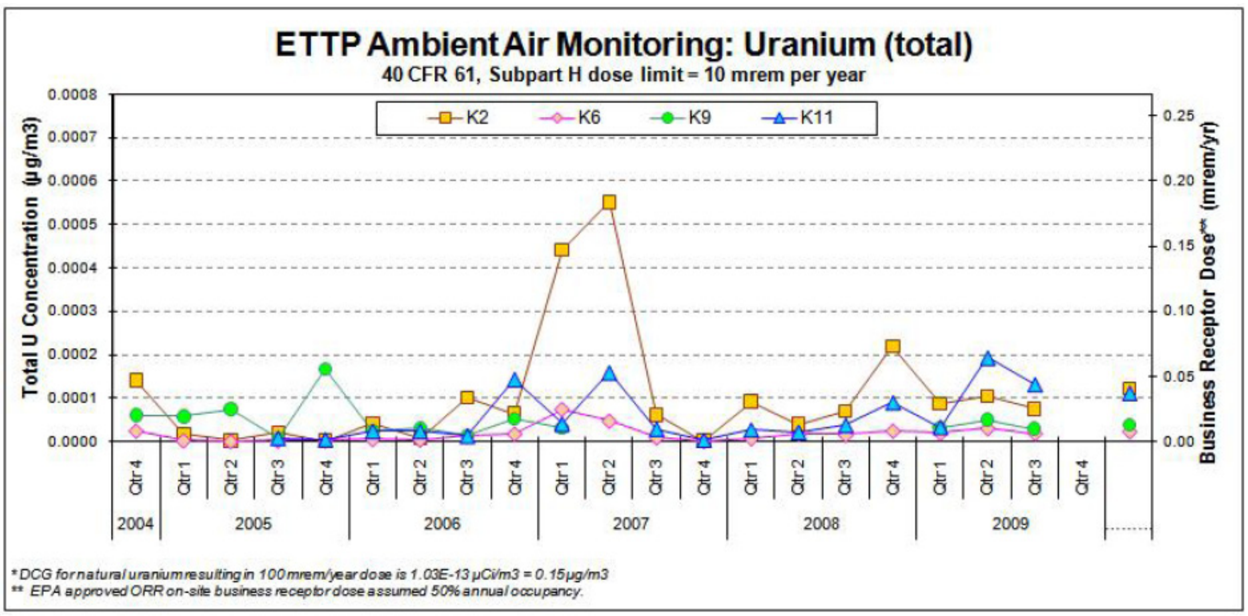

Fig. 3.16. Uranium metal monitoring results: 5-year history through 2009.

All pollutant parameters were chosen with regard to existing and proposed regulations and with respect to activities at ETTP. Station K9 was reactivated due to new remediation activities during this reporting period that have the potential to produce fugitive airborne emissions. Changes of emissions from ETTP may warrant periodic reevaluation of the parameters being sampled. Ongoing ETTP reindustrialization efforts also introduce new members of the public locations that may require modifications to monitoring site locations.

Table 3.4. Total uranium in ambient air by inductively coupled plasma analysis at East Tennessee Technology Park, 2009

Station	No. of Samples	Concentration[a]				Percentage of DCG[b] (%)	
		μg/m^3		μCi/mL			
		Avg	Max[c]	Avg	Max	Avg	Max
K2	4	0.000122	0.000218	8.12E–17	1.45E–16	0.08	0.15
K6	4	0.000024	0.000031	1.60E–17	2.06E–17	0.02	0.02
K9[d]	3	0.000038	0.000051	2.51E–7	3.38E–7	0.03	0.03
K11	4	0.000112	0.000194	7.49E–17	1.29E–16	0.07	0.13
ETTP total	15	0.000074	0.000218	4.93E–17	1.45E–6	0.05	0.15

[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.

[d] Station K9 resumed operations April 2009.

Table 3.5. Radionuclides in ambient air at East Tennessee Technology Park, 2009

Station	Concentration (μCi/mL)								
	Total U	^{237}Np	^{238}Pu	^{239}Pu	^{99}Tc	^{234}U	^{235}U	^{236}U	^{238}U
K2	5.49E–7	ND[a]	7.57E–8	7.20E–8	4.78E–7	2.25E–7	4.54E–9	ND	3.20E–7
K6	2.58E–7	ND	4.41E–8	7.46E–9	6.21E–7	2.01E–7	ND	ND	5.70E–8
K9[b]	3.71E–7	ND	2.28E–8	8.90E–9	7.16E–7	2.77E–7	ND	ND	9.42E–8
K11	2.26E–6	ND	5.68E–8	4.81E–8	3.16E–6	1.83E–6	9.36E–8	3.31E–8	3.12E–7
Station	40 CFR 61, Effective dose equivalent (mrem/year)[c]								
	Total U	^{237}Np	^{238}Pu	^{239}Pu	^{99}Tc	^{234}U	^{235}U	^{236}U	^{238}U
K2	0.027	ND	0.016	0.015	<0.001	0.012	<0.001	ND	0.015
K6	0.013	ND	0.009	0.002	<0.001	0.011	ND	ND	0.003
K9	0.014	ND	0.005	0.001	<0.001	0.011	ND	ND	0.003
K11	0.118	ND	0.012	0.010	0.001	0.097	0.005	0.002	0.015

[a] ND = not detected.

[b] Station K9 resumed operations April 2009.

[c] 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 3.17 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.

3.5 Water Quality Program

3.5.1 ETTP NPDES Permit History

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.

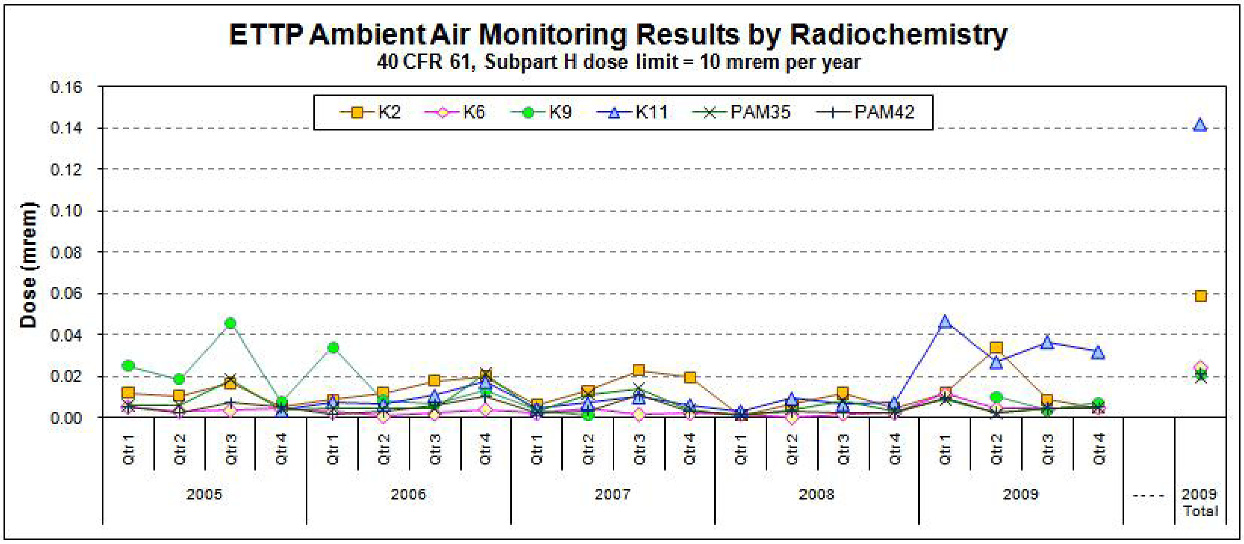

Fig. 3.17. Radionuclide monitoring results: 5-year history through 2009.

Because the ETTP is an operating facility that discharges wastewater to several bodies of surface water, it is required to have a NDPES permit. The ETTP was issued its first NPDES permit in 1975 by the U.S. Environmental Protection Agency (EPA). The permit was to remain in effect until 1980. This permit established technology-based effluent limitations for nine outfalls.

In 1980, the site submitted an application for renewal of the permit within the required 180 days of the expiration date of the permit. The permit was not renewed, and the site operated under the expired permit until 1984. EPA issued the site a new NPDES Permit in 1984 that remained in effect until February 1989. Under this permit, ETTP had eight NPDES monitoring locations, including the K-1700 weir, K-1203 Sewage Treatment Plant (STP), K-1007-P1 Pond, K-901-A Pond, K-710 STP, K-1515-C Holding Lagoon, K-1407-E/F Ponds, and Central Neutralization Facility (CNF).

The EPA granted the State of Tennessee primacy for administration of the NPDES permitting program in 1986. The ETTP submitted an application for renewal of the NPDES permit to TDEC in August 1988. Because of staffing shortages at TDEC, permit negotiations were delayed until early 1992. Written approval was granted by TDEC to allow the site to continue operating under the conditions of the expired permit until a renewed permit could be issued.

On October 1, 1992, NPDES Permit TN0002950 became effective. Several of the eight monitoring locations specified in the previous ETTP NPDES permit were re-designated as ambient surface water monitoring locations. Effluent limitations in the 1992 NPDES permit were water quality-based, which reflected the trend toward considering the effects of industrial discharges on the quality of the receiving streams. In accordance with the federal regulations requiring the inclusion of storm water discharges in the NPDES permitting program, each of the 137 storm water outfalls that had been identified at ETTP were included in this permit, in addition to several other major outfalls. Also, the development of a Storm Water Pollution Prevention (SWPP) Plan was required. TDEC issued a major modification to this NPDES Permit that became effective June 1, 1995. This modification included: (1) removal of Outfalls 010 and 012; (2) changes to monitoring requirements for Outfall 014 to allow for treatment of contaminated groundwater; (3) changes to Outfall 005 permit limits to make them more consistent with other sewage treatment plants; (4) clarification of some ambiguous permit language; and (5) updating of storm water outfall numbers.

ETTP NPDES Permit TN0002950 expired on September 29, 1997. An application for renewal of the ETTP NPDES Permit was submitted to TDEC in March 1997. To facilitate the privatization of ETTP facilities, separate permits were requested for the K-1203 STP, the CNF, the K-1515 Sanitary Water Plant (SWP) and the ETTP storm water outfalls. A general permit for the K-1515 SWP (permit number TN0074233) was issued by TDEC and became effective on March 1, 2000. A permit for the K-1203 STP (permit number TN0074241) was issued by TDEC and became effective on August 1, 2003. A permit for the CNF (permit number TN0074225) was issued by TDEC and became effective on November 1, 2003. The current permit for the ETTP storm water outfalls (permit number TN0002950) was issued by TDEC and became effective on April 1, 2004. This permit expired on March 31, 2008. ETTP discharged storm water under the expired NPDES Permit until March 31, 2010.

An application for a new NPDES storm water discharge permit was submitted to TDEC in October 2007. The new NPDES permit was issued on February 26, 2010 and became effective on April 1, 2010. This permit will remain in effect until December 31, 2013. This NPDES Permit regulates the discharge of storm water runoff, groundwater infiltration, groundwater from sumps, and steam condensate from ETTP to Mitchell Branch, Poplar Creek, and the Clinch River. There will be 108 NPDES-permitted storm water outfalls at ETTP addressed in the reissued permit listed in two groups based on the types of flows being discharged through the outfalls.

Management of the sanitary sewer system at ETTP has been turned over to the City of Oak Ridge (COR) as part of an agreement between DOE, the Community Reuse Organization of East Tennessee (CROET), and the City of Oak Ridge. Under this agreement, sewage from ETTP is now being piped to the Rarity Ridge sanitary sewage treatment plant located approximately one mile west of ETTP. The NPDES permit for this facility is assigned to the COR who performs all monitoring and reporting required by the permit.

All BJC connections to the sewage colleciton system are covered by a “No Discharge Certification” process derived from the COR wastewater control requirements in accordance with the City Sewage Treatment Plant NPDES permit. The “No Discharge” certification states that BJC Operations will only discharge waste that is associated with normal quantities of material associated with normal human habitation to the COR sewage collection system. These discharges primarily include waste from break rooms, rest rooms, change houses, etc. As part of the “No Discharge Certification” process, notification is provided to the COR by BJC when planned operational changes are made to BJC facilities that could affect the COR sewage collection system. ETTP is also subject to the provisions of the COR “Sewer Use Ordinance”, which defines the terms and conditions under which the COR accepts discharges to its sewage collection system.

3.5.1.1 ETTP NPDES Permit Requirements

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. 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—**Group IV 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 3.6).
- **Group III storm water outfalls—**Group III 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 3.7).
- **Group II storm water outfalls—**Group II 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 3.8).

Table 3.6. 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

[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 analyses shall be performed within 15 min of sample collection.

Table 3.7. 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	<6.4 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

[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 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.

- **Group I storm water outfalls**—Group I 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 3.9).

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

Table 3.8. 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	<6.4 or >8.4
Total suspended solids (TSS) (mg/L)	SM-2540 D	Annually	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 3.9. Group I Storm Water Outfalls[a,b]

Parameter	Method	Frequency	Sample type	Minimum	Maximum	Screening level
Flow (MGD)	Estimated[c]	Semiannually	NA	NA	NA	NA
pH (standard units)[d]	EPA-150.1	Semiannually	Grab	6.0	9.0	<6.4 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.

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.

Storm water discharges from ETTP 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.

The Biological Monitoring and Abatement program (BMAP) is also a requirement of NPDES Permit No. TN0002950. Its purpose is to assess the ecological health of the ETTP's receiving streams and ponds. The BMAP consists of three tasks: toxicity monitoring, bioaccumulation monitoring, and ecological surveys of in-stream communities (both fish and benthic macroinvertebrates). The BMAP monitoring program is conducted by the Oak Ridge National Laboratory (ORNL) Environmental Sciences Division (ESD) under the direction of the ETTP EC&P Organization. Details of the monitoring are provided in the most current revision of BJC/OR-763, *East Tennessee Technology Park Biological Monitoring and*

Abatement Program Sampling and Analysis Plan. In addition, each task is governed by task-specific procedures generated and maintained by ESD.

The toxicity monitoring task for BMAP includes tests of effluent from selected storm water outfalls concurrently with surface water from ambient sites in Mitchell Branch. Water fleas (*Ceriodaphnia dubia*) are used for toxicity testing. Caged clams *(Corbicula fluminea)* are placed in several water bodies at ETTP. After four weeks, they are removed and analyzed for polychlorinated biphenyls (PCBs) and mercury. Fish are collected from selected water bodies at ETTP. Largemouth bass are collected from the pond sites, and redbreast sunfish are collected from creek sites. Game fish of a size large enough to be taken by sports fishermen are selected both to provide more accurate data of potential human health concerns and to reduce the amount of variation in contamination levels in the individual fish due to age and size differences. Fillets are taken from each game fish and analyzed for PCBs. Beginning in CY 2009, fish are also being analyzed for mercury. Both fish communities and benthic macroinvertebrate communities at selected locations are sampled. Species diversity and density of each are examined.

3.5.1.2 Comparison of SWP3 Sampling Results to Screening Levels

The purpose of the SWPP sampling program is to evaluate and characterize storm water runoff from ETTP. Analytical parameters to be monitored at each storm water outfall were chosen based on the following criteria:

- a review of available analytical data from previous storm water sampling efforts;
- knowledge of various processes and functions which have been conducted at ETTP;
- current and past material storage and handling practices; and
- current and past waste disposal practices employed at ETTP.

The SWPP Program sampling effort provides information that is required as part of the ETTP NPDES Permit renewal process. The sampling effort also incorporates an increased emphasis on the identification of specific sources of pollutants that may be transported by storm water. This information is used to support the site cleanup program that is being conducted in accordance with CERCLA requirements.

Analytical results from the SWP3 sampling effort conducted in 2009 were compared with applicable screening levels to identify locations where storm water runoff could be contributing pollutants to receiving waters. These screening levels were applied to all data collected as part of the 2009 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 level for that parameter. Applicable screening levels for data collected as part of the SWP3 sampling program are listed in Table 3.10.

Screening levels are provided for implementation with the laboratory, in order to receive early and immediate notification that a result is approaching or has exceeded an effluent limitation. Early notification can lead to actions that prevent a noncompliance or multiple noncompliances with the permit. Notification of storm water screening level exceedances should be sent automatically from designated subcontract laboratories to the BJC Sample Management Office (SMO) upon completion of sample analysis and verification of analytical results. The SMO is responsible for immediately notifying ETTP Environmental Compliance and Protection (EC&P) personnel that the screening level exceedance has occurred.

The screening level 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 levels 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 levels 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.

Table 3.10. Project quantitation[a] 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
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

Table 3.10 (continued)

Parameter	Project quantitation level	Screening level	Reference standard	Units
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
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

[a] Quantitation is defined as the lowest amount of analyte in a sample that can be quantitatively determined with suitable precision and accuracy.

Exceedances of screening levels indicate potential areas of concern. Screening levels are used to identify discharges that may require further investigation. If a screening level is exceeded, an investigation is undertaken by EC&P personnel to determine the cause of the exceedance. Personnel from the EC&P Organization will observe the storm water outfall(s) where the screening levels were exceeded to determine if best management practices or other corrective measures may be required. When necessary, corrective actions will be implemented to ensure that an NPDES permit limit or other reference standard is not exceeded during subsequent sampling events.

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 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 radiological 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 3.11 were analyzed for gross alpha/gross beta radiation, isotopic uranium, total uranium, and ^{99}Tc.

Table 3.11. Storm water sampling for the PCCR

Sampling location	Gross alpha/ gross beta	Total uranium	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	X	X	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 Documen*t (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 2008, 2009) concerning sample documentation, analytical procedures, quality assurance (QA), and quality control (QC) were followed as part of this sampling effort.

Sampling locations were chosen based on the observed runoff characteristics for the building pad. The exact number of sampling locations was also changed in some instances based on runoff flow patterns. 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.

As part of the 2009 SWPP Program sampling effort, samples were collected at the north side of the K-1420 building footprint (Fig. 3.18) 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, these samples were only collected during March, September, and October 2009. Analytical results exceeding screening levels in 2009 for outfalls 158, 160, and 170 as well as for the K-1420 pad runoff are given in Table 3.12.

Fig. 3.18. The K-1420 pad after demolition.

Table 3.12. Results exceeding screening levels for 2009 radiological monitoring performed in conjunction with D&D activities[a]

Sampling Location	Date Sampled	Gross alpha radiation (pCi/L)	Gross beta radiation (pCi/L)	Tc-99 (pCi/L)	U-233/234 (pCi/L)	U-238 (pCi/L)	Total Uranium (µg/L)
Outfall 158	3/26/09	153	58.4	*b*	75.6	47.3	145
Outfall 160	3/26/09	568	131	–	491	73	230
K-1420 Pad runoff	3/26/09	43.6	--	–	63	--	--
Outfall 158	9/16/09	79.2		–	47	32.1	97.2
Outfall 160	9/16/09	347	68.4	–	275	48	149
Outfall 170	9/16/09	–	–	–	–	–	–
K-1420 Pad runoff	9/16/09	49.1	–	–	35.9	–	–
Outfall 158	10/14/09	79	–	–	38.1	–	71.8
Outfall 160	10/14/09	312	–	–	205	60.2	186
Outfall 170	10/14/09	–	–	–	–	–	–
K-1420 Pad runoff	10/14/09	91.4	–	–	69.1	–	41.5

[a] Screening levels are 15 pCi/L gross alpha radiation, 50 pCi/L gross beta radiation, 4,000 pCi/L Tc-99, 20 pCi/L U-233/234, 24 pCi/L U-235 and U-238, and 31 µ/L total uranium.

b Dash indicates below screening level thresholds.

In 2009, gross alpha radiation was detected in the discharges from storm water outfalls 158 and 160 and the K-1420 pad at levels greater than 15 pCi/L, which is the screening level developed from the maximum contaminant level (MCL) established by the Safe Drinking Water Act. Gross alpha radiation for outfall 170 was below screening level. Compared to historical data (Fig. 3.19 and Tables 3.13, 3.14, 3.15, and 3.16) the results for the 2009 SWPP Program sampling effort are representative of the levels of gross alpha radiation normally found at these locations.

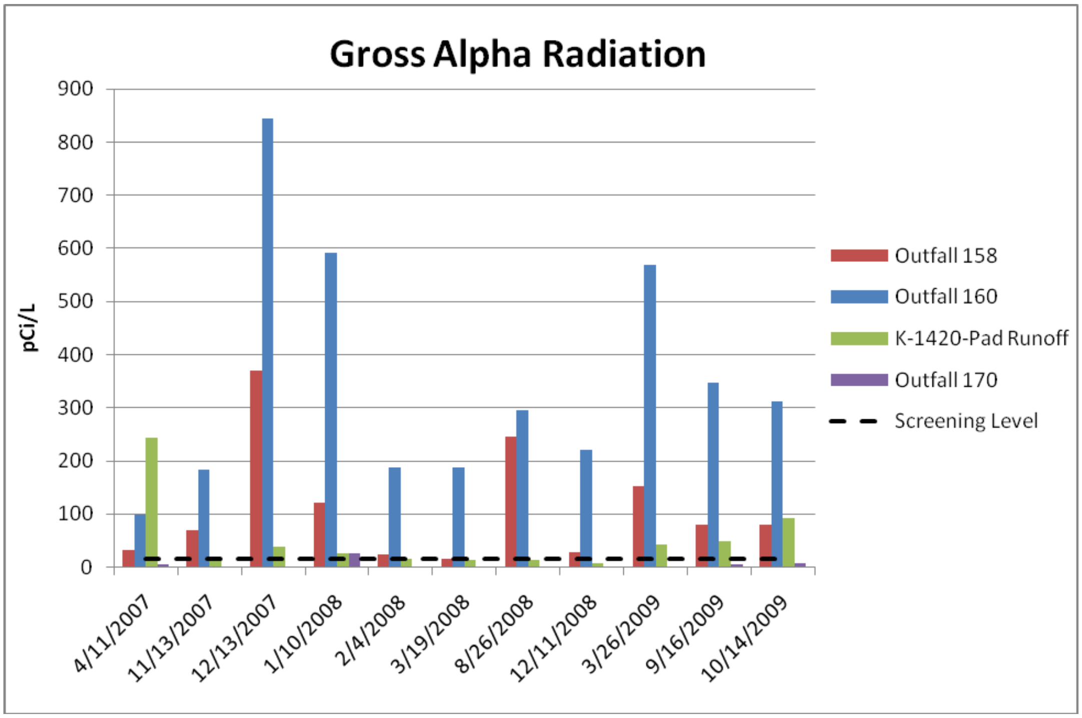

Fig. 3.19. Relative levels of gross alpha radioactivity in discharges from outfalls 158, 160, 170 and the K-1420 pad.

Table 3.13. Analytical results from sampling performed at storm water outfall 158

	Gross alpha (pCi/L)	Gross beta (pCi/L)	U-233/234 (pCi/L)	U-235/236 (pCi/L)	U-238 (pCi/L)	Tc-99 (pCi/L)	Total U (μg/L)
Screening level	15	50	20	24	24	4000	31
July 2003	98.8	97.5	0.068 U[a]	–0.021	–0.034	No data	No data
May 2004	64.9	44.7	31.87	1.86	18.59	No data	No data
April 2007	33.2	14	19.9	1.94	12.3	No data	37.5
November 2007	69.2	50.1	37.1	1.91	23.1	47.4	69.6
December 2007	370	100	153	12	96.9	69.5	294
January 2008	121	42.3	48.3	3.55	32.4	26.2	98
February 2008	23.8	17.6	11.3	0.994	7.7	14.5	23.4
March 2008	15.8	19.7	8.71	0.041 U	5.44	13.7	16.2
July 2008	89.6	60.7	40.9	3.94	30.9	46.3	93.7
August 2008	245	66	121	7.36	68.2	55.7	206
December 2008	27.3	19.5	63 U	0.72	8.2	14.4	25.2
March 2009	153	58.4	75.6	5.18	47.3	32	145
September 2009	79.2	46.1	47	3.53	32.1	45.1	97.2
October 2009	79	20.8	38.1	2.29	23.8	23	71.8

[a] U—analyte not detected in sample.

Table 3.14. Analytical results from sampling performed at storm water outfall 160

	Gross alpha (pCi/L)	Gross beta (pCi/L)	U-233/234 (pCi/L)	U-235/236 (pCi/L)	U-238 (pCi/L)	Tc-99 (pCi/L)	Total U (µg/L)
Screening level	15	50	20	24	24	4000	31
March 2001	114	49	66	4.32	38	84	No data
August 2001	48	49	37.38	1.78	7.42	54	No data
January 2002	1020	421	591.9	32.01	108.9	445	No data
February 2004	203	78.2	151.7	10.89	89.68	23.7	65.4
April 2007	98.2	56.3	85.9	5.04	21.2	78	37.5
November 2007	183	72.9	117	8.88	62.7	61.9	191
December 2007	845	152	547	30.3	202	96.2	615
January 2008	592	239	405	18.6	73.8	280	228
February 2008	188	47.5	130	6.31	21.1	54.1	65.7
March 2008	185/191	54.8/90.8	137/150	8.7/10.3	20.7/22.2	58.4/61.4	65.6/70.8
August 2008	296	135	216	10.3	59.7	213	182
December 2008	221	73.9	170	8.1	23.2	74.8	73.4
March 2009	568	131	491	22.7	73	174	230
September 2009	347	68.4	275	13.5	48	73.8	149
October 2009	312	43.9	205	14.9	60.2	41.5	186

Table 3.15. Analytical results from sampling performed at storm water outfall 170

	Gross alpha (pCi/L)	Gross beta (pCi/L)	U-233/234 (pCi/L)	U-235/236 (pCi/L)	U-238 (pCi/L)	Tc-99 (pCi/L)	Total U (µg/L)
Screening level	15	50	20	24	24	4000	31
January 2002	2.77 U	9.09	1.10	0.03 U	0.44	2.96 U	No data
July 2002	2.46 U	15.2	1.32	0.05 U	0.57	<8.24	No data
September 2005	1.28 U	4.68 J	0.60 J	0.01 U	0.37 J	2.98U	No data
April 2007	5.07	2.46 U	7.17	0.44	2.93	27.2 U	8.92
January 2008	26.3	36.3	98.1	6.14	7.89	13.8	26.3
September 2009	6.11	8.11	2.96	0.19	0.67	10.3	2.09
October 2009	7.16	7.37	3.09	0.29 U	1.01	13.6	3.13

Table 3.16. Analytical results from sampling performed at the K-1420 building pad

	Gross alpha (pCi/L)	Gross beta (pCi/L)	U-233/234 (pCi/L)	U-235/236 (pCi/L)	U-238 (pCi/L)	Tc-99 (pCi/L)	Total U (µg/L)
Screening level	15	50	20	24	24	4000	31
April 2007	243	117	194	12	24.8	222	79.4
November 2007	20.8	9.94	15	0.923	2.95	5.04 U	9.2
December 2007	39.1	12.5	28.6	1.66	5.11	4.97 U	16
January 2008	26.7	15.1	17.3	1.03	3.3	11.7	10.3
February 2008	16.1	10.6	11.6	0.426	1.69	12	5.23
March 2008	12.6	23.4	11.2	0.73	1.69	24.7	5.37
August 2008	13.6	2.11 U	11.2	0.766	2.07	4.09 U	6.51
December 2008	6.9	5.34	63 U	0.23	1.2	2.9 U	3.9
March 2009	43.6	19.9	63 U	1.8	6	13.9	19
September 2009	49.1	25.5	35.9	2.13	7.22	48.2	22.5
October 2009	91.4	24.7	69.1	5.02	13.2	17.3	41.5

Gross beta radiation was detected in the discharges from outfalls 158 and 160 at levels that exceed the screening level of 50 pCi/L developed from the MCL compared to historical data (Fig. 3.20 and Tables 3.13, 3.14, 3.15, and 3.16). The results for the 2009 sampling effort are representative of the level of gross beta radiation normally found at these locations. Gross beta radiation for outfall 170 was below screening level.

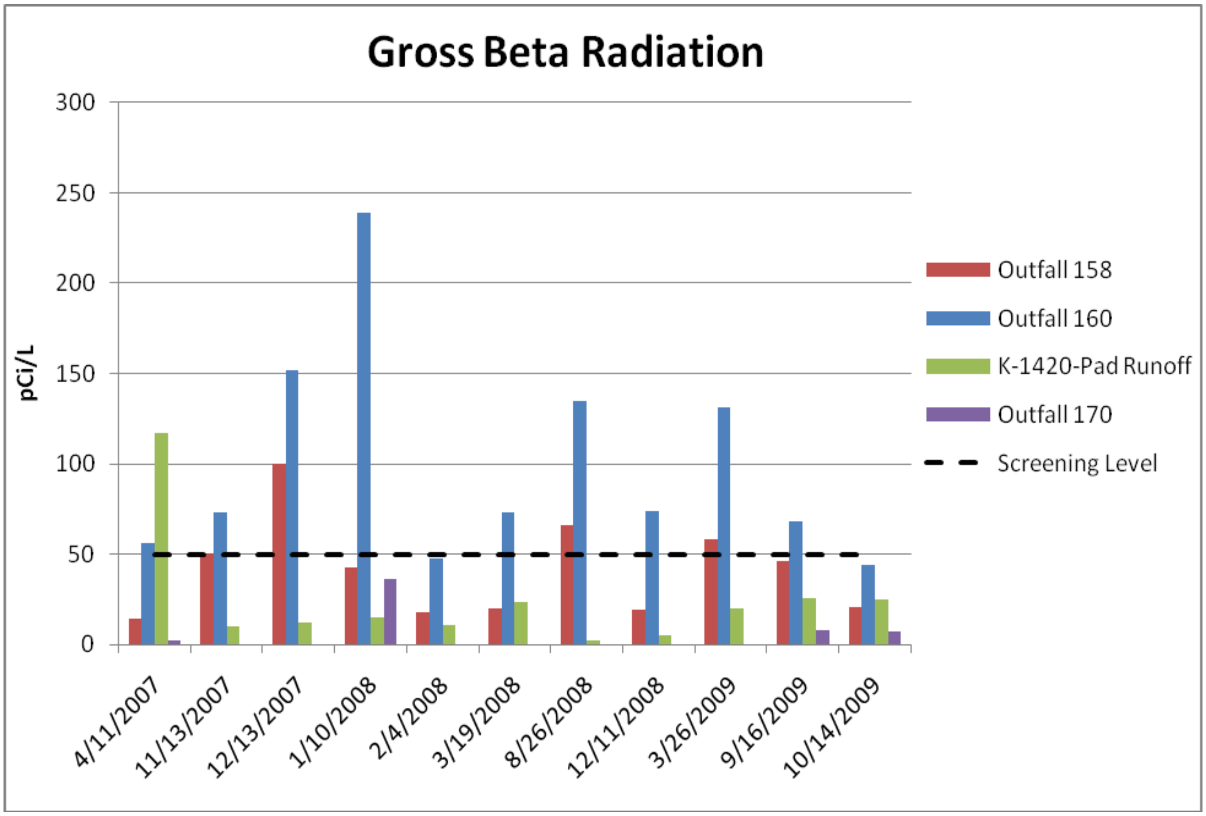

Fig. 3.20. Relative levels of gross beta radioactivity in discharges from outfalls 158, 160, 170 and the K-1420 pad.

No Tc-99 was detected at levels above the screening level of 4000 pCi/L in samples collected at outfalls 158, 160, and 170 and the K-1420 pad as part of the 2009 SWPP Program (Tables 3.13, 3.14, 3.15, and 3.16).

Uranium 233/234 was detected in the discharge from outfalls 158, 160, and the K-1420 Pad in 2009 at levels that exceed the 4% of DCG level of 20 pCi/L for this radionuclide, as seen in Fig. 3.21. Exceedances were not detected for outfall 170. Historical data for U-233/234 collected at this location (Tables 3.13, 3.14, 3.15, and 3.16) indicate that the U-233/234 data for 2009 were near the middle of the range of the historical results.

U-235/236 was not detected at levels above the 4% of DCG level of 24 pCi/g for the 2009 SWPP Program sampling effort (Tables 3.13, 3.14, 3.15, and 3.16).

Uranium 238 was detected in discharges from outfalls 158 and 160 at levels that exceed the 4% of DCG level of 24 pCi/L. Exceedances were not detected for outfall 170 or the K-1420 pad. Comparing the 2009 results to historical data for U-238 collected from these locations (Tables 3.13, 3.14, 3.15 and 3.16) indicate that U-238 results collected as part of the 2009 SWPP Program are near the middle of the range of the historical results.

Total uranium was detected in the discharge from storm water outfalls 158 and 160 and K-1420 pad at levels that exceed the screening level of 31 µg/L. Exceedances were not detected for outfall 170. Total uranium results collected as part of the 2009 SWPP Program are several times higher than the screening level at outfalls 158 and 160. However, a comparison to historical results available for total uranium

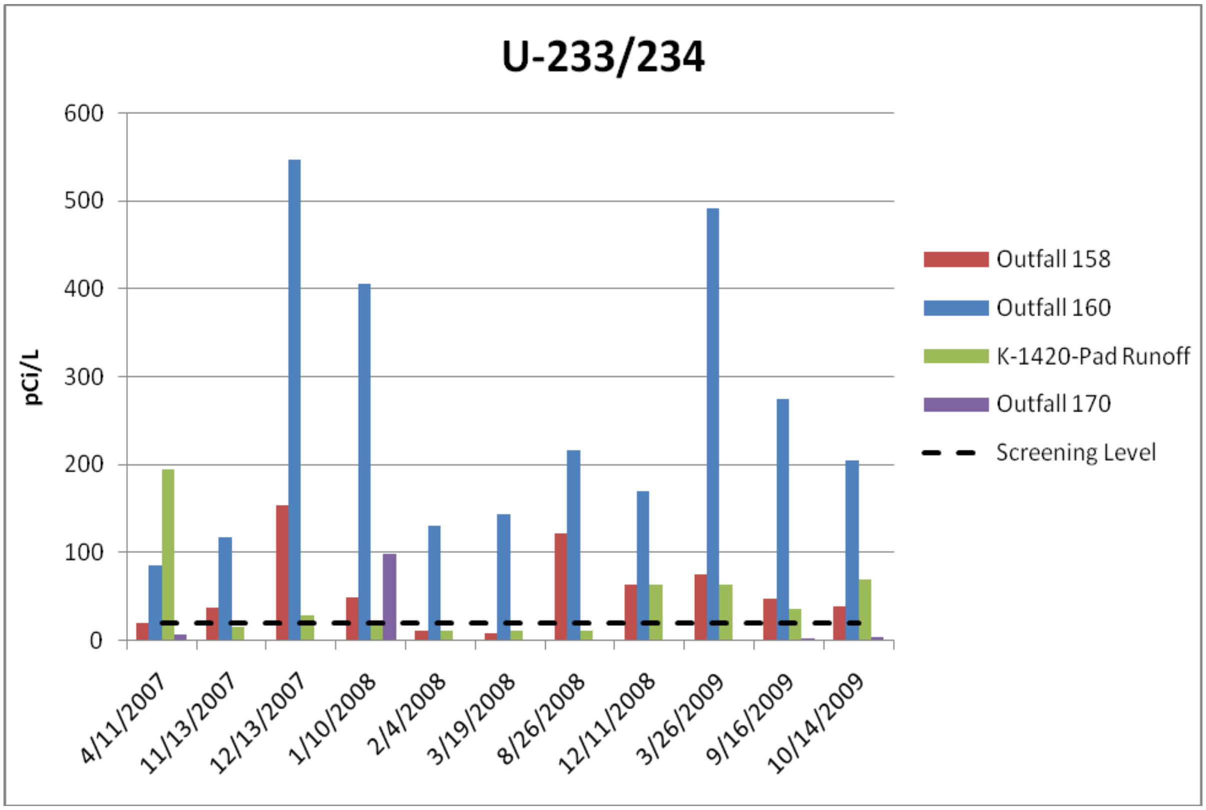

Fig. 3.21. Relative levels of U-233/234 in discharges from outfalls 158, 160, 170 and the K-1420 pad.

(Tables 3.13, 3.14, 3.15, and 3.16) indicates that total uranium results collected as part of the FY 2009 SWPP Program are within the range of historical results.

Gross alpha radiation was detected in the runoff from the K-1420 pad at levels greater than the MCL of 15 pCi/L (Fig. 3.19). However, the levels of gross alpha radiation were, in almost all cases, much lower than levels observed in the storm water outfalls associated with the 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. Analytical results collected since April 2007 (Table 3.16) indicate that total uranium concentrations are two orders of magnitude below the 2600 pCi/L level. Therefore, it can be concluded that the K-1420 pad is no longer a significant contributor of radioactive contaminants to the storm drain system.

In April 2010, approval was granted by TDEC and EPA to discontinue monitoring of the K-1420 pad.

Table 3.17. Storm water sampling for radiological discharges,[a] 2009

Storm water outfall	Date sampled
100	06/29/09
292	06/10/09
350	07/13/09
430	06/10//09

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

3.5.1.4 Radiological Monitoring of Storm Water Discharges

The ETTP conducts radiological monitoring of storm water discharges to determine compliance with applicable dose standards. It also applies the ALARA process to minimize potential exposures to the public. Sampling for gross alpha and gross beta radioactivity, as well as specific radionuclides, is conducted periodically as part of the SWPPP sampling efforts. In 2009, new radiological sampling results were obtained for four storm water outfalls (Table 3.17). These results were used with radiological results for other storm water outfalls from other years, along with calculated flows based on rain events in 2009, to

Table 3.18. Radionuclides

estimate the total discharge of each radionuclide from ETTP via the storm water discharge system (Table 3.18).

released to off-site surface waters from the East Tennessee Technology Park storm water system, 2009 (Ci)[a]

Radionuclide	Amount
^{99}Tc	2.1E–2
^{234}U	7.0E–3
^{235}U	5.8E–4
^{238}U	4.4E–3

[a] 1 Ci = 3.7 × 10^{10} Bq.

Storm water samples were collected from discharges resulting from a storm event greater than 0.1 inch that occurred within a time period of 24 hours or less and which occurred at least 72 hours after any previous rainfall greater than 0.1 inch in 24 hours. Composite samples were collected at each outfall using Isco 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 Isco 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.

Radiological monitoring was conducted in 2009 as part of the SWPPP for different purposes. Results of all SWPPP radiological monitoring that exceeded screening levels in 2009 are shown in Table 3.19. Comparisons of historical analytical results to results from the 2009 sampling effort are given in Tables 3.14, 3.20, 3.21 and 3.22.

Table 3.19. Storm water radiological results exceeding screening levels for radiological discharges, 2009 (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)
160	138	106	97	62.5	189
292	43	--	22.6	--	32.8
350	187	62.4	79.1	63.9	192
490		57.1	--	--	--

[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.

Table 3.20. Analytical results from sampling performed at storm water outfall 292

	Gross alpha (pCi/L)	Gross beta (pCi/L)	U-233/234 (pCi/L)	U-235/236 (pCi/L)	U-238 (pCi/L)	Tc-99 (pCi/L)	Total U (μg/L)
Screening level	15	50	20	24	24	4000	31
May 2001	63.3	87.6	30.83	1.70	19.11	67.5	32.96
March 2002	227	116	121.2	8.89	72.86	104	No data
December 2003	38.3	16.7	17.89	1.11	11.01	12.2	No data
February 2007	136	88	84.1	5.63	51.4	79.5	156
June 2009	43	29.1	22.6	1.64	10.8	39.5	32.8

Table 3.21. Analytical results from sampling performed at storm water outfall 350

	Gross alpha (pCi/L)	Gross beta (pCi/L)	U-233/234 (pCi/L)	U-235/236 (pCi/L)	U-238 (pCi/L)	Tc-99 (pCi/L)	Total U (μg/L)
Screening level	15	50	20	24	24	4000	31
May 2001	162	76.5	70.31	4.36	54.65	26.5	No data
May 2002	25.2	14.8	16.83	1.25	13.3	0.69 U[a]	No data
February 2005	242	76.5	139	7.39	106	4.87 U	No data
December 2006	171	30.4	91.4	6.87	71.8	20.2	217
July 2009	187	62.4	79.1	4.77	63.9	13.7	192

[a] U—analyte not detected in sample.

Table 3.22. Analytical results from sampling performed at storm water outfall 490

	Gross alpha (pCi/L)	Gross beta (pCi/L)	U-233/234 (pCi/L)	U-235/236 (pCi/L)	U-238 (pCi/L)	Tc-99 (pCi/L)	Total U (µg/L)
Screening level	15	50	20	24	24	4000	31
July 2001	5	52	1.22 U	0.24 U[a]	0 U	17	1 U
January 2002	17.3	81.5	2.01	0.05 U	0.38	60.9	2.75 U
August 2005	2.45 J	7	1.57	No data	0.44	108	No data
February 2007	9.71	22.8	3.32	No data	0.9	28.6 U	No data
October 2008	7.57	29.6	0.82	No data	-0.08 U	38.5	–0.18 U
February 2009	10.6	57.1	No data	0.079	0.41	95.4	1.3

[a] U—analyte not detected in sample.

Gross alpha radiation was detected in the discharges from storm water outfalls 160, 292, and 350 at levels that exceeded the screening level for gross alpha activity of 15 pCi/L (Tables 3.14, 3.20, and 3.21). Results for gross alpha radiation collected at these locations since 2001 indicate that the gross alpha radiation results collected during this portion of the 2009 SWPP Program sampling effort are within the historical range.

Gross beta radiation was detected in the discharges from storm water outfalls 160, 350 and 490 at levels which exceed the MCL of 50 pCi/L for this analyte (Tables 3.14, 3.21 and 3.22). Results for gross beta radiation collected at these location since 2001 indicate that the gross beta radiation results collected during this portion of the 2009 SWPP Program sampling effort are within the historical range.

Uranium 233/234 was detected in the discharges from storm water outfalls 160, 292, and 350 at levels which exceed the 4% of DCG level of 20 pCi/L for this radionuclide (Tables 3.14, 3.20 and 3.21). Results for U-233/234 collected at these locations since 2001 indicate that the U-233/234 results collected during this portion of the 2009 SWPP Program sampling effort are within the historical range.

Uranium 238 was detected in the discharges from storm water outfalls 160 and 350 at levels which exceed the 4% of DCG level of 24 pCi/L for this radionuclide (Tables 3.14 and 3.21). Results for U-238 collected at these locations since 2001 indicate that the U-238 levels in data collected during this portion of the 2009 SWPP Program are within the historical range.

Total uranium was detected in the discharges from outfalls 160, 292 and 350 at levels which exceeds the screening level of 31 µg/L for this analyte (Tables 3.14, 3.20 and 3.21). Limited historical data for total uranium indicate that the total uranium level in data collected during this portion of the 2009 SWPP Program are within the historical range.

3.5.1.5 Monitoring Conducted as Part of the Demolition of Building K-1035

Building K-1035 was built in 1945 as a maintenance general stores warehouse. In the early 1960s it was converted to an instrument maintenance facility. Shop activities have included an instrument shop, metal cabinet fabrication, a photoelectroplating process, printed circuit board fabrication shop, acid cleaning area, line recorder cleaning, and pneumatic repair shop. To the south of the building are the K-1035 Acid Pits. These two pits, an acid pit and neutralization pit, received acid and solvent wastes from two dedicated instrument shops, the Printed Circuit Board Fabrication Facility and the Acid Cleaning Area, within the building. The process drains from the acid pit and the neutralization pit flow to a single catch basin that discharges to the storm drain 190 network. The Acid Cleaning Area operated from the early 1960s to 1985, and the Printed Circuit Board Fabrication Facility operated from the early 1960s to 1977.

In April 2009, work began on the demolition of Building K-1035 (Fig. 3.22). All materials that potentially contained asbestos, including siding, pipe insulation, roofing material, etc. were removed prior to general demolition using heavy equipment. The remainder of the building was demolished using heavy equipment. In June 2009, the building was reduced to rubble (Fig. 3.23). Final removal of building rubble

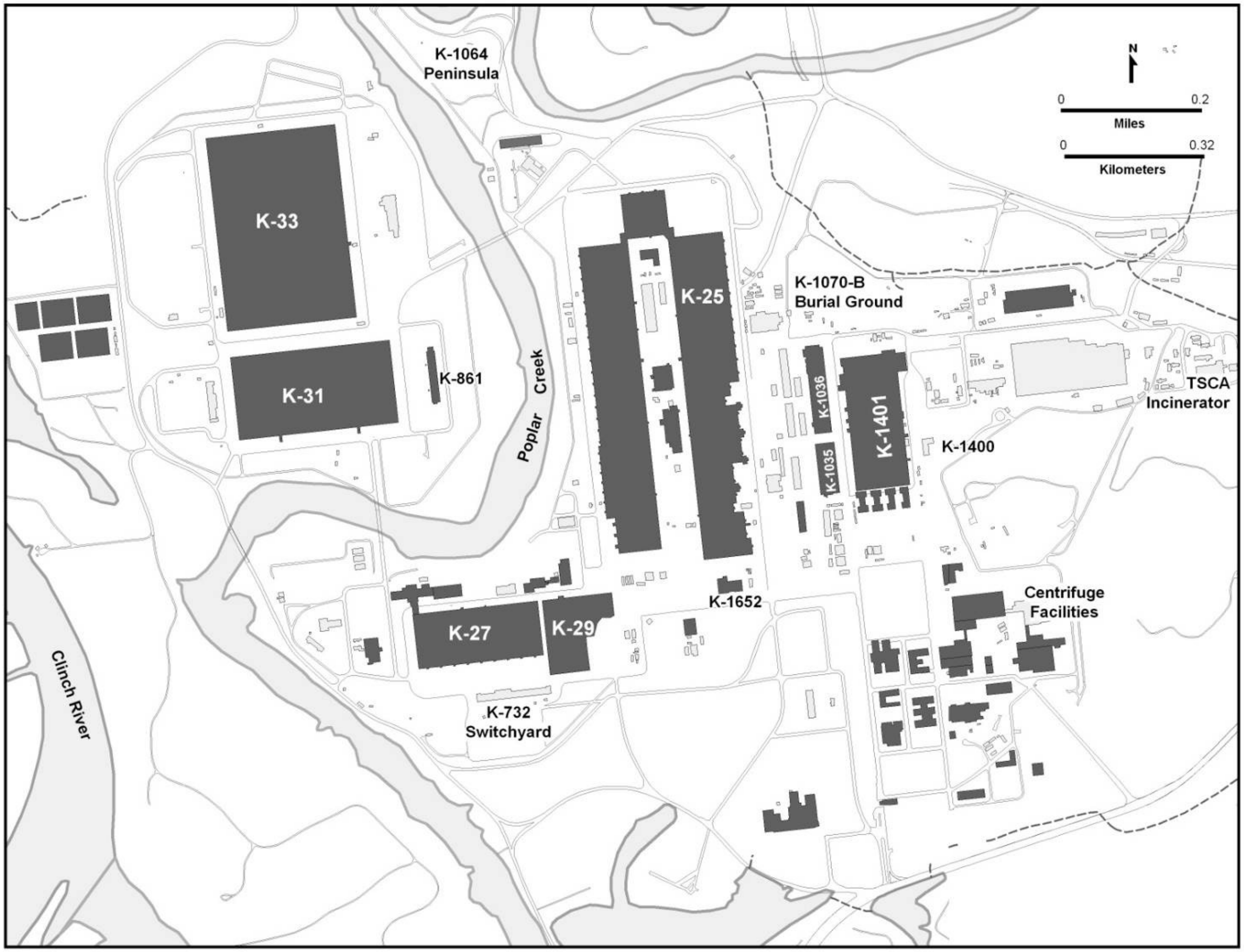

Fig. 3.22. Map of ETTP locations including areas involved in 2009 sampling activities.

Fig. 3.23. K-1035 building demolition.

was completed in July 2009. Waste material generated by the demolition of the building was sent to the EMWMF or other offsite disposal facilities (Fig. 3.24).

Before the demolition of Building K-1035 began, sampling of water in nearby storm drain inlets and at storm water outfall 190 was conducted. This provided a baseline for determining if contaminants might be present in the runoff from the K-1035 area. Sampling was also performed during the demolition of the building. This was done to determine the efficacy of the protective measures that were installed around storm drain inlets to prevent any demolition materials from entering the storm drain system. Additionally, sampling will be performed after demolition to determine the impact of the demolition on the storm water runoff from this area. Samples were collected for analysis for gross alpha/gross beta radiation, isotopic uranium, Tc-99, metals, mercury, VOCs, and PCBs.

In conjunction with the D&D of the Building K-1035, manholes 13037A, 13050, and 13074A were sampled as part of the FY 2009 SWPP Program. "Before demolition" samples were collected in November 2008, and "during demolition" samples were collected in May, June and August 2009. The "after demolition" samples have not yet been collected.

Sampling locations were chosen by EC&P personnel and sampling subcontractor personnel based on their close proximity to the area that was being remediated and their accessibility and ease of sampling. Locations with the greatest likelihood of receiving storm water runoff from the area were preferred sampling locations. However, due to fact that many of the storm drains in the area are inaccessible, sampling locations were chosen where flow could be observed and Isco sampling equipment could be installed with minimal complications.

All samples collected as part of this portion of the 2009 SWPP Program sampling effort were grab samples that were collected manually or by the use of Isco samplers. For the purposes of the ETTP SWPP Program sampling, a grab sample is defined as a discrete, individual sample that can be collected manually or by the use of an Isco sampler that is taken within a short period of time, usually 15 minutes or less. Both manual grab samples and grab samples collected using an Isco sampler were collected within the first 30 minutes of a discharge. All samples collected in conjunction with the D&D of Building K-1035 were collected in accordance with the guidelines presented in the *East Tennessee Technology*

Fig. 3.24. Demolition debris generated from K-1035 building being sent to EMWMF.

Park Storm Water Pollution Prevention Program Sampling and Analysis Plan (BJC/OR-758/R8). All guidelines stated in the ETTP SWPP Program Sampling and Analysis Plan concerning sample documentation, analytical procedures, Quality Assurance / Quality Control, etc. were followed as part of this sampling effort.

The metals results from the sampling performed in conjunction with the Building K-1035 D&D are presented in Figs. 3.25, 3.26, and 3.27. The figures indicate that:

- With the exception of arsenic, all metals were present at higher concentrations in the “during demolition” samples collected in summer 2009 compared to the “before demolition samples” collected in November 2008;
- With the exception of arsenic, all metals were present at concentrations at or near the Water Quality Criteria for the given metal;
- Metal results were fairly consistent between the three manholes; and,
- Improvements in the sediment controls in the Building K-1035 demolition area may have been needed to provide more effective removal of contaminants from the storm water runoff from the area.

The VOC results from the sampling performed in conjunction with the Building K-1035 D&D are presented in Figs. 3.28, 3.29, and 3.30. The figures indicate that:

- No clear conclusions can be drawn from the VOC results from samples collected as part of the Building K-1035 sampling effort;
- Many of the results showed VOCs at non-detectable levels; and,
- The concentration of VOCs in the three manholes sampled does not appear to have been affected by the demolition of Building K-1035.

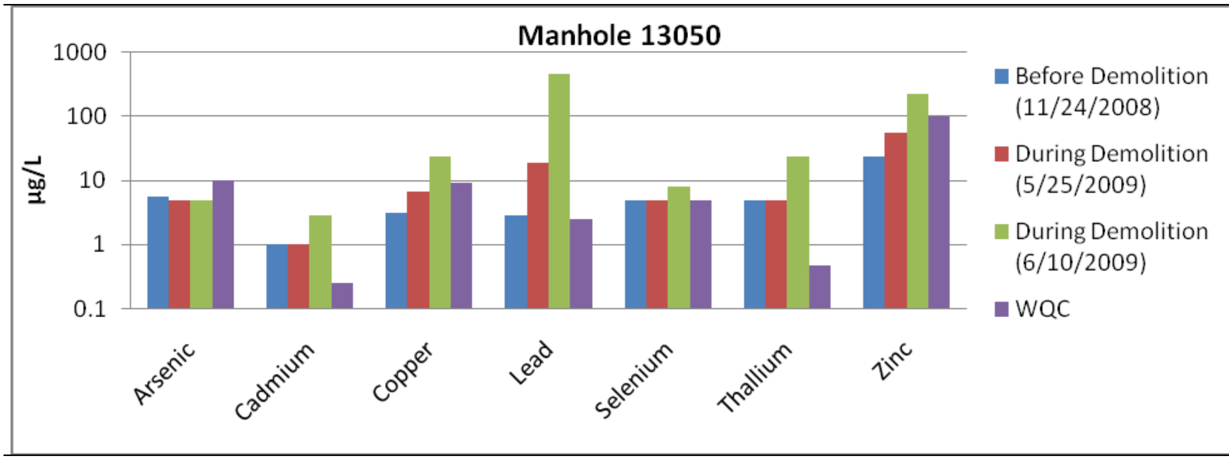

Fig. 3.25. Metals results at manhole 13050.

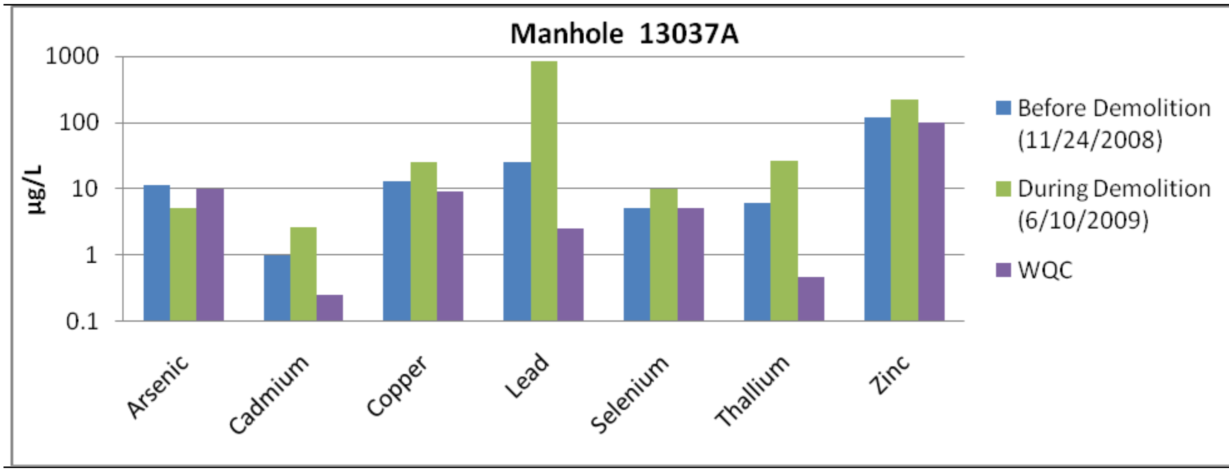

Fig. 3.26. Metals results at manhole 13037A.

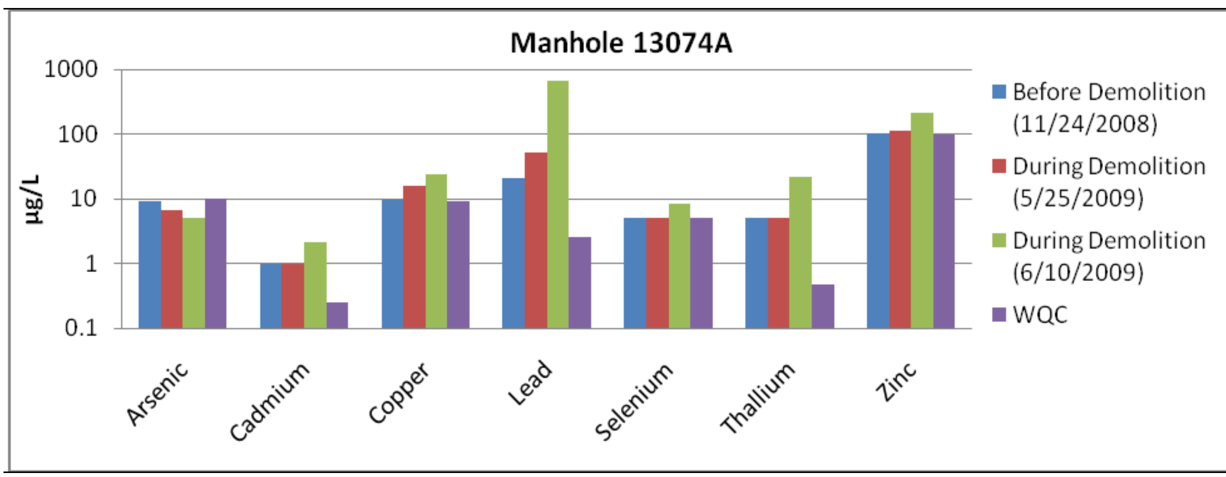

Fig. 3.27. Metals results at manhole 13074A.

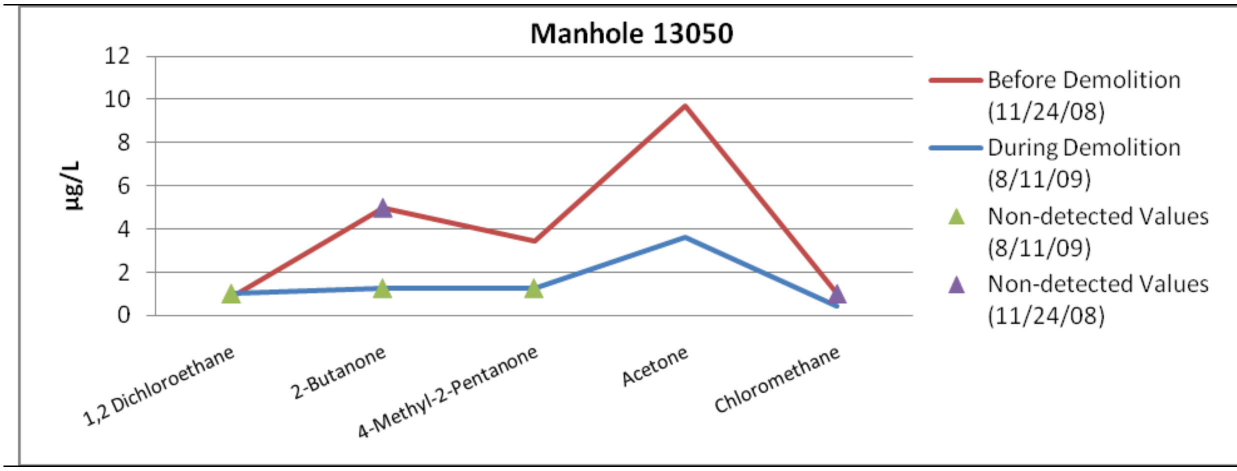

Fig. 3.28. VOC results at manhole 13050.

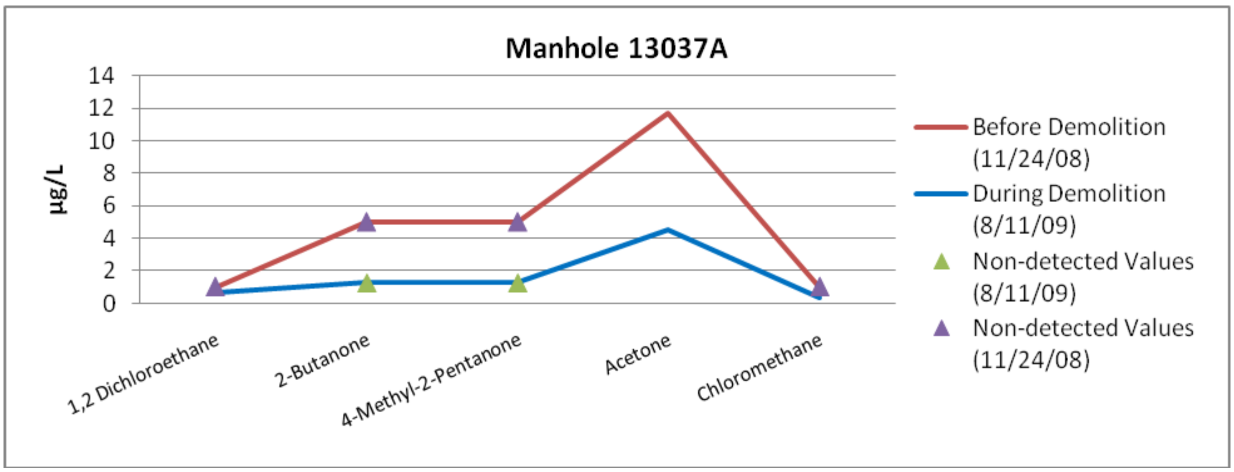

Fig. 3.29. VOC results at manhole 13037A.

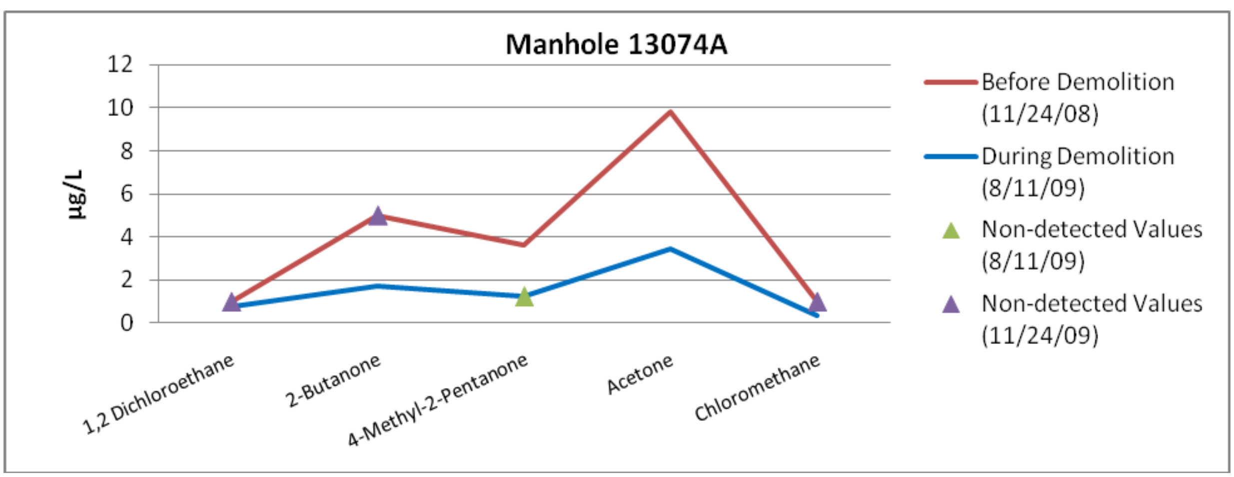

Fig. 3.30. VOC results at manhole 13074A.

The PCB results from the sampling performed in conjunction with the Building K-1035 D&D are presented below in Figs. 3.31, 3.32, and 3.33. The figures indicate that:

- Concentrations of PCB-1254 and PCB-1260 both increased in the summer 2009 "during demolition" sampling event,
- All other concentrations of PCBs did not appear to have been affected by the demolition of Building K-1035.

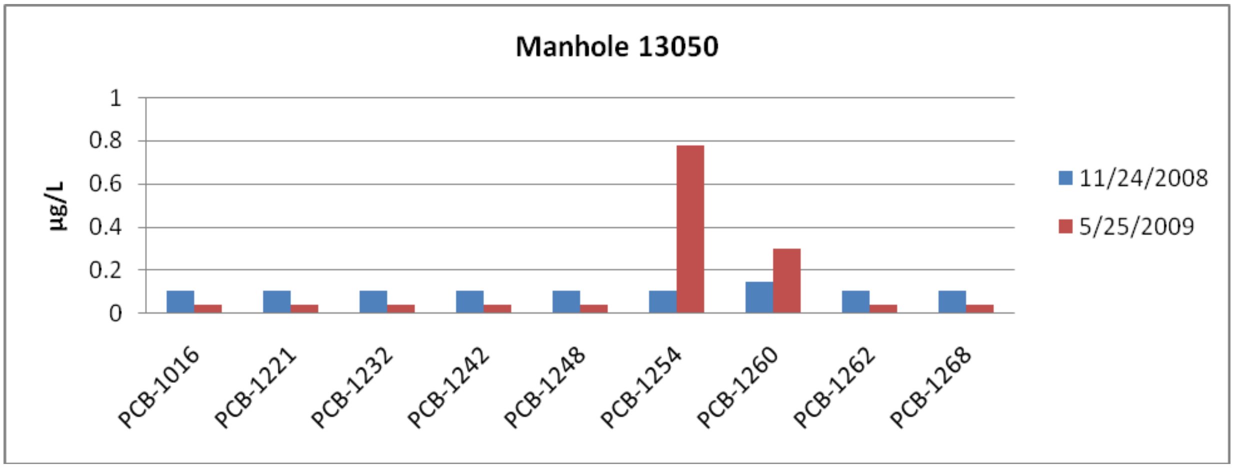

Fig.3.31. PCB results at manhole 13050.

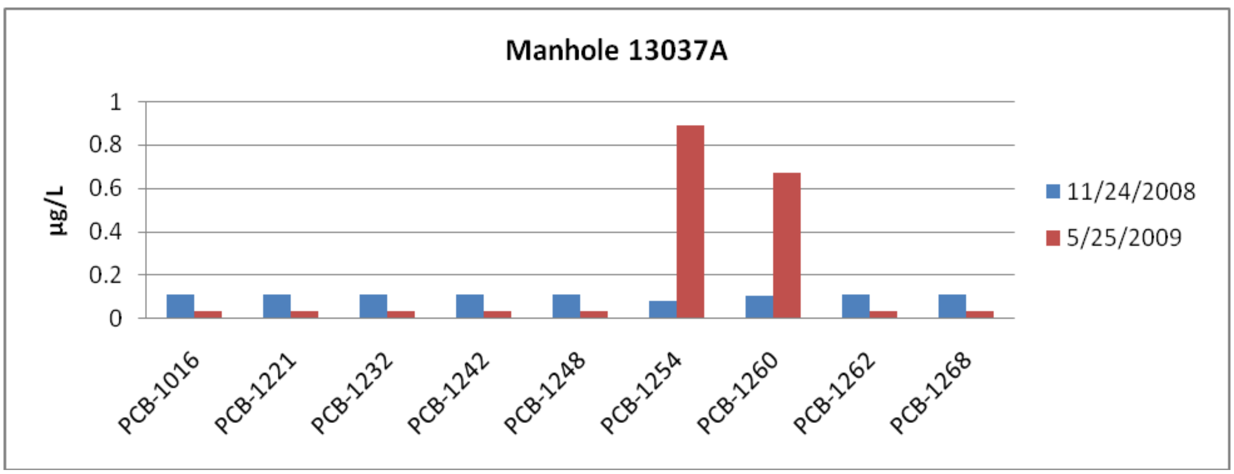

Fig. 3.32. PCB results at manhole 13037A.

None of the radiological samples collected as part of the Building K-1035 D&D sampling had results that were above the screening levels.

The demolition of the building structure at K-1035 was completed in 2009. As part of the D&D activities that were conducted at this building, the acid pits that were located on the south end of the building were removed. Visible mercury and other contaminants were found to be present in the former location of the acid pits. Therefore, remediation of the soil at the south end of Building K-1035 will be conducted in 2010. Specified manholes will be sampled during the soil removal activities on the south end of the building as part of the 2010 SWPP Program sampling and analysis plan. EC&P personnel will assist in planning the times these samples should be collected. In addition, final closure activities are scheduled to be performed at K-1035 in 2010. Specified manholes and outfalls will be sampled upon completion of all closure activities at Building K-1035.

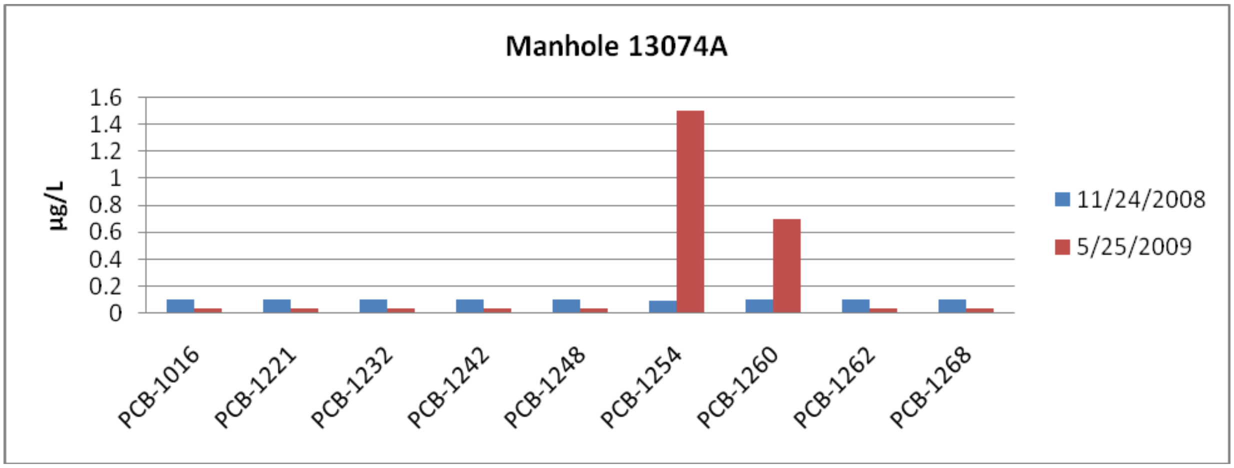

Fig. 3.33. PCB results at manhole 13074A.

3.5.1.6 Monitoring of K-1006 Sump

The Building K-1006 basement sump is a 30 inch diameter by 36 inch deep concrete structure. It is located in the northeast corner basement of the K-1006 laboratory building (Fig. 3.22) beneath the interior stairwell. The sump receives groundwater flow that is periodically pumped to the sanitary sewer system by a float-controlled pump. The Baseline Environmental Assessment Report *(BEAR) for the K-1006 Material and Chemistry Laboratory,* K/EM-543/R1, states that the sump located in the northeast corner of the basement accumulates rain water from a drain in the concrete floor area adjacent to the outside door of the basement. Discharge from this sump was believed to be routed to storm drain 100. It used to also receive water from steam condensate and a sink drain in the room C 107. The sink drain has been removed from service. The sump had not previously been recorded as part of the sump registration program that was conducted in the mid 1990's, and it had never been assigned an identification number. The sump was registered in 2008 and was designated as sump S-073A.

In May 2007, sediment present in the bottom of the sump was sampled. This sampling was performed under CERCLA to determine if the sump met the requirements of the Zone 2 Record of Decision. Samples of the solids were found to exceed applicable remediation levels for the radium/thorium decay series (41.64 pCi/g), PCB-1254 (23,000 mg/kg), and U-238 (116 pCi/g). Due to these exceedances of remediation levels, the sump did not meet the applicable CERCLA requirements, and remediation of the sediments in the sump was required.

In January 2009, water samples from the sump were obtained while the sediment was still in the sump to determine if any contaminants of concern were being discharged from the sump. The samples were analyzed for gross alpha, gross beta, VOCs, metals, isotopic uranium and thorium. The analytical results from this water sampling effort that exceeded screening levels are presented in Table 3.23.

In February 2009, a dye test was performed to verify whether the sump discharges to the environment, and if it does, whether it discharges to the storm drain system, the sanitary sewer system, or into the soil. Several floor drains in the basement of K-1006 appeared to drain into the sump. These floor drains were also tested to verify whether or not the floor drains are connected to the sump. A drain at the foot of an external stairwell was also thought to drain into the sump, so it was also dye tested. The dye test indicated that the sump was connected to the sanitary sewer system. The floor drain at the north end of the basement was found to discharge to the sump. A floor drain located near the exit door of the basement was found to be plugged. Additionally, it was found that the drain located at the foot of the external stairs was also connected to the sump. This drain appears to be the major contributor of water to the sump.

Table 3.23. Analytical results exceeding screening levels from water samples collected at sump S-073A before sediment removal

Location	Cadmium (μg/L)	Copper (μg/L)	Lead (μg/L)	Nickel (μg/L)	Silver (μg/L)	Zinc (μg/L)	Mercury (μg/L)	Gross alpha (pCi/L)	PCB-1254 (μg/L)	PCB-1260 (μg/L)
Before sediment removal	9.5	114	105	54.6	2.5	263	2	19.8	1.2	NA
After sediment removal	1.18	15	8.76	NA	NA	NA	0.189	NA	0.46	0.31

Personnel from the City of Oak Ridge who are involved with the management of the sanitary sewer system were notified about the results of the dye testing effort. Because of the levels of some contaminants in the tested water, city personnel requested an estimate of the quantity of the discharge from the sump into the sanitary sewer system. In February 2009, flow monitoring equipment was placed in the sump to determine how much water the sump was discharging. Data were collected from February 2009 through the first week of May 2009. It was found that the sump did not discharge during periods of dry weather. The discharge rate of the sump was found to be directly related to the amount of rainfall that occurred. The sump was found to discharge approximately 6–8 gallons of water per 0.1 inch of rainfall. The flow monitoring equipment was removed from the sump in August 2009.

Removal of the solids in the bottom of the sump was initiated in March 2009. The water present in the sump at the time the solids were to be removed was pumped into 5-gallon containers using a peristaltic pump. After all free water was removed from the sump, the solids were removed using a small hand-held shovel and placed into 5-gallon waste containers. Grout was added to the solids, hydrated with water from the sump, and allowed to set. Excess water was returned to the sump. The solidified material was turned over to Waste Management personnel for disposal at Energy Solutions.

After the sediments were removed, the sump was allowed to discharge for a period of approximately 2 months before additional water samples were collected. This was done to allow the sump adequate time to discharge and refill several times. The water in the sump was sampled in June 2009. The levels of some of the contaminants that had exceeded screening levels before the solids were removed were found to have dropped below screening levels after the solids were removed. However, several of the contaminants remained above screening levels. The analytical results from this water sampling effort that exceeded screening levels are presented in Table 3.23.

It has been determined that sump S-073A will remain in place until the demolition of the K-1006 building occurs.

3.5.1.7 Monitoring of Runoff from K-1070-B Burial Ground

The K-1070-B Burial Ground (Fig. 3.22) covers approximately 3.7 acres and has an average depth of 30 ft. This burial ground was opened in the early 1950s when the amount of equipment, materials, and parts reached a level that made warehouse storage impractical. The burial ground grew outward from the side of the hill south of Mitchell Branch. As waste was added and covered, the elevation became level with the K-1300 complex to the south. The unit is estimated to have been in operation from 1950 through the mid-1970s. Technological advances in barrier, compressor, and coolant systems resulted in plant improvement programs that generated large quantities of obsolete machinery, equipment, materials, and parts for disposal. Also, a former disposal site located near the junction of Highways 95 and 58 that was jointly used by the Y-12 National Security Complex, Oak Ridge National Laboratory (formerly X-10), and ETTP was cleaned up in the 1960s. At least ten tractor-trailer loads of materials were brought to K-1070-B for disposal. These materials included ferrules, seal parts, radioactive green/yellow compounds, stators, and contaminated valves. Operation of K-1070-B continued until the opening of the K-1070-C/D Burial Ground in the mid-1970s. The K-1070-B Old Burial Ground was closed by covering the site with soil, seeding with fescue, and planting black locust trees.

The overall site surface slopes toward the north downward to the Northeast Patrol Road. Surface runoff from the site is collected in a shallow ditch along the Patrol Road that discharges to Mitchell Branch.

In order to meet the closure requirements for this facility, the materials buried in the K-1070-B burial ground must be excavated and moved to EMWMF, where they will be properly disposed. Excavation activities at the K-1070-B burial ground were initiated in 2008 and are ongoing.

Manholes 8002 and 8017 are located upgradient of the K-1070-B burial ground. Outfall 190 is located downgradient of the burial ground. Manholes 8002 and 8017 and outfall 190 were sampled together after activities at the K-1070-B burial ground had been initiated in an effort to determine if the ongoing remedial activities were changing the water quality of the storm water runoff in the area as it passed through the burial ground area (Table 3.24).

Table 3.24. Surface water sampling to support CERCLA RA activities at the K-1070-B Burial Ground

RA or D&D activity	Sampling location	Sampling frequency	Sampling events	Gross alpha/beta	U Isotopic, Tc-99	PCBs	VOCs	Metals[a]/ Mercury
K-1070-B Burial Ground	MH 8002	During closure activities	1	X	X	X	X	X
	MH 8017	During closure activities	1	X	X	X	X	X
	SD-190	During closure activities	1	X	X	X	X	X

[a] Metals analysis should include Al, Ag, As, Ba, Be, B, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, Se, V, Zn, and Tl.

The results from the K-1070-B closure sampling event conducted in February 2009 were reviewed, and results above screening level were plotted as seen in Figs. 3.34 and 3.35. Several of the parameters of interest did increase downgradient of the burial ground, including: chromium, mercury, and PCB-1260. However, this trend was not consistent for all of the parameters of interest. As apparent from the figures, no definite conclusions can be drawn about the effect of the K-1070-B burial ground closure activities on storm water runoff quality.

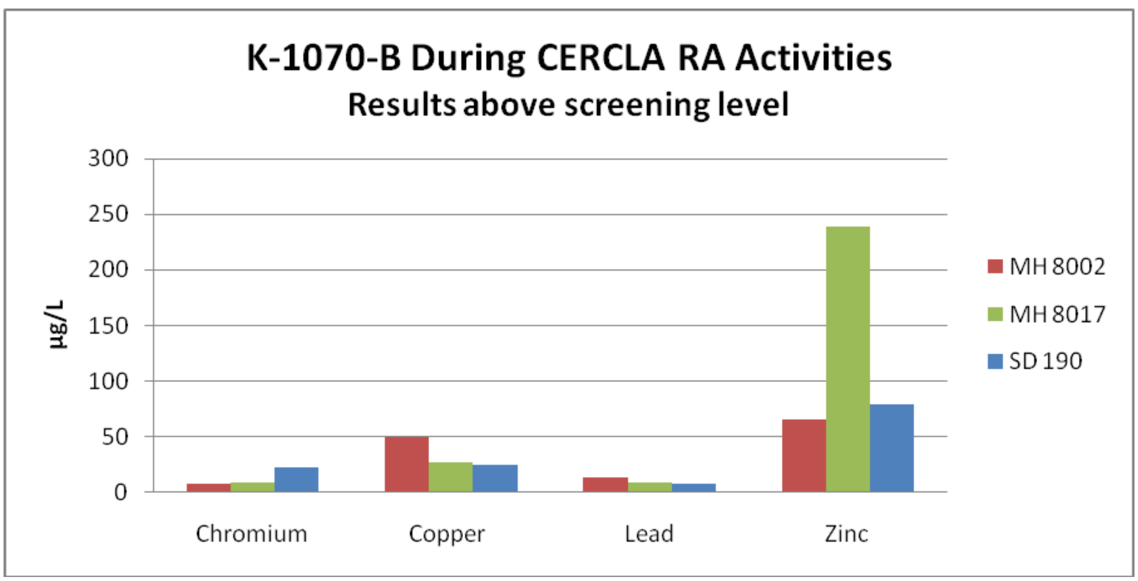

Fig. 3.34. Sample results for chromium, copper, lead and zinc obtained during K-1070-B CERCLA RA activities.

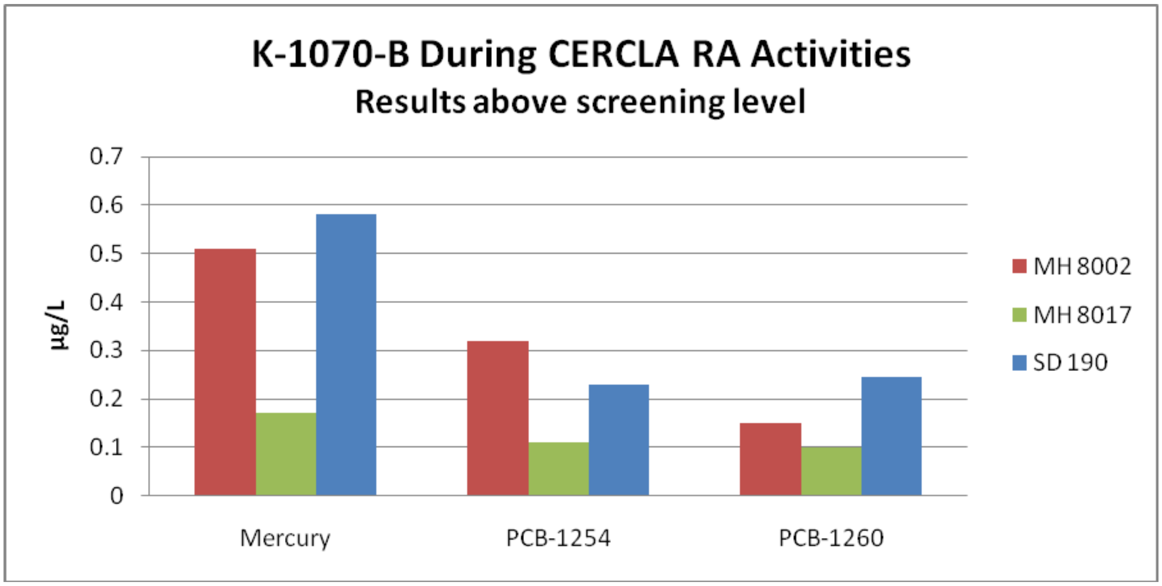

Fig. 3.35. Sample results for mercury and PCBs obtained during K-1070-B CERCLA RA activities.

3.5.1.8 K-31 and K-33 Area Storm Water Sampling

As stated in the "2008 Remediation Effectiveness Report for the United States Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee" that was prepared as part of the BJC Water Resources Restoration Program, chromium concentrations in groundwater measured between the K-31/K-33 buildings (Fig. 3.22) and Poplar Creek are somewhat elevated. Significant chromium concentrations (highest of any wells in the area) are shown for groundwater well UNW-043. The highest chromium concentration shown for this well is about 9 mg/L measured in 2003; most of the other chromium results for this well are between 1 and 4 mg/L. The residual chromium contamination is attributed to leaks of recirculated cooling water. The chromium at this location is almost entirely trivalent, with little or no hexavalent chromium being observed. These chromium concentrations greatly exceed the Tennessee Fish and Aquatic Life criterion continuous concentration for trivalent chromium which is based on the applicable water hardness, and any groundwater with these concentrations entering surface water would be a concern.

As part of the FY 2009 SWPP Program sampling effort, samples were collected from the ETTP storm drain system in the K-31/K-33 area to monitor for metals and radiological contaminants in storm water discharges (Table 3.25). Several of these samples could not be collected because there was no dry weather or wet weather flow present at any of the times they were visited. No dry or wet weather sampling was performed at outfalls 510, 560, 600, 660, or 690 due to lack of flow. Efforts to collect samples from these outfalls will continue through 2010.

Table 3.25. Storm water sampling in the K-31/K-33 area

Storm water outfall	Sampling event(s)	Area of investigation	Metals by EPA-200.7	Gross alpha/ gross beta
590	1 Wet weather	K-861	X	X
700	1 Wet weather	K-33	X	X
710	1 Dry weather	K-33	X	X

Table 3.26. Storm water results from K-31/K-33 sampling exceeding screening levels

Storm water outfall	Chromium (μg/L)	Copper (μg/L)
590	8.1	
710		10.2

Analytical results for the K-31/K-33 area that exceeded screening levels in samples collected in 2009 are given in Table 3.26. Analytical results from these samples were used to provide information for determining if chromium or other metals are present in storm water discharges in quantities that exceed the Tennessee Water Quality Criteria. In addition, the total amount of chromium and other metals in combined storm water and groundwater discharges to receiving waters could be determined.

Chromium was detected in the discharge from storm water outfall 590 at a level of 8.1μg/L (Table 3.26). This exceeds the screening level for chromium, which is 8 μg/L. No previous analytical data is available for this outfall. Outfall 590 receives discharges from the former location of the K-861 cooling tower and associated facilities. Including the K-861 cooling tower, there were a total of five cooling towers that were constructed of either treated redwood or Douglas fir to dissipate the heat from the recirculating cooling water system to the environment. A chromate/zinc/phosphate treatment was used for corrosion control. In the 1960s, a Martreat treatment was used to control biological fouling in the cooling towers. That process reportedly produced copper fluorides, copper chromate, zinc arsenate, and zinc chromate. The cooling towers were demolished as part of the Cooling Tower Demolition Project, which was conducted in 1996–1998.

Copper was detected in the discharge from storm water outfall 710 at a level of 10.2 μg/L (Table 3.26). This exceeds the screening level for copper, which is 7 μg/L. Copper has not been detected at levels above screening criteria in sampling performed in 2006 and 2007. Outfall 710 receives storm water discharges from Building K-33, a portion of Building K-31, the former location of the K-792 switchyard, 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. The K-792 Electrical Switchyard transferred electrical power to the K-33 cascade operations. A series of French drains were installed underneath the gravel bed of the switchyard when it was constructed in 1954. An oil skimmer for storm water runoff was installed in 1981. All of the equipment has been removed from this switchyard, and it is no longer active.

3.5.1.9 Sampling of the K-702-A Slough

A portion of the Powerhouse area drains to Poplar Creek through the K-702-A slough. This flume is connected to Poplar Creek by underground piping. Discharges from the Powerhouse area into the K-702-A slough currently consist almost entirely of storm water runoff.

The K-702-A slough receives storm water runoff from the K-700 Powerhouse and associated area. The Powerhouse generated and distributed electrical power for Oak Ridge Gaseous Diffusion Plant operations using fossil fuel fired steam generating facilities. Several storm water outfalls carry storm water runoff from the general Powerhouse area to the slough. The slough also receives discharges from the K-720 Fly Ash Pile, which was historically utilized for disposal of fly ash generated by the coal-fired boilers in the K-700 Powerhouse. Discharges from the K-720 Coal Ash Pile enter the slough via outfall 992.

Arsenic and selenium have been detected in historical sampling events conducted at outfall 992. Also, the discharge from outfall 992 has been observed to have a very low pH on several occasions. Runoff from the K-720 Fly Ash Pile is believed to be the primary contributor of arsenic and selenium to the discharge from outfall 992. It is also believed to be the source of the low pH discharges from this outfall. In 1994, the K-720 Fly Ash Pile area was covered with soil and seeded. In 2008, the drainage channel for runoff from the K-720 area was lined with rip-rap in an effort to prevent the discharge of low-pH runoff from the ash pile. Elevated levels of arsenic or selenium have not been noted in the K-702-A slough.

Radiological contamination is not expected to be present in the K-702-A slough. In addition, the K-702-A slough is not a contributor of mercury or PCBs to Poplar Creek.

As part of the discussions involved with the new NPDES permit application, it was discovered that there was very little recent information on the water quality in the K-702-A slough. Also, there was little available data on the effect of the discharge from Outfall 992 had on the water quality of the K-702-A slough. Therefore, sampling of the slough was requested as part of the 2009 SWPP Program sampling effort.

Samples were collected at both the easternmost and westernmost ends of the slough. In addition, samples were collected from the portion of the slough immediately downstream of the inflow of outfall 992. The samples were collected during dry weather conditions and wet weather conditions. Dry weather conditions were defined as flows following a period of at least 72 hours after a storm event of 0.1 inch or greater in 24 hours. Wet weather samples were collected from discharges resulting from a storm event greater than 0.1 inch that occurred within a time period of 24 hours or less and which occurred at least 72 hours after any previous rainfall greater than 0.1 inch in 24 hours. All of the recommended locations were sampled as part of a single sampling event. All samples were collected by the manual grab sampling technique. Table 3.27 contains information on how the samples for this effort were to be collected.

Table 3.27. K-702-A Slough Sampling

Storm water outfall	Sampling event(s)	PCBs	Metals by EPA-200.7	Gross alpha/ gross beta	Mercury
K-702-A West End	1 Dry weather	X	X	X	X
K-702-A West End	1 Wet weather	X	X	X	X
K-702-A East End	1 Dry weather	X	X	X	X
K-702-A East End	1 Wet weather	X	X	X	X
K-702-A Middle	1 Dry weather	X	X	X	X
K-702-A Middle	1 Wet weather	X	X	X	X
Outfall 992 Pooled Area	1 Dry weather	X	X	X	X
Outfall 992 Pooled Area	1 Wet weather	X	X	X	X

NOTE: All wet weather samples were collected during the first 30 minutes of a qualifying storm event discharge.

For the purpose of this sampling effort, it was assumed that the water in the slough was fairly homogeneous. Therefore, the grab samples were collected from the bank instead of requiring them to be collected from a boat. Also, the entire water column from the surface of the slough to the bottom of the slough was not requested to be represented as part of each sample. Samples at each location were analyzed for metals (using EPA 200.7), mercury, gross alpha/beta, PCBs, and VOCs.

The analytical results from this water sampling effort that exceeded screening levels are presented in Table 3.28. Mercury and thallium were detected above screening levels in each of the wet and dry weather samples that were collected as part of this sampling effort. However, the screening level for both of these materials is any amount of the substance that is detectable by approved laboratory methods.

This sampling effort will be repeated after the water level in the Clinch River has been lowered, which will also lower the water level in Poplar Creek. This would most likely provide “worst case” samples since any contaminants would be less diluted by the backflow of water from Poplar Creek into the slough.

Table 3.28. Storm water sampling results from K-702-A Slough exceeding screening levels

Location sampled	Sampling Event	Mercury (ng/L)	Thallium (μg/L)
Outfall 992 Pool	Dry weather	10.1	18
Outfall 992 Pool	Wet weather	10.8	19.4
K-702-A West End	Dry weather	5.18	23.9
K-702-A West End	Wet weather	4.82	17.5
K-702-A East End	Dry weather	10.5	18.2
K-702-A East End	Wet weather	16.2	13.3
K-702-A Middle	Dry weather	13.5	18.4
K-702-A Middle	Wet weather	14.2	13.1

3.5.1.10 Investigation of PCBs, Mercury, and Metals in Mitchell Branch and Associated Storm Water Outfalls

PCBs, mercury and other metals have been detected in the water sampling performed at outfalls that contribute flow to Mitchell Branch. In an effort to obtain more current analytical data from the discharges from these outfalls and identify how the discharges from these outfalls might be affecting the water quality of Mitchell Branch, sampling for PCBs, mercury, and metals was requested at several storm water outfall locations and at several locations within Mitchell Branch.

Sampling was conducted at the following nine locations: Outfalls 170, 180, 190, 198; Mitchell Branch locations MIK-1.4, 0.71, 0.59, 0.45; and K-1700.

Samples at all locations were analyzed for PCBs, total mercury, and metals. In addition, samples were collected at outfall 180, MIK-0.59, and K-1700 for analysis for methyl mercury. Comparison of analytical results to the Tennessee Water Quality Criteria (TN 1200-4-3 General Water Quality Criteria) was performed.

The applicable water quality criterion for mercury is 0.051 μg/L; therefore, total mercury samples were analyzed by a laboratory that has a method detection limit (MDL) for mercury that is below this criterion. The laboratory method used for total mercury analysis is the EPA 1631 method since it can detect mercury below the water quality criterion. Depending on the laboratory that runs the analysis, the EPA 1631 method has a detection limit as low as 0.5 ng/L. Methyl mercury samples were to be analyzed using the EPA 1630 method. Based on the laboratory that performs the analysis, this method has a detection limit as low as 0.02 ng/L. Analysis for metals at all storm drain and in-stream locations was performed using the EPA 200.7 method. In addition, replicate metals samples that were analyzed using the EPA 200.8 method were collected at all in-stream locations. The additional metals sampling was collected to provide analytical data on all metals detected by these two analytical methods for the in-stream locations. The sampling effort also provided a quality assurance/quality control check for the laboratories. Analysis for PCBs was done using the EPA 608 method.

Samples were collected during both wet weather and dry weather conditions. Wet weather samples were collected from flows resulting from a storm event greater than 0.1 inch in magnitude in 24 hours and that occurred at least 72 hours after any previous storm event of 0.1 inch or greater in 24 hours. If an intermittent rainfall occurred over a period of 24 hours and did not equal or exceed 0.1 inch, it was not considered to be a storm event, and the 72-hour delay until the next rainfall which can potentially be sampled was not in effect. Wet weather sampling of all locations was conducted during the same storm event, when possible. Mitchell Branch samples were collected progressing from the farthest downstream sampling location to the farthest upstream sampling location. All of the wet weather samples were collected by the manual grab sampling technique. This sampling effort is outlined in Table 3.29.

Table 3.29. Wet Weather Sampling for PCBs, Mercury, and Metals

Sampling location	PCBs	ICP metals (by EPA 200.7)	ICP metals (by EPA 200.8)	Total mercury	Methyl mercury
Outfall 170	X	X		X	
Outfall 180	X	X		X	X
Outfall 190	X	X		X	
MIK-1.4	X	X	X	X	
MIK-0.71	X	X	X	X	
MIK-0.59	X	X	X	X	X
MIK-0.45	X	X	X	X	
K-1700	X	X	X	X	X

Table 3.30 indicates the parameters that exceeded screening levels in samples collected in September 2009 under wet weather conditions. Analytes that exceeded an applicable water quality criterion included thallium at K-1700 (result of 1.13 µg/L exceeded criterion of 0.051 µg/L), mercury at outfall 180 (0.0884 µg/L, and total chromium at outfall 170 (16.1 µg/L). No other exceedances of screening levels were noted in the analytical data from this sampling effort.

Table 3.30. Results of wet weather sampling for PCBs, mercury, and metals that exceeded screening levels—September 2009

Sampling location	Total mercury (ng/L)	Thallium (µg/L)	Chromium (µg/L)
MIK-1.4	5.4		
Outfall 170	5.3		16.1
MIK-0.71	4.2		
Outfall 180	88.4		
MIK-0.59	10.4		
Outfall 190	36		
MIK-0.45	18.4	<0.402	
K-1700	22.1	1.13	

Dry weather samples collected in Mitchell Branch were collected in July 2009 progressing from the farthest downstream sampling location to the farthest upstream sampling location. Dry weather samples were collected from flows following a period of at least 72 hours after a storm event of 0.1 inch or greater in 24 hours. All of the dry weather samples were collected by the manual grab sampling technique. This sampling effort is outlined in Table 3.31.

Table 3.32 indicates parameters that exceeded screening levels in dry weather sampling conducted in July 2009. The only exceedance of an applicable water quality criterion was mercury at outfall 180 (result of 0.1145 µg/L exceeded criterion of 0.051 µg/L). The only other result that approached an applicable water quality criterion was thallium at K-1700; however, the field replicate was a non-detect. No other exceedances of screening levels were noted in the analytical data from this sampling effort.

Figure 3.36 shows the thallium concentrations noted in the analytical data. Figure 3.37 indicates the progression of mercury concentrations in Mitchell Branch from the upper reaches of the branch (MIK 1.4) to a location near the point where Mitchell Branch discharges into Poplar Creek (K-1700). Figure 3.38 indicates the progression of chromium concentrations in Mitchell Branch from MIK 1.4 to K-1700.

Mercury is almost nonexistent in the upper reaches of Mitchell Branch. Outfall 170 discharges a small amount of mercury into Mitchell Branch, but it is attenuated by the flow of the branch by the time it reaches MIK 0.71. At outfall 180, an elevated amount of mercury is discharged into Mitchell Branch. Even though mercury levels are still elevated, this mercury discharge from outfall 180 is somewhat attenuated by the time the flow of Mitchell Branch reaches MIK 0.59. At outfall 190, a small amount of mercury is once again discharged into Mitchell Branch, but is attenuated by the other flow in the branch

Table 3.31. Dry Weather Sampling for PCBs, Mercury, and Metals—July 2009

Sampling location	PCBs	ICP metals (by EPA 200.7)	ICP metals (by EPA 200.8)	Total mercury	Methyl mercury
Outfall 170	X	X		X	
Outfall 180	X	X		X	X
Outfall 190	X	X		X	
MIK-1.4	X	X	X	X	
MIK-0.71	X	X	X	X	
MIK-0.59	X	X	X	X	X
MIK-0.45	X	X	X	X	
K-1700	X	X	X	X	X

Table 3.32. Results of dry weather sampling for PCBs, mercury, and metals that exceeded screening levels—July 2009

Sampling location	Total mercury (ng/L)	Thallium (μg/L)
MIK-1.4	0.8	
Outfall 170	5.5	
MIK-0.71	3.1	
Outfall 180	114.5	
MIK-0.59	10.8	
Outfall 190	13.9	
MIK-0.45	11.4	
K-1700	12.1	<0.407

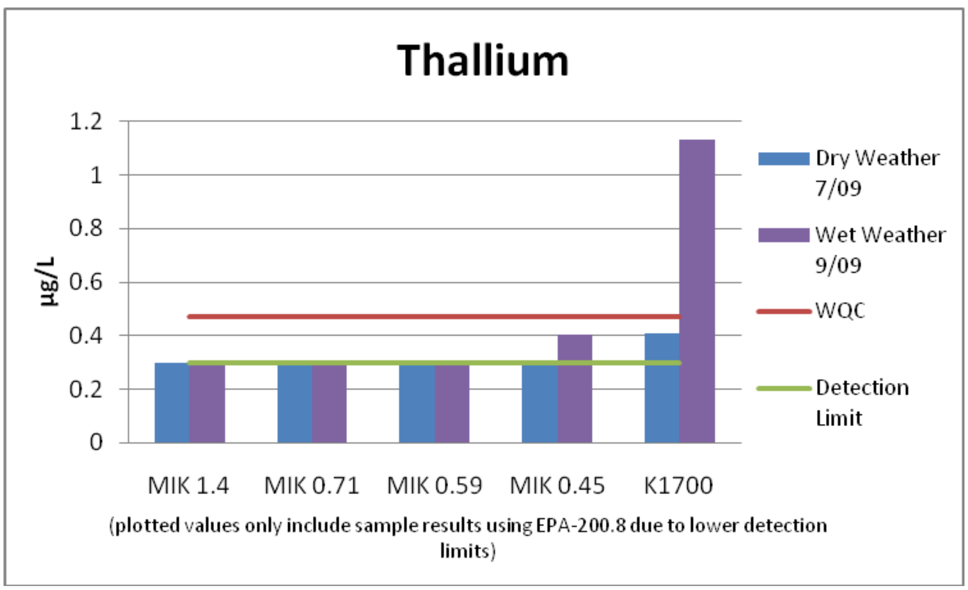

Fig. 3.36. Thallium results from Mitchell Branch investigation sampling event.

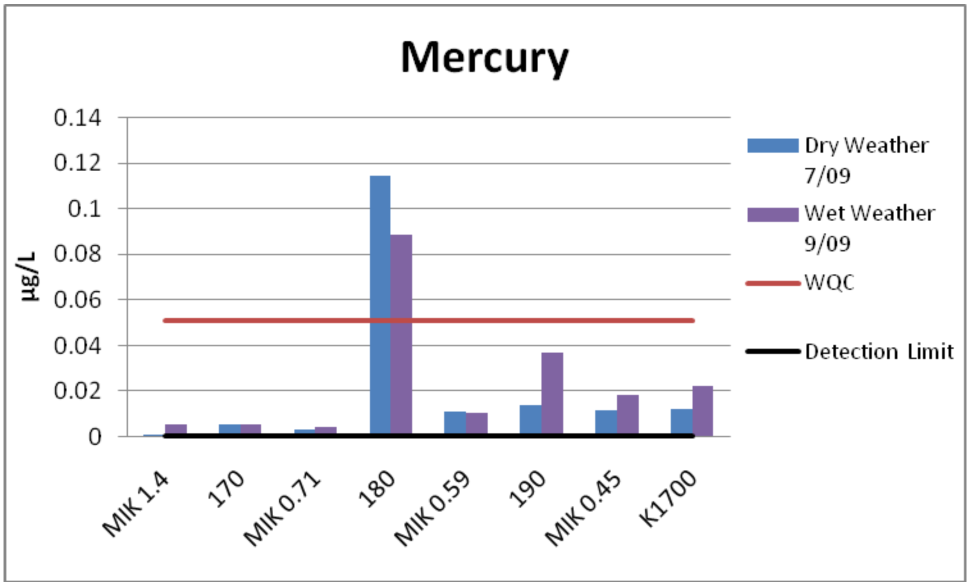

Fig. 3.37. Mercury results from Mitchell Branch investigation sampling event.

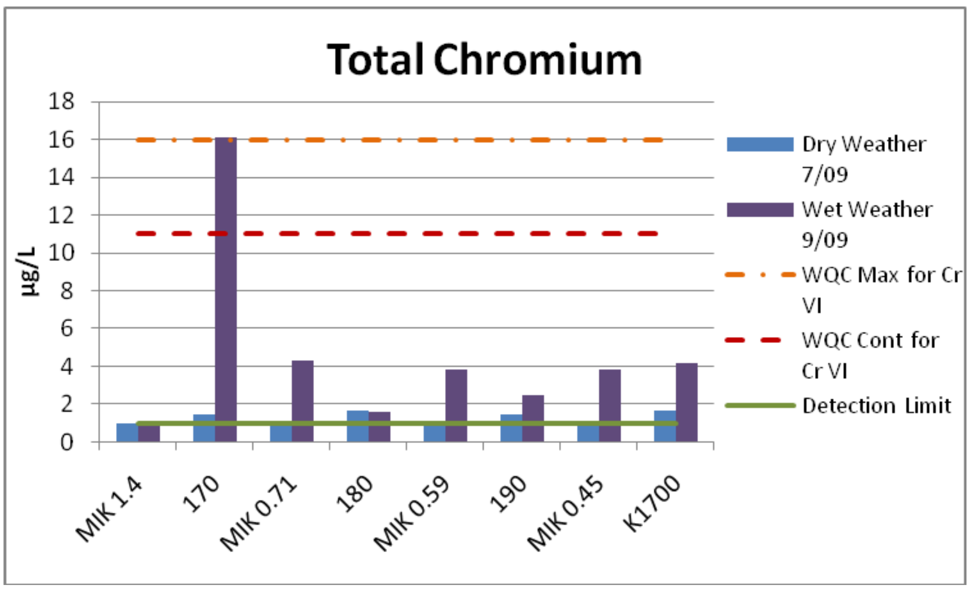

Fig. 3.38. Chromium results from Mitchell Branch investigation sampling event.

by MIK-0.45. Between MIK 0.45 and K-1700, mercury levels rise somewhat, possibly due to the presence of contaminated sediments in the K-1700 area. Figure 3.39 is an aerial photo showing the sampling locations along Mitchell Branch and the mercury levels at each of the sampling locations.

Outfall 180 appears to be a primary source of mercury discharges into Mitchell Branch. Past operations that involved the use of mercury have occurred in the outfall 180 drainage area. The K-1303 Mercury Distillation and Recovery Unit operated from 1948–1954. This facility included a rinsing operation that generated a waste stream containing small levels of mercury that were discharged to K-1407-B Pond and Poplar Creek via Mitchell Branch. In 1948 the K-1303 Building ventilation was modified to discharge mercury fumes above the roof of the building. Mercury contamination was subsequently identified on the roof and in the soils surrounding the building. The facility was demolished in 2004. In addition, the Building K-1401 housed an instrument development lab in the north end of the

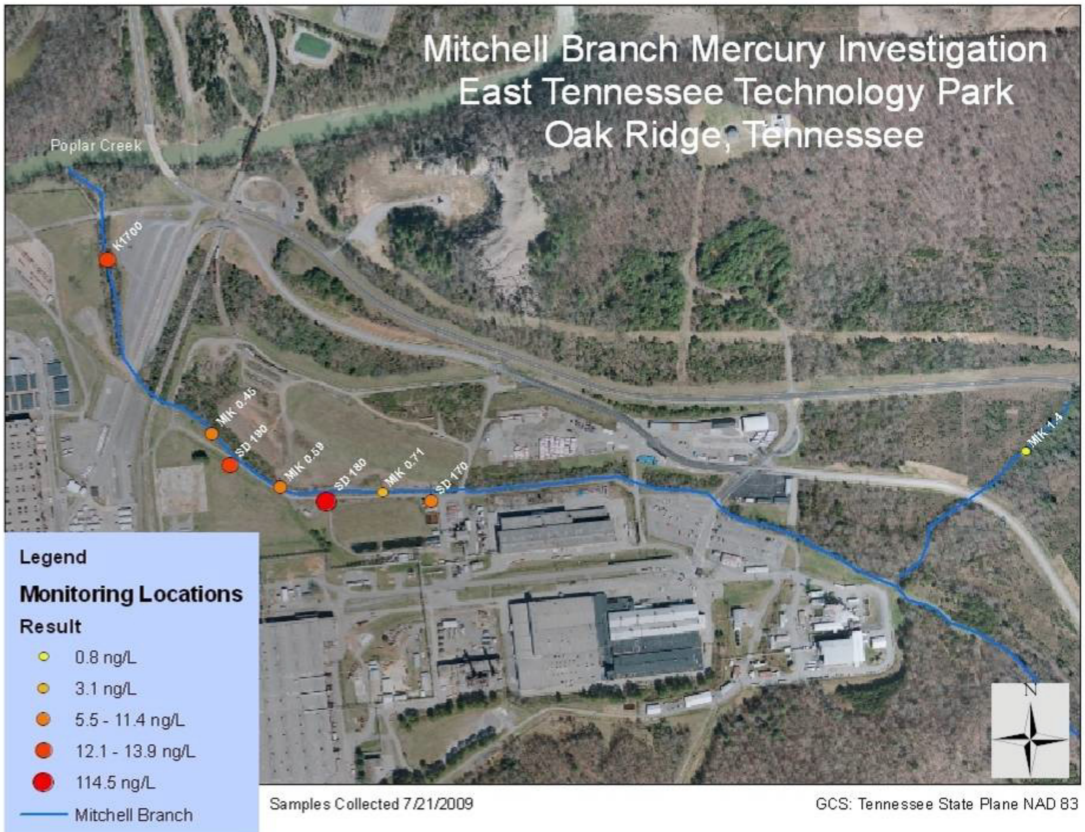

Fig. 3.39. Aerial photo of Mitchell Branch mercury sampling locations and results.

building. Mercury diffusion pumps were used in this area in conjunction with mass spectrometers. Other activities conducted in K-1401 that involved mercury included the acid cleaning of mercury flasks from Y-12. The practice of dumping tanks of used cleaning fluids into Mitchell Branch and bypassing the holding pond was performed weekly. Mercury was also stored and handled in the instrument development laboratory in the north end of K-1401. Building K-1401 was demolished in 2008.

Outfall 170 discharges small amounts of mercury into Mitchell Branch. The most likely source of mercury in this drainage system is from the K-1420 area. Recovery operations in K-1303 were transferred to K-1420 in 1956. From then until 1980, operations in the K-1420 ground floor recovery room included the recovery and purification of mercury from wastes using a washing and distillation process. The recovery room was located in the northwest corner of K-1420. The total amount of mercury processed over the years is uncertain, but records refer to the recovery of tons of mercury. Mercury contamination has been identified in K-1420 floor drains, holding ponds that received building drainage, and beneath the concrete floor of the building. Building K-1420 was demolished in 2007.

Mercury is also present in the discharge from outfall 190 to Mitchell Branch. The most likely source of mercury in the outfall 190 drainage system is from operations conducted in Building K-1401, as described previously. In addition, mercury may have come from the treatment of mercury-contaminated waste waters at the K-1413 facility. Wastewater from Y-12 was transported by tanker truck to K-1413 for treatment. At least one shipment of Y-12 wastewater to K-1413 was known to have been contaminated with mercury.

3.5.1.11 Sampling of Active Sumps at ETTP

Approximately 104 sumps were once located in various building basements, switchyards, and other facilities around ETTP. Many of the sumps no longer discharge because the sump pump has been removed or de-energized, or the building served by the sump has been demolished or abandoned and the sumps have been filled. Water from the sumps that are still active may be discharged to the ETTP storm water drainage system, the ETTP sanitary sewer system, or may be routed to the CNF.

Sumps were sampled as part of the ETTP accumulated water discharge program from 1994 until 1998. During 1998, ETTP Clean Water Act Program personnel analyzed the historical data from the previous year's sampling events and determined that the sump program would be suspended. Except for the sampling of a few selected sumps as part of the 2002 SWPP Program sampling program, no analytical data have been collected from the sumps since the program was suspended.

As part of the 2009 SWPP Program, all of the sumps that actively collect and discharge groundwater and storm water were identified. Approximately 15 sumps were thought to be currently active at the ETTP. In order to obtain current analytical data for these active sumps, each was to be sampled for parameters that were selected based on past analytical results from the sump. Table 3.33 provides information on the locations of the active sumps that were sampled in 2009, where they discharge, and the parameters they were sampled for.

Table 3.33. Sampling of sumps believed to be active at the ETTP

Sump number	Building/area	Location/sump description	Discharge point	Parameters to be sampled
S054	K-732 Switchyard	basement, center, near columns 15 and 16	Outfall 440	PCBs, VOCs, pH, visual check for oily sheen
S055	K-732 Switchyard	valve vault 2	Outfall 440	PCBs, VOCs, pH, visual check for oily sheen
S056	K-732 Switchyard	valve vault 3	Outfall 440	PCBs, VOCs, pH, visual check for oily sheen
S057	K-732 Switchyard	synchronous condenser 101	Outfall 440	PCBs, VOCs, pH, visual check for oily sheen
S058	K-732 Switchyard	synchronous condenser 102	Outfall 440	PCBs, VOCs, pH, visual check for oily sheen
S059	K-732 Switchyard	synchronous condenser 103	Outfall 440	PCBs, VOCs, pH, visual check for oily sheen

The sumps located in the K-732 switchyard (Fig. 3.22) were sampled in August 2009. The analytical results from this water sampling effort that exceeded screening levels are presented in Table 3.34. PCBs were detected at levels above screening criteria in four of the six sumps that were sampled. All of the sumps that were found to contain elevated levels of PCBs discharge through oil/water separators. These devices have proven to be effective in removing any traces of oil which may contain PCBs. PCBs have only rarely been noted in analytical data from storm water outfalls which are served by oil/water separators.

Table 3.34. K-732 Switchyard sump sampling results exceeding screening levels

Location sampled	PCB-1254 (μg/L)	PCB-1260 (μg/L)
S054		0.086
S057	6	
S058	0.36	
S059	36.6	

Sampling of the sumps located in the K-762 Switchyard, Building K-1037, and Building K-1210 will be performed in 2010.

3.5.1.12 NPDES Monitoring at the CNF 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 3.35. Wastewater from CNF is discharged through outfall 001 into the Clinch River.

Table 3.35. 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	Bimonthly	Grab
Ethylbenzene	Bimonthly	Grab
Toluene	Bimonthly	Grab
Methylene chloride	Bimonthly	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
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

Table 3.35 (continued)

Parameter	Collection frequency	Sample type
Total toxic organics (TTO)[a]	Quarterly	Grab
Settleable solids[b]	Biannually	Grab
Cyanide, total	Annually	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.

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 3.36 lists the total discharges in 2009 by isotope. The radiological results are compared with the DCGs. The sum of the fractions must be kept below 100% of the DCGs; in practice the effluent results from the CNF/WWTS were well below 100% of the DCGs until 2007. Figure 3.40 shows a rolling 12 month average for 2009. Beginning in September 2006 and continuing at irregular intervals until February 2009, 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 2009 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 0.8 in December 2009.

Table 3.36. Isotopic discharges from the Central Neutralization Facility/Waste Water Treatment System, 2009

Isotope	Curies	Isotope	Curies
241Am	1.2E–5	239Pu	1.2E–5
		99Tc	1.6E–1
137Cs	2.4E–3	230Th	2.4E–5
60Co	2.8E–7	234Th	2.4E–3
3H	1.6E–1	234U	6.9E–3
		235U	7.5E–4
237Np	5.0E–5	236U	4.2E–4
238Pu	1.9E–5	238U	2.7E–2

Although uranium isotopes constitute the greatest mass (approximately 82 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.

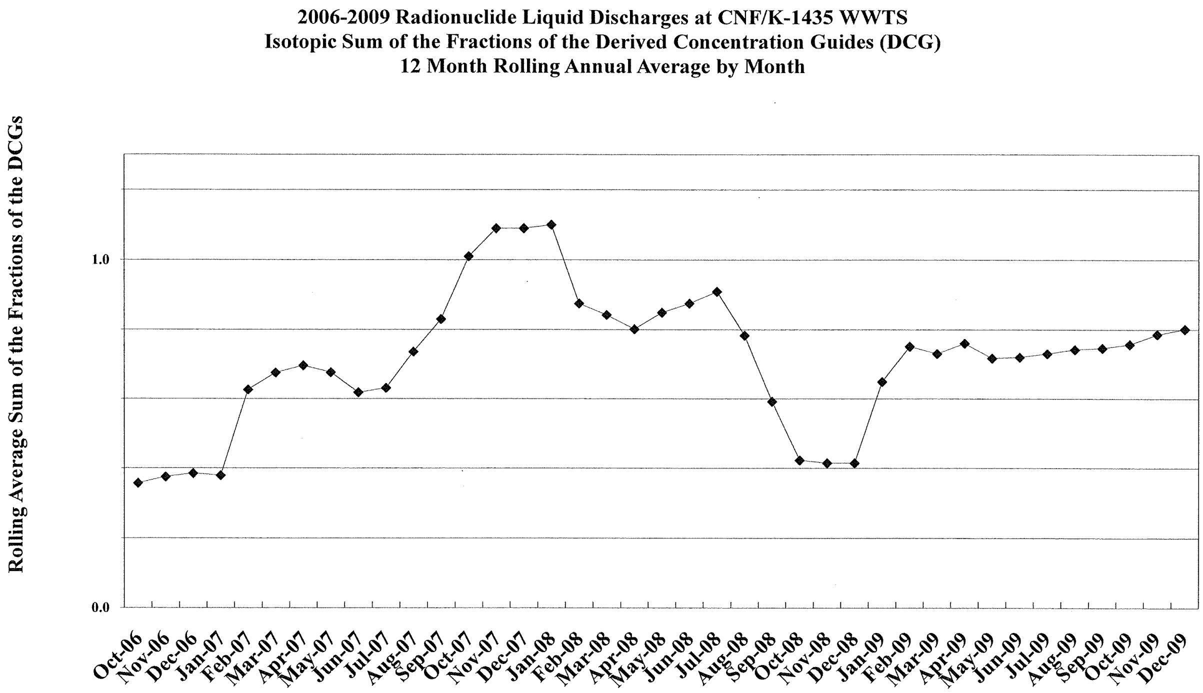

Fig. 3.40. CNF/K-1435 WWTS radionuclide liquid discharges.

3.5.1.13 NPDES Permit Noncompliances

There was one CWA or NPDES permit noncompliances at ETTP in 2009.

Storm water outfall 340 is monitored on a monthly basis as part of the ETTP NPDES permit compliance program. This outfall is located near the southwest corner of the K-25 Building. It receives surface runoff and roof drainage from the west wing of the K-25 Building.

On January 6, 2009, sampling subcontractor personnel were collecting routine NPDES permit compliance data at storm water outfall 340. They obtained a pH reading of 9.1standard units at the designated NPDES monitoring location for that outfall. Sampling subcontract personnel then verified the calibration of the pH meter according to procedure. The pH meter calibration proved to be accurate. The pH reading of 9.1 standard units is outside the NPDES permitted range of 4.0–9.0 standard units for this outfall. This constitutes a noncompliance with the ETTP NPDES storm water permit.

In preparation for the demolition of the K-25 Building, a Storm Water Pollution Prevention Plan (SWPPP) was prepared. The SWPPP described the various methods that would be employed to prevent demolition debris and contaminated runoff from entering the storm drain system. One of the main protective measures that was implemented as part of the SWPPP was the temporary sealing of storm drain inlets near the demolition area. The inlets were covered with rubberized mats, and the mats were sealed with flowable fill. It is believed that the elevated pH at outfall 340 may have been related to either or both of the following conditions concerning the sealing of the storm drain inlets:

1. The sealing of the storm drain inlets caused the backup of storm water into debris piles that had accumulated in the vicinity of the inlets. The pH of the storm water may have been raised by the contact of the storm water with concrete powder and other residue generated during the demolition of the K-25 Building. Due to infiltration of the accumulated storm water into cracks in the storm drain piping, and because incomplete sealing of some of the storm drain inlets occurred, storm water with an elevated pH entered the storm drain system.
2. The gap between the rubberized mats that were placed over the storm drain inlets and the ground surface at the inlet was sealed with a cementitious material. The cementitious material is strong enough to withstand regular truck traffic that might pass over the sealed storm water inlets. However, heavy construction equipment involved in building demolition had been driven over the sealed storm

drains, which caused the cementitious material to break apart and fall into the storm drain inlet. This created the potential for storm water to enter the storm drain inlet by bypassing the damaged seal. It also created the opportunity for the storm water to contact the broken cementitious material as it entered into the storm drain, which could raise the pH of the water.

A corrective action plan was developed shortly after the elevated pH measurement was taken. The corrective actions included:

1. Identification of all storm water inlets that might have defective seals;
2. Removal of as much of the building debris and sealing material from the storm water inlets where the seals had failed as possible;
3. Plugging the risers and damaged storm water inlets with 4000 PSI concrete instead of flowable fill to provide additional strength and to prevent future damage;
4. Placement of jersey bouncers over the storm drain inlets to prevent future damage due to truck and heavy construction equipment traffic;
5. Continued routine inspections of the storm drain inlets for damage or undesired entry of storm water into them; and,
6. Modification of the SWPPP and changing of storm water control measures as dictated by changing conditions as demolition of the K-25 Building progresses.

All of these corrective actions were implemented as soon as possible after this incident occurred.

No threat to human health or the environment occurred as a result of this event. No fish kills or other adverse impacts to the biota were observed.

3.5.2 Surface Water Monitoring

The ETTP environmental monitoring program personnel conduct environmental surveillance activities at eleven surface water locations (Fig. 3.41). 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, a source investigation would be required. Sources exceeding DCG requirements would need 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%. 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. 3.42). The exceptions are K-1700 and three of the downstream locations on Mitchell Branch as indicated by the sums of the fractions of the DCGs for these locations as follows:

- K-1700: 2.7%,
- MIK 0.5: 2.3%,
- MIK 0.6: 1.9% , and
- MIK 0.7: 1.6%.

The percentage of the DCGs at K-1700 (2.7%) was slightly below the percentage of the 2008 monitoring results (3.4%).

Depending on the monitoring location, water samples may be analyzed for pH, selected metals, and VOCs. Analytical results were well within the appropriate water quality standards.

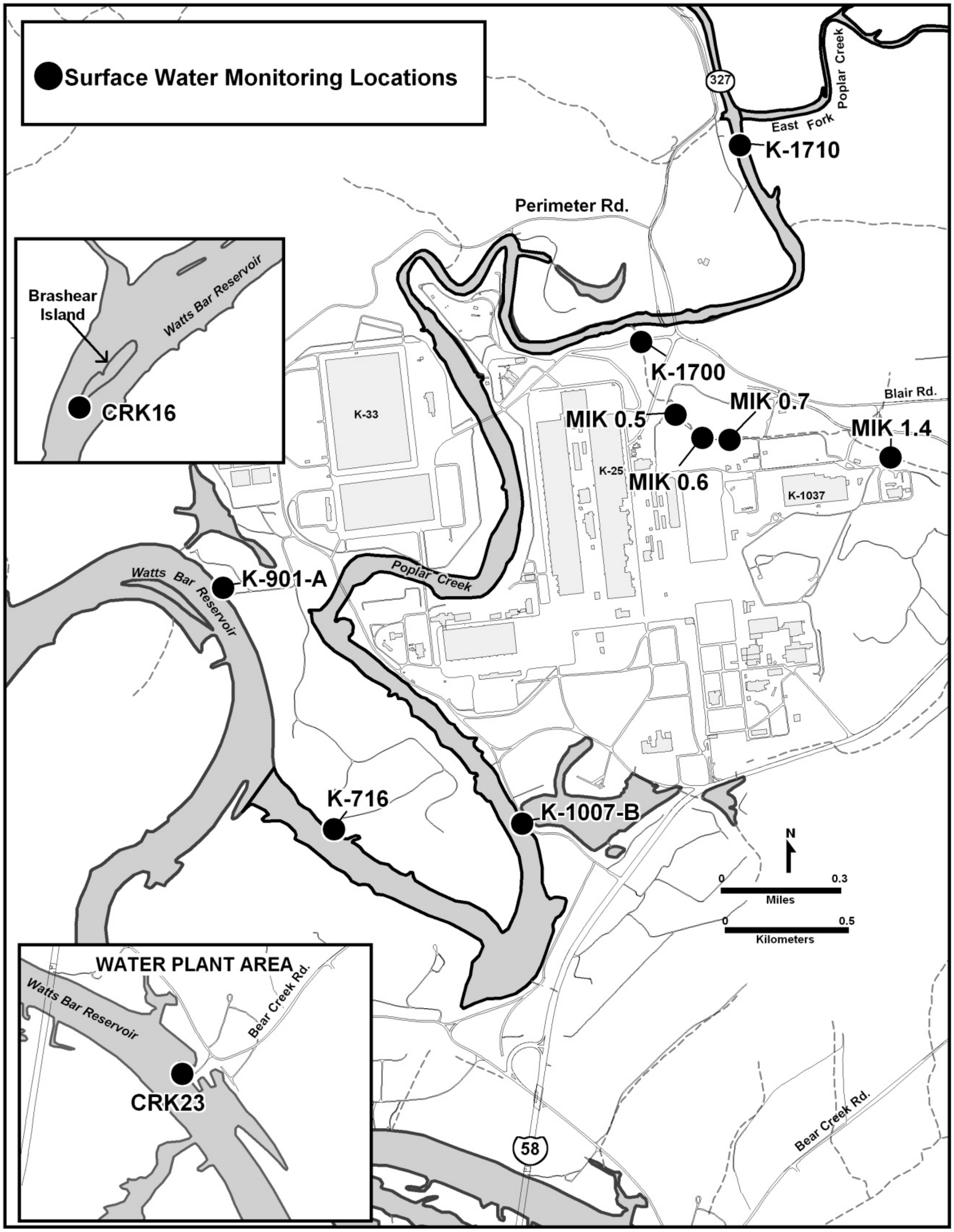

Fig. 3.41. Environmental monitoring program surface water monitoring locations.

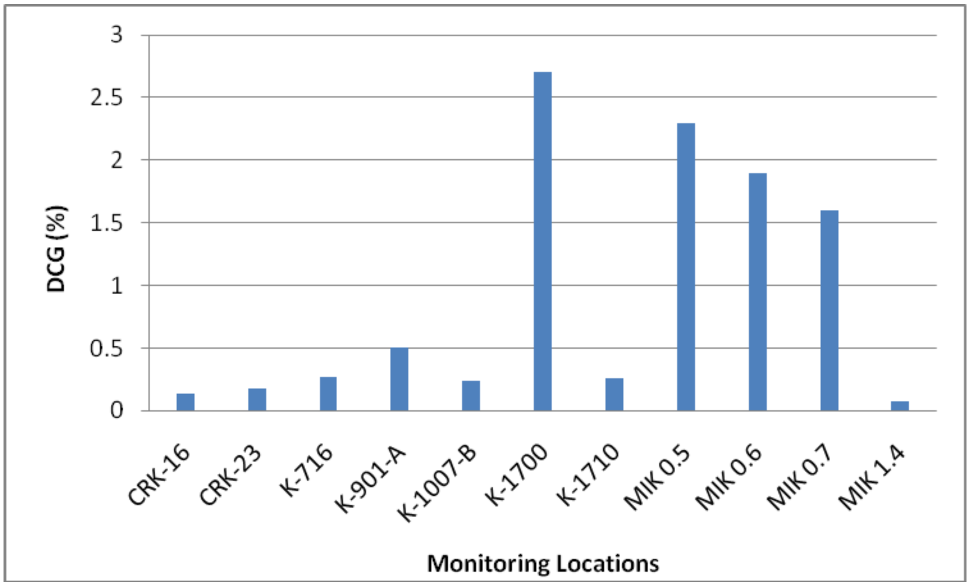

Fig. 3.42. Percentage of derived concentration guides (DCGs) at surface water surveillance locations, 2009.

Figures 3.43 and 3.44 illustrate the concentrations of TCE (trichloroethene, trichloroethylene) and total 1,2-DCE (dichloroethene, cis-1,2-dichloroethylene, trans 1,2-dichloroethylene) 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), (Appendix D, Table D.2), 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. In addition, vinyl chloride has sometimes been detected in Mitchell Branch water (Fig. 3.45). 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. 3.46) 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 140 µg/L, which exceeded the then-applicable WQC of 100 µg/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 being routinely measured at less than 3 µg/L.

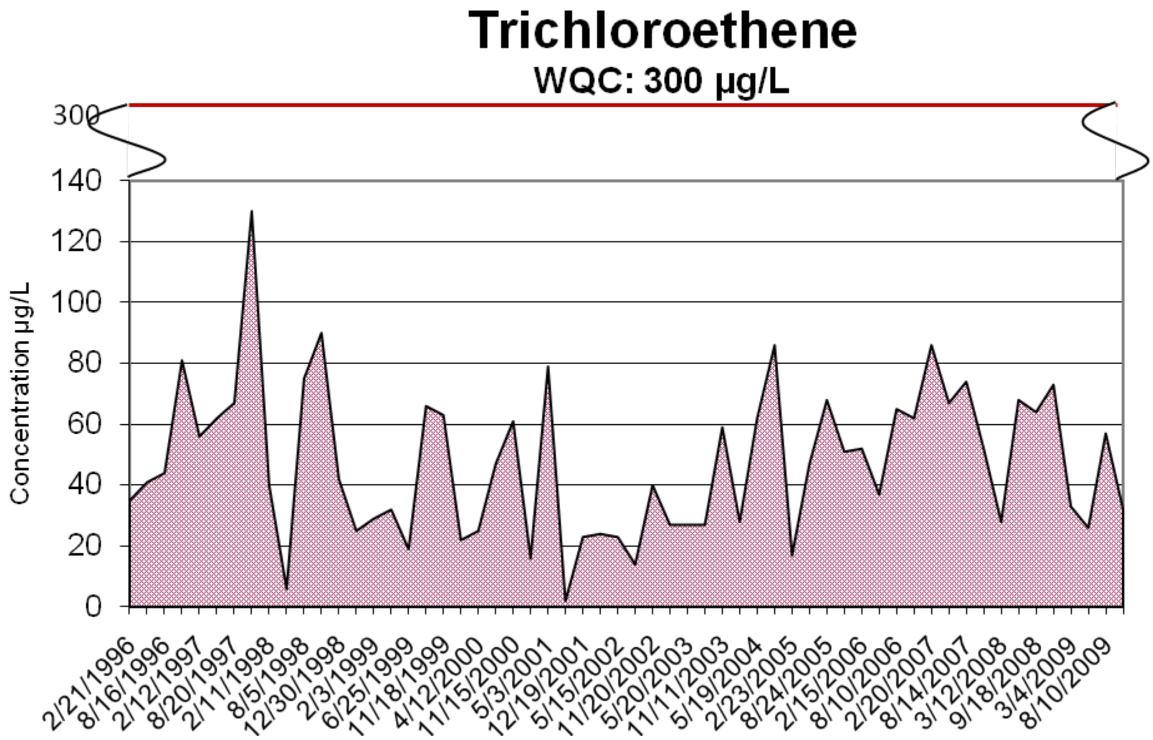

Fig. 3.43. TCE concentrations at K-1700.

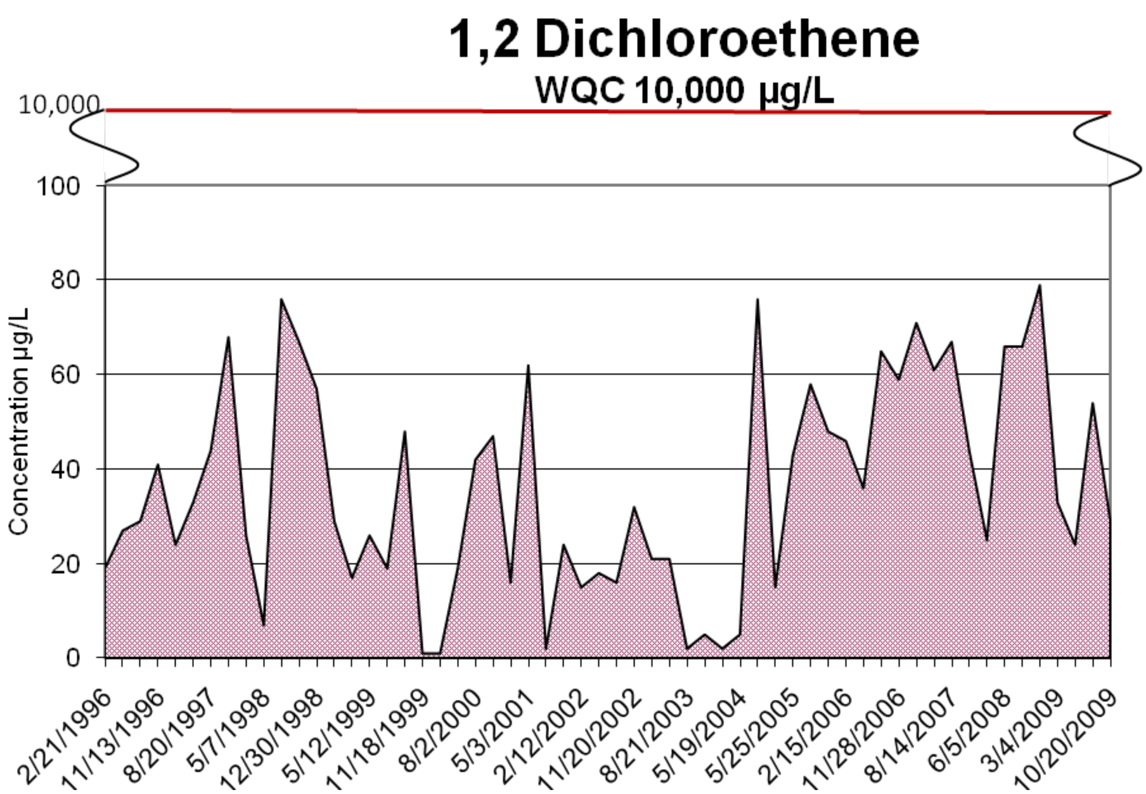

Fig. 3.44. 1,2-DCE concentrations at K-1700.

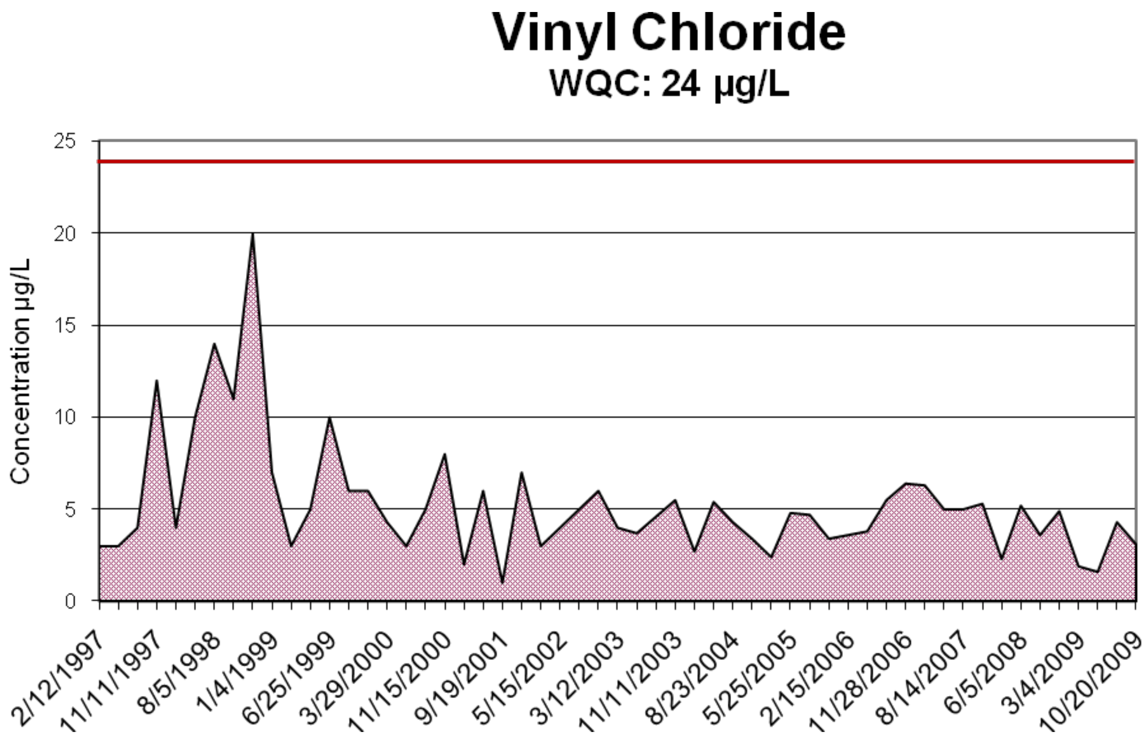

Fig. 3.45. Vinyl chloride concentrations at K-1700.

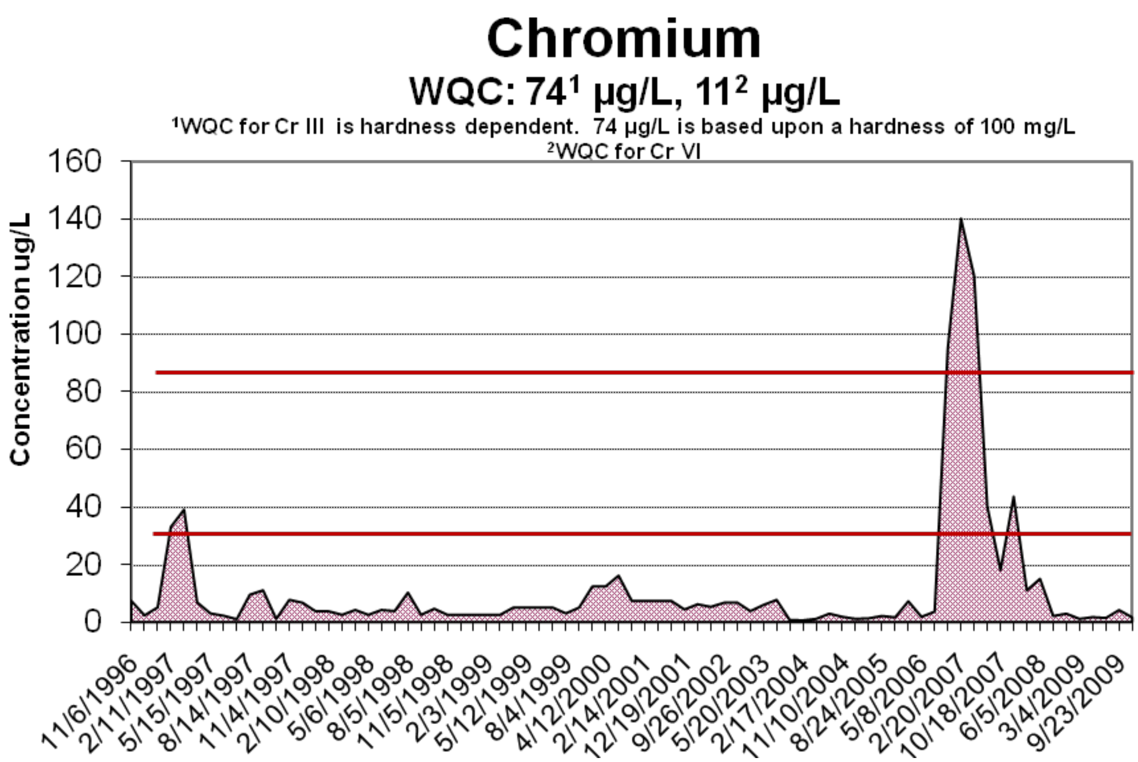

Fig. 3.46. Total chromium concentrations at K-1700.

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 3.47 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 3.48 shows the monitoring locations along Mitchell Branch.

In April and October, 2009, survival and reproduction toxicity tests using the water flea *Ceriodaphnia dubia* (Fig. 3.49) were conducted at four ambient locations in Mitchell Branch. At the same time, survival and reproduction toxicity tests using *C. dubia* were conducted on effluent from storm water outfalls (SD)-170 and -190. In the April tests (Table 3.37), none of the water from the ambient station or from SD-170 exhibited toxicity. Water from storm water outfall 190 did not affect *Ceriodaphnia* survival, but did reduce reproduction at concentrations as low at 12%. Previously, the overall trend was one of consistent toxicity to *Ceriodaphnia* from SD-190, with infrequent toxicity from the ambient locations and occasional toxicity at SD-170. The sources of these problems have not been definitively identified. The data gathered in previous studies indicates 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 this groundwater flows into the storm drain system, and likely contributes to the toxicity at SD- 190. Nickel and zinc are present in water collected from the storm drain system near K-1070-B, at levels that have been shown to be toxic to *Ceriodaphnia.* However, other factors have not been ruled out.

In the October tests (Table 3.38), none of the water from SD-170 or SD-190 exhibited toxicity. In contrast, water from ambient stations MIK 0.8, MIK 0.7, and MIK 0.4 did not affect *Ceriodaphnia* survival, but did reduce reproduction. Water from MIK 0.2 also reduced reproduction, but not by a statistically significant amount. Serial dilutions are not used in the tests of water from the ambient locations, so no No-Observed Effects Concentrations are available. While not unprecedented, the occurrence of toxicity in the water from the ambient stations is unusual. Chemical analyses of water collected from the ambient stations failed to show any obvious explanation for the toxicity.

In June and July, 2009, caged clams *(Corbicula fluminea)* were placed at several locations around ETTP (Table 3.39). The clams (Fig. 3.50) were allowed to remain in place for four weeks, and were then analyzed for uptake of PCBs and mercury. Results of the PCB analyses were generally consistent with those of previous years, although the concentration of PCBs in clams from storm water outfall 100 were substantially lower than in the 2008 test. The highest concentrations were found in the clams from the K-1007-P1 Pond, with lower concentrations found in the clams from Mitchell Branch. In the clams from storm water outfall 100 PCB concentrations decreased from 2008 to 2009. However, the concentrations were still elevated above levels seen at most of the other locations on ETTP. 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. On the other hand, elevated levels of Arochlors-1248, -1254, and -1260 were detected in the clams from the K-1007-P1 Pond. In the K-901-A Pond, low levels of Arochlors-1248, -1254 and -1260 were detected. In general, the concentrations of PCBs at most locations from the 2009 monitoring exhibited similar distributions to those from the 2008 effort. However, the measured concentrations at almost every location were decreased from 2008. For example, levels at MIK 0.7 averaged 0.41 µg/g in the 2008 samples, but dropped to 0.17 µg/g in 2009, while at MIK 0.4, the average dropped from 1.6 µ/g in 2007 to 0.84 µg/g in 2009. Levels at MIK 0.2 were very similar in both years (2.76 µg/g in 2008 and 2.43 in 2009). Concentrations in clams from the lower storm water outfall 100 dropped from 4.1 µg/g in 2008 to 1.52 in 2009. It is too early to tell if these measurements reflect actual decreases in environmental PCB concentrations, or if they are just within the normal range of variations.

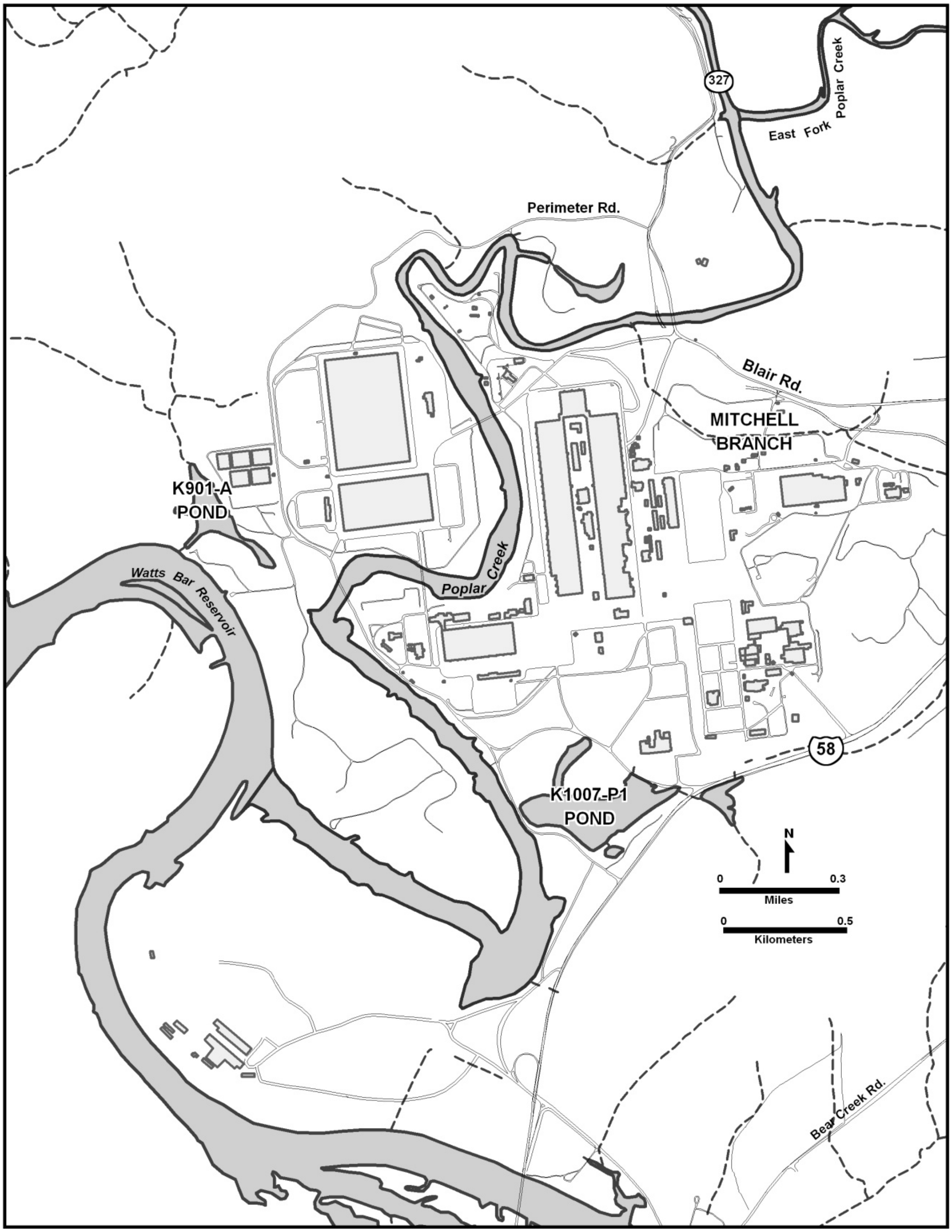

Fig. 3.47. Waterways at ETTP.

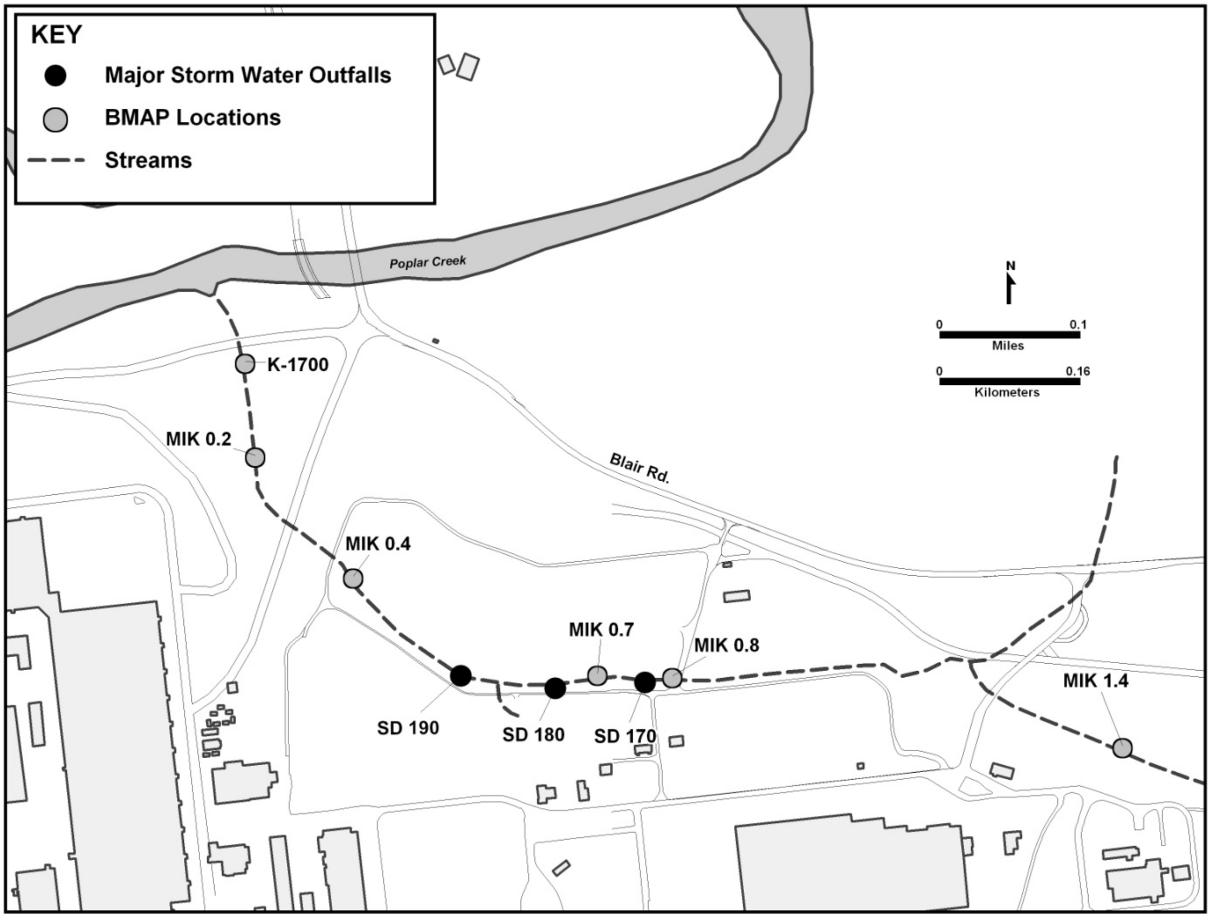

Fig. 3.48. Major storm water outfalls and biological monitoring locations on Mitchell Branch.

Fig. 3.49. Water flea *Ceriodaphnia dubia*.

Clams from the Mitchell Branch watershed were analyzed for mercury (both total mercury and methyl mercury) in 2009 for the first time in many years (Table 3.39). Although mercury was detected in all clams, the highest levels of mercury were found in the clams from SD-190 (62.6 ng/g total mercury) and below SD- 170 at MIK 0.5(56.9 ng/g total mercury). Mercury levels decreased downstream from SD-190. Methyl mercury concentrations in clams from Mitchell Branch ranged from 20%-40% of the total mercury concentration with the highest levels of methyl mercury being found in the clams from MIK 0.5 (15.0 ng/g) and MIK 0.4 (14.4 ng/g)

Fish were collected from K-1007-P1 Pond (Fig. 3.51) in February 2009. The fish were collected earlier than usual because of the remediation activities planned for the pond. Fish were also collected from Mitchell Branch and K-901-A Pond in May 2009 (Table 3.39). Largemouth bass were collected from the pond sites, and redbreast sunfish (Fig. 3.52) were collected from Mitchell Branch. Game fish of a size typically caught by sports fishermen were selected both to provide more accurate data of potential human health concerns, and to reduce the amount of variation in contamination levels in the individual fish due to age and size differences. Fillets were taken from each game fish and analyzed for PCBs. Results from all three monitoring locations were lower than last year's results, but the relative spatial results were similar to those of historical results. The fish

Table 3.37. Mitchell Branch and associated storm water outfall toxicity test results—April 2009

(No-Observed Effects Concentrations)

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 (%)	100	100	100	6	100	100

Table 3.38. Mitchell Branch and associated storm water outfall toxicity test results—October 2009

(No-Observed Effects Concentrations)

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 (%)	NA	100	NA	100	NA	NA

Table 3.39. Average PCB concentrations in biota—2009

Location	Species	Average PCB concentration µg/g	Range µg/g	Number of fish above 1 µg/g	Total Hg ng/g	Methyl Hg ng/g	Total aqueous Hg ng/g
K-1007-P1 Pond	Largemouth Bass	14.9	5.8-41	6/6			
K-901-A Pond	Largemouth Bass	0.48	0.26–1.1	1/6			
Mitchell Branch	Redbreast Sunfish	0.99	0.11–2.1	2/6	0.49		
Hinds Creek (ref)	Redbreast Sunfish	0.01	<0.01–0.002	0/6			
MIK 0.8	*Corbicula fluminea*	0.10	NA	NA	41.3	11.5	12.96
SD170	*Corbicula fluminea*	0.26	NA	NA	30.9	9.1	19.23
MIK 0.7	*Corbicula fluminea*	0.17	NA	NA	36.15	14.2	14.59
MIK 0.5	*Corbicula fluminea*	0.23	NA	NA	56.9	15.0	77.99
SD190	*Corbicula fluminea*	2.03	NA	NA	62.55	10.8	57.4
MIK 0.4	*Corbicula fluminea*	0.84	NA	NA	44.55	14.4	25.09
MIK 0.2	*Corbicula fluminea*	2.43	NA	NA	41.3	11.5	24.27
SD100 (upper)	*Corbicula fluminea*	0.83	NA	NA			
SD100 (lower)	*Corbicula fluminea*	1.52	NA	NA			
SD 120	*Corbicula fluminea*	0.46	NA	NA			
SD 490	*Corbicula fluminea*	0.43	NA	NA			
K-1007-P1 outfall	*Corbicula fluminea*	0.88	NA	NA			
K-1007-P1 mid-pond	*Corbicula fluminea*	1.02	NA	NA			
K-901-A outfall	*Corbicula fluminea*	0.15	NA	NA			
Sewee Cr (ref)	*Corbicula fluminea*	0.02	NA	NA	25.6	5.9	

ppm = parts per million

Fig. 3.50. Asian Clam *Corbicula fluminea*.

with the highest concentrations (14.8 µg/g) were from P1 pond, while fish from the K-901-A pond had the lowest concentrations (0.48 µg/g). Fish from Mitchell Branch averaged 0.99 µg/g. Concentrations in one fish from the K-901-A pond, and two fish from Mitchell Branch, exceeded the State of Tennessee posting limit of 1 µg/g. Concentrations in all six of the fish from the K-1007-P1 pond exceeded the limit. As a result of these studies, a remedial action to remove the contaminated fish from the K-1007-P1 pond and re-contour the pond to reduce the availability of PCB contaminated sediments was implemented in 2009. Details of the remedial action are given in section 3.8.2 below.

Fish from Mitchell Branch were also analyzed for total mercury (Table 3.39). The fish averaged 0.49 µg/g of total mercury. Previous studies have shown that methyl mercury accounts for greater than 95 % of the total mercury in fish, so a separate analysis for methyl mercury was not conducted. Mercury analyses have not been performed as part of the fish bioaccumulation subtask of the ETTP BMAP program in many years; therefore, no meaningful historical comparisons could be made.

In April 2009, the benthic macroinvertebrate community at four Mitchell Branch locations (MIKs 0.4, 0.7, 0.8, and 1.4) was sampled using the traditional techniques developed by ORNL's Environmental Sciences Division (ESD). MIK 1.4 was the reference location. In the last ten years, the condition of the benthic macroinvertebrate community at all locations in Mitchell Branch has generally improved. In 2009, total taxa richness and richness of the Ephemeroptera, Plecoptera, and Trichoptera (EPT) species was greatest at MIK 1.4 and decreased at the downstream locations (Fig.3.53). EPT species are generally pollution intolerant, and lower values generally correlate to some degree of impact to the stream. Total density at MIK 0.8 and MIK 0.7 was greater than at MIK 1.4, but the density of pollution intolerant species was generally lower at all of the locations downstream of MIK 1.4 with the exception of MIK 0.8. One possible explanation for the lower number of individuals at MIK 1.4 when compared to MIK 0.7 and MIK 0.8 may be the fact that Mitchell Branch is shallower at MIK 1.4, and the lower flows may inhibit the population size. Higher densities downstream of MIK 1.4 may also be indicative of nutrient enrichment, which commonly leads to increases in density.

Consequently, in August 2008, TDEC protocols were used at monitoring locations MIKs 0.4, 0.7, and 0.8. In August 2009, TDEC protocols were used at the same three locations on Mitchell Branch and MIK 1.4, additionally (Fig. 3.54). TDEC protocols differ from the ORNL protocols in several key respects. 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 not all of the locations along Mitchell Branch meet the habitat goals for this region. In the 2008 study, all three locations (i.e., MIK 0.4, 0.7, and 0.8) failed to meet the habitat goals. In the 2009 study, locations MIK 0.7, 0.8, and 1.4 met the goals, with the exception being MIK 0.4. However, even at MIK 0.8, the parameter score for the 2009 study (108) compares favorably with the score at the same location in 2008 (90). The results of the semi-quantitative assessment indicated that Mitchell Branch is slightly impaired, which is consistent with the results from the studies using the ORNL protocols. Although improvements in the water quality and health of the community may be due to improvement in the stream's quality, it may also be possible that the actual biotic indices (only slightly different) indicate that the changes were within range of natural annual fluctuations.

Fish communities in Mitchell Branch (MIK 0.4 and 0.7), as well as three reference sites, were sampled in March and June of 2009 (Table 3.40). Species richness, density, and biomass were examined. Results for MIK 0.4 were very similar to those in 2008, although one new species, the banded sculpin (*Cottus carolinae*) was collected. Total density and biomass increased slightly for the second year in a row. At MIK 0.7 biomass and density showed slight decreases from last year while species richness

Fig. 3.51. Fish bioaccumulation at K-1007-P1 pond.

Fig. 3.52. Redbreast sunfish *Lepomis auritus*.

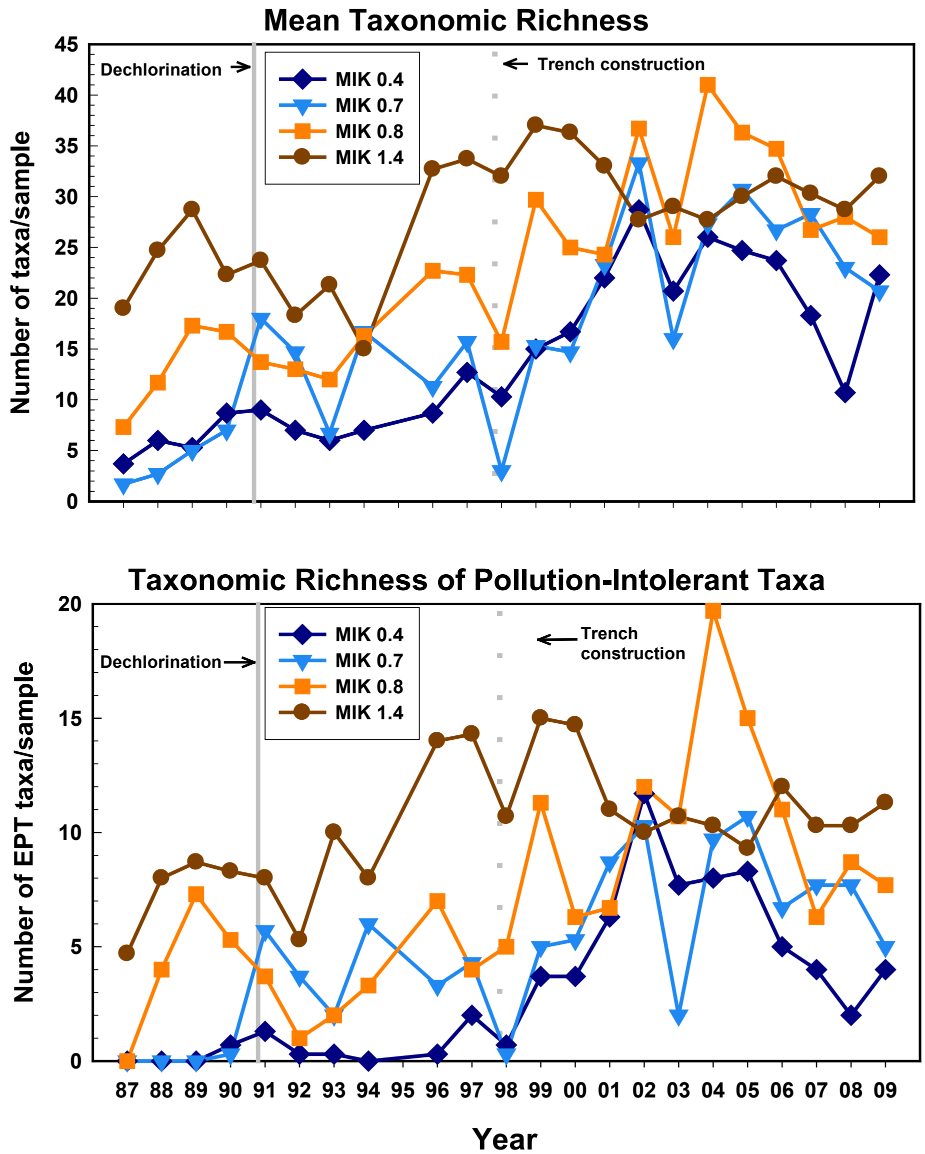

Fig. 3.53. Temporal trends in mean total taxonomic richness (top) and mean taxonomic richness pollution-intolerant taxa (EPT, or Ephemeroptera, Plecoptera, and Trichoptera) in Mitchell Branch based on samples collected with ORNL protocols in April of each year, 1987–2009.

remained unchanged. Wide swings in these three parameters are typical of streams that have been severely impacted and are still in the process of recovering. The stream is still dominated by more tolerant fish species though, while the condition of the fish community has not yet reached a stable condition typical of less impacted streams in the area.

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

Fig. 3.54. Benthic macroinvertebrate sampling using TDEC protocols.

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.

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,

Table 3.40. Fish species richness, density (individuals/m[2]), and biomass (g fish/m[2]) at Mitchell Branch sites and reference sites, Mill Branch (MBK), Scarboro Creek (SCK), and Ish Creek (ISK) for March and June, 2009

Species	MIK 0.7	MIK 0.4	MBK 1.6	SCK 2.2	ISK 1.0
Unidentified larval minnow	0.02 (0.01)	–	–	–	–
Largescale stoneroller *Campostoma oligolepis*	3.20 (13.19)	1.79 (5.12)	–	0.01 (0.01)	0.21 (0.69)
Striped shiner *Luxilus chrysocephalus*	1.51 (4.84)	0.63 (1.87)	–	–	0.20 (0.90)
Tennessee dace *Phoxinus tennesseensis*	–	–	0.01 (0.01)	–	0.05 (0.02)
Bluntnose minnow *Pimephales notatus*	–	–	–	–	0.01 (0.01)
Western blacknose dace *Rhinichthys obtusus*	2.08 (4.07)	0.66 (1.07)	0.30 (0.55)	0.36 (1.39)	0.61 (1.26)
Creek chub *Semotilus atromaculatus*	0.42 (1.74)	0.32 (2.60)	0.27 (1.45)	–	0.33 (1.47)
White sucker *Catostomus commersoni*	–	–	0.03 (0.26)	–	0.01 (0.04)
Western mosquitofish *Gambusia affinis*	0.02 (<0.01)	0.21 (0.09)	–	–	–
Banded sculpin *Cottus carolinae*	0.05 (0.27)	0.02 (0.08)	–	0.51 (2.35)	0.13 (1.10)
Redbreast sunfish *Lepomis auritus*	0.02 (0.12)	0.06 (1.15)	–	–	–
Hybrid sunfish *Lepomis sp. x*	–	–	–	0.01 (0.02)	–
Green sunfish *Lepomis cyanellus*	–	0.02 (0.17)	–	0.01 (0.15)	0.49 (1.75)
Bluegill *Lepomis macrochirus*	–	–	0.09 (1.30)	–	–
Stripetail darter *Etheostoma kennicotti*	–	–	0.03 (0.04)	–	0.06 (0.08)
Species richness	7	8	6	4	10
Total density	7.32	3.71	0.73	0.90	2.10
Total biomass	24.24	12.15	3.61	1.92	7.32

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.

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.

Environmental monitoring programs at ETTP incorporate data quality objectives and other quality assurance protocols through the sampling and analysis plans and the associated laboratory statements of work (SOW). The monitoring program subject matter expert (SME) and the BJC Sample Management Office (SMO) collaborate in choosing the most appropriate analytic methodology for both radiological and non-radiological monitoring. Sample quantitation levels (the concentration at which it is possible to quantify the concentration within the appropriate level of confidence), screening levels for notification, analytical methods, and other information necessary to ensure that the data collected is of the appropriate quality are included in the plans. The SMO and the SME review these criteria with the contracting laboratories in order to ensure that they are capable of meeting the criteria. If for any reason the laboratory is unable to meet any of the requested criteria, the SME must determine if the laboratory's capabilities are adequate. The appropriate action is then taken to either amend the statement of work or to send the analytical work to a laboratory capable of meeting the monitoring program needs.

Laboratories conducting radiological and non-radiological analyses for ETTP environmental monitoring programs are reviewed periodically by the SMO to ensure that the quality of the analytical work continues to meet the appropriate standards. Laboratories used by ETTP must be approved by the Department of Energy Analytical Services Program (DOECAP Audit Team), which conducts routine audits (at least once per year, and more frequently if a problem is noted) to ensure that the analyses are of the highest quality.

When data is received from the laboratory, the SMO reviews the data package from the laboratory. Data completeness, quantitation levels, screening levels, holding times, and methodology are examined to ensure that all quality aspects of the analyses meet the criteria set forth in the S&A plan and the SOW. Any deficiencies are noted and the laboratory is contacted for clarification. When the SMO is satisfied that the data is complete and meets all criteria, the data is forwarded to the SME. The SME conducts further reviews, and uses the data in the appropriate calculations and reports.

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. 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 was one of the few facilities licensed to incinerate both PCB waste and radioactive mixed waste. The TSCA Incinerator treated waste from all across the DOE complex and as such was a key component of DOE remediation efforts across the nation. The incinerator treated approximately 2.2 million lbs of waste in 2009 (2,066,050 lbs of liquid waste and 119,203 lbs of solid waste). On December 2, 2009, waste treatment operations ceased at the incinerator, and the facility entered the decontamination and decommissioning phase. Fuel oil used to rinse the waste storage and feed tanks was incinerated at the facility. When the decontamination is completed, the facility will be demolished.

The CNF, ETTP's primary wastewater treatment facility, which processes both hazardous and nonhazardous waste streams, treated more than 18,351,000 million gal of wastewater in 2009. Although the largest single contributor by far is the TSCA Incinerator, wastes also arise from other facilities and remediation projects, including the chromium-contaminated groundwater collection system. With the shutdown of the TSCA Incinerator, CNF has reduced operational hours to a single day shift. 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 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. The EMWMF 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 EMWMF received approximately 14,700 truckloads of waste accounting for 173,600 tons during FY 2009. In addition, approximately 3.4 million gal of leachate were collected and disposed of at the ORNL Liquids and Gases Treatment Facility. An additional 8.9 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 EMWMF include the following:

- David Witherspoon, Inc. Site Remedial Action Project;
- the K-25/K-27 D&D Project, including hazardous materials abatement, excess materials removal; and K-25 Building west wing demolition debris and equipment; and
- other ETTP D&D projects, including K-1401; K-1066-G Scrapyard; K-1070-B Burial Ground; and K-1035 demolition debris.

To ensure the continuity of disposal capacity for the ORR cleanup waste, construction of a new cell at EMWMF began in 2009. The new cell will bring the total capacity of the EMWMF to slightly below 1.7 million cubic yards. Planning is also underway for a sixth cell, if it should prove necessary.

The use of radio frequency identification devices (RFIDs) was implemented for waste shipments to EMWMF. This innovation allows for faster, and more accurate tracking of waste shipments and reduces paperwork, decreases the shipment cycle time, and improves security of the materials being transported along the haul road.

The Oak Ridge Reservation Landfills (ORRL) are located near the Y-12 complex, and are designed for the disposal of sanitary, industrial, construction, and demolition wastes that meet the waste acceptance criteria for each landfill. In FY 2009, more than 145,000 cubic yards of waste were disposed of at these facilities, and more than 1.6 million gallons of leachate were collected, monitored, and discharged to the Oak sewer system. In 2009, planning also began to expand Landfill V of the ORRL.

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 Environmental Management Program (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 of land at ETTP. The area encompasses approximately about 567 ha outside the main plant security fence (Zone 1), and about 324 ha 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.

In 2009, the American Recovery and Reinvestment Act (ARRA) provided funds to the Oak Ridge office of the Department of Energy. Much of these funds (approximately $755 million) were allocated to speeding up environmental restoration and remediation activities. In addition to the creation of new jobs and the preservation of existing ones, it is hoped that by accelerating these activities, long term costs will be lower and remediation goals will be reached sooner than had been planned before the ARRA funds became available.

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. By the end of FY 2009, approximately 5,500 loads of demolition debris, 1,300 compressors, and 700 converters had been removed and shipped to the Environmental Management Waste Management Facility (EMWMF) for disposal. Demolition of the west wing was completed in December 2009, although removal of the debris continues and is expected to be completed in 2010.

Activities under way to prepare the east wing for demolition include the removal of 104 of the 343 high-risk equipment items; vent, purge, drain, and inspection activities; asbestos removal; and draining of lubricants and oils from process systems.

There were several buildings inside of the K-25 Building footprint. Two of the buildings, K-1101 and K-1201, which had housed support facilities for the K-25 Building, were prepared for demolition in 2009. Preparations included removal of approximately eight million pounds of scrap metal. This metal had been slated to be shipped to landfills, but it was determined that the metal could be recycled instead. The recycling will therefore provide metal resources as well as saving valuable landfill space.

The K-1035 maintenance and instrument shop was demolished in 2009. Demolition debris was disposed of at EMWMF.

Preparations for the demolition of the K-27 Building included installation of much of the construction power supply and the removal of most of the combustible materials from the vault and cell levels.

In FY 2009, four predominantly uncontaminated and eleven low risk/low complexity facilities were demolished. In addition, three high risk buildings in the Poplar Creek area (K-1231, K-1233, and K-413) were demolished.

In 2007, surveillance data indicated that the levels of chromium in Mitchell Branch had exhibited a marked increase. Subsequent analyses showed that the chromium was almost entirely in the hexavalent state. Since hexavalent chromium has not been used at ETTP for many years, it is believed that the source is groundwater contaminated with legacy material, and not a result of current operational issues. 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. In January 2009, the original pumps were changed to electric pumps to both increase pumping capacity and reduce maintenance costs. 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 well below the water quality criteria of 11 μg/L, and near or below the detection levels of 1 to 3 μg/L.

Largemouth bass from the K-1007-P1 Pond were known to accumulate high concentrations of PCBs in their muscle tissue. As a result of multiple studies of the pond, the major source of PCB contamination was thought to be contaminated sediments, which are easily suspended by bottom-feeding fish like carp and shad, especially in this system where grass carp totally decimated pond plants that historically served to stabilize the sediments. High nutrient loads in the pond from a large goose population were thought to contribute high suspended algal biomass. Lipid-rich gizzard shad, which forage on sediment and suspended algae and therefore accumulate very high PCBs, served as a major vector of PCB transfer to largemouth bass and wildlife. In 2009, a non-time-critical-removal-action was implemented that used fish management, wildlife management, and plant management principles to minimize the risks associated with PCBs in the pond. The problem fish were removed from the pond, geese were discouraged from the area, and extensive pond recontouring and planting was conducted. The goal was to create a fish population in the pond that are relatively low bioaccumulators (that is, primarily small sunfish), and create dense areas of rooted aquatic vegetation to stabilize the sediment to prevent re-suspension. This innovative approach was deemed to be more cost-effective than traditional dredging operations, and served to preserve the pond as an ecological and aesthetic asset for the area

A plume of groundwater contained with solvents left from degreasing and other maintenance operations lies near the old K-1401 footprint area. In 2009, a treatability study to determine the best treatment options began with the installation of seven boreholes. Water and soil samples were collected to characterize the nature and extent of the plume. In 2010, sampling of selected intervals will be conducted. Once the data has been collected and reviewed, the appropriate treatments will be determined.

The K-770 Scrapyard contained huge quantities of contaminated scrap metal. This scrap metal had been removed previously, but in 2009 work continued on defining the limits of the contaminated soil. This soil is being removed to allow future industry to use the area, and to protect groundwater resources. Work also continued on remediation of the K-1070-B Burial Ground.

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 the Community Reuse Organization of East Tennessee (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.

The transfer of the Phase I Electrical Distribution System and the Phase I Plant Roadway System to the City of Oak Ridge was ongoing in FY 2009. The Phase I Electrical Distribution System includes all direct off-site main plant power lines. The Phase I Plant Roadway System includes the main plant entrance and the main arterial roads.

Buildings K-1000, K-1501, and K-1008-F were transferred to CROET. K-1000 was renovated to become the ETTP Welcome Center, while the other two buildings were leased to private companies.

One fourteen acre parcel referred to as ED-4 was transferred to CROET for future development.

One land parcel, referred to as ED-5 West, 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. During FY 2009 construction of two speculative building and associated utilities proceeded.

Approximately 3,000 ft2 of security fence was removed and recycled in order to shrink the footprint of the plant security area.

These activities are all 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 ETTP Groundwater

Groundwater at the ETTP site occurs in residual soils, manmade fill, alluvial soils, and bedrock. Because of extensive terrain modification that occurred during site construction, large areas of the main industrial site were subjected to cut and fill activities that modified site hydrology. Most of the ETTP site is underlain by carbonate bedrock of the Chickamauga Group with subordinate areas underlain by the carbonates of the Knox Group and clastic dominated sandstones, shales, and siltstones of the Rockwood formation. The geologic structure of bedrock beneath the ETTP site is the most complex of the ORR facilities because of structural rock deformation associated with the White Oak Mountain thrust fault and footwall deformation associate with motion along that fault. The structural complexity coupled with the presence of soluble carbonate bedrock beneath the site lead to very complex groundwater flow conditions.

3.9.1 ETTP Groundwater Monitoring

Groundwater monitoring at the ETTP is focused primarily on investigating and characterizing sites for remediation under CERCLA and groundwater exit pathway monitoring. 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. 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 groundwater exit pathway monitoring.

ETTP groundwater monitoring is conducted by the Water Resources Restoration Program to assess the performance of completed CERCLA actions. Groundwater monitoring wells have been placed down-gradient of potential contamination sources. 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 towards these surface water bodies. Groundwater monitoring wells have been placed near these exit points, and groundwater monitoring is supplemented by the ETTP Environmental Monitoring Plan surface water surveillance program.

The cleanup strategy being followed at ETTP is 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. At ETTP surface water and groundwater hydrologic conditions differ from those typical of the ORNL and Y-12 sites because of geologic and site development characteristics. At ETTP the surface water system involves several small, local streams that drain to Poplar Creek or directly to Clinch River as well as extensive areas with dispersed surface runoff and groundwater seepage to the large water bodies. Figure 3.55 shows the three principal defined watershed areas (K-1007, Mitchell Branch, and K-901 Watersheds) as well as the K-27 groundwater basin. Also shown are areas of known VOC plumes at the site and exit pathway groundwater monitoring locations. Groundwater is monitored primarily from constructed monitoring wells however sampling is also conducted at several springs or seeps where groundwater emanates to surface water bodies.

Groundwater data pertaining to contaminant trends in the vicinity of CERCLA source areas and related to specific remedial actions can be found discussed in the *2010 Remediation Effectiveness Report* (DOE 2010). VOCs, chiefly chlorinated solvents (tetrachloroethene (PCE), trichloroethene (TCE), and 1,1,1-tetrachloroethane (TCA) were the most commonly used solvents at ETTP) and their degradation products, are the main contaminants of concern at most of the groundwater monitoring locations. Very little of these compounds are still used at ETTP, and the contamination in the plumes is due to legacy materials. The degree of degradation that has occurred over time is highly variable depending on local groundwater geochemical conditions and the ability of indigenous microbes to degrade the chlorinated compounds. Radionuclides are a minor concern at the locations down-gradient of the K-1407-B/C ponds. The *2010 Remediation Effectiveness Report* (DOE 2010) 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.

3.9.2 Exit Pathway Monitoring Results

This section summarizes the results of exit pathway groundwater monitoring at the ETTP site. Similar information is also included in the *2010 Remediation Effectiveness Report* (DOE 2010).

Groundwater monitoring results for the exit pathways are discussed below starting with the Mitchell Branch exit pathway and then progressing in a counterclockwise fashion.

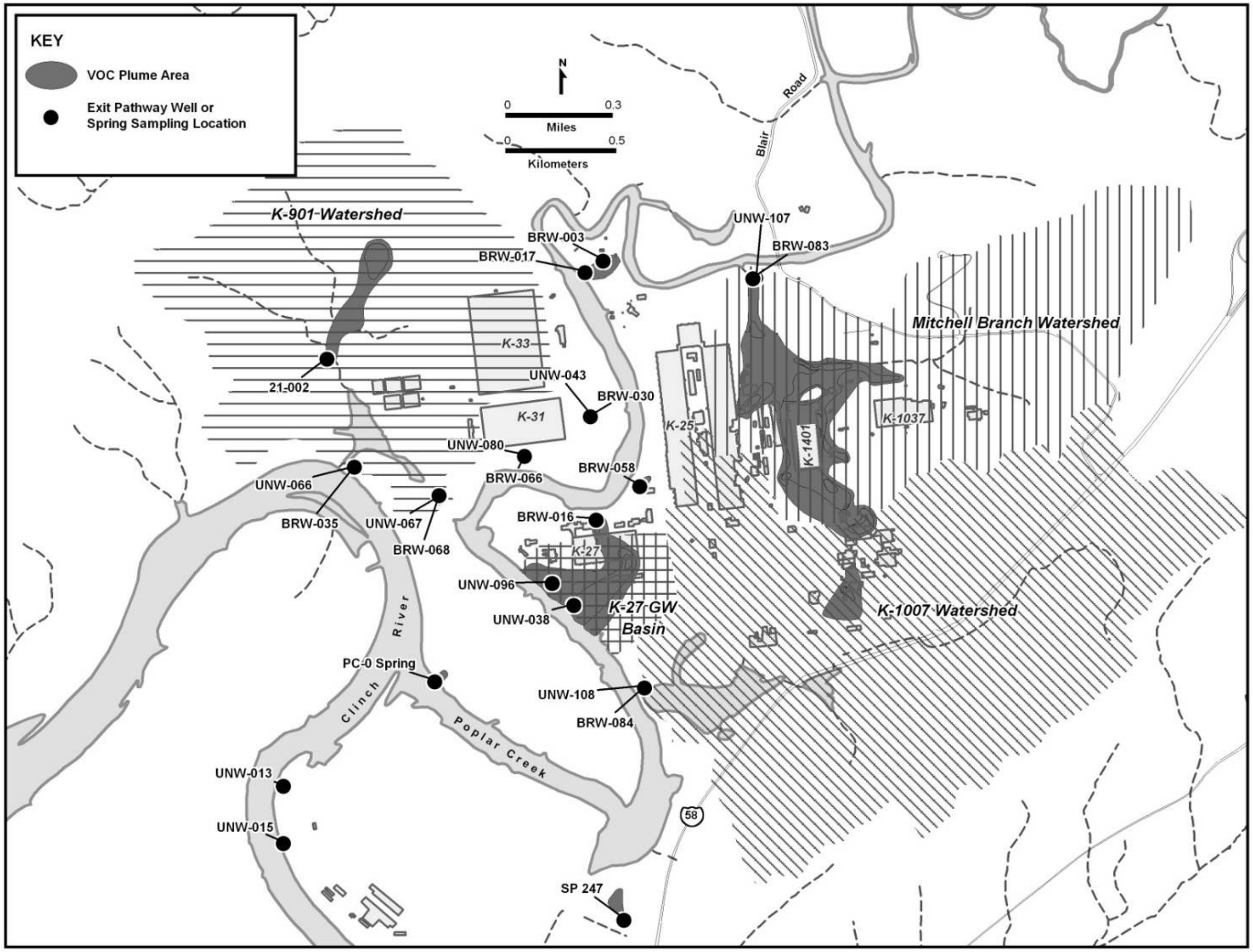

Fig. 3.55. ETTP site exit pathway groundwater monitoring locations.

The Mitchell Branch exit pathway is monitored using surface water data from the K-1700 Weir on Mitchell Branch and wells BRW-083 and UNW-107. TCE, 1,2-Dichloroethene (DCE) (essentially all cis-1, 2-DCE), and vinyl chloride are the major contaminants in Mitchell Branch, although low concentrations of carbon tetrachloride, chloroform, and TCA are sometimes detected. VOC concentrations measured during FY 2009 were below AWQC levels for organisms at K-1700.

Wells BRW-083 and UNW-107, located near the mouth of Mitchell Branch, have been monitored since 1994. Table 3.41 shows the history and concentrations of detected VOCs in groundwater. Detection of VOCs in groundwater near the mouth of Mitchell Branch is considered an indication of the migration of the Mitchell Branch VOC plume complex. The intermittent detection of VOCs in this exit pathway is thought to be a reflection of variations in groundwater flowpaths that can fluctuate with seasonal hydraulic head conditions which are strongly affected by rainfall. PCE and TCE were detected at BRW-083 during FY 2009 as a result of the above average rainfall.

Table 3.41. VOCs detected in groundwater in the Mitchell Branch Exit Pathway

Well	Date	cis-1,2-Dichloroethene	Tetrachloroethene	Trichloroethene	Vinyl chloride
BRW-083	8/29/2002	ND	5	28	ND
	3/16/2004	0.69	2.2	9.9	ND
	8/26/2004	2	4.7	20	ND
	3/14/2007	5	9	28	ND
	3/20/2008	ND	ND	ND	ND
	8/21/2008	ND	ND	ND	ND
	3/12/2009	ND	ND	1.31 J	ND
	8/3/2009	ND	2.66	14.2	ND
UNW-107	8/3/1998	ND	ND	3	ND
	8/26/2004	4.7	ND	3.6	ND
	8/21/2006	3.4	14	2	1.2
	3/13/2007	25	2 J	23	2a
	8/21/2007	17	ND	30	0.3 J
	3/5/2008	ND	ND	ND	ND
	8/18/2008	ND	ND	ND	ND
	3/12/2009	ND	ND	ND	ND
	7/30/2009	ND	ND	ND	ND

[a] Detection occurred in a field replicate. Constituent not detected in regular sample.

Bold table entries exceed primary drinking water MCL screening values (PCE, TCE = 5 μg/L, cis-1,2-DCE = 70 μg/L, vinyl chloride = 2 μg/L)

All concentrations μg/L.

BRW = bedrock well

J = estimated value

ND = Not Detected

UNW = unconsolidated well

Wells BRW-003 and BRW-017 monitor groundwater at the K-1064 Peninsula burn area. Concentrations of the VOC contaminants TCE, 1,1,1-TCA, and 1,2-DCE have declined to levels less than their respective MCLs.

Groundwater is monitored in four wells (BRW-066, BRW-030, UNW-080, and UNW-043) that lie between buildings K-31/K-33 and Poplar Creek, as shown on Fig. 3.55. VOCs are not COCs in this area; however, historic leaks of recirculated cooling water have left residual subsurface chromium contamination. Well UNW-043 exhibits the highest residual chromium concentrations of any in the area. Chromium concentrations in well UNW-043 correlate with the turbidity of samples, and acidification of unfiltered samples that contain suspended solids often causes detection of high metals content because the acid preservative dissolves metals that are adsorbed to the solid particles at the normal groundwater pH. During FY 2006, an investigation was conducted to determine if groundwater in the vicinity of the

K-31/K-33 buildings contained residual hexavalent chromium from recirculated cooling water leaks. The data indicated the chromium in groundwater near the leak sites was essentially all the less toxic trivalent species. During FY 2008 and FY 2009 field filtered and unfiltered samples were collected from UNW-043. The samples filtered in the field prior to acid preservation contained very little chromium and the dissolved chromium levels did not exceed the MCL. This indicates that most of the chromium in this area is particle-bound rather than dissolved in groundwater.

Several exit pathway wells are monitored in the K-27/K-29 area, as shown on Fig. 3.55. TCE is consistently measured at concentrations above its MCL in well UNW-038. The source of persistent 1,2-DCE measured in well BRW-058 at about half its MCL. VOC contamination is not suspected to be from K-27/K-29 area operations. VOC concentrations in this area show very slowly declining concentrations.

Wells BRW-084 and UNW-108 are exit pathway monitoring locations at the northern edge of the K-1007-P1 Pond (see Fig. 3.55). These wells have been monitored intermittently from 1994 through 1998 and semiannually from FY 2001 through FY 2009. The first detections of VOCs in these wells occurred during FY 2006 with detection of low (~10 μg/L or less) concentrations of TCE and cis-1,2-DCE. The source area for these VOCs has not been confirmed although the VOC plume to the east in the K-1007 watershed is a suspected source. Volatile organic compounds were not detected in either of these wells during FY 2009. Metals were detected and associated with the presence of high turbidity in the samples. No primary or secondary MCLs for metals were exceeded in sample aliquots that were field-filtered prior to acid preservation during FY 2009.

Exit pathway groundwater in the K-901-A Watershed area (see Fig. 3.55) is monitored by four wells (BRW-035, BRW-068, UNW-066, and UNW-067) and one spring (21-002). Very low concentrations (<5 μg/L) of VOCs are occasionally detected in wells adjacent to the K-901 Pond. However, these contaminants are not persistent in groundwater west and south of the pond. No VOCs were detected in the K-901-A Pond exit pathway wells during FY 2009, and alpha and beta activity levels were less than 15 pCi/L and 25 pCi/L, respectively. TCE is the most significant groundwater contaminant detected in spring 21-002 and its concentration varies from near the 5 μg/L MCL to about 50 μg/L.

Spring PC–0 was added to the sampling program in 2004. During the spring through autumn seasons, spring PC–0 is submerged beneath the Watts Bar lake level, so this location is accessible for sampling only during winter when the lake level is lowered by TVA. Measured TCE concentrations in this spring have varied between about 15 to 25 μg/L with an apparent decreasing trend.

Exit pathway groundwater monitoring is also conducted at the K-770 area, where wells UNW-013 and UNW-015 are used to assess radiological groundwater contamination along the Clinch River (see Fig. 3.55). Alpha and beta activity are measured in this area as indicators of residual radiological constituents. Analytical results indicate that the alpha activity is largely attributable to uranium isotopes. Alpha activity in well UNW-015 varies between about 25–50 pCi/L and is less than 5 pCi/L in UNW-013. Well UNW-013 historically contained ^{99}Tc that is a strong beta emitting radionuclide responsible for the elevated beta activity in that well. Beta activity in well UNW-013 has exhibited a gradual decrease from levels greater than 100 pCi/L in 2002 to less than 50 pCi/L in 2009.

3.11 References

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4. The Y-12 National Security Complex

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. The roles of the Y-12 Complex include the following:

- 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;
- provision of technical support to the National Nuclear Security Administration (NNSA) Defense Nuclear Nonproliferation Program;
- provision of fuel for the nation's naval reactors program;
- transfer of technology to private industry;
- maintenance of DOE capabilities; and
- provision of 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. Located within the town limits of Oak Ridge, Y-12 covers more than 328 ha (810 acres) in the Bear Creek Valley, stretching 4.0 km (2.5 miles) down the valley and nearly 2.4 km (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 the Office of Secure Transportation (OST) Agent Operations Eastern Command (AOEC) Secure Transportation Center and Training Facility and an analytical laboratory. 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 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 continue to significantly change the face of the Y-12 Complex. In FY 2009, an additional 1425.5 m^2 (15,328 ft^2) of floor space was demolished, bringing Y-12's total to more than 0.1 million m^2 (1.2 million ft^2) or 284 buildings demolished since the program was initiated in 2001.

The Infrastructure Reduction project team completed the demolition of Buildings 9706-1 and 9706-1A. The Infrastructure Reduction project team completed planning efforts for FY 2009, which focused on the demolition of 13 facilities targeted to be funded under Transformation Disposition Program. Although the Transformation Disposition Program went unfunded in FY 2009, Facilities

Infrastructure Recapitalization Program (FIRP) underruns from FY 2008 were utilized to complete the planning effort for Buildings 9709 and 9766 including utility isolations on Building 9766. Both buildings are key demolitions needed to support the overall transformation efforts. The planning effort made the projects “shovel ready” in the event demolition funding could be obtained in FY 2010.

4.1.2.2 American Recovery and Reinvestment Act

In the spring of 2009, several projects were designated to receive funding under the American Recovery and Reinvestment Act (Recovery Act). The scope of these projects was based primarily on projects identified in the near-term baseline of the Integrated Facilities Disposition Project Critical Decision-1 schedule which was approved in November 2008. This work was deemed to meet Recovery Act criteria aimed at being ready to start work, expend available funding quickly to increase employment, accomplish needed cleanup work, and show visibly demonstrable achievement.

The projects initiated at Y-12 in May of 2009 are cleanout of legacy materials in Buildings 9201-5 and 9204-4; cleanout of a recovery furnace and demolition of a bag house in Building 9206; demolition of Buildings 9211, 9220, 9224, 9735, and 9769; removal and disposal of scrap metal on the surface of the Old Salvage Yard; and cleanout and repair of storm sewers in the West End Mercury Area (WEMA). Scrap metal remediation at the Old Salvage Yard and WEMA storm sewer remediation were previously authorized in Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Interim Records of Decision. The other projects are being conducted as CERCLA removal actions under Action Memoranda issued in May 2009.

By the end of 2009, legacy material removal was well under way, Building 9735 had been readied for demolition, containers of scrap metal were being shipped to disposal from the Old Salvage Yard, and inspection of accessible storm sewers was completed.

4.1.2.3 New Construction

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.

- **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 (Fig. 4.1), 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 2,745 m (9,000 ft) of deteriorated original cast mains; and sprinkler system modifications. As of the end of December, the project is 92.9% complete.
- **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%, particulate matter by 72%, and greenhouse gas (GHG) carbon dioxide by 11%. In

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Fig. 4.1. Lifting the new 195,045 kg (215-ton) west tank for the potable water system into place.

addition, the new plant will require less water and fewer chemicals because it uses reverse osmosis for water purification. As of the end of December, the project is 95% complete overall and on track to turn over the new plant to Operations in the spring of 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) 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. The project has registered with the United States Green Building Council (USGBC) and is working towards achieving a Leadership in Energy and Environmental Design (LEED) Silver rating, and quite possibly Gold, depending on how many points are ultimately accepted post-occupancy by USGBC.
- **Uranium Process Facility (UPF)—**The UPF (Fig. 4.2), cornerstone of Y-12's modernization strategy, is proposed to replace current enriched uranium and other processing operations. This involves a new, fully modernized manufacturing facility optimized for safety, security, and efficiency. It would be the only facility of its type in the United States.

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Fig. 4.2. Uranium Process Facility conceptual image.

4.2 Environmental Management System

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

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 ISMS for environmental compliance, pollution prevention, waste minimization, and resource conservation. B&W Y-12 self-declared implementation based on the principles of the ISO 14001 standard after verifying and validating implementation based on a third-party independent audit conducted in accordance with Executive Order (E.O.) 13423 (2007) requirements. The audit concluded that B&W Y-12's EMS is fully integrated within ISMS and the required elements from ISO 14001 and DOE orders have been achieved. In addition the DOE Office of Health, Safety and Security (HSS) annual environmental progress reports on implementation of EO 13423, *Strengthening Federal Environmental, Energy, and Transportation Management* and Office of Management and Budget's Environmental Stewardship Scorecard gave Y-12 an EMS scorecard rating for FY 2009 of green indicating full implementation of EO 13423 requirements.

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 and public documents such as this one. The B&W Y-12 ES&H policy is presented in Fig. 4.3.

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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. B&W Y-12 environment, safety, and health policy.

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.

4.2.3 Planning

4.2.3.1 Environmental Aspects

Environmental aspects 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 continues to respond to change and pursue sustainability initiatives by establishing and maintaining 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 and are amended as necessary to reflect new developments and changing conditions at the Y-12 Complex. Targets and action plans are established for broad objectives to pursue improvement in environmental performance in five areas: clean air, energy efficiency, hazardous materials, stewardship of land and water resources, and waste reduction/recycling/buy green. Highlights of the 2009 B&W Y-12 environmental targets achieved are presented in Sect. 4.2.6.1.

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.

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 standards, DOE orders, environmental laws and regulations; and consistent with B&W Y-12's 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 administers compliance programs aligned with 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.

The ECD also maintains and ensures implementation of the Y-12 EMS and spearheads initiatives to proactively address environmental concerns in order to continually improve environmental performance and go "beyond compliance."

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.

Sustainability and Stewardship

The Sustainability and Stewardship Program has two major missions. The first is to establish and maintain company-wide programs and services to support sustainable waste management operations. These sustainable operations include Pollution Prevention and Recycling Programs, PrYde, Excess Materials, Burn House Operations, and Waste Generator Services. The second is the stewardship practices, the programs that manage the legacy issues and assist in the prevention of additional problematic areas being formed. Stewardship Programs include Clean Sweep, Unneeded Materials and Chemicals (UMC), and Legacy Waste.

This program establishes and maintains company-wide systems to ensure activities are conducted in a manner which ensures protection of employees from workplace hazards and promotes the well-being of the worker, protects the public and the environment, prevents pollution and conserves resources, promotes recycling/reuse and source reduction, supports environmentally preferable purchasing, complies with applicable regulations, and promotes sustainability principles in a safe and cost-effective manner.

Energy management

Energy management is an ongoing and comprehensive effort containing key strategies to reduce consumption of energy, water, and fuel (electricity, coal, natural gas, and gasoline/diesel). The energy manager is responsible for developing energy and water reduction projects; performing facility energy surveys; communicating with Y-12 facility/building managers and plant population regarding energy use and reduction opportunities; maintaining the DOE energy database for Y-12; providing energy management input to capital project design; and interfacing with contractors regarding energy conservation measures.

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 Program is in place to facilitate communication of environmental regulatory requirements and to promote the EMS as a tool to drive continual environmental improvement at Y-12. Environmental Officers coordinate their organization's efforts to maintain environmental regulatory compliance and promote other proactive improvement activities.

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, composed of 20 members from a cross section of the community, including environmental advocates, neighborhood residents, Y-12 retirees, and business and government leaders, serves to facilitate communication between Y-12 and the community. The council provides feedback to B&W regarding its operations and ways to enhance community and public communications. A few examples of Y-12's community outreach activities are described in the following paragraphs.

B&W Y-12 sponsored and participated in community events in 2009 including WaterFest at the Ijams Nature Center in Knoxville and Oak Ridge Earth Day to provide highlights of Y-12's environmental management, sustainability and stewardship, pollution prevention activities, and information about the Tennessee Pollution Prevention Partnership (TP3) to more than 2,000 members of the public. B&W also sponsored Oak Ridge Associated Universities Science Bowl, East Tennessee Fuels Coalition Run for Clean Air, and the Foothills Land Conservancy in 2009. In addition B&W Y-12 has promoted the history of Oak Ridge by partnering with The Oak Ridge Secret City Festival and the American Museum of Science and Energy to provide guided tours of the Y-12 Complex.

A "State of the Creek Address" was presented on April 16, 2009 (Fig. 4.4) to interested stakeholders and environmental regulators describing ecological changes that have occurred over the last 20 years in

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Fig. 4.4. "State of the Creek Address" presented in April to interested stakeholders.

East Fork Poplar Creek (EFPC). The presentation was well attended by such groups as the ORR Local Oversight Committee, the Site Specific Advisory Board, City of Oak Ridge, TDEC, EPA, NNSA, and members of the public. The primary message of the presentation was that the health of EFPC has improved over the years; however, some legacy contaminants persist and require more work to reduce their presence in the environment.

B&W Y-12 held an Environment, Safety and Health Expo on June 10, 2009, with a theme of "It's Easy Being Green" that was attended by approximately 8,000 employees and community members. The Expo included 115 booths and exhibits of information, equipment, supplies, and success stories to promote ES&H responsibilities at home and at work (Fig. 4.5).

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Fig. 4.5. NNSA Site Manager addresses the crowd at the 2009 ES&H Expo.

As part of Y-12 America Recycles Day activities, staff from the Y-12 Pollution Prevention Program visited five local charities to distribute $200 checks raised by Y-12 employee aluminum beverage can (ABC) recycling efforts. Since the ABC recycling program began in 1994, more than $76,000 has been donated to various charities.

B&W Y-12 actively promoted the TP3 program by mentoring and sharing information with interested organizations to encourage pollution prevention and involvement in TP3. In 2009, B&W Y-12 mentored the Oak Ridge National Laboratory (ORNL) and shared information with Denso Manufacturing Tennessee, Inc., and the East Tennessee Technology Park (ETTP). Y-12 also hosted a TDEC East Tennessee TP3 Program Workshop (Fig. 4.6) on October 8, 2009, to offer guidance on the program, mentoring in sustainable practices, and a forum for networking and sharing various pollution prevention initiatives with other industries and organizations.

4.2.4.3 Emergency Preparedness and Response

Local, state and federal emergency response organizations (EROs) are fully involved in the Y-12 emergency drill and exercise program. The annual drill and exercise schedule is coordinated with all organizations to ensure maximum possible participation. At a minimum, the Tennessee Emergency Management Agency (TEMA) Duty Office and the DOE Headquarters (HQ) Watch Office participate in all Y-12 emergency response exercises.

Y-12 conducted two full-scale and four functional exercises during FY 2009. The focus of FY 2009 exercises was on supporting site readiness activities. Three exercises were conducted in support of the readiness review for the recently constructed Highly Enriched Uranium Materials Facility (HEUMF), and one exercise was conducted in support of secure transportation readiness. In addition, one exercise was conducted involving a simulated active shooter in a Y-12 building and one exercise was conducted involving a fire and hazardous material release in a Y-12 building.

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Fig. 4.6. East Tennessee TP3 Program Workshop was held at Y-12's New Hope Center in October 2009.

Y-12's expertise in emergency management is recognized within the Nuclear Weapons Complex. Y-12 Emergency Management Program Office (EMPO) staff performed an evaluation of the Savannah River Site annual exercise April 26–30, 2009. EMPO staff also participated in the DOE Emergency Management Issues Special Interest Group Conference held in San Francisco, California. Y-12 ERO members made presentations, participated in steering committee meetings, and distributed Y-12 Emergency Management Program information to other DOE facility emergency management professionals.

4.2.5 Checking

4.2.5.1 Monitoring and Measurement

Y-12 maintains procedures 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 are well established, and the results of the 2009 program activities are reported elsewhere in this document. Y-12 also maintains a process 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. A monthly program review meeting with counterparts from the YSO includes discussions of these metrics as well as compliance information.

In 2009, Y-12 piloted a new Versatile Electronic Records Management System for improved indexing, retrieval, and long-term retention of electronic records and documents. The ECD implemented this system to digitize and electronically store environmental records, which contributed to streamlining the paper-based system and reducing the environmental impact of compliance activities.

4.2.5.2 EMS Assessments

To periodically verify that the EMS is operating as intended, assessments are conducted as part of Y-12's assessment program. The assessments are designed to ensure that nonconformities with the ISO 14001 standard are identified and addressed. Y-12's EMS assessment program consists of a three-prong approach that includes focused EMS assessments, routine surveillances, inspections and data reviews, and environmental multi-media assessments integrated with regularly scheduled facility evaluations lead by the Independent Assessment Organization.

Three EMS assessments and four facility evaluations employing an environmental multi-media approach were conducted in 2009. The EMS assessments included a review of Records Management and Document Control systems and an external third-party EMS audit to satisfy the DOE Order 450.1A (2008a) requirement for the site to make a formal declaration of conformance consistent with the requirements of DOE EO 13423 by June 30, 2009. The third-party audit determined that the Y-12 EMS was in conformance and met all requirements. The 2009 EMS assessments identified nine issues as continuous improvement opportunities which were subsequently corrected and implemented.

4.2.6 EMS Performance

B&W Y-12 prepared a plan for achieving compliance with DOE EO 13423, DOE Order 450.1A, *Environmental Protection Program* (DOE 2008a), and DOE O 430.2B, *Departmental Energy, Renewable Energy and Transportation Management* (DOE 2008b). The plan identified 16 actions in seven categories. Plans for improving the Environmental Management System, Training, Green Acquisition, Electronic stewardship, and Toxic/Hazardous Materials were completed. Progress has been made in the areas of High Performance Sustainable Buildings and Energy/Water conservation but more work is required to fully satisfy DOE EO 13423 requirements. The EMS objectives and targets and other plans, initiatives, and successes that work together to accomplish DOE EO 13423 goals and reduce environmental impacts are discussed in this section.

4.2.6.1 EMS Objectives and Targets

B&W Y-12 achieved 15 of 16 of the environmental targets on schedule in 2009. Highlights included the following with additional detail and success presented in other sections.

- Clean Air—A project continues to replace the existing coal-fired boiler steam plant by FY 2011. The project achieved a construction milestone by erecting and securing the new boiler stacks. As of the end of December the project was 95% complete overall. In addition, an estimate of GHG emissions for baseline year 2008 was developed (see Sect. 4.2.6.7).
- Energy Efficiency—Y-12 replaced 1,092, or 22%, of the older PC's and monitors at Y-12 that were not Energy Star or Electronic Product Environmental Assessment Tool (EPEAT) qualified with new energy-efficient equipment (achieving 146% of goal), and 43 virtual servers were deployed as part of a phased transition away from traditional data centers, exceeding the goal of 30 and reducing the number of physical servers required (which is expected to save more than 10.5 kW). Additional accomplishments are presented in Sect. 4.2.6.3.
- Hazardous Materials—Completed disposition of excess Chemicals Stage II (Stores), cleanup of the 9720-16 yard, shipment of 212 H-gears for off-site recycle, and the majority of the 9720-58 yard cleanup. Additional facility clean-out efforts resulted in removal of more than 1,451,496 kg (1,600 tons) of materials including some chemicals from 10 facilities, of which more than 570,619 kg (629 tons) of materials were recycled or reused rather than disposed (see Sect. 4.2.6.2).
- Land/Water Conservation—Completed an evaluation of options for reducing mercury loading in lower East Fork Poplar Creek. Pilot studies indicated that reduction of flow in certain areas of the creek is expected to reduce the amount of mercury in the water flow. A permit modification to reduce the amount of flow augmentation to EFPC by approximately 7.5 million liters (2 million gallons) per day was issued by TDEC. Additional water conservation successes are presented in Sect. 4.2.6.4.

- Reduce/Reuse/Recycle/Buy Green—A pollution prevention opportunity assessment was completed on a key hazardous waste stream, the Y-12 Procurement Handbook was updated to incorporate requirements of Environmentally Preferable Procurement, and awareness training of new DOE Acquisition goals was conducted for Y-12 buyers. Section 4.2.6.2 presents additional successes that support this EMS target area.

4.2.6.2 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, these efforts have been recognized by our customer, our community, and other stakeholders (see Sect. 4.2.7). Not only have the pollution prevention efforts at Y-12 benefited the environment, they have also resulted in avoided costs (Fig. 4.7).

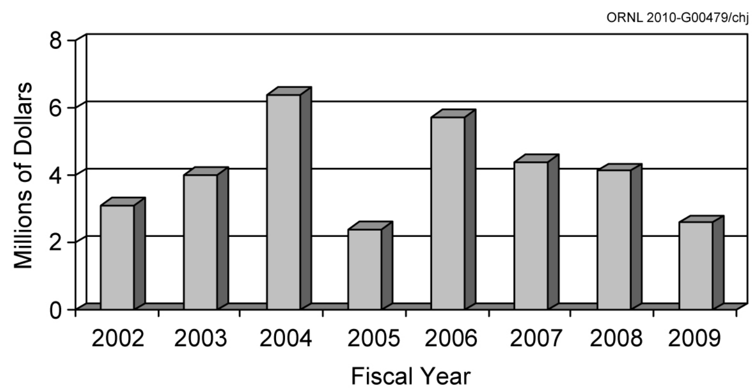

Fig. 4.7. Cost avoidance from Y-12 pollution prevention activities.

In FY 2009, Y-12 implemented 104 pollution prevention initiatives (Fig. 4.8), with a reduction of more than 16.25 million kilograms (36 million pounds) of waste and a cost savings/avoidance of more than $2.58 million. The completed projects include the activities presented below.

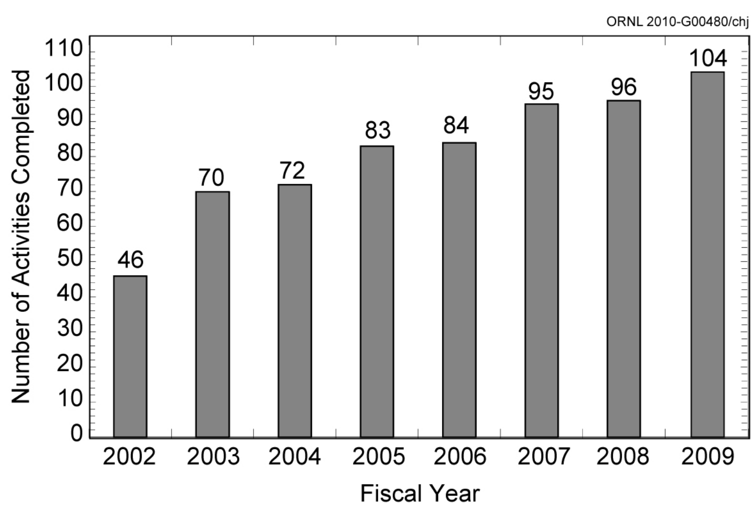

Fig. 4.8. Y-12 pollution prevention initiatives.

Initiatives with Pollution Prevention Benefits and Source Reduction

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 or targets eliminating the source of pollution, including the 2009 activities highlighted in this section.

Y-12 Clean Sweep Program

This program (Fig. 4.9) conducted cleanup events at key operating facilities in FY 2009 as part of a major initiative to improve the overall condition of the Y-12 Complex and support pollution prevention goals. Due to the complexity of these cleanups, Y-12 established a multi-organization team to ensure that the materials/chemicals are reused or recycled if at all possible and to plan these cleanups to ensure that all health and safety, security, operational, radiological, and environmental requirements are met. The cleanups resulted in the removal of more than 907,185 kg (1,000 tons) of materials and chemicals from more than six facilities, of which more than 317,515 kg (350 tons) of materials were recycled or reused. The effort resulted in an estimated cost avoidance of more than $15,770 due to reduced waste disposal costs; eliminated more than 108 m^2 (1,160 ft^2) of radiation management areas; and freed over 328.8 m^2 (3,535 ft^2) of valuable floor space that could be used for other mission critical tasks, with an associated estimated cost avoidance of $3,600,000 based on an estimated cost of $1,036 per 0.09 square meter (1 square foot) if such space had to be constructed. 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.

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Fig. 4.9. Y-12 Clean Sweep Program.

Environmentally Preferable Purchasing

Environmentally preferable products, including recycled-content materials, are procured for use across the Y-12 Complex. In 2009, B&W Y-12 procured recycled-content materials valued at more than $2.83 million for use at the site.

Y-12 Digital Radiography

The Y-12 Complex is implementing a high-energy digital radiography to automate part setup and alignment and digitize radiographs of products. The development of this high-resolution imaging system will make Y-12's digital capability equal to or better than film at all energy levels. The Y-12 technical team developed a mid-energy radiographic capability for operational use, which was followed by the development of a low-energy digital radiographic capability in 2009. Digital techniques provide additional capabilities such as image enhancements and feature extractions to support product analysis. Benefits include reducing setup time and the time associated with obtaining high-quality radiographs, eliminating the use of film and film processing chemicals, eliminating storage and archive costs associated with legacy radiographic films, enabling teleradiography collaboration and communications with Nuclear Weapons Complex partners, and implementing computed tomography. The implementation of digital radiography is a long-term process, and the progress made to date has reduced the chemical waste stream from film processing significantly and will continue to grow as the technology matures.

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 Fig. 4.10, over 0.7 million kilograms (1.7 million pounds) of materials was diverted from landfills and into viable recycle processes. Currently, recycled materials range from office-related materials to operations-related materials such as scrap metal, tires, and batteries. Many recycling activities have been implemented, including the 2009 activities highlighted in this section.

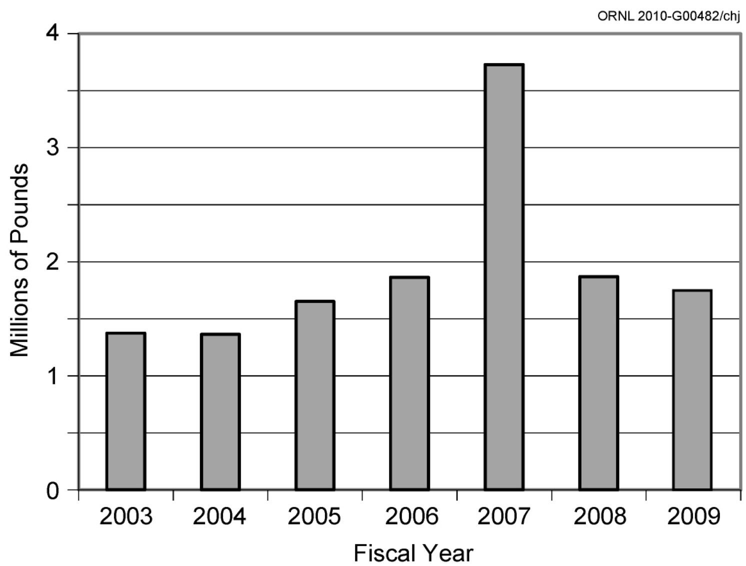

Fig. 4.10. Y-12 Recycling Results.

DOE-Wide Secure Electronics Recycling

Like all DOE facilities, Y-12 faced the challenge of managing electronic waste (items such as printed circuit boards and hard drives) in a manner that met cyber security and potential hazardous waste requirements. Based on past successes of collaborative efforts with DOE's Business Center for Precious Metals Sales and Recovery, Y-12 approached the center to establish a team to address electronic media waste. The team was able to select and establish a contract vehicle with a facility for the destruction of Y-12's electronic storage media followed by recovery of the resulting precious metals. The contract vehicle is being made available to the entire DOE Complex with the anticipation that other DOE sites will take advantage of this opportunity. All DOE NNSA sites and contractors that use this center see reduced waste generation and associated cost avoidance due to using these services. In 2009 alone, Y-12 reduced its generation of silver-bearing Resource Conservation and Recovery Act (RCRA) waste and electronic media waste by 9,532 kg (21,016 lb), resulting in a cost avoidance $82,848 from recycling via the DOE Business Center for Precious Metals Sales and Recovery.

Expanded Recycling Program

B&W Y-12 expanded recycling initiatives in 2009 to include the recycling of electronic media including circuit boards, used oil filters, and security sensitive paper to an off-site recycling vendor. These recycling initiatives were fully implemented during 2009.

4.2.6.3 Energy Management

Progress Meeting DOE EO 13423 Goals

The Y-12 Complex developed the *FY 2009 Y-12 National Security Complex Executable Plan Update and Annual Report on Energy Management for the National Nuclear Security Administration*

(B&W Y-12 2009) reporting progress on Y-12 energy and water management activities established by DOE EO 13423 as defined by DOE Order 430.2B (DOE 2008b). The goals for energy and water management are summarized below along with current status (Table 4.1).

Table 4.1. DOE Order 430.2B goals and summary status

Goal	Status and Plans
30% energy intensity reduction by FY 2015 from a FY 2003 baseline	Y-12 has achieved a 12% reduction in energy intensity from the 2003 baseline. Implementation of the ESPC is projected to provide an additional 11.6% reduction in energy intensity.
16% water intensity reduction by FY 2015 from a FY 2007 baseline	Y-12 has achieved a 9% water intensity reduction from a FY 2007 baseline, despite metering problems with the utility. ESPC implementation will further assist with water conservation at Y-12.
7.5% of a site's annual electricity consumption from on-site renewable sources by FY 2010	The purchase and installation of a renewable energy source are being evaluated in a solar photovoltaic study and a fuel cell feasibility study.
Every site to have at least one on-site renewable energy generating system	The purchase and installation of a renewable energy source are being evaluated.
10% annual increase in fleet alternative fuel consumption relative to a FY 2005 baseline	Y-12 has already exceeded the alternative fuel goal with a 193% increase within 4 years.
2% annual reduction in fleet petroleum consumption relative to a FY 2005 baseline	Y-12 has already achieved the petroleum reduction goal with a 43% reduction within 4 years
75% of light duty vehicle purchases must consist of alternative fuel vehicles	Plans and budget requests for light duty vehicle purchases comprise 100% alternative fuel vehicles.
All new construction and major renovations greater than $5 million to be LEED® Gold certified	Existing plans for any new construction or leased facilities are being developed with the LEED certification criteria.
15% of existing buildings to be compliant with the five guiding principles of HPSB design	Building assessments are under way and a schedule for inspecting the building inventory before 2012 was established and specific buildings have been targeted for upgrade.
Advanced metering to the maximum extent practicable	Advanced electrical and water meters were installed to establish baseline data for the ESPC estimates and additional advanced metering is projected and budgeted in the Utilities Migration Plan.

Energy Performance

Energy consumption has continued a downward trend by continued modernization efforts and energy conservation measures. In FY 2009, the Y-12 Complex achieved a 20% reduction in electricity usage (Fig. 4.11) and a 29% reduction in natural gas usage from the FY 2003 baseline. This was the final year of coal consumption due to the replacement of the old coal-fired steam plant with the new natural-gas-fired steam plant.

The following energy improvement and sustainable building activity highlights were completed in FY 2009.

- A Y-12 Energy Steering Team was established which has conducted benchmarking and has engendered ideas for energy and water upgrades, as well as potential renewable projects.
- Significant work was completed on the $61.5 million natural gas-fired steam plant (to be operational in early CY 2010) which will eliminate coal burning and reduce emissions of sulfur dioxide by 99.5%, nitrogen oxides by 94%, and the GHG carbon dioxide by 11%.
- A $62.5 million potable water upgrade replaces a World War II–era piping system, saving $25 million in deferred maintenance costs.

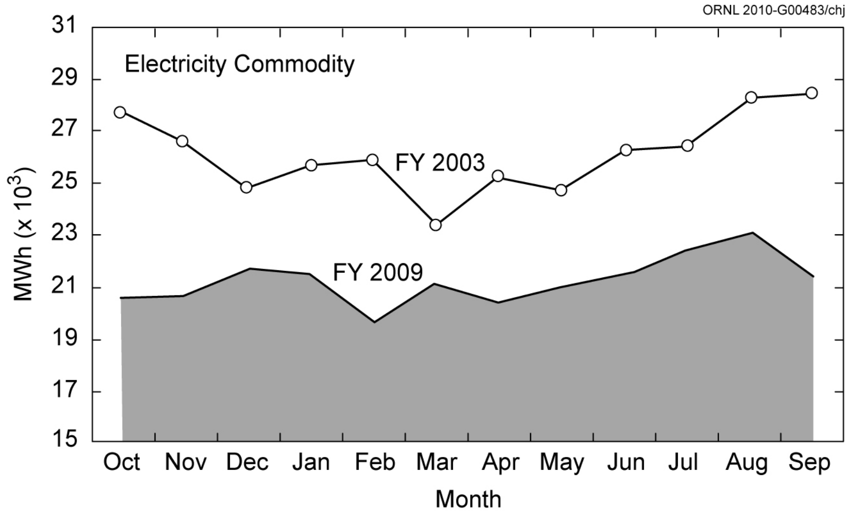

Fig. 4.11. Y-12 Electrical consumption by month.

- A $22.5 million Energy Savings Performance Contract (ESPC) was signed in September 2009 that will reduce energy intensity by 4%, potable water use by 5%, and save over $2 million annually in electricity, natural gas, water, sewer, and annual maintenance costs. Construction on the projects begins in FY 2010.
- Y-12 submitted several proposals to NNSA and Energy Efficiency Renewable Energy/Federal Energy Management Program (EERE/FEMP), which include measures for building metering, setback systems, renewable energy projects, smart grid systems, retro-commissioning, cooling tower replacement, and site-wide energy and water audits.
- The Facility Infrastructure Recapitalization Program (FIRP) Roof Asset Management Program replaced over 60,450 m^2 (650,000 ft^2) of deteriorated and leaking roof structures with energy-efficient and environmentally friendly white roof installations that support facility High-Performance Sustainable Building (HPSB) standards (Fig. 4.12).

Fig. 4.12. Replacement of deteriorated roof on Building 9113 with a sustainable white roof.

- The development team for the third-party financed Complex Command Center has included a preference of LEED Goal–certified structure in lease agreement documents, including pervious concrete, waste recycling, rainwater collection, high-performance HVAC systems, building commissioning, and LEED-related design and processing fees.

4.2.6.4 Water Conservation

Potable water use has continued to decline due to the removal of excess buildings which include 0.1 million m^2 (1.2 million ft^2) of high-water-intensity facilities over the past 7 years. ESPC projects will reduce potable water consumption by 185 million liters (49 million gallons) per year. In 2009 three new potable water supply meters were installed to ensure accurate measurement and better control of water usage, and significant progress was made on a Potable Water Upgrade Project (FY 2010 project completion) to replace piping that is over 60 years old to eliminate potential underground piping leaks and resolve low system pressure and backflow preventer isolation issues. A total of 21 m (69 ft) have been installed at eight building and cooling tower locations, and 16 of these meters were connected to the Utilities Management System for performance monitoring and automated baseline metering data collection and report generation.

4.2.6.5 Fleet Management

The Y-12 site has already achieved the petroleum reduction goal with respect to the 2005 baseline. The site achieved a 55.6 % reduction within 4 years, which surpasses the requirement for the reduction of 2% per year. These three initiatives have helped spur that significant reduction.

- Vehicle pools were established at facilities with large concentrations of workers.
- Shuttle buses are provided throughout areas of the plant site.
- Vehicles not meeting site-use goals have been removed or reassigned on the basis of site needs.

Furthermore, the site has been very successful in achieving the goals for alternative fuel usage, as summarized in chart below (Table 4.2). A 192.6% increase in alternative fuels has been achieved from the 2005 baseline (surpassing the goal of 100%), with 11% of the current Y-12 fleet being alternative fuel vehicles. (Of Y-12’s 527 vehicles, 56 are now Flex Fuel vehicles and 73 were converted to ultralow sulfur diesel fuel.) All Flex Fuel–capable vehicles have been operated on E85 ethanol alternative fuel since 2008.

Table 4.2. Summary of petroleum and alternative fuel usage over a 4-year period

	2005 Baseline	2009 Data	% Increase/ Decrease	EO 13423 Goal	Actual
Petroleum (Non-fleet)	54,426 L (14,378 gal)	24,181 L (6,388 gal)	55.6% decrease	2% per year decrease	14% per year decrease
Petroleum (Fleet)	606,141 L (160,126 gal)	348,802 L (92,144 gal)	42.5% decrease	2% per year decrease	11% per year decrease
E-85 fuel + biodiesel	18,174 L (4,801 gal)	53,132 L (14,036 gal)	192.6% increase	10% per year increase	48% per year increase

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.

4.2.6.6 Electronic Stewardship

The Y-12 Complex is committed to the Federal Electronics Challenge (FEC) pledge in 2008 to improve the management of electronic assets during all life-cycle phases: acquisition and procurement, operation and maintenance, and end-of-life management. In 2009, as an FEC Partner, B&W Y-12 completed all FEC annual reporting to account for procurement of energy-efficient electronics and implementation of other practices to maximize Y-12 energy efficiency, reduce electronic-related wastes, and improve end-of-life management. B&W Y-12 received a 2009 FEC Bronze Level Award in June 2009 (see Sect. 4.2.7).

4.2.6.7 Greenhouse Gas

Y-12 began a greenhouse gas (GHG) management initiative in FY 2009, recognizing that minimizing GHG emissions is a growing component to ensuring sustainable long-term operations. Y-12's environmental management planners and the Executive Steering Group established an EMS target to "initiate planning and data collection to develop a Y-12 Complex GHG Inventory." The target included actions to establish a GHG team, benchmark GHG inventories from similar facilities, and initiate development of a GHG Inventory Management Plan. Y-12 GHG team members included representatives from Energy Management, Utilities, Environmental Compliance, Air Quality, Pollution Prevention, Fleet Management, and Business Travel.

The GHG Team benchmarked other GHG inventories to help define the scope of Y-12's GHG inventory, participated in Y-12's ES&H Expo to present GHG educational materials, and gather data on GHG emissions from employee commuting, identify GHG emission data sources, and created a preliminary Y-12 GHG Inventory Management Plan and GHG emission inventory. The preliminary estimate indicates more than 320,000 metric tons of GHG emissions (carbon dioxide equivalents per year) in 2008. Results presented in Fig. 4.13 indicate that the majority (54%) of Y-12's GHG emissions are from indirect (scope 2) emission from purchased electricity. The largest direct (scope 1) emission was from combustion of coal to produce steam (35%), and estimated GHG emissions from employees commuting to work accounted for approximately 6% of the preliminary site-wide GHG emissions included in this inventory. Additional scopes to be evaluated include business travel, process emissions, and waste disposal.

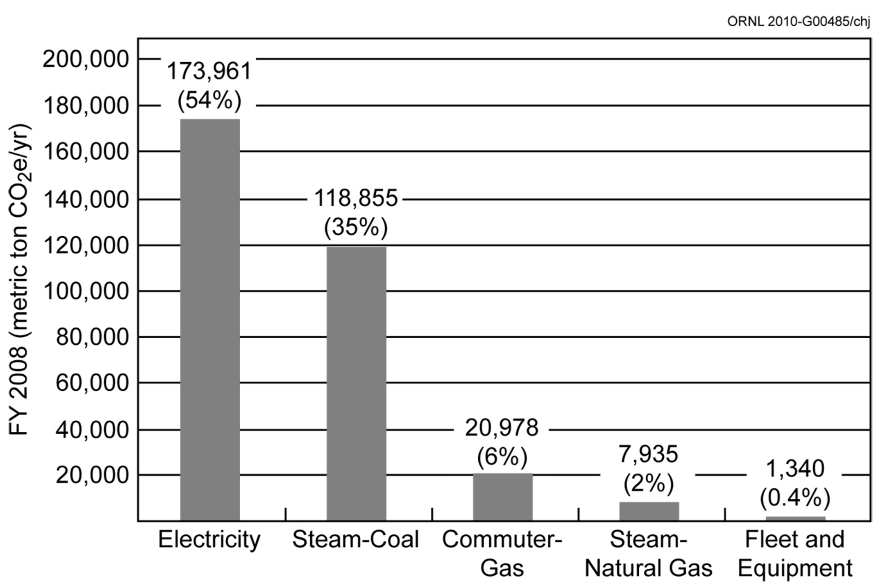

Fig. 4.13. Preliminary B&W Y-12 GHG inventory by source.

4.2.7 Awards and Recognition

The Y-12 commitment to environmentally responsible operations has been recognized by more than 45 external environmental awards since November 2000 from local, state, and national agencies. The awards received in 2009 are summarized below.

White House Closing the Circle Award. "Y-12 Manufacturing Makes High-Tech P2 Look Easy" submitted in the Waste/Pollution Prevention category was selected as one of 15 activities to receive a 2009 White House Closing the Circle Award (Fig. 4.14) for outstanding Federal environmental stewardship from the Office of the Federal Environmental Executive (OFEE). The White House Closing the Circle Award recognizes Federal facilities and employees for innovative practices and programs that have improved environmental performance and conditions at Federal facilities. Y-12 was selected to receive this prestigious award signed by the President of the United States of America from more than 150 nominations and was the only DOE activity recipient.

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Fig. 4.14. Y-12 was recognized for outstanding environmental stewardship with a White House Closing the Circle award in 2009.

Tennessee Chamber of Commerce and Industry (TCC&I). Y-12 received two TCC&I Awards for environmental excellence and three achievement certificates for outstanding environmental accomplishments at the Twenty-seventh Annual Environmental Awards Conference in October 2009. 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 for the following projects (and award/certificate categories):

- "Complex-Wide Precious Metals Recovery Shines" (Hazardous Waste Management)
- "Y-12 UMC Reuse Efforts Right on Track" (Solid Waste Management)

- "Y-12 Cleaning Its Way to a Greener More Sustainable Facility"(Solid Waste Management)
- "Y-12's "Go Green" Transportation Movement Just Keeps Going, Growing, and Greening" (Air Quality)
- "Y-12 Manufacturing Makes High-Tech P2 Look Easy" (Environmental Excellence)

DOE/NNSA Awards. The Y-12 Complex also received three 2009 NNSA Pollution Prevention Best in Class Awards, one NNSA Environmental Stewardship Award Certificate, and three DOE E-Star Awards for the projects honored by the TCC&I. This is the sixth consecutive year that the Y-12 Complex has been recognized by NNSA for award-winning activities. These awards recognize innovation and/or excellence in pollution prevention and environmental sustainability stewardship efforts within the NNSA and DOE and are selected by an independent panel.

Tennessee Pollution Prevention Partnership. Y-12 was awarded a TP3 Performer green flag by TDEC Commissioner Jim Fyke on March 17, 2009 (Fig. 4.15), showing Y-12's commitment to positive environmental action through pollution prevention activities. Y-12 is thus far 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.

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Fig. 4.15. Y-12 was presented with a Tennessee Pollution Prevention Partnership Performer flag on March 17, 2009.

Federal Electronics Challenge (FEC). B&W Y-12 received a 2009 FEC Bronze Level Award in June 2009 which recognizes the achievements of FEC partners and their leadership in federal electronics stewardship. Y-12 was one of 16 Bronze Level Award winners. This FEC Bronze Award was specifically received for Y-12's accomplishments in end-of-life management activities of electronics.

4.3 Compliance Status

4.3.1 Environmental Permits

Table 4.3 notes environmental permits in force at Y-12 during 2009. 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 2009, environmental evaluations were completed for 28 proposed actions, all of which were determined to be covered by a categorical exclusion (CX).

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

The NEPA implementing procedures, 10 CFR 1021 (DOE 1996), require a 5-year evaluation of the current Y-12 Complex site-wide 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 was issued in October 2009 (NNSA 2009) and a notice of availability was published in the *Federal Register* on October 30, 2009. Two public hearings for the draft SWEIS were held on November 17 and 18, 2009. These hearings allowed members of the public to provide comments on the draft SWEIS. The meetings were attended by approximately 350 members of the public. The public comment period for the draft SWEIS ends on January 29, 2010. Once all comments are received the final SWEIS will be published and the SWEIS ROD will be issued.

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 2009 included completing an NHPA Section 106 review on 28 proposed projects, and participating in various outreach projects with local organizations and schools.

Twenty-eight 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 28 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.

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 on 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, located in The New Hope Center, continues to be a work in progress featuring new artifacts, photographs, and pop-up signs. The Exhibit Hall, renamed "The Y-12 History Center," 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, is available free to the public. Tours of the Exhibit Hall were conducted for various organizations, local schools, and VIP visitors.

Table 4.3. 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[a]	DOE	DOE	B&W Y-12
CAA	Chip Oxidizer Operating Permit	554594	10/21/2004	10/21/2009[b]	DOE	DOE	B&W Y-12
CAA	Operating Permit (Title V)	554701	10/21/2004	10/21/2009[b]	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	4/1/2005	3/31/2010	DOE	DOE	B&W Y-12
CWA	National Pollutant Discharge Elimination System Permit	TN0002968	3/13/2006	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	2/6/2004	The Notice of Termination was sent to TDEC in December 2009.	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	1/11/2010	1/31/2011	DOE	DOE	B&W Y-12

Table 4.3 (continued)

Regulatory Driver	Permit Title/Description	Permit Number	Issue Date	Expiration Date	Owner	Operator	Responsible Contractor
RCRA	Hazardous Waste Corrective Action Permit	TNHW-121	9/28/2004	9/28/2014	DOE	DOE, NNSA, and all ORR co-operators of hazardous waste permits	BJC
RCRA	Container Storage Units	TNHW-122	8/31/2005	8/31/2015	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 4.3 (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

[a]A request for extension was submitted to TDEC on January 7, 2009. This permit is addressed in the Title V renewal application.

[b]The Y-12 Title V Operating Air Permit Renewal Application was submitted to TDEC on April, 23, 2009. As part of the permit application renewal, it was requested that TDEC combine Air Permit 554594 into Air Permit 554701 followed by cancellation of Air Permit 554594.

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

Outreach activities in 2009 consisted of providing tours of the Y-12 Complex for the Secret City Festival and for the American Museum of Science and Energy. Twenty thousand people attended the annual Secret City Festival, held in June, 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 1545 tourists from 42 states. Other outreach activities include visiting local schools and conducting presentations on the history of Y-12 and Oak Ridge.

4.3.3 Clean Air Act

This section contains a review of the major elements of the Clean Air Program at the Y-12 Complex Including program highlights for 2009.

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

There was no noncompliance as a result of monitoring activities during 2009.

In 2009, only one construction air permit was in effect at the Y-12 Complex. Under a permit issued in 2007, construction began in 2008 on the replacement steam plant. The new steam plant is planned to be transitioned to management and the operating contractor in April 2010. Completion of the new steam plant will ultimately result in the shutdown of the existing steam plant.

More than 90% of the Y-12 Complex pollutant emissions to the atmosphere is 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 2009.

In 2009, TDEC personnel performed an inspection of the Y-12 Complex on January 21 and 22 to verify compliance with applicable regulations and permit conditions. No compliance issues were 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.

In 2008 an evaluation of options for reducing mercury loading in lower East Fork Poplar Creek was completed. The pilot studies indicated that a reduction of flow in certain areas of the creek would reduce the amount of mercury in the water flow. To implement this improvement effort, a permit modification was required. The request to reduce flow was embraced by both state and EPA regulators. The request to modify flow was in part a result of activities associated with a team of NNSA, DOE-EM, and contractor employees formed to study proposed state requirements for a mercury Total Maximum Daily Load (TMDL) in EFPC. On December 30, 2008, the permit was modified to change the required minimum flow in East Fork Poplar Creek at Station 17 to 19 million L/day (5 million gal/day). The permit expired December 31, 2008, and Y-12 Complex discharges are continuing under the requirements of this permit pending TDEC action on the renewal application submitted on July 1, 2008. 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 2009 the Y-12 Complex continued its excellent record for compliance to the National Pollutant Discharge Elimination System (NPDES) water discharge permit. More than 6,000 data points were obtained from sampling required by the NPDES permit; only one noncompliance was reported. Some of the key requirements in the 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 a 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 the additional 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);
- a requirement for an annual storm water monitoring report, an annual report of the Biological Monitoring and Abatement Plan (BMAP) data;
- a requirement to manage the flow of East Fork Poplar Creek such that a minimum flow of 26 million L/day (7 million gal/day) is guaranteed by adding raw water from the Clinch River to the headwaters of East Fork Poplar Creek [note: the permit was modified in 2008 to require a minimum flow of 19 million L/day (5 million gal/day; 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 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 2009 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 waterlines), the Steam Plant Life Extension, and Building 9720-82. Construction of Building 9720-82 was completed and the storm water permitted in 2009. Y-12 Environmental Compliance staff continue to keep TDEC apprised of site developments, and as of January 2010 TDEC had not yet issued a draft of the new permit.

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 2009. One was for exceeding the discharge limit (monthly average) for nickel, and three 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 (January 14, 2009, and September 14, 2009). The City of Oak Ridge requested, and Y-12 has delivered, an action plan to address inflow/infiltration into the sanitary sewer system. 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. 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 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.

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 are conducted by Y-12 Utilities Management Organization:

- Total Coliform
- Chlorine Residuals
- Lead
- Copper
- Disinfectant By-product
- Propylene Glycol

In 2009, the Y-12 potable water system retained its approved status for potable water with the 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 2009 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 2009 were analyzed by the state of Tennessee lab, and the results 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, and the system sampling was last completed in August 2008. These results were below the TDEC and SDWA limits and meet the established requirements.

Major improvements were performed during 2009 to the potable water system included the following:

- Construction of two 7.5 million liters (2 million gallons) elevated water tanks that are scheduled for completion in 2010 to replace legacy ground storage tanks.
- Replacement of 702 m (2,300 ft) of potable water lines
- Cleaned and lined 645 m (2,115 ft) of potable water lines
- Excavated and inspected 317 m (1,040 ft) of existing potable water lines
- Installed 52 new backflow assemblies
- Isolation and conversion of 152 anti-freeze loop fire sprinkler systems.

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 (2,205 lb) 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).

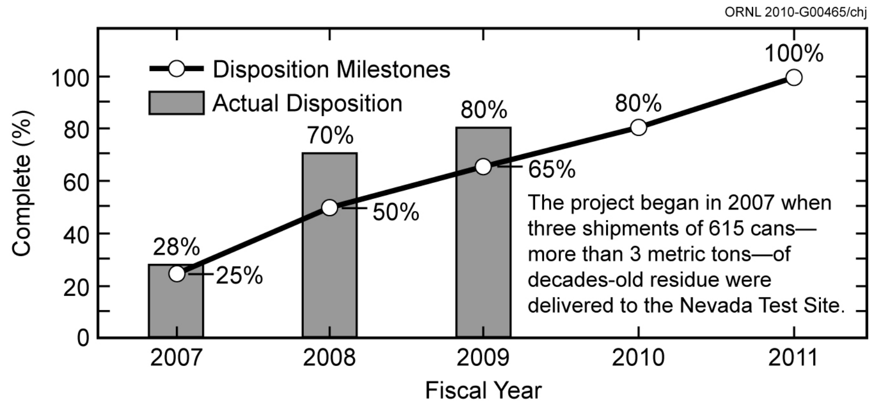

Fig. 4.16. Reducing inventory of legacy mixed waste as part of the ORR Site Treatment Plan.

The quantity of hazardous and mixed wastes generated by Y-12 increased in 2009 (Fig. 4.17). The increase was attributed to the treatment of more than 6,000,000 kg of additional contaminated groundwater. This directly correlates to 43 cm (17 in.) more rainfall in 2009 than in 2008. 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 ORR Site Treatment Plan. Progress on disposition of legacy mixed wastes exceeded established milestones for FY 2009. Ninety-seven percent of the total hazardous and mixed waste generated in 2009 was generated as contaminated leachate from

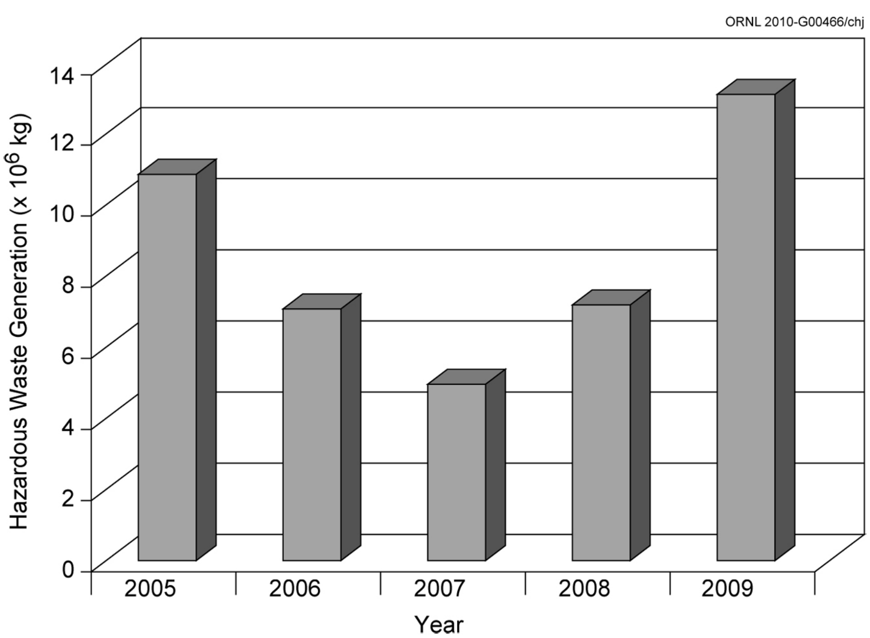

Fig. 4.17. Hazardous waste generation, 2005–2009.

legacy operations. The Y-12 Complex currently reports waste on 126 active waste streams. Y-12 is a state-permitted treatment, storage, and disposal facility. Under its permits, Y-12 received 1,535 kg (3,385 lb) of hazardous and mixed waste from the off-site Union Valley analytical chemistry laboratory in 2009. In addition, 218,035 kg (480,767 lb) of hazardous and mixed waste was shipped to DOE-owned and commercial treatment, storage, and disposal facilities. More than 12 million kg (26 million lb) 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 November 2009, including permitted storage facilities, satellite accumulation areas, and 90-day accumulation areas. No violations were noted during the inspection.

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 fees for the tanks are current, enabling fuel delivery until March 31, 2011. 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 August 2009. 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 the Oak Ridge Reservation landfills operated by the DOE-EM (Office of Environmental Management) program. The facilities include 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 8,945 m^3 (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 4.3.

Landfill V, a Class II landfill, is used for disposal of sanitary, industrial, construction, and demolition waste. This landfill is being expanded with ARRA funding. Expansion of the landfill will increase capacity by 294,354 m^3 (385,000 yd^3) to provide more capacity for the increased cleanup work on the Reservation. The expansion also includes upgrading and refurbishing support facilities.

A Notice of Violation (NOV) for Maximum Contaminant Limit (MCL) Exceedance in Ground Water Monitoring Well GW-305 at Industrial Landfill IV was issued by TDEC in November 2009 (see Sect. 2.5).

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 Waste Corrective Action permit (formerly known as 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 4.4). 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 2010) for the ORR.

Table 4.4. 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 the Toxic substances Control Act (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. Certain equipment containing PCBs and PCB waste containers must be inventoried and 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. Y-12 operations involving TSCA-regulated materials were conducted in accordance with TSCA regulations and the ORR-PCB-FFCA.

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 last issued 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 2009 through the submittal of reports under EPCRA Sections 302, 303, 311, and 312. Y-12 had no releases of extremely hazardous substances as defined by EPCRA, in 2009.

The required Section 311 notifications were made in 2009 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 Section 312 requirements. Y-12 reported 70 chemicals that were in inventory over threshold during the 2009 reporting year.

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 2009 reportable toxic releases to air, water, and land, and waste transferred off site for treatment, disposal, and recycling were 73,111 kg (161,180 lb). Table 4.5 lists the reported chemicals for the Y-12 Complex and summarizes releases and off-site transfers for those chemicals exceeding reporting thresholds.

Table 4.5. Emergency Planning and Community Right-to-Know Act Section 313 toxic chemical release and off-site transfer summary for the Y-12 Complex, 2009

Chemical	Year	Quantity[a] (lb)[b]
Chromium	2008	*c*
	2009	*6,106*
Copper	2008	*c*
	2009	*c*
Lead Compounds	2008	*21,652*
	2009	*12,859*
Mercury Compounds	2008	*31*
	2009	*125*
Methanol	2008	*33,814*
	2009	*92,020*
Nickel	2008	*c*
	2009	*c*
Nitric Acid	2008	*4,000*
	2009	*3,320*
Ozone	2008	*c*
	2009	*c*
Sulfuric Acid	2008	*45,000*
	2009	*46,000*
Total	2008	104,497
	2009	161,180

[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 500 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 was one release of a hazardous substance (asbestos) exceeding an RQ. There were no fish kills at Y-12 in 2009. There was one release of hydraulic fluid that resulted in an observed oil sheen on upper East Fork Poplar Creek (see Sect. 4.3.9.4).

4.3.9.4 Environmental Occurrences

The Y-12 Occurrence Reporting program provides timely notification to the DOE Complex of Y-12 events and site conditions that could adversely affect the public or worker health and safety, the environment, national security, DOE's safeguards and security interests, functioning of DOE facilities, or the department's reputation.

Y-12 occurrences are categorized and reported through the Occurrence Reporting and Processing System (ORPS). ORPS provides NNSA and the DOE community with a readily accessible database of information about occurrences at DOE facilities, causes of those occurrences, and corrective actions to prevent recurrence of the events. DOE analyzes aggregate occurrence information for generic implications and operational improvements.

On June 22, 2009, a hydraulic line on a construction crane failed, resulting in a leak of approximately 370 L (98 gal) of hydraulic fluid (Occurrence Report N/A--YSO-BWXT-Y12CM-2009-0002). Efforts were made to capture and absorb the material; however, some hydraulic fluid reached a storm drain system inlet to East Fork Poplar Creek, resulting in an oil sheen and prompting reporting to the National Response Center, the Tennessee Emergency Management Agency, and the Local Emergency Planning Committee. This event was the result of mechanical failure (hydraulic hose rupture), and all personnel involved followed the proper protocol that mitigated the release. There were no observed effects to fish and aquatic conditions as result of this event. After notification, a TDEC inspector visited the site to review the spill and the subsequent actions of the Y-12 personnel involved in the spill event. The TDEC representative concluded that response to the spill and cleanup efforts had been dealt with effectively and efficiently and had no negative remarks (concerns) relating to the cleanup effort.

On September 2, 2009, while performing cleanup activities and operating heavy equipment at the 9720-58 yard, a pressurized acetylene cylinder was inadvertently punctured resulting in a release of asbestos material on the ground that exceeded the reportable quantity (Occurrence Report NA--YSO-BWXT-Y12SITE-2009-0026). The work site was inspected by hand prior to restart of activities. This activity included hand removal of bulky items, wearing the proper personal protective equipment, as well as clearing and combing through overgrown areas in an attempt to reveal any items which may have been hidden. Thorough training on the identification of various types of anomalous waste likely to be encountered and instructions on how to respond to the discovery was provided to all employees working in the area.

A Notice of Violation (NOV) for maximum contaminant limit (MCL) exceedance in groundwater monitoring well GW-305 at Industrial Landfill IV was issued by TDEC in November 2009 to Bechtel Jacobs, the DOE-EM contractor at Y-12 (see Sect. 2.5). Such notifications are also reported in the DOE Occurrence Reporting system (Occurrence Report EM-ORO--BJC-Y12WASTE-2009-0001).

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 2009, spill response and waste services personnel conducted one removal and recovered an estimated 0.5 kg (1.0 lb) of mercury. Approximately 30 kg (66 lb) have been recovered since 2003.

4.3.10 Audits and Oversight

A number of federal, state, and local agencies oversee Y-12 activities. In 2000, Y-12 was inspected by federal, state, or local regulators on five occasions. The TDEC Department of Energy Oversight Division maintained a part-time regulator on site who provided periodic oversight of Y-12 activities. Except for work completed under the Federal Facilities Agreement (FFA), TDEC DOE Oversight work is non-regulatory. This clarification should be made to avoid a misunderstanding of TDEC DOE Oversight's role at Y-12. Most other matters such as CAA, CWA, and RCRA are regulated by TDEC's Knoxville Basin Office, not TDEC DOE Oversight. The Environmental Restoration Section at TDEC DOE-O handles CERCLA matters at Y-12. In addition to external audits and oversight, Y-12 has a comprehensive self-assessment program. A summary of external regulatory audits and reviews for 2009 is provided in Table 4.6.

Table 4.6. Summary of external regulatory audits and reviews, 2009

Date initiated	Date completed	Conducted by	Title of assessment	Total findings
1/14/2009	1/14/2009	City of Oak Ridge	Semi-Annual Industrial Pretreatment Compliance Inspection	1[a]
1/21/2009	1/22/2009	TDEC	TDEC Annual Clean Air Compliance Inspection	0
8/4/2009	8/4/2009	TDEC	Underground Storage Tank Compliance Inspection	0
9/14/2008	9/14/2009	City of Oak Ridge	Semi-Annual Industrial Pretreatment Compliance Inspection	0
11/2/2009	11/5/2009	TDEC	TDEC Annual RCRA Inspection	0

[a]The City of Oak Ridge requested an action plan to address inflow/infiltration into the sanitary sewer system.

Abbreviations:

RCRA—Resource Conservation and Recovery Act

TDEC—Tennessee Department of Environment and Conservation

4.3.10.1 Enforcement Actions and Memos

There was no consent orders issued to Y-12 in 2009. The DOE-EM contractor for the Oak Ridge Reservation construction demolition landfill at Y-12 received a NOV for MCL exceedance in groundwater monitoring well GW-305 at Industrial Landfill IV from TDEC in November 2009. There was no impact to the operation of Industrial Landfill IV. Due to the remote location of this groundwater monitoring well from public property and/or drinking water sources, there is negligible impact at this point from a health and safety viewpoint. Environmental impacts will be determined as part of the required Phase III Assessment Monitoring Program Plan as required by the TDEC Solid Waste Regulations.

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.

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 ensured 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 2009, Y-12 Complex had only one construction air permit. A construction permit for the replacement steam plant continued in 2009.

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. The Tennessee Air Pollution Control Board issued a minor modification to the Title V Major Source Operating Permit 554701 on April 5, 2009. The minor modification was to align permit conditions with site transformation activities. Permit change requests still pending at the end of 2009 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 site-wide permit;
- a request to add the new steam plant to the operating permit; and
- a request to add Fuel Station Stage 1 emission control requirements to the permit.

The Y-12 Complex major source (Title V) operating air permit renewal application was prepared and hand-delivered to the TDEC personnel in April 2009. As part of the permit application renewal, it was requested that TDEC combine Air Permit 554594 into Air Permit 554701 followed by cancellation of Air Permit 554594. The complete permit application consists of four volumes. The complete, unedited application consists of Volumes 1, 2, 3.2, and 4.3. Volumes 3.1, 4.1, and 4.2, which are edited for classification reasons, were provided to the TDEC for their review and approval. Any classified information is held on site at the Y-12 National Security Complex for the appropriately Q-cleared TDEC personnel to review as needed.

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 2009, emissions categorized as actual emissions totaled 2,697,704 kg (2,973.71 tons), and emissions calculated by the allowable methodology totaled 756,365 kg (833.75 tons). The total emissions fee paid was $139,736.57.

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 (CFR 2009a), 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. Asbestos, ozone-depleting substances, and fugitive particulate emissions are notable examples.

Control of Asbestos

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. There was one reportable release of asbestos in 2009, when an acetylene cylinder was inadvertently punctured while performing site cleanup activities and operating heavy equipment at the 9720-58 yard (see Sect. 4.3.9.4). Corrective actions were implemented, and the area cleared of asbestos with approval from the Supervisor of the Asbestos Abatement Activity for resumption of normal activities. There was no impact to the environment.

Stratospheric Ozone Protection

Y/TS-1880, *Y-12 Complex Ozone Depleting Substances (ODS) Phase-Out and Management Plan* (B&W Y-12 2009a), provides a complete discussion of requirements and compliance activities at the Y-12 Complex. ODS reductions are based on the DOE Order 450.1A (DOE 2008a) objective to phase out as equipment reaches life expectance, equipment repairs are no longer cost-effective, or viable solvent replacements are identified. Past ODS reduction initiatives began in the early 1980s and focused on Class I ODS usage in refrigerants and solvent cleaning operations. Only one small chiller remains at the Y-12 Complex which contains Class I ODS. This system has a 181-kg (400-lb) charge of refrigerant and was manufactured in 1992. If it is determined to be economically practicable, this system will be retrofitted in accordance with the DOE 2010 implementation goal.

Y-12 Complex initiatives in support of the DOE objectives have also involved elimination of solvents in cleaning processes. Operations personnel developed and implemented changes in one process which reduced the amount of ODS solvent emissions by up to 8,891 kg (19,600 lb) each year. Evaluation of ODS reduction opportunities continue for another solvent cleaning operation. Future actions related to this process will be dependent on ongoing efforts to identify a safe and viable replacement chemical or to identify practical and cost-effective modifications to process equipment.

Any Class I and Class II substitutions are made in accordance with EPA's Significant New Alternatives Program (SNAP). Y-12 Complex personnel are notified as EPA issues regulations detailing SNAP replacement chemicals which may be applicable to plant operations. In order to prevent ODS from coming on-site, procurement documents are written to ensure that no additional equipment or processes using Class I ODS are brought onsite, and Class II ODS usage is limited wherever possible.

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. Recovered ODS are typically recycled/reused in other equipment in the Y-12 Complex. However, Class I ODS deemed excess must be transferred to Defense Logistics Agency as needed. Remaining ODS are offered to other DOE sites or government agencies, sold, or properly disposed if not useable.

Fugitive Particulate Emissions

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.

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 (CFR 2009b),
- 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 2009, 41 process exhaust stacks were continuously monitored, 34 of which were major sources; the remaining 7 were minor sources. (Stack US-143 began operation in 2009, and Stack US-011 did not run during 2009.) The sampling systems on these stacks have been approved by EPA Region 4.

During 2009, unmonitored uranium emissions at the Y-12 Complex occurred from 40 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 (CFR 2009b). 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 2009 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. **TBD** emission points from room ventilation exhausts were identified in 2009 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.

The Y-12 Complex Title V Major Source Operating Permits contain a site-wide, streamlined alternate emission limit for enriched and depleted uranium process emission units. A limit of 907 kg (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 0.0081 Ci (0.7 kg) of uranium was released into the atmosphere in 2009 as a result of Y-12 activities (Figs. 4.18 and 4.19).

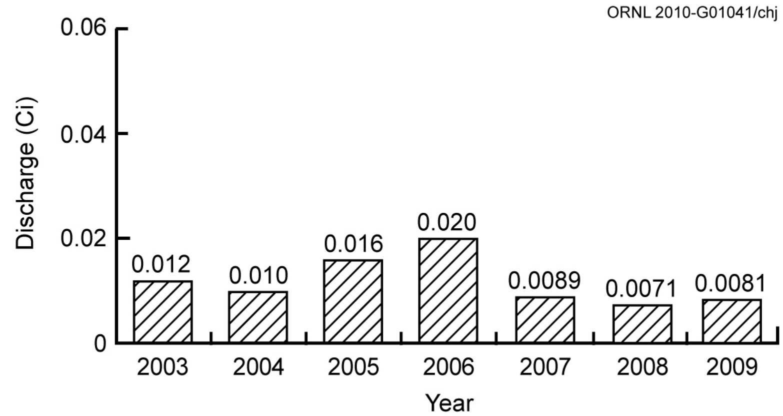

Fig. 4.18. Total curies of uranium discharged from the Y-12 Complex to the atmosphere, 2003–2009.

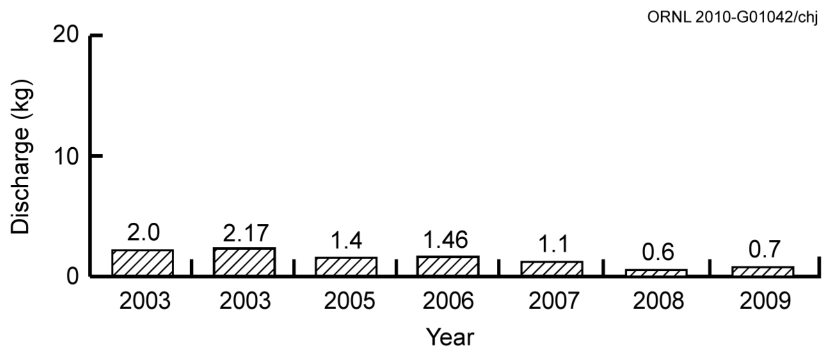

Fig. 4.19. Total kilograms of uranium discharged from the Y-12 Complex to the atmosphere, 2003–2009.

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 (CFR 2007), 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.

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 4.7. The Y-12 Title V operating

Table 4.7. Actual vs allowable air emissions from the Oak Ridge Y-12 Steam Plant, 2009

Pollutant	Emissions (tons/year)[a]		Percentage of allowable
	Actual	Allowable	
Particulate	38	945	4.0
Sulfur dioxide	2,337	20,803	11.2
Nitrogen oxides[b]	584.9	5,905	9.9
Nitrogen oxides (ozone season only)	126.1[c]	174	72.5
Volatile organic compounds[b]	3	41	7.3
Carbon monoxide[b]	25	543	4.6

[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, N.C. January 1995 and September 1998.)

[c]Monitored emissions.

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 2009, the opacity monitoring systems were operational for more than 95% of the operational time of the monitored units during each month. During 2009, 26, 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 4.8 is a record of excess emissions and inoperative conditions for the east and west stack opacity monitors for 2009. 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 2009 ozone season was 114,396 kg (126.1 tons) of NO_x, the limit being 157,850 kg (174 tons), as shown in Fig. 4.20. Boiler 3 was shutdown and its tonnage was removed from the total NO_x limit for the steam plant.

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.

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 2009.

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 first semiannual calibration error tests were conducted on April 11 and 12, 2009, for the west and east opacity monitors, respectively. The second semiannual calibration error tests were conducted on December 12 and 17, 2009, for the west and

Table 4.8. Periods of excess emissions and out-of-service conditions for Y-12 Steam Plant east and west opacity monitors, 2009

Date	Stack	Condition	Comments
January 26	East	One 6-min period of excess emissions	Due to bad/damaged bags in Compartment 7 of Baghouse 4
July 14	East	One 6-min period of excess emissions	Due to maintenance personnel checking the Boiler 4 ID fan damper system while the fan was running which caused an upset condition of the ductwork system that created the excess emission (opacity)
October 22	East	One 6-min period of excess emissions	Due to initial start-up of the fans on Boiler 4 after an overhaul
October 5	West	One 6-min period of excess emissions	Due to damaged/deteriorated bags in Baghouse 1
October 7	West	One 6-min period of excess emissions	Due to damaged/deteriorated bags in Baghouse 1
October 8	West	Eight 6-min periods of excess emissions	Due to damaged/deteriorated bags in Baghouse 1
October 9	West	Four 6-min periods of excess emissions	Due to damaged/deteriorated bags in Baghouse 1
October 19	West	One 6-min period of excess emissions	Due to damaged/deteriorated bags in Baghouse 1
November 4	West	Five 6-min periods of excess emissions	Due to damaged/deteriorated bags in Baghouse 1
November 5	West	Three 6-min periods of excess emissions	Due to damaged/deteriorated bags in Baghouse 1

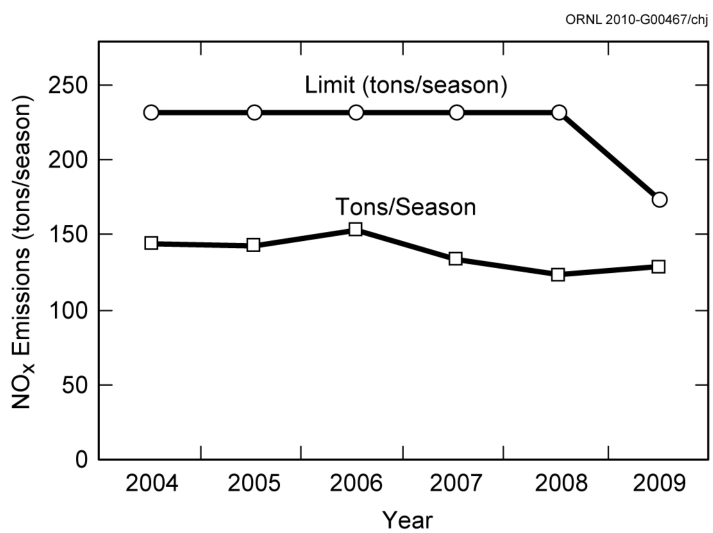

Fig. 4.20. Y-12 steam plant NO_x emissions per ozone season.

east opacity monitors, respectively. Both monitors passed the test. The tests are submitted to TDEC staff as proof of the continuous operation of the opacity monitoring systems within acceptable accuracy limits.

The NO_x continuous emissions monitoring systems are operated in conformance with the requirements of 40 CFR 75 (CFR 2010). 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 in February and March 2009 for all three boilers. A pair of regular non-redundant backup monitors were completed. The reports were submitted on April 15, 2009, 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 checks for NO_x analyzers were conducted in April and August 2009, in accordance with 40 CFR 75. 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. 4.4.2, 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 new natural-gas-fired steam plant will be on-line in 2010 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 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 (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.

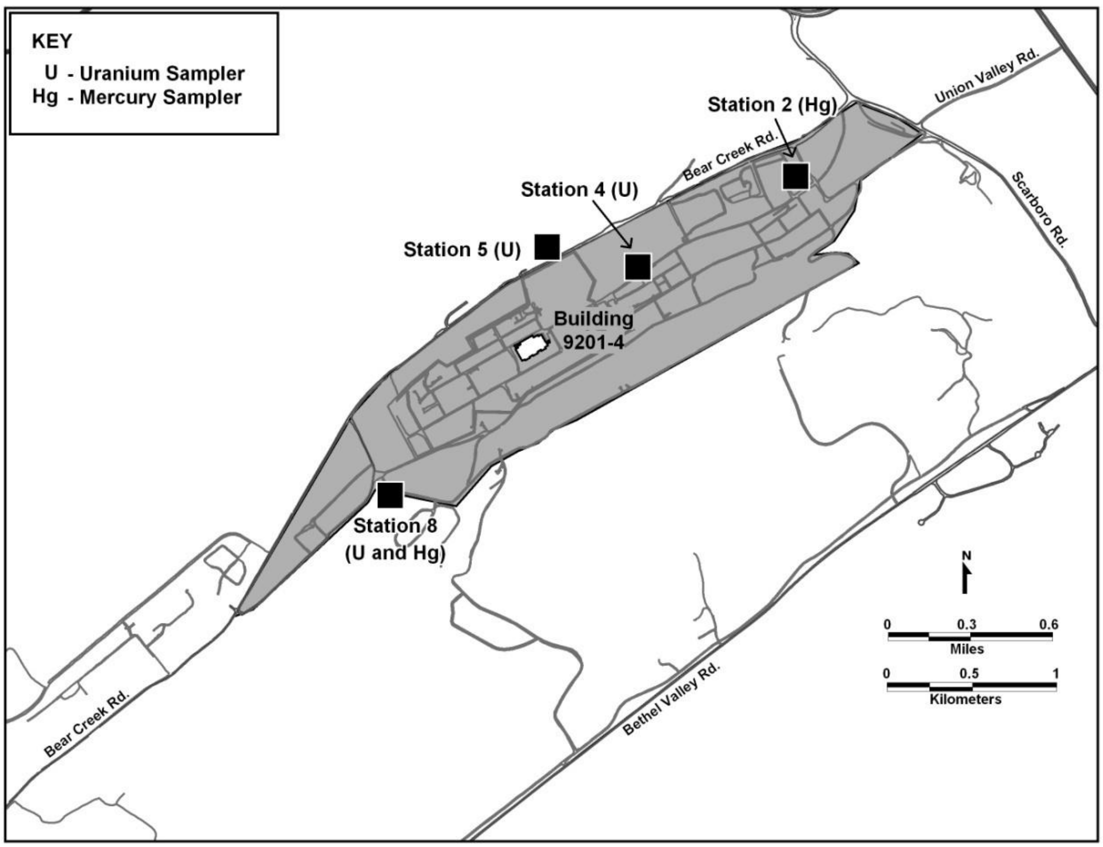

Fig. 4.21. Locations of ambient air monitoring stations at the Y-12 Complex.

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 4.9). Average mercury concentration at the AAS2 site for 2009 is 0.0030 µg/m^3 (N = 50; S.E. = ±0.0002), comparable to the previous year of 0.0029 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 2009 was 0.0041 µg/m^3 (N = 49; SE = 0.0002) or similar to levels recorded in 2008 and prior to 2005.

Table 4.9. Summary of data for the Oak Ridge Y-12 National Security Complex mercury in ambient air monitoring program, 2009

Ambient air monitoring stations	Mercury vapor concentration (µg/m^3)			
	2009 average	2009 maximum	2009 minimum	1986–1988[a] average
AAS2 (east end of the Y-12 Complex)	0.0030	0.0058	0.0011	0.010
AAS8 (west end of the Y-12 Complex)	0.0041	0.0099	0.0017	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

[a]Period in late-80s with elevated ambient air Hg levels.
[b]Data for period from February 9 through December 31, 1988.
[c]Data for period from January 1 through October 31, 1989.

Table 4.9 summarizes the 2009 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 2009 (plots 1, 2) and seasonal trends at AAS8 from 1993 through 2009 (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, 2009 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, that is, 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.

4.4.2.2 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.

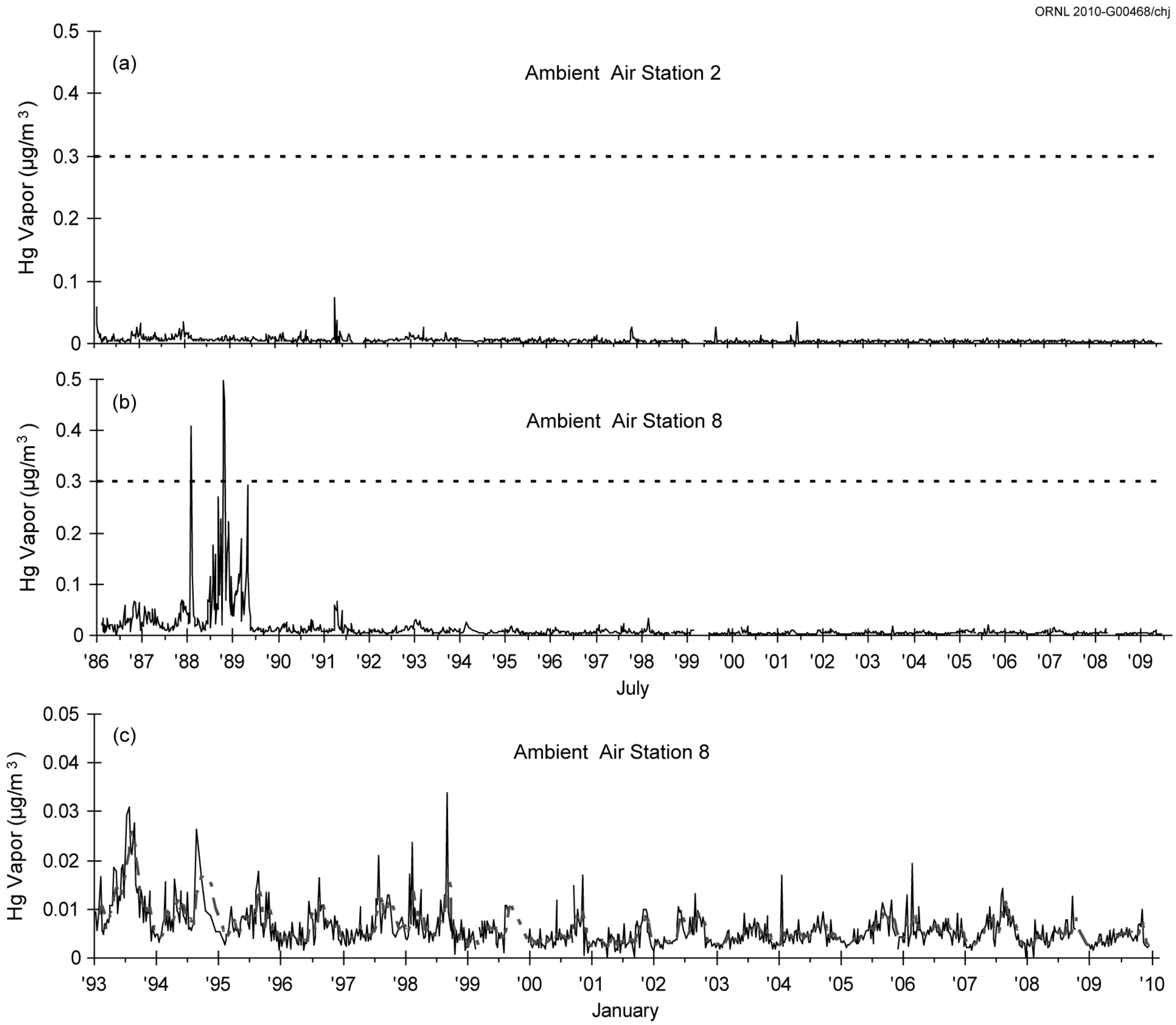

Fig. 4.22. Temporal trends in mercury vapor concentration for the boundary monitoring stations at the Y-12 National Security Complex, July 1986 to January 2010 (plots 1 and 2) and January 1993 to January 2010 for AAS8 (plot 3).

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.

A field performance evaluation is conducted annually by the project manager to ensure that proper procedures are followed by the sampling technicians. No issues were identified in the last evaluation conducted March 25, 2009.

Analytical QA/QC requirements include

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

- analysis of laboratory duplicates (one per 10 samples; any laboratory duplicates differing by more than 10% at five 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.

4.4.2.3 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 the 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

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

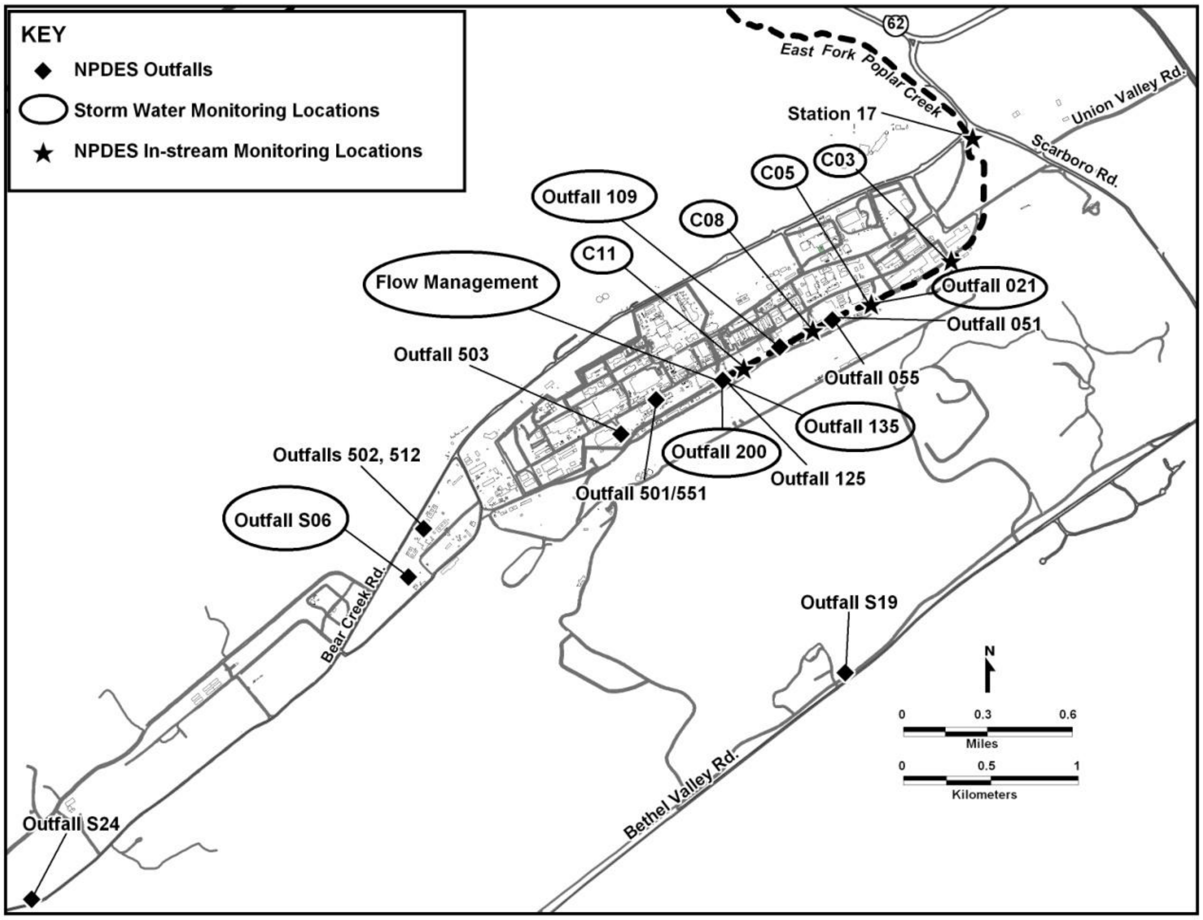

Fig. 4.23. Major Y-12 Complex National Pollutant Discharge Elimination System (NPDES) outfalls and storm water monitoring locations.

Creek, and several tributaries on the south side of Chestnut Ridge, all of which eventually drain to the Clinch River.

Discharges to surface water allowed under the permit include storm drainage, cooling water, cooling tower blowdown, steam condensate, and treated process wastewaters, including effluents from wastewater treatment facilities. Groundwater inflow into sumps in building basements and infiltration to the storm drain system are also permitted for discharge to the creek. The monitoring data collected by the sampling and analysis of permitted discharges are compared with NPDES limits 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 2009 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 2009 was >99.9%. The only 2009 NPDES permit excursion occurred when the measured cadmium monthly average at Outfall 200, 0.00162 mg/L, exceeded the permit limit of 0.001 mg/L on April 4, 2009. At the time of the reading, there were no observed adverse effects on the receiving stream.

Dechlorination treatment in the upper reach of EFPC provided excellent control of chlorinated discharges, and toxicity testing results of three outfalls in the upper reach have shown no toxicity. Table 4.10 lists the NPDES compliance monitoring requirements and the 2009 compliance record.

Table 4.10. NPDES compliance monitoring requirements and record for the Y-12 Complex, January through December 2009

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	100	4
	Total suspended solids	19	36.0	31.0	40.0	100	4
	Total toxic organic				2.13	100	1
	Hexane extractables			10	15	100	4
	Cadmium	0.16	0.4	0.075	0.15	100	4
	Chromium	1.0	1.7	0.5	1.0	100	4
	Copper	1.2	2.0	0.5	1.0	100	4
	Lead	0.26	0.4	0.10	0.20	100	4
	Nickel	1.4	2.4	2.38	3.98	100	4
	Nitrate/Nitrite				100	100	4
	Silver	0.14	0.26	0.05	0.05	100	4
	Zinc	0.9	1.6	1.48	2.0	100	4
	Cyanide	0.4	0.72	0.65	1.20	100	4
	PCB				0.001	100	1
Outfall 503 (West End 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 4.10 (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	b	0
Outfall 200 (North/South pipes)	pH, standard units			*a*	9.0	100	55
	Hexane extractables			10	15	100	53
	Cadmium			0.001	0.025	92	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	52
	Mercury			0.002	0.004	100	52
Outfall 051	pH, standard units			*a*	9.0	100	12
Outfall 135	pH, standard units			*a*	9.0	100	14
	Lead			0.04	1.190	100	12
	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	14
	Mercury				0.004	100	52
	Total Residual Chlorine				0.5	100	8
Outfall 109	pH, standard units			*a*	9.0	100	7
	Total Residual Chlorine				0.5	100	6
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	b	0
Outfall EFP	pH, standard units			*a*	9.0	100	210

Table 4.10 (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	27
	Total Residual Chlorine				0.019	100	26
	Temperature (°C)				30.5	100	27
Outfall S06	pH, standard units			*a*	9.0	100	2
Outfall S19	pH, standard units			*a*	9.0	100	1
Outfall S24	pH, standard units			*a*	9.0	100	5
Category I outfalls	pH, standard units			*a*	9.0	100	20
Category II outfalls	pH, standard units			*a*	9.0	100	29
	Total Residual Chlorine				0.5	100	28
Category III outfalls	pH, standard units			*a*	9.0	100	10
	Total Residual Chlorine				0.5	100	10

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

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 4.11). 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 2009 were reported in *Annual Storm Water Report for the Y-12 National Security Complex* (B&W Y-12 2010), which was issued in January 2010. 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 2009 are noted in Fig. 4.24. Table 4.12 identifies the monitored locations, the frequency of monitoring, and the sum of the percentages of the derived concentration guidelines (DCGs) for radionuclides measured in 2009. Radiological data were well below the allowable DCGs.

In 2009, 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 187 kg or 0.067 Ci (Table 4.13). 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).

Table 4.11. Radiological parameters monitored at the Y-12 Complex, 2009

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

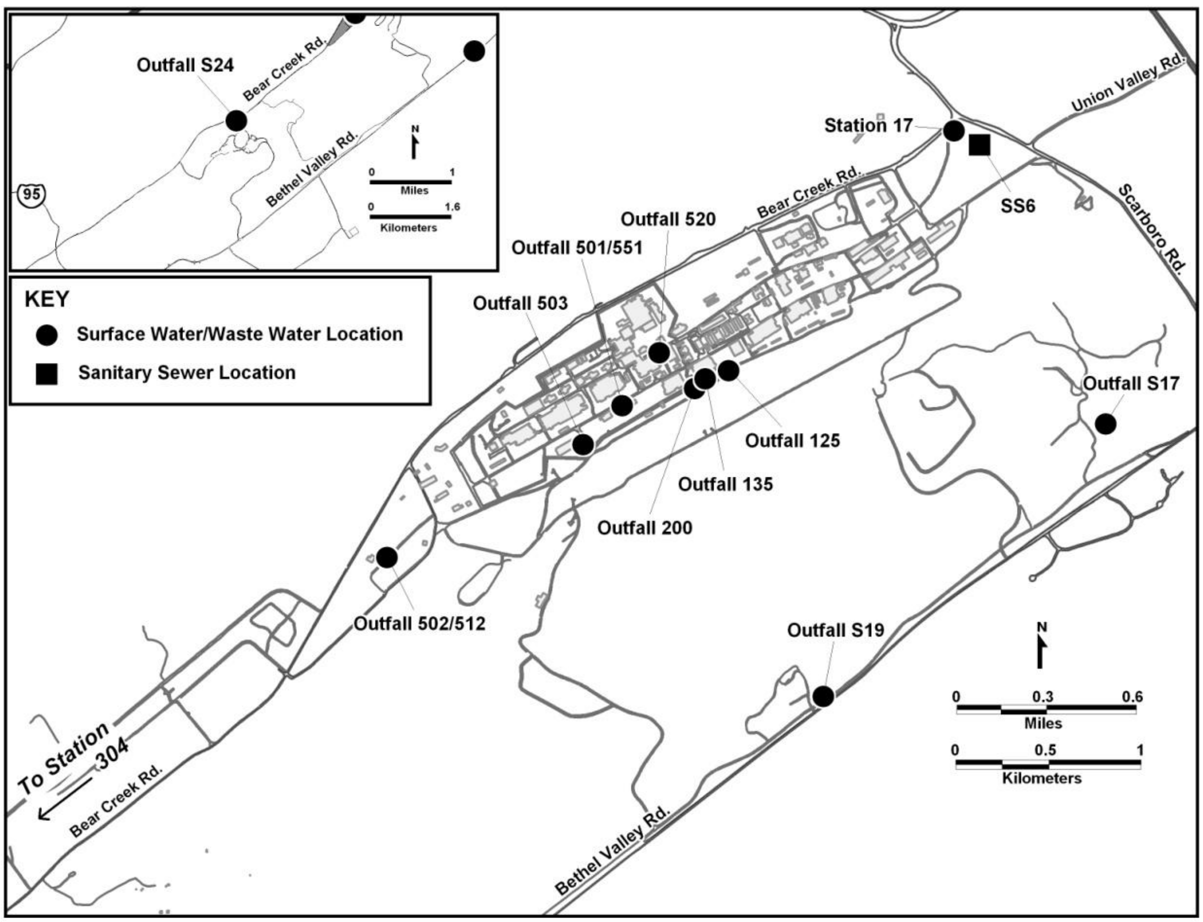

Fig. 4.24. Surface water and sanitary sewer radiological sampling locations at the Y-12 Complex.

Table 4.12. 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	1.4
503	Steam Plant Wastewater Treatment Facility	4/year	24-hour composite	No flow
512	Groundwater Treatment Facility	4/year	24-hour composite	4.2
520	Steam condensate	1/year	Grab	No flow
551	Central Mercury Treatment Facility	4/year	24-hour composite	0
	Other Y-12 Complex point and area source discharges			
125	Outfall 125	4/year	24-hour composite	5.8
135	Outfall 135	4/year	24-hour composite	0
S17	Kerr Hollow Quarry	1/year	24-hour composite	0
S19	Rogers Quarry	1/year	24-hour composite	1.1
	Y-12 Complex instream locations			
S24	Outfall S24	4/year	7-day composite	5.7
Station 17	East Fork Poplar Creek, complex exit (east)	1/month	7-day composite	0
200	North/south pipes	1/month	24-hour composite	4.0
	Y-12 Complex Sanitary Sewer			
SS6	East End Sanitary Sewer Monitoring Station	1/week	7-day composite	8

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

Table 4.13. Release of uranium from the Y-12 Complex to the off-site environment as a liquid effluent, 2005–2009

Year	Quantity released	
	Ci[a]	kg
	Station 17	
2005	0.043	93
2006	0.050	131
2007	0.036	70
2008	0.046	75
2009	0.067	187

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

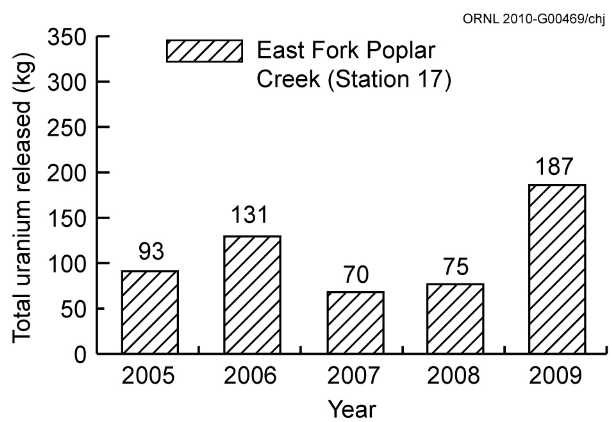

Fig. 4.25. Five-year trend of Y-12 Complex release of uranium to East Fork Poplar Creek.

Converting units and multiplying by 365 days per year yields the calculated discharge. The increase in uranium quantity in 2009 may be the result of higher rainfall and subsequent movement of sediment and runoff from surfaces such as rooftops.

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 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 was conducted for 2009 during rain events that occurred in August, September, and October. Results were published in the *Annual Storm Water Report for the Y-12 National Security Complex* (B&W Y-12 2010), which was submitted to the Division of Water Pollution Control in January 2010. 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 (Fig. 4.23). The permit also calls for sampling of stream baseload sediment that is being transported due to the heavy flow. Sediment sampling is performed at the four instream locations.

In general, results of storm water monitoring in 2009 indicated improvement in the quality of storm water exiting the Y-12 Complex. Results of sediment sampling, while inconclusive, did indicate reduction of levels of PCBs at all instream sampling locations.

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 26 million liters (7 million gallons) per 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).

A request to modify the NPDES permit to allow the minimum flow, measured at Station 17, to be reduced to 19 million liters (5 million gallons) per day was made, and on December 30, 2008, TDEC modified the permit. The modified permit requires 19 million liters (5 million gallons) rather than 26 million liters (7 million gallons) minimum daily flow as measured at the Station 17 location. In addition to water conservation, this action offers the potential benefit of reducing the transport of mercury from a contaminated section of the streambed.

During 2009 DOE and B&W Y-12 personnel were in discussion with City of Oak Ridge water system management regarding modification of the raw water supply system for EFPC. A design proposal for modification has been prepared. The proposed new control system will allow Y-12 to reduce total flow to the 19 million liters (5 million gallons) per day, maintain a more consistent flow during rain events, and provide more flexibility.

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 is 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.

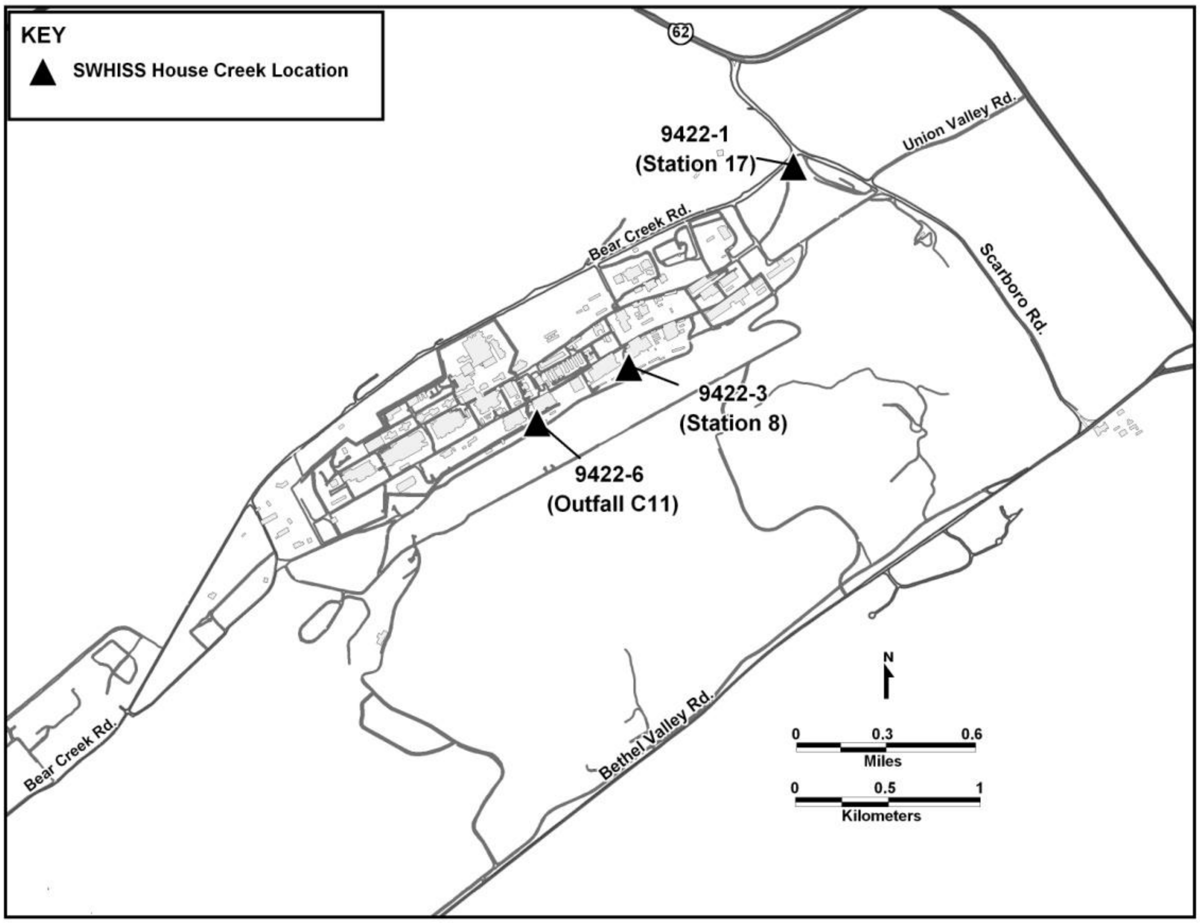

Fig. 4.26. Surface Water Hydrological Information Support System (SWHISS) monitoring locations.

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-h 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 2009 (Table 4.14) indicated four exceedances of permit limits. One was for exceedance of permit limits (monthly average) for nickel. The other three were for exceedance of the permit limit for maximum daily flow.

Table 4.14. Y-12 Complex Discharge Point SS6, Sanitary Sewer Station 6, January through December 2009

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	12	NA	9/6[c]	100
Silver	12	0.05	0.1	100
Arsenic	12	0.01	0.015	100
Biochemical oxygen demand	13	200	300	100
Cadmium	12	0.0033	0.005	100
Chromium	12	0.05	0.075	100
Copper	12	0.14	0.21	100
Cyanide	12	0.041	0.062	100
Iron	12	10	15	100
Mercury	12	0.023	0.035	100
Kjeldahl nitrogen	12	45	90	100
Nickel	12	0.021	0.032	99
Oil and grease	12	25	50	100
Lead	12	0.049	0.074	100
Phenols—total recoverable	12	0.3	0.5	100
Suspended solids	12	200	300	100
Zinc	12	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.

Over the last several years Y-12 personnel have conducted flow monitoring at key locations of the sanitary sewer system during wet and dry weather conditions. This effort has enabled a determination to be made of the general areas of the system most likely to contribute the greatest volume of infiltration or inflow of extraneous water into the lines. Examination of the data in 2009 led to the conclusion that inflow of surface water was this major, and in November 2009 a plan was developed to conduct a smoke test of the lines to locate specific inflow problem. This work will be conducted in 2010.

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 entered 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 2009 using fathead minnow larvae and *Ceriodaphnia dubia*. Table 4.15 summarizes the inhibition concentration (IC_{25}) results of biomonitoring tests conducted during 2009 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 2009.

Table 4.15. Y-12 Complex Biomonitoring Program summary information[a] for Outfalls 200, 135, and 125 in 2009

Site	Test date	Species	IC_{25}[b] (%)
Outfall 200	12/10/09	*Ceriodaphnia*	>100
Outfall 200	12/10/09	Fathead minnow	>100
Outfall 135	12/11/09	*Ceriodaphnia*	>20
Outfall 135	12/11/09	Fathead minnow	>20
Outfall 125	12/10/09	*Ceriodaphnia*	>36
Outfall 125	12/10/09	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 Biological Monitoring and Abatement Program (BMAP) with the objective of demonstrating that the effluent limitations established for the facility protect the classified uses of the receiving stream, East Fork Poplar Creek. The 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).

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 less diverse than the corresponding communities in reference streams.

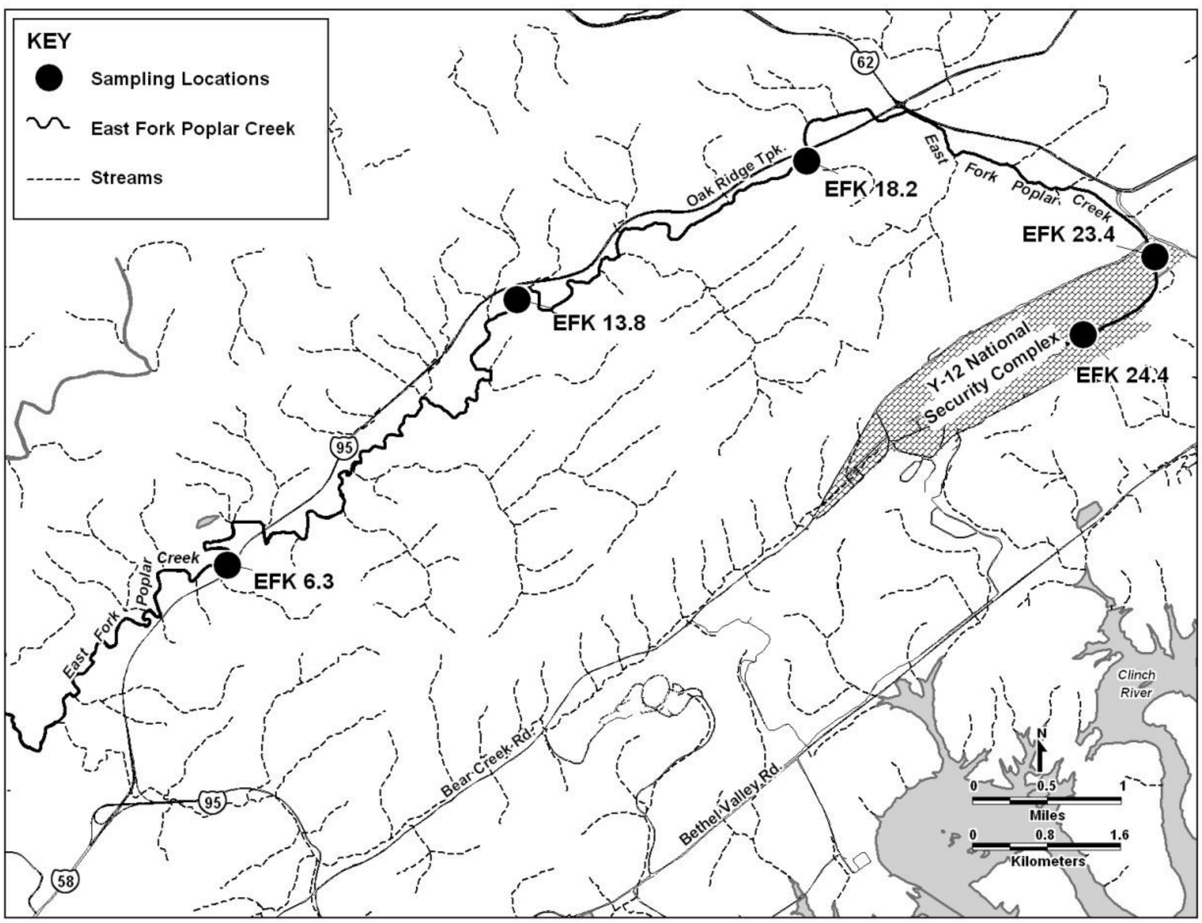

Fig. 4.27. Locations of biological monitoring sites on East Fork Poplar Creek in relation to the Oak Ridge Y-12 National Security Complex.

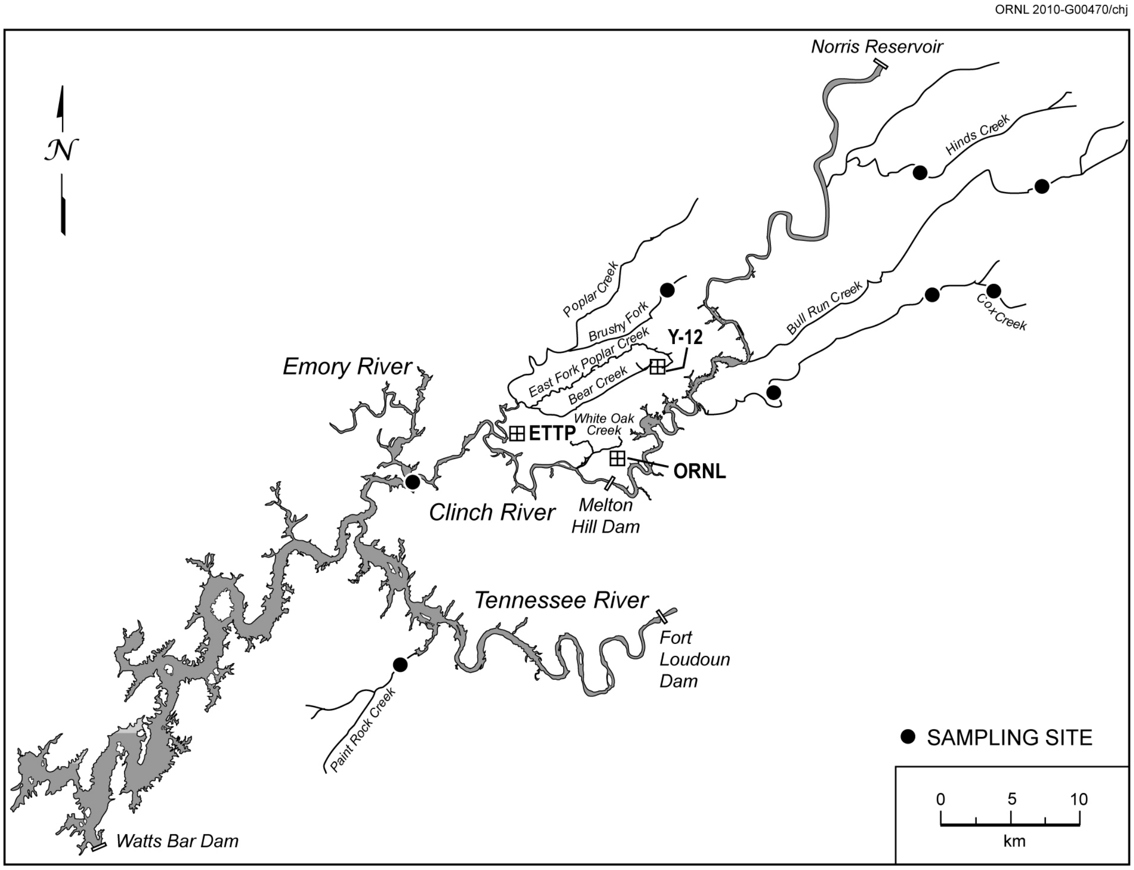

Fig. 4.28. Locations of biological monitoring reference sites in relation to the Oak Ridge Y-12 National Security Complex.

4.5.9.1 Bioaccumulation Studies

Mercury and PCB levels in fish from East Fork Poplar Creek (EFPC) have been historically elevated relative to fish in uncontaminated reference streams. Fish in EFPC are monitored regularly for mercury and PCBs to assess spatial and temporal trends in bioaccumulation associated with ongoing remedial activities and Y-12 Complex operations.

As part of this monitoring effort, redbreast sunfish (*Lepomis auritus*) and rock bass (*Ambloplites rupestris*) are collected twice a year from five sites throughout the length of EFPC and are analyzed for tissue concentrations of mercury (twice yearly) and PCBs (annually). Mercury concentrations remained much higher during 2009 in fish from East Fork Poplar Creek than in fish from reference streams. Elevated mercury concentrations in fish from the upper reaches of EFPC 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 EFPC 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 and were significantly higher in 2009 than in recent years. Mean concentrations of PCBs in fish at EFK 23.4 (the site where PCBs in fish are highest) continued to be much lower in 2009 than peak concentrations observed in the mid 1990s (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 2009. 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 (i.e., EPT taxa richness; Fig. 4.31). Of note is a similar recent trend of reductions

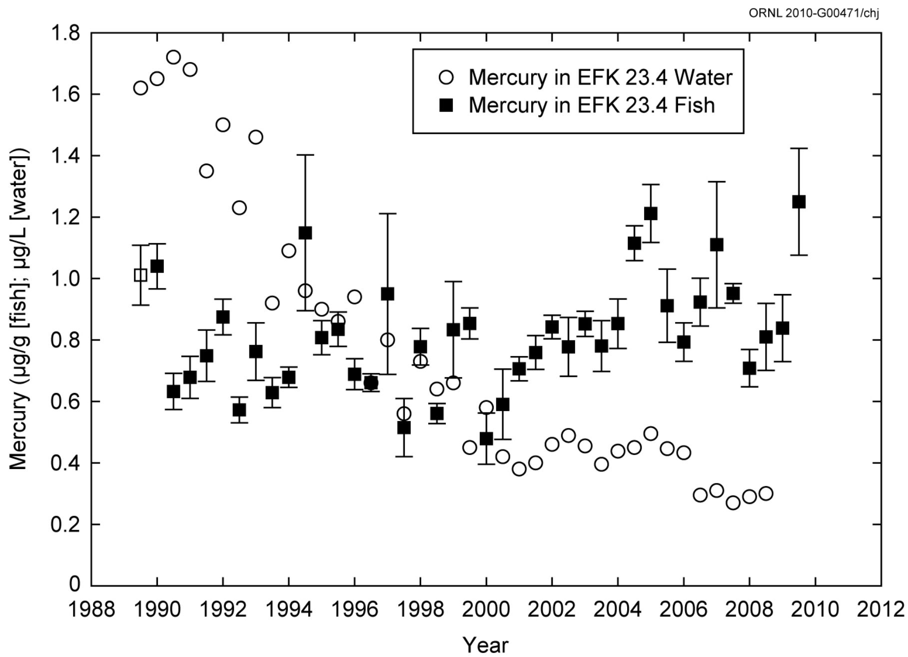

Fig. 4.29. Semiannual average mercury concentration in water and muscle fillets of redbreast sunfish and rock bass in East Fork Poplar Creek at EFK 23.4 through spring 2009.

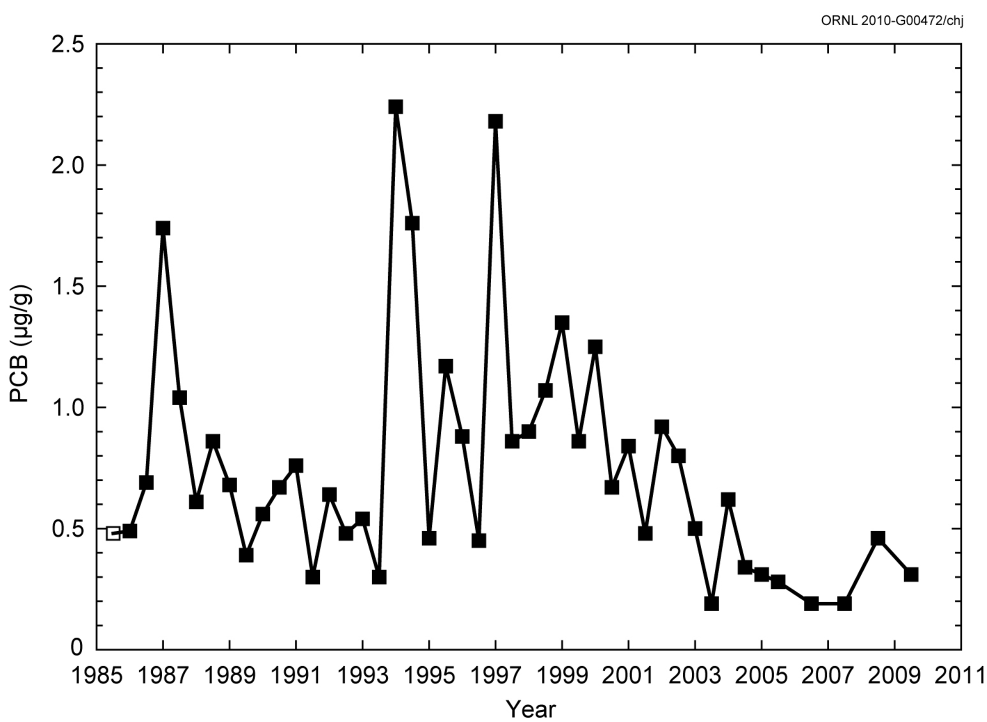

Fig. 4.30. Mean concentrations of PCBs in redbreast sunfish and rock bass muscle fillets in East Fork Poplar Creek at EFK 23.4 through Spring 2009 (EFK = East Fork Poplar Creek kilometer).

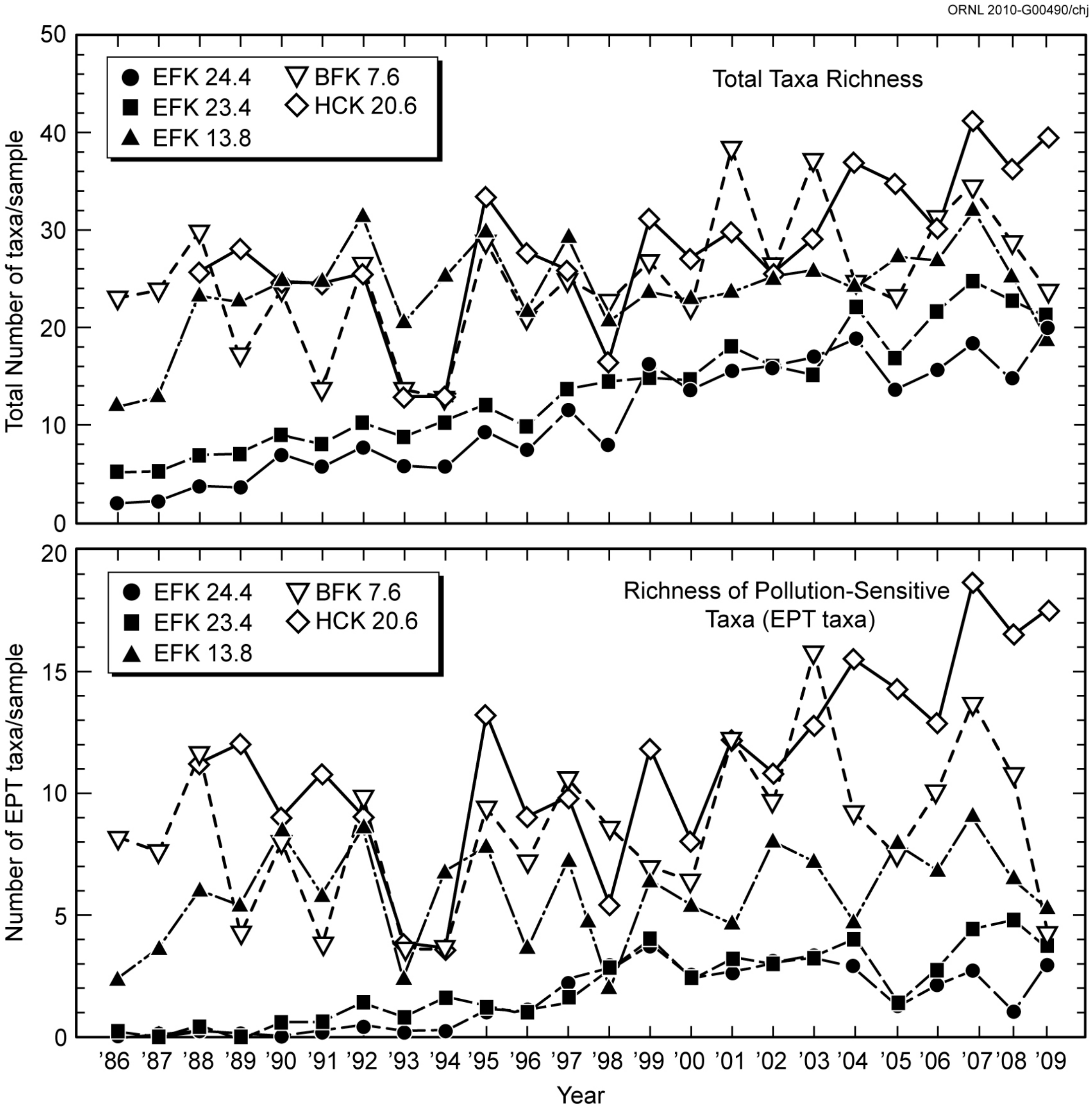

Fig. 4.31. Total taxonomic richness (mean number of taxa/sample) and total taxonomic richness of the *Ephemeroptera*, *Plecoptera*, and *Trichoptera* (EPT) (mean number of EPT taxa/sample) of the benthic macroinvertebrate communities sampled in spring from East Fork Poplar Creek and references sites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

in total taxa richness and EPT taxa richness at EFK 13.8 and the BFK 7.6 reference site. Although empirical evidence is not available, the trends at these sites may be related to weather changes, specifically precipitation. Heavy rains in spring 2009 may have affected these sites, although it is not clear why the HCK 20.6 site was not similarly affected unless precipitation patterns in that watershed were different. The upstream sites in EFPC, on the other hand, are dominated by species that are tolerant of a wide range of both natural and human-caused disturbances. While the benthic macroinvertebrate community at EFK 24.4 appears to have stabilized in recent years, there appears to have been a small increase in both total taxa richness and EPT taxa richness at EFK 23.4.

4.5.9.3 Fish Community Monitoring

Fish communities were monitored in the spring and fall of 2009 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

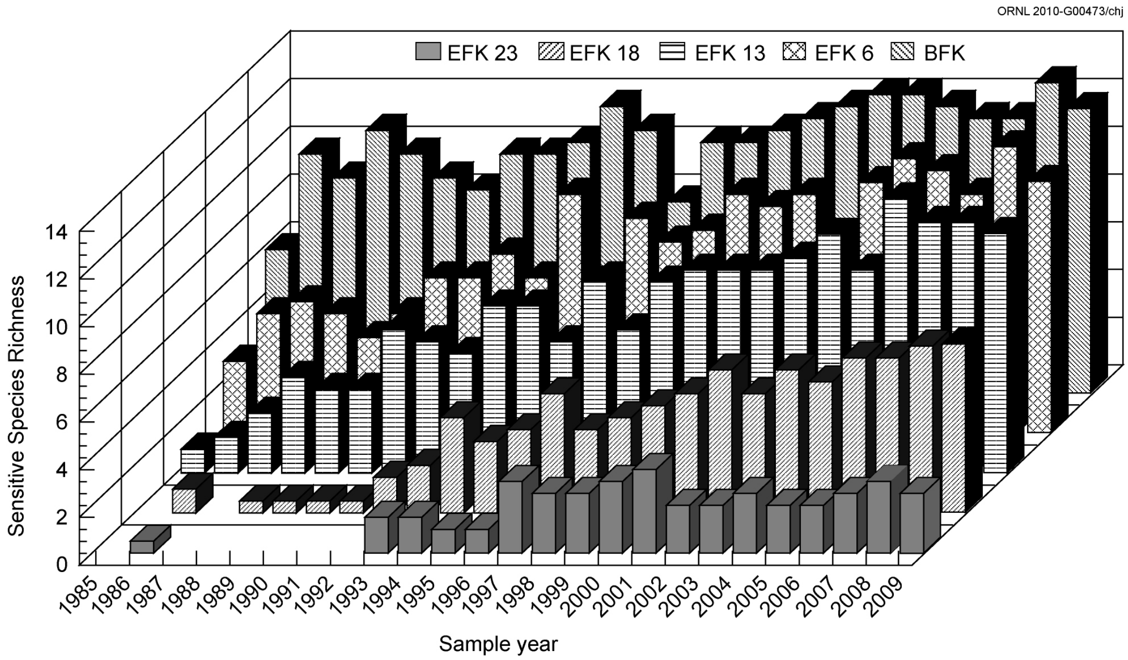

Fig. 4.32. Comparison of mean sensitive species richness (number of species) collected each year from 1985 through 2008 from four sites in East Fork Poplar Creek and a reference site (Brushy Fork).

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 monitoring at Y-12 is performed to determine what impacts to the environment from legacy and current operations are occurring. 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. Monitoring provides information on the nature and extent of contamination of groundwater which is then used to determine what actions must be taken to protect the worker, public, and the environment in compliance with regulations and DOE orders. Figure 4.33 depicts the major facilities or areas for which groundwater monitoring was performed during CY 2009.

4.6.1 Hydrogeologic Setting

The Y-12 Complex is divided into three hydrogeologic regimes (i.e., Bear Creek, Upper East Fork Poplar Creek, and Chestnut Ridge), which are delineated by surface water drainage patterns, topography, and groundwater flow characteristics (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 the 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.

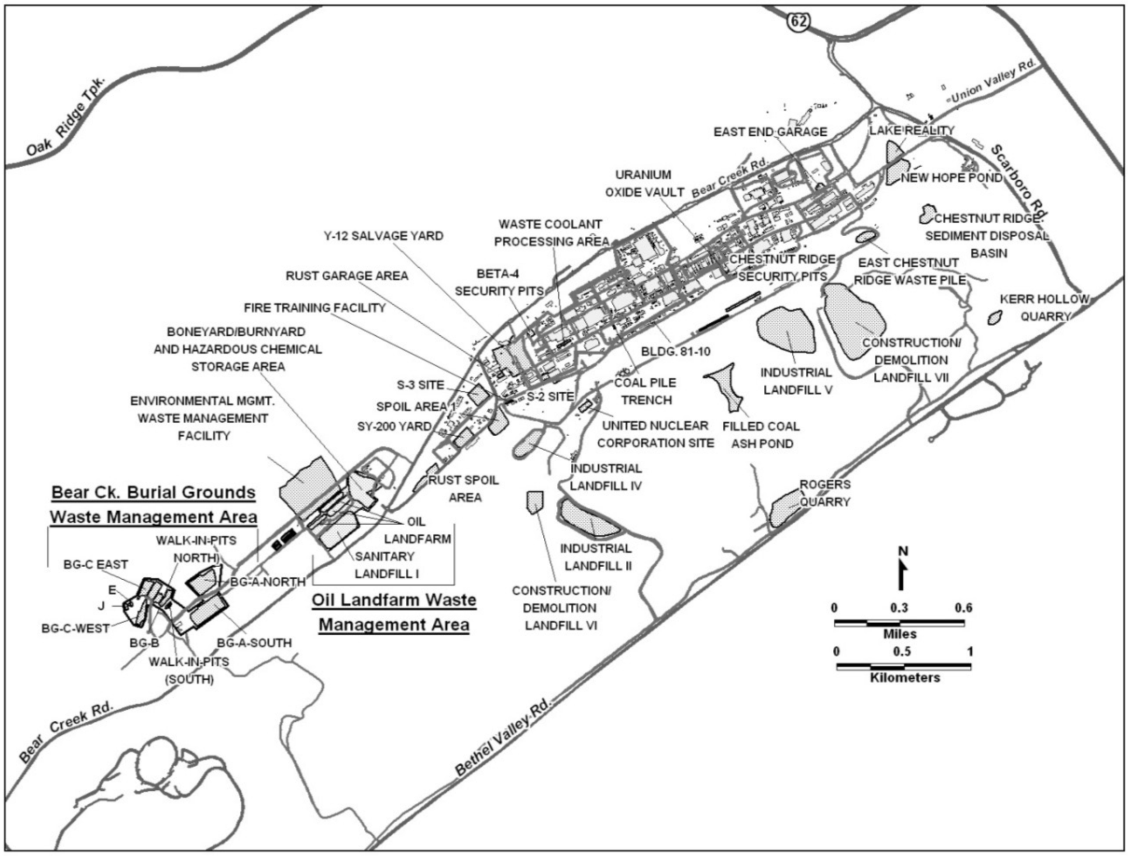

Fig. 4.33. Known or potential contaminant sources for which groundwater monitoring was performed at the Y-12 Complex during CY 2009.

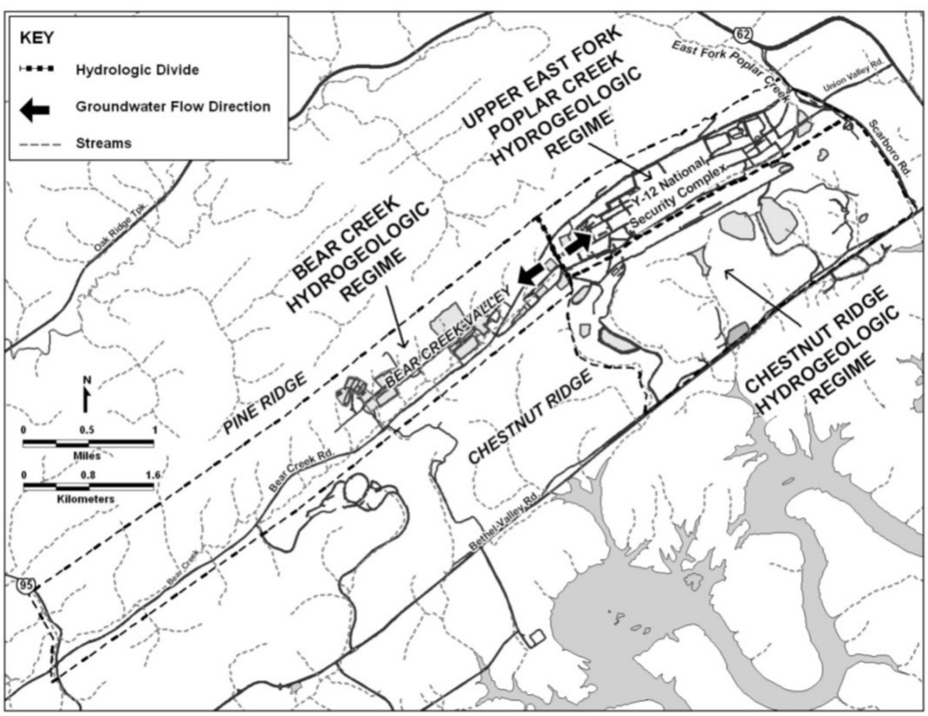

Fig. 4.34. Hydrogeologic regimes at the Y-12 Complex.

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). The rate of groundwater flow perpendicular to geologic strike from the fractured noncarbonate rock to the Maynardville Limestone is also very slow below.

Contaminant migration is primarily advective (contaminants are transported along with flowing groundwater through the pore spaces, fractures, or conduits of the hydrogeologic system). Strike-parallel transport of some contaminants can occur within the fractured noncarbonate rock for significant distances, where they discharge to surface water tributaries or underground utility and stormwater distribution systems in industrial areas. Continuous elevated levels of nitrate (a groundwater contaminant from legacy waste disposals) within the fractured noncarbonate rock are known to extend east and west from the S-3 Site for thousands of feet. Volatile organic compounds (e.g., petroleum products, coolants, and solvents) at source units in the fractured noncarbonate rock, however, can 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 more rapid transport occurs for longer 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 similar in

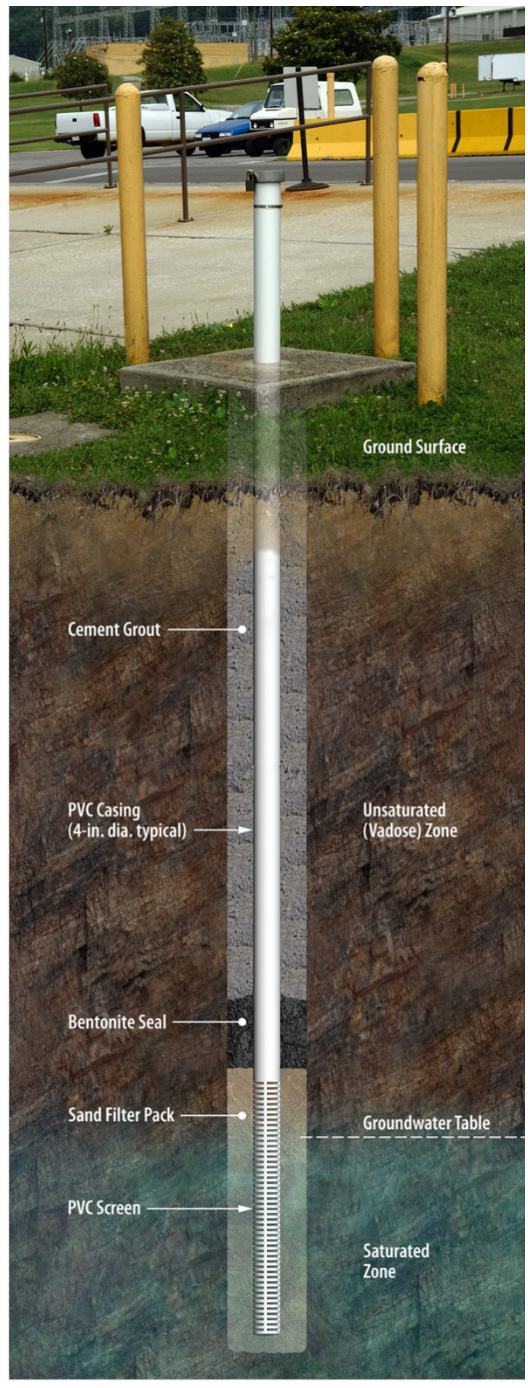

Fig. 4.35. Cross section of a typical groundwater monitoring well.

construction to monitoring wells but are primarily temporary devices used to measure groundwater levels. Other devices or techniques are sometimes employed to gather groundwater data, including drive points and push probes.

In CY 2009, 17 monitoring wells and two piezometers were installed at Y-12. One new well and two piezometers were installed at the Environmental Management Waste Management Facility (EMWMF) to support monitoring requirements of a newly constructed disposal cell, and four surveillance monitoring wells were installed north of Bear Creek Road to replace wells previously removed to make way for construction activities. Twelve 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 investigate the interactions and processes within a contaminated groundwater system to assist in the development of remediation strategies and tools for groundwater cleanup.

No monitoring wells were plugged and abandoned during the year, but six piezometers at the EMWMF were removed in support of the newly constructed disposal cell.

4.6.3 CY 2009 Groundwater Monitoring

Groundwater monitoring in CY 2009 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 223 wells and 50 surface water locations and springs (Table 4.16). Figure 4.36 shows the locations of Y-12 Complex perimeter/exit pathway groundwater monitoring stations.

In an attempt to gain efficiencies in sampling activities, the Y-12 Groundwater Protection Program initiated the use of passive diffusion bag samplers (Fig. 4.37). The passive diffusion bag sampling method is suitable only for monitoring for the presence and concentration of selected volatile organic compounds in groundwater. This method involves suspending a polyethylene bag (semipermeable membrane) filled with deionized water at a selected depth within the monitored interval of the well and leaving the passive diffusion bag in place for a prescribed period (at least 2 weeks). The chemical concentration gradient between the uncontaminated deionized water in the passive diffusion bag and the surrounding contaminated groundwater induces volatile organic compounds in the groundwater to diffuse through the bag into the deionized water until equilibrium conditions are achieved. When retrieved, the water in the passive diffusion bag is decanted into volatile organic compound sample bottles and analyzed using standard procedures.

Comprehensive water quality results of groundwater monitoring activities at Y-12 in CY 2009 are presented in the annual *Calendar Year 2009 Groundwater Monitoring Report* (B&W Y-12 2010a).

Details of monitoring efforts performed specifically for CERCLA baseline and remediation evaluation are published in the FY 2009 and FY 2010 Water Resources Restoration Program sampling and analysis plans (Bechtel Jacobs Company 2008; Bechtel Jacobs Company 2009), and the 2010 *Remediation Effectiveness Report* (DOE 2010).

Groundwater monitoring compliance reporting to meet RCRA postclosure permit requirements can be found in the annual RCRA *Groundwater Monitoring Report* (Bechtel Jacobs Company 2010).

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 due to their common use and disposal. 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 4.16. Summary groundwater monitoring at the Y-12 Complex, 2009

	Purpose for which monitoring was performed				
	Restoration[a]	Waste Management[b]	Surveillance[c]	Other[d]	Total
Number of active wells	60	32	114	131	337
Number of other monitoring stations (e.g., springs, seeps, surface water)	29	6	15	5	55
Number of samples taken[e]	159	40 *	145	2,815	3,159
Number of analyses performed	9,456	3,556 *	10,561	3,8000	61,580
Percentage of analyses that are non-detects	75.6	86.1	80.6	40.8	55.6
Ranges of results for positive detections, VOCs (µg/L)[f]					
Chloroethenes	0.3–2,730	0.045–15	1–180,000	NA[g]	
Chloroethanes	1–373	0.12–40	1–11,000	NA	
Chloromethanes	1–1,340	0.045-0.13	1–690	NA	
Petroleum hydrocarbons	0.4–8,110	0.027-0.11	1–2,100	NA	
Uranium (mg/L)	0.0044–0.6	0.004-0.004	0.0006–1.33	0.0054-64.93	
Nitrates (mg/L)	0.01–8,030	0.5–2.8	0.059–10,400	0-25,778	
Ranges of results for positive detections, radiological parameters (pCi/L)[h]					
Gross alpha activity	2.44–433	0.83–4.39	3.5–400	NA	
Gross beta activity	3.18–16,200	3.12–16.7	1.7–11,000	NA	

[a]Monitoring to comply with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements and with Resource Conservation and Recovery Act post closure detection and corrective action monitoring.

[b]Solid waste landfill detection monitoring and CERCLA landfill detection monitoring; * = excludes EMWMF

[c]DOE Order 450.1 surveillance monitoring

[d]Research-related groundwater monitoring associated with activities of the DOE Natural and Accelerated Bioremediation Research Field Research Center.

[e]The number of unfiltered samples, excluding duplicates, determined for unique location/date combinations.

[f]These ranges reflect concentrations of individual contaminants (not summed VOC concentrations):
Chloroethenes—includes tetrachloroethene, trichloroethene, 1,2-dichloroethene (*cis* and *trans*) 1,1-dichloroethene, and vinyl chloride
Chloroethanes—includes 1,1,1-trichloroethane, 1,2-dichloroethane, and 1,1-dichloroethane
Chloromethanes—includes carbon tetrachloride, chloroform, and methylene chloride
Petroleum hydrocarbon—includes benzene, toluene, ethylbenzene, and xylene

[g]NA – Not analyzed

[h]1 pCi = $3.7 \times 10^{!2}$ Bq

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 4.17. 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.

4.6.4.1.1 Plume Delineation

Sources of groundwater contaminants monitored during CY 2009 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 Y-12 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. As previously mentioned, contaminant plumes in the East Fork regime are elongated in shape due to the result of preferential

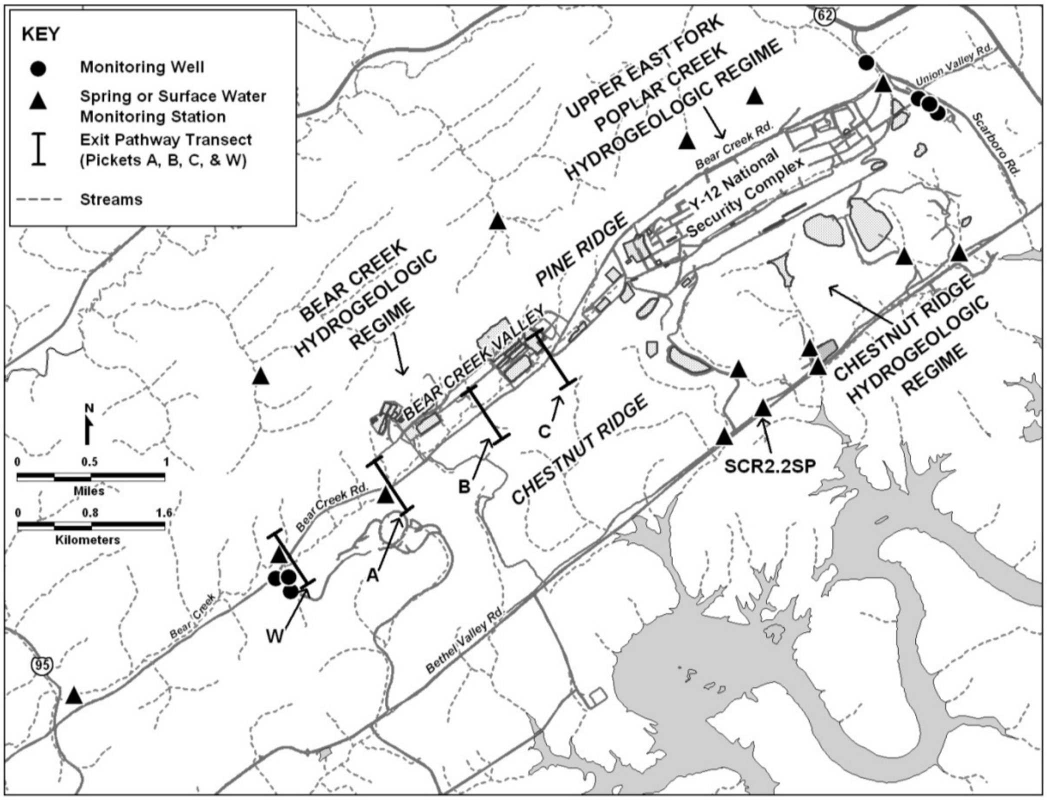

Fig. 4.36. Locations of Y-12 Complex perimeter/exit pathway well, spring, and surface water monitoring stations.

Fig. 4.37. Groundwater sampling at Y-12. Technicians use a passive diffusion bag to sample for volatile organic compounds in groundwater.

Table 4.17. History of waste management units and underground storage tanks included in groundwater monitoring activities, Upper East Fork Poplar Creek Hydrogeologic Regime, 2009

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 firefighting 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

transport of the contaminants parallel to strike (parallel to the valley axis) in both the Knox Aquifer and the fractured noncarbonate rock.

4.6.4.1.2 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 2009, groundwater containing nitrate concentrations as high as 8,960 mg/L (Well GW-275) occurred in the shallow bedrock just east of the S-3 Site (Fig. 4.38). These results are consistent with results from previous years.

4.6.4.1.3 Trace Metals

Concentrations of arsenic, barium, beryllium, cadmium, chromium, lead, nickel, and uranium exceeded drinking water standards during CY 2009 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., S-3 Site, production areas and the Former Oil Skimmer Basin) and contribute to the uranium concentration in Upper East Fork Poplar Creek.

One trace metal absent from the list of those that exceed drinking water standards in CY 2009 is mercury. Mercury has a very high affinity for clay-rich soils such as those on the ORR, and hence exhibits little tendency for extensive transport in diffuse groundwater plumes. Additionally, the hydrogeologic complexities of the fracture/conduit flow system underlying Y-12 make it challenging to delineate the vertical and horizontal extents of any groundwater contamination. Elevated mercury concentrations (above analytical detection limits) in groundwater have been consistently observed only near known source areas (Fig. 4.39). In the past, mercury concentrations above the drinking water standard (0.002 mg/L) have been observed in groundwater monitoring wells at the identified source areas presented in Fig. 4.39.

Due to past processes and disposal practices, mercury is a legacy contaminant at Y-12. It is commonly found in the soils near specific areas where it was used in processes in the 1950s and 1960s. This metal is a contaminant of concern in surface waters discharging from these areas. It appears that high mercury concentrations in water within the storm drain network in those areas arise from the oxidation and dissolution of mercury from metallic mercury deposits in close proximity to flowing water that produces high localized concentrations of dissolved mercury that infiltrate the storm drain system. A similar process occurs in reaches of the open stream where mercury metal is buried under gravel sediments. When dissolved mercury is discharged from the storm drain system into the open creek channel, it is rapidly sequestered by particulate materials, and fluvial sediment/particle transport becomes the primary mechanism of mobility.

In tightly fractured shale and other noncarbonate bedrock, the natural flow paths are such that significant transport of mercury is not likely. In industrialized areas of Y-12 where the shallow subsurface has been reworked extensively, some preferential transport along building foundations and underground utilities is occurring. This is evident from elevated surface water concentrations of mercury.

Interconnection between the surface water and groundwater systems have been demonstrated by tracer investigations (DOE 2001) and the discharge of elevated concentrations of mercury from a buried spring (i.e., OF-51) adjacent to East Fork Poplar Creek. This discharge is presently captured and treated to remove the mercury at the Big Springs Water Treatment System. It has been proposed that dissolved mercury in the spring discharge arises from metallic mercury that has infiltrated into the solution cavities and conduits of the karstic Maynardville Limestone Formation below the water table. Although the subsurface inventory of metallic mercury in the limestone bedrock has not been determined, it could account for a part of the quantities lost during operational use. Subsurface storage may also minimize mobility of mercury due to decreased surface area (i.e., immobilized in filled seams, fractured, and conduits, in contrast to the surface exposure of mercury as particles) (Rothschild et al. 1984).

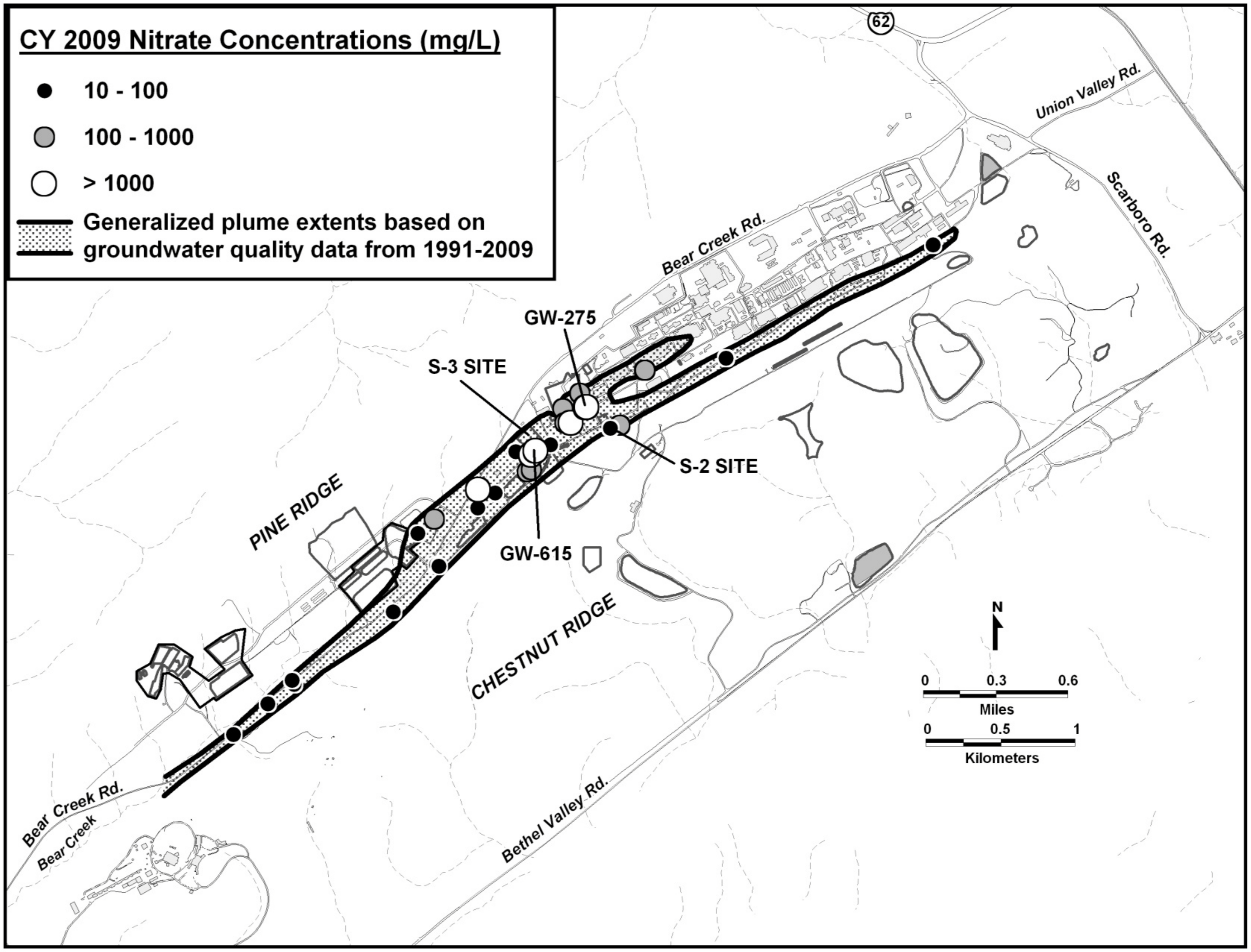

Fig. 4.38. Nitrate observed in groundwater at the Y-12 Complex, 2009.

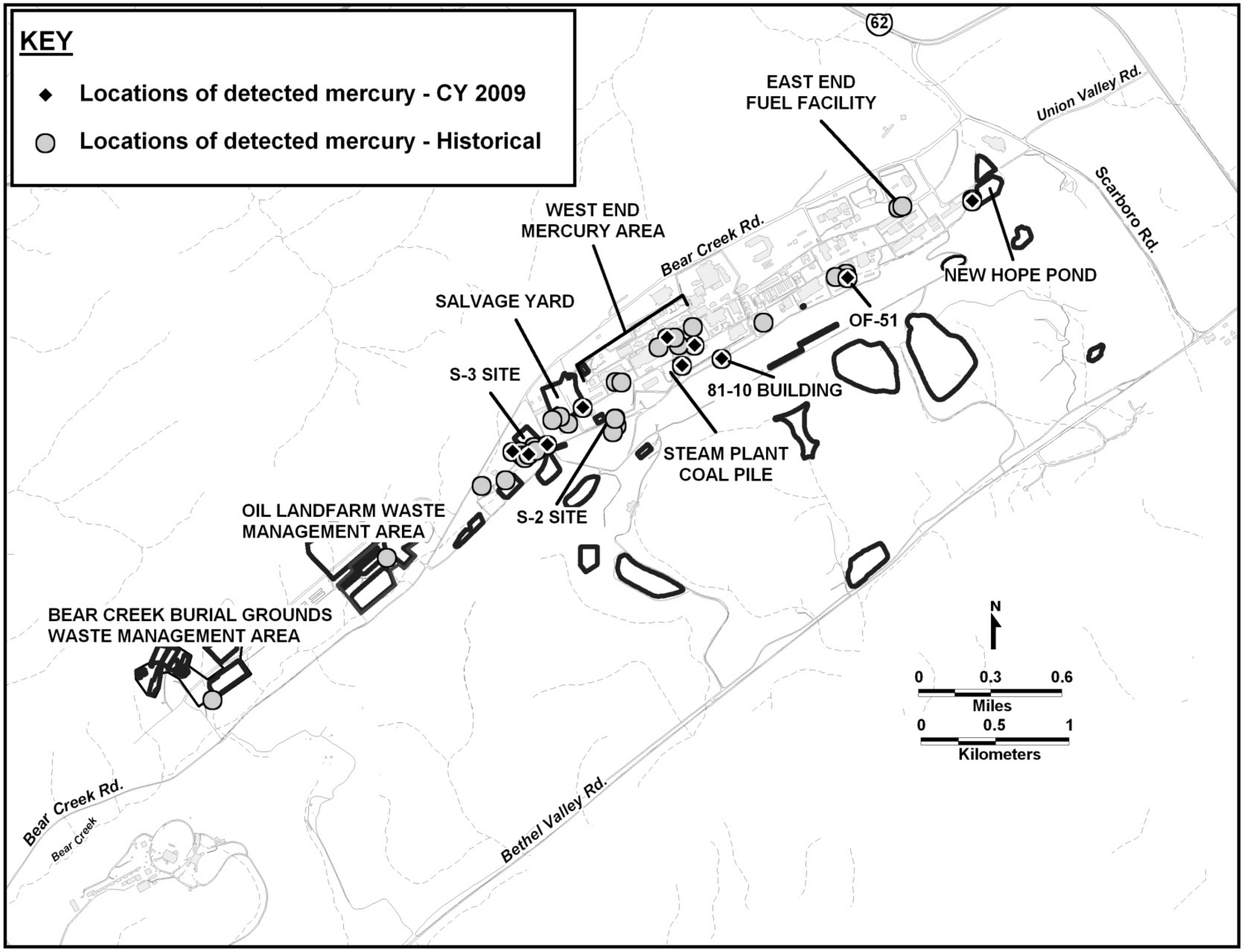

Fig. 4.39. Y-12 groundwater monitoring stations where mercury has been detected.

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 2009, the highest summed concentration of dissolved chlorinated solvents (59,767 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 (14,780 µg/L) was obtained from Well GW-658 at the closed East End Garage.

The CY 2009 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. 4.40). 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 Rust Garage and S-3 site in western Y-12, some production/process facilities in central areas, and the chloroethene component of the East End volatile organic compound plume, indicating that some portions of the plume are still showing activity.

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 southwest to 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.

4.6.4.1.5 Radionuclides

The primary alpha-emitting radionuclides found in the East Fork regime during CY 2009 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 (433 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. 4.41).

The primary beta-emitting radionuclides observed in the Upper East Fork regime during CY 2009 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. 4.42).

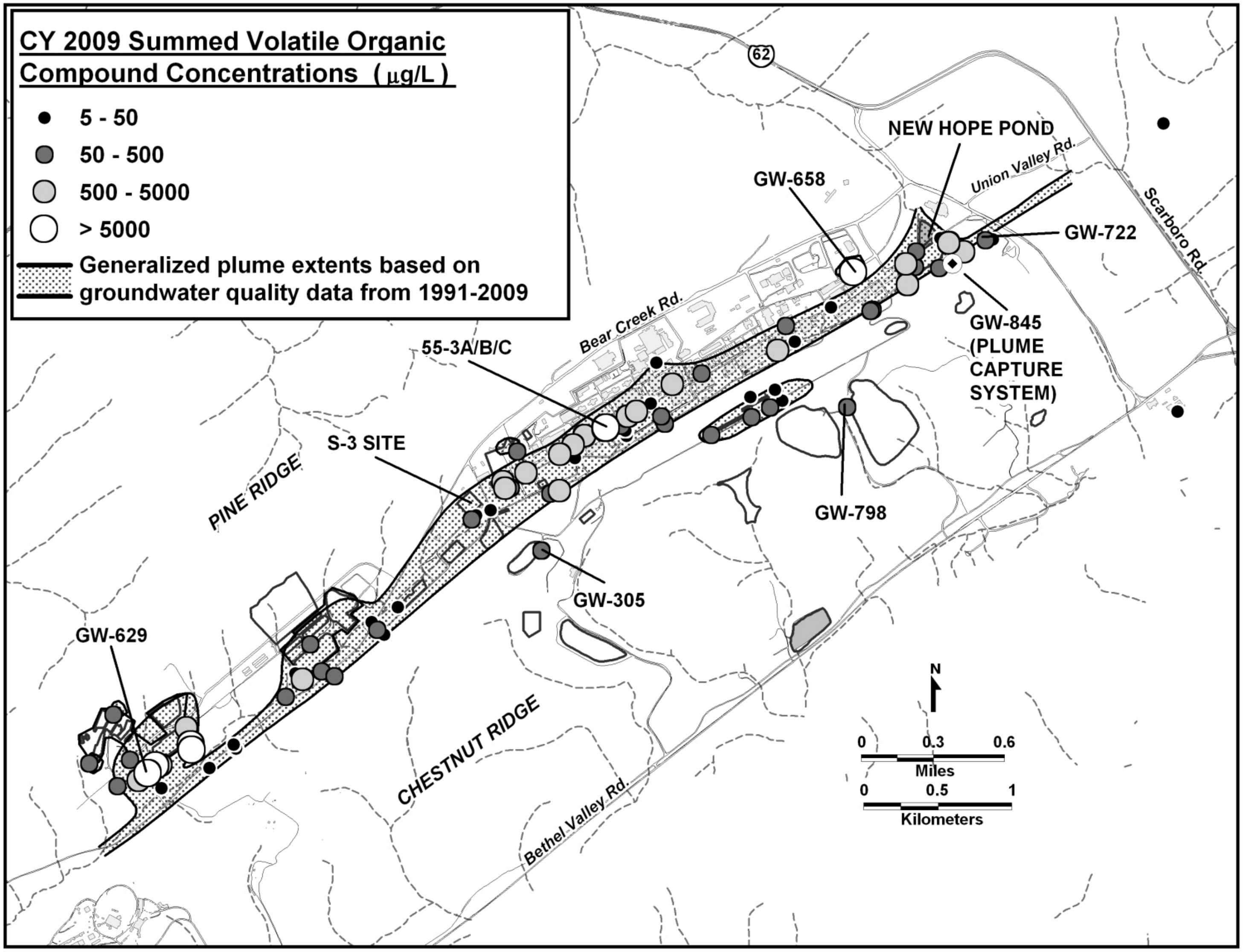

Fig. 4.40. Summed volatile organic compounds observed in groundwater at the Y-12 complex, 2009.

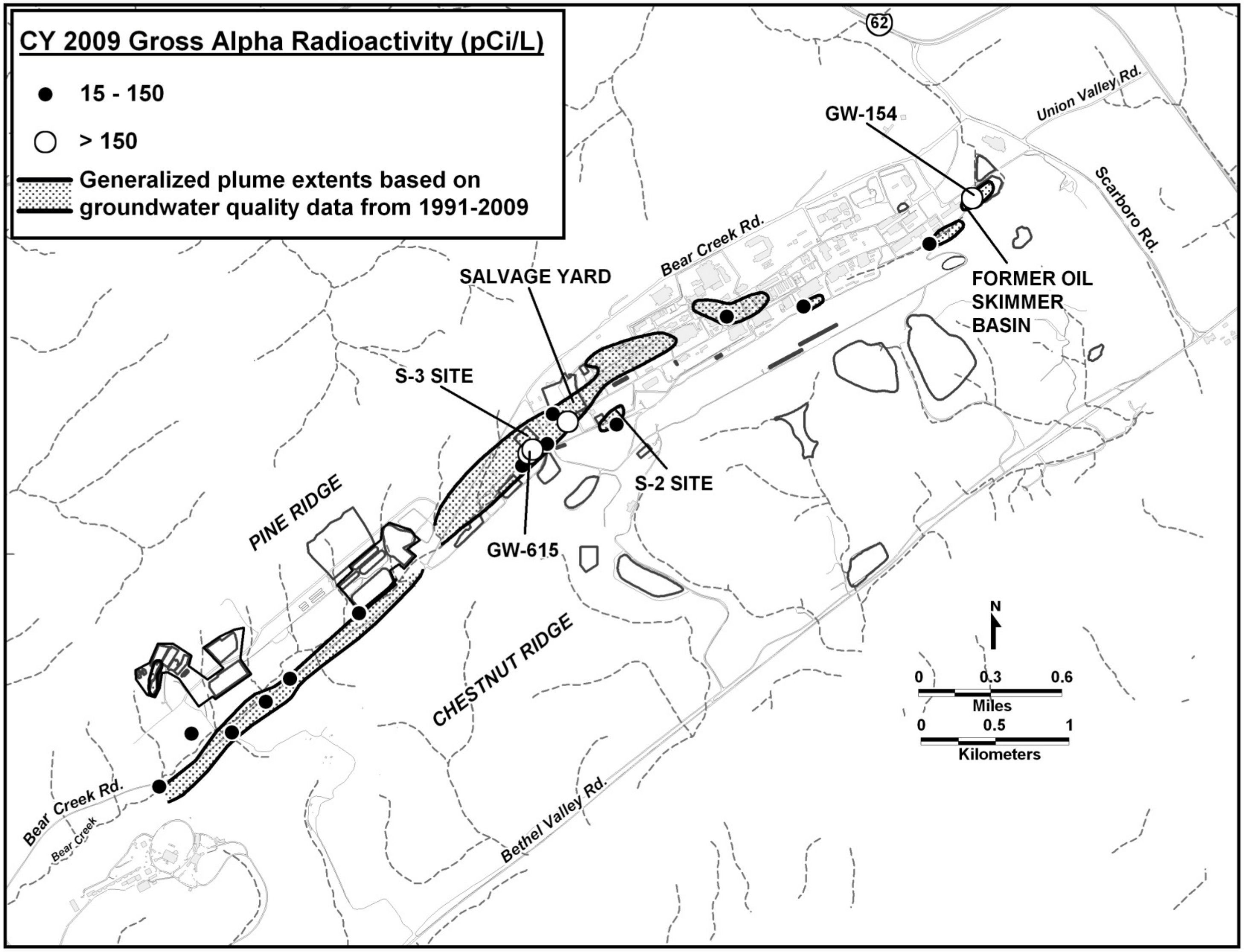

Fig. 4.41. Gross alpha radioactivity observed in groundwater at the Y-12 complex, 2009.

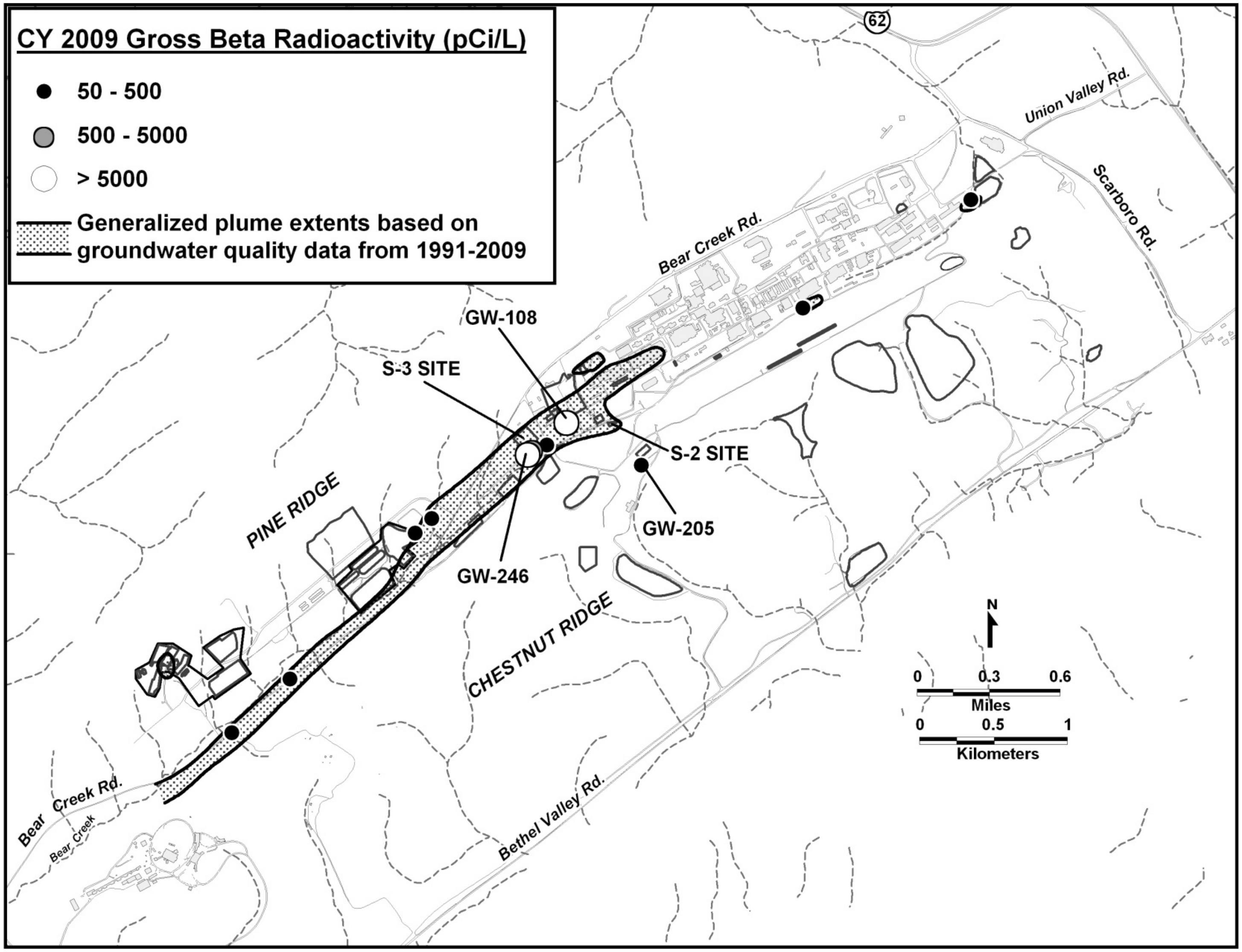

Fig. 4.42. Gross beta radioactivity observed in groundwater at the Y-12 complex, 2009.

The highest gross beta activity in groundwater was observed during CY 2009 from well GW-108 (16,200 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. Historically, the compounds have been observed at depths of almost 500 ft in the Maynardville Limestone, the primary exit pathway on the east end of the Y-12 Complex. The deep fractures and solution channels that constitute flow paths within the Maynardville Limestone appear to be well connected, resulting in contaminant migration for substantial distances off the ORR into Union Valley to the east of the complex.

In addition to the intermediate to deep pathways within the Maynardville Limestone, shallow groundwater within the water table interval 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 2009, the observed concentrations of volatile organic compounds at the New Hope Pond distribution channel underdrain continue to remain low. This may be because the continued operation of the groundwater plume–capture system in Well GW-845 southeast of 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 95 L/min (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 153 m (500 ft) east and downgradient of Well GW-845, permits sampling of vertically discrete zones within the Maynardville Limestone between 27 and 130 m (87 and 425 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. 4.43). 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.

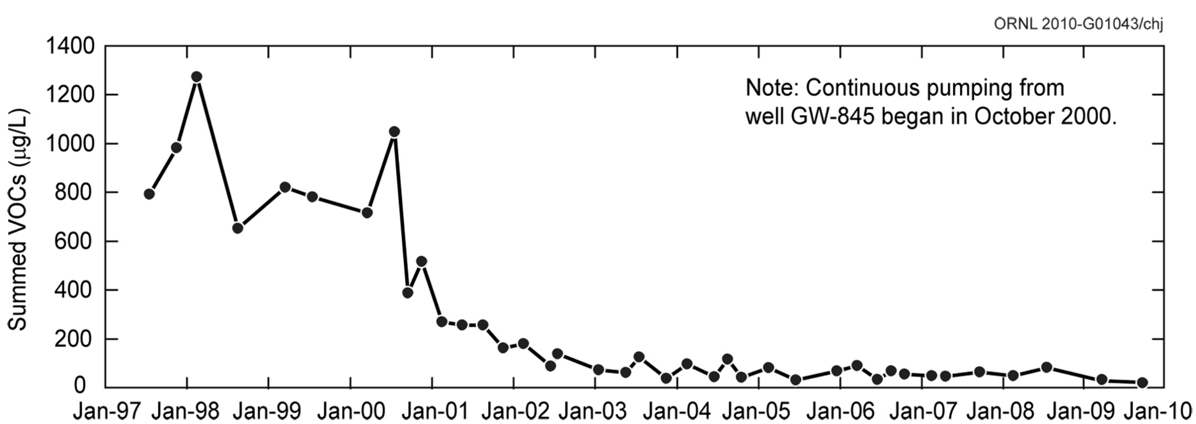

Fig. 4.43. Decreasing summed volatile organic compounds observed in exit pathway Well GW-722-17 near the New Hope Pond, 2009.

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. 4.36). Only one shallow well was monitored in CY 2009, 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.

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 2009, 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 Record of Decision (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 2010).

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

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

Table 4.18. History of waste management units included in CY 2009 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 amounts of debris and inorganic salts. Ponds 1 and 2, built in 1971 and 1972, respectively, captured waste oils seeping into two Bear Creek tributaries. The ponds were closed and capped under RCRA in 1989. Certification of closure and capping of Burial Grounds B and part of C was granted February 1995
Rust Spoil Area	Used from 1975 to 1983 for disposal of construction debris, but may have included materials bearing solvents, asbestos, mercury, and uranium. Closed under RCRA in 1984. Site is a source of volatile organic compounds to shallow groundwater according to CERCLA remedial investigation.
Spoil Area I	Used from 1980 to 1988 for disposal of construction debris and other stable, 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 ROD 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

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 82 m (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 92 m (300 ft) below the ground surface].

Data obtained during CY 2009 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 (10,400 mg/L) was observed at Well GW-615 adjacent to the S-3 Site at a depth of 68 m (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 226 m (740 ft) below ground surface.

4.6.4.2.3 Trace Metals

During CY 2009, uranium, barium, cadmium, lead, beryllium, and nickel 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, the final remedial actions at the Boneyard/Burnyard were performed with the objective of removing materials contributing to surface water and groundwater contamination to meet existing ROD goals. Approximately 65,752 m^3 (86,000 yd^3) of waste materials was excavated and placed in the EMWMF (DOE 2007). 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 a primary source of uranium in Bear Creek Valley. In CY 2009, a corresponding decrease in uranium concentrations is continuing to be observed downstream in Bear Creek (Table 4.19). Other trace metal contaminants that have been observed in the Bear Creek regime are arsenic, boron, chromium, cobalt, copper, lithium, manganese, mercury, strontium, thallium, and zinc. Concentrations have commonly exceeded background values in groundwater near contaminant source areas.

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 up to 92 m (300 ft) below ground surface. Groundwater in the fractured noncarbonate rock that contains detectable levels of volatile organic compounds occurs primarily within about 305 m (1,000 ft) of the source areas. The highest concentrations observed in CY 2009 in the Bear Creek regime occurred in the intermediate bedrock zone at the Bear Creek Burial Ground waste management area, with a maximum

Table 4.19. Nitrate and uranium concentrations in Bear Creek[a]

Bear Creek Monitoring Station (distance from S-3 site)	Contaminant	Four-Year Average Concentration (mg/L) 1990–1993	1994–1997	1998–2001	2002–2005	2006–2009
BCK[b]-11.84 to 11.97	Nitrate	119	80	80	79.5	33.4
(~0.5 miles downstream)	Uranium	0.196	0.134	0.139	0.133	0.122
BCK-09.20 to 09.47	Nitrate	16.4	9.6	10.6	11.3	9.1
(~2 miles downstream)	Uranium	0.091	0.094	0.171	0.092	0.067
BCK-04.55	Nitrate	4.6	3.6	2.6	2.9	1.1
(~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

summed volatile organic compound concentration of 219,070 µg/L in Well GW-629 (Fig. 4.40). This result is an order of magnitude higher than concentrations seen in all previous years.

When this monitoring well was sampled using the passive diffusion bag sampler, the bag was hung about 88 m (290 ft) below ground surface. When the sampler was removed from the well, it was coated with an oily substance. This discovery initiated an additional sampling event with a standard Teflon bailer to capture this substance. The bailer sample consisted of a heavy free phase oil and water. The analysis of the oil showed high concentrations of volatile organic compounds (primarily tetrachloroethene), semivolatile organic compounds, and PCBs. The compounds detected in the water sample were consistent with the oil sample, but at much lower concentrations. These results are consistent with oil and water samples taken during the installation of this and other nearby wells in 1990 (MMES 1990). These results, coupled with increasing trends observed downgradient of the Bear Creek Burial Ground waste management area in the fractured noncarbonate rock (Fig. 4.44), indicate that a considerable mass of dense non-aqueous phase organic compounds is still present at depth below the Bear Creek Burial Grounds, providing a source for dissolved phase migration of volatile organic compounds. 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.

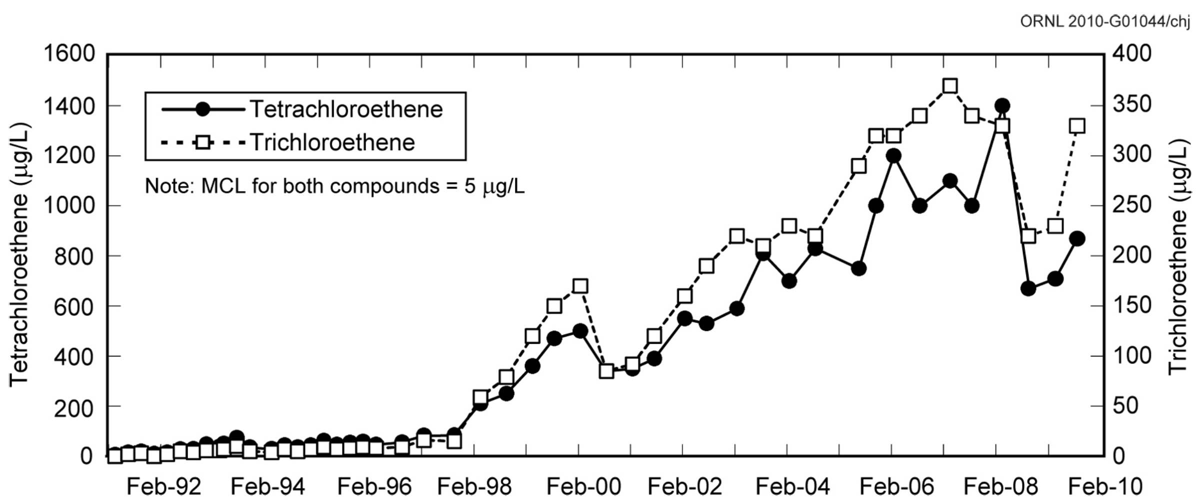

Fig. 4.44. Increasing volatile organic compounds observed in groundwater at Well GW-627 west and downgradient of the Bear Creek Burial Grounds, 2009.

Significant transport of volatile organic compounds has occurred in the Maynardville Limestone. Data obtained from exit pathway monitoring locations show that in the shallow groundwater interval, an apparently continuous dissolved plume extends at least 2,440 m (8,000 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 2009 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 at elevated levels 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. 4.41). 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 3,355 m (11,000 ft) west of the S-3 Site. The highest gross alpha activity observed in CY 2009 was 400 pCi/L in Well GW-615 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 2009, 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 2,440 to 3,050 m (8,000 to 10,000 ft) from the S-3 Site (Fig. 4.42). The highest gross beta activity in groundwater in the Bear Creek Regime in 2009 was 11,000 pCi/L at Well GW-246 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. 4.36).

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 2009 from the exit pathway monitoring wells indicate that groundwater is contaminated above drinking water standards in the Maynardville Limestone as far west as Picket A and trends are generally decreasing (Fig. 4.45).

Surface water samples collected during CY 2009 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. The concentrations in the creek decrease with distance downstream of the waste disposal sites (Table 4.19). Individual monitoring locations along Bear Creek also show a decrease in concentration with respect to time, reflecting the positive steps toward remediation of legacy wastes and active mitigating practices of pollution prevention.

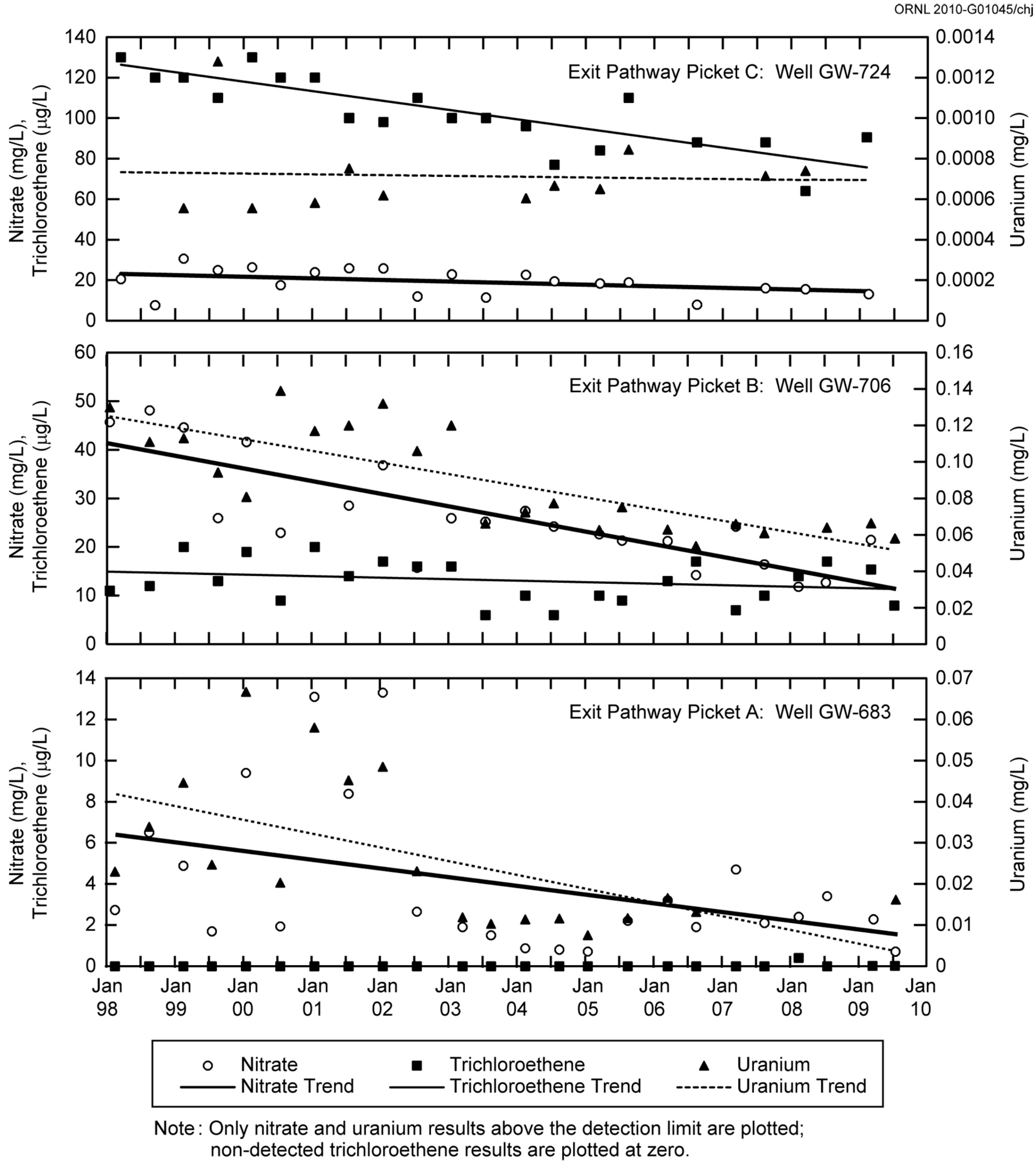

Fig. 4.45. CY 2009 Concentrations of selected contaminants in exit pathway monitoring wells GW-724, GW-706, and GW-683 in the Bear Creek Hydrogeologic Regime.

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 4.20 summarizes the operational history of waste management units in the regime.

Table 4.20. History of waste management units included in groundwater monitoring activities, Chestnut Ridge Hydrogeologic Regime, 2009

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

4.6.4.3.1 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 [305 m (<1,000 ft)]. Groundwater quality data obtained during CY 2009 indicate that the western lateral extent of the plume of volatile organic compounds at the site has not changed significantly from previous years. The continued observation of volatile organic compound contaminants over the past several years at a well approximately 458 m (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 2745 m (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

A chromium result exceeding the drinking water standard (0.1 mg/L) was observed in a groundwater sample from one well (GW-305) at the Industrial Landfill IV (Fig. 4.33) with a maximum concentration of 0.13 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 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. 4.40). Elevated concentrations observed in GW-798 appear to fluctuate with changing precipitation conditions. The volatile organic compounds detected in CY 2009 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 exhibited a shallow increasing trend. In CY 2009, samples slightly exceeded the standard for 1,1-dichloroethene, resulting in the issuance of a regulatory notice of violation by the Tennessee Department of Environment and Conservation (see Section 2.5 for more details).

4.6.4.3.5 Radionuclides

In CY 2009, 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. 4.42) at the United Nuclear Corporation site (the maximum detected activity was 64.3 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 2009. No contaminants were detected in any of these natural discharge points above drinking water standards.

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 (UEFPC) Watershed is being conducted in stages under Records of Decision using a phased approach. Phase 1 addresses 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 UEFPC.

With ARRA funding, cleanup and repair of storm sewers in the West End Mercury Area (historic mercury use area) was initiated in FY 2009. The initial phase, videotaping the storm sewer system, has been completed and the videotape has been evaluated. An Engineering Study Report that documents the results has been completed and submitted to the regulatory agencies for their comment. Future phases of this action will include the removal of contaminated sediments from the storm sewers and relining or replacement of leaking sewer sections. This action is part of three actions identified in the Phase 1 ROD to limit mercury migration by hydraulically isolating the West End Mercury Area. A Characterization Plan for the 81-10 Area, the site of a historic mercury recovery process, has been prepared and submitted to the regulatory agencies for comment.

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 FFA parties in April 2006. ARRA funding is being used to remove scrap metal from the Old Salvage Yard, one of the remedies authorized in the Phase II ROD.

The initial project of the Phase 2 ROD is remediation of the Y-12 Old Salvage Yard. The Y-12 Old Salvage Yard Project started in 2009 using ARRA funding. In addition, a Remedial Action Work Plan for remediation of all contaminated soils at the Y-12 Complex has been submitted to the regulatory agencies for comment and approval.

4.7.2 Time-Critical Removal Actions Planned

ARRA funding was received in FY 2009 to expedite removal of legacy wastes and building demolition at the Y-12 National Security Complex. Two CERCLA Time-Critical Removal Actions were initiated to remove legacy wastes from the Alpha 5 and Beta 4 buildings , demolish some of the Biology Complex Buildings (9211, 9220, 9224, and 9769), and demolish 9735 and clean and remove some uranium recovery system components in 9206.

A Waste Handling Plan has been prepared for submission to the regulators to allow disposition of Alpha 5 wastes at EMWMF. Some wastes are being packaged for shipment to the Nevada Test Site, and some will be disposed at EMWMF, while wastes meeting the Y-12 Landfill waste acceptance criteria are being disposed at that facility.

4.7.3 Waste Management

The Environmental Management Waste Management Facility (EMWMF), located in east Bear Creek Valley near the Y-12 Complex, was selected as the remedy for disposal of waste resulting from CERCLA cleanup actions on the Oak Ridge Reservation. This remedy called for the detailed design, construction, operation, and closure of a 1.3 million m^3 (1.7 million yd^3) disposal facility. The facility currently consists of four disposal cells with a fifth cell under construction at the end of FY September 2009. To ensure the continuity of disposal capacity for ORR cleanup waste, Cell 5 was redesigned to enable a sixth cell to be added if appropriate regulatory approvals are secured. Construction of Cell 5 began in May 2009.

EMWMF is an engineered landfill that accepts low-level radioactive and hazardous wastes that meet specific waste acceptance criteria developed in accordance with agreements with state and federal regulators. Waste types that qualify for disposal include soil, dried sludge and sediment, solidified wastes, stabilized waste, building debris, scrap equipment, and secondary waste such as personal protective equipment.

During FY 2009, EMWMF operations collected, analyzed, and dispositioned approximately 12.8 million liters (3.4 million gallons) of leachate at the ORNL Liquids and Gases Treatment Facility. An additional 34 million liters (8.9 million gallons) of contact water was collected and analyzed. After determining that it met the release criteria, the water was released to the sediment basin. Operating practices also effectively controlled site erosion and sediments.

EMWMF received approximately 14,700 truckloads of waste accounting for approximately 157 million kilograms (173,600 tons) during FY 2009. Projects that have disposed of waste at EMWMF during the fiscal year include the following:

- David Witherspoon, Inc. 1630 Site Remedial Action Project;
- K-25/K-27 Project, including hazardous material abatement, excess materials removal, and K-25 Building (west wing) demolition debris and equipment; and
- ETTP Decontamination and Decommissioning Project, including K-1401, K-1066-G Scrapyard, K-1070-B Burial Ground, and K-1035 demolition debris.

Concurrent with the activities at EMWMF, DOE also operates the solid waste disposal facilities called the Oak Ridge Reservation Landfills (ORRL), which are located near the Y-12 Complex (see Sect. 4.3.6.2). The ORRL are engineered facilities permitted by the State 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 2009, more than 110,860 m^3 (145,000 yd^3) of industrial, construction/demolition, classified, and spoil material waste were disposed.

Operation of the ORRL generated more than 6 million liters (1.6 million gallons) of leachate that was collected, monitored, and discharged to the Oak Ridge sewer system.

EMWMF and ORRL are serving the disposal needs of the Oak Ridge Reservation cleanup program as well as the active missions of ORNL and the Y-12 Complex.

4.7.4 Wastewater Treatment

The National Nuclear Security Administration (NNSA) at the Y-12 Complex treated513 million liters (135.5 million gallons) of contaminated ground/sump water at the Groundwater Treatment Facility, the Central Mercury Treatment System, Big Springs Water Treatment System, and the East End Volatile Organic Compounds Treatment System.

The Big Springs Water Treatment System treated 436 million liters (115.3 million gallons) of mercury-contaminated groundwater and realized an annual savings of $10,000 by optimizing the treatment system to reduce filter change-out and disposal.

The East End Volatile Organic Compound Treatment System treated 57 million liters (15.1 million gallons) of contaminated groundwater. The West End Treatment Facility and the Central Pollution Control Facility at the Y-12 Complex processed 3,205,895 liters (847,000 gallons) of wastewater primarily in support of NNSA operational activities.

The Central Pollution Control Facility also downblended more than 113,460 liters (30,000 gallons) of enriched wastewaters using legacy and newly generated uranium oxides from on-site storage.

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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's mission is to provide solutions to America's scientific challenges, and a diverse, highly qualified staff of more than 4,600 continues a rich tradition of scientific exploration to support this mission. In addition, more than 3,000 visiting scientists spend 2 weeks or longer in Oak Ridge each year at the 12 advanced research user facilities made available to scientists all over the world. 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 Office of Science−sponsored Bioenergy Science Center. During 2009 UT-Battelle, Wastren Advantage, Inc. (WAI), and Isotek operations were conducted in compliance with contractual and regulatory environmental requirements with the exception of two interrelated exceedances of National Pollutant Discharge Elimination System permit discharge limits. There were no notices of violation or penalties issued by the regulatory agencies.

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) and is managed for the DOE by UT-Battelle, LLC, a partnership of the University of Tennessee and Battelle Memorial Institute. The main ORNL site occupies approximately 1,809 ha (4,470 acres) and includes facilities in two valleys (Bethel and Melton) and on 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 supports DOE's mission. With more than $2 billion in new facilities completed since 2003, ORNL has one of the world's most modern campuses for the next generation of scientific discovery. The $1.4 billion Spallation Neutron Source, located adjacent to the new Center for Nanophase Materials Sciences, combines with one of the nation's largest research reactors to continue the Laboratory's reputation as a leader in the study of materials. ORNL's Center for Computational Sciences houses the world's most powerful open science supercomputer capable of 1,600 trillion calculations per second. Each of these facilities works closely with the new Bioenergy Science Center, funded by DOE, to develop a new form of cellulosic ethanol that will not require land currently needed for the production of food.

UT-Battelle also manages several facilities located off the main ORNL campus. These include several buildings and trailers located at the Y-12 Complex, at the American Museum of Science and Energy in the city of Oak Ridge, and several others locations around the Oak Ridge vicinity.

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.

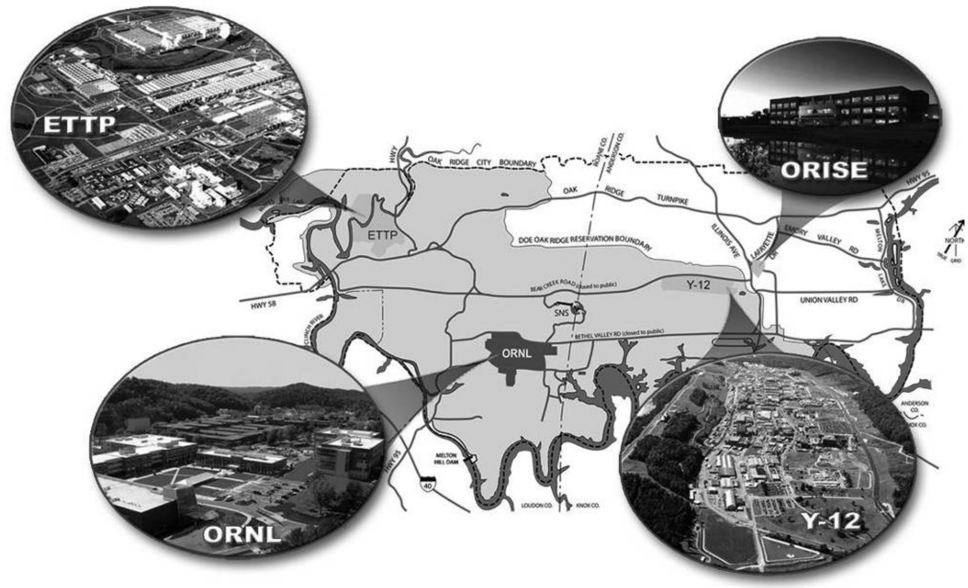

Fig. 5.1. Location of ORNL within the ORR and its relationship to other local DOE facilities.

The TWPC, managed by WAI for DOE, is located on the western boundary of ORNL on about 5 ha of land adjacent to the Melton Valley Storage Tanks along State Route 95. In late 2009, Wastren Advantage Inc. (WAI) was awarded the contract to operate the TWPC. Until this award the TWPC was operated by EnergX. 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 debris waste in December 2005, and the remote-handled debris waste 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:

- process, downblend, and package the DOE inventory of ^{233}U (and the 715 gallons of ^{233}U-contaminated thorium nitrate stored in Tank P-24) to eliminate the need for safeguards, security, and nuclear criticality controls, and to render these materials suitable for safe disposition;
- remove the ^{233}U material from the Building 3019 Complex;
- transport the downblended material to one or more licensed disposal facilities; and
- place the Building 3019 Complex in safe and stable shutdown condition.

During CY 2009, Isotek continued to manage the Building 3019 Complex in a surveillance and maintenance mode and design the facilities and operations needed to accomplish the above objectives. Isotek also completed demolition of Buildings 3074 and 3136. In CY 2009, an environmental assessment for the U-233 Material Downblending and Disposition Project was completed, and a Finding of No Significant Impact under the National Environmental Policy Act (NEPA) process was issued in January 2010.

UT-Battelle performs air and water quality monitoring for the 3019 facility and for the TWPC, and the discussions in the chapter include the results for the Isotek and WAI 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 private 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 High Flux Isotope Reactor (HFIR). Construction of the first ORSTP facility, Pro2Serve's 115,000-ft^2 National Security Engineering Center, was completed in 2009, and the company has moved into the building. In addition, the former Building 2033, which was leased to Halcyon, LLC, and is now known as the Halcyon Commercialization Center, continues to attract tenants. Expansion of the ORSTP will continue as more environmental cleanup in ORNL's central campus is completed. The EPA has designated ORSTP lessees as collocated workers since these tenants are located on DOE property and are issued security badges to access the facilities. These badges provide access to the S&T Park facilities and, during regular business hours, the ORNL Conference Center (Building 5200) only. Access to any other ORNL facility requires additional DOE approval.

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 environmental policy statement for ORNL is shown in Fig. 5.2.

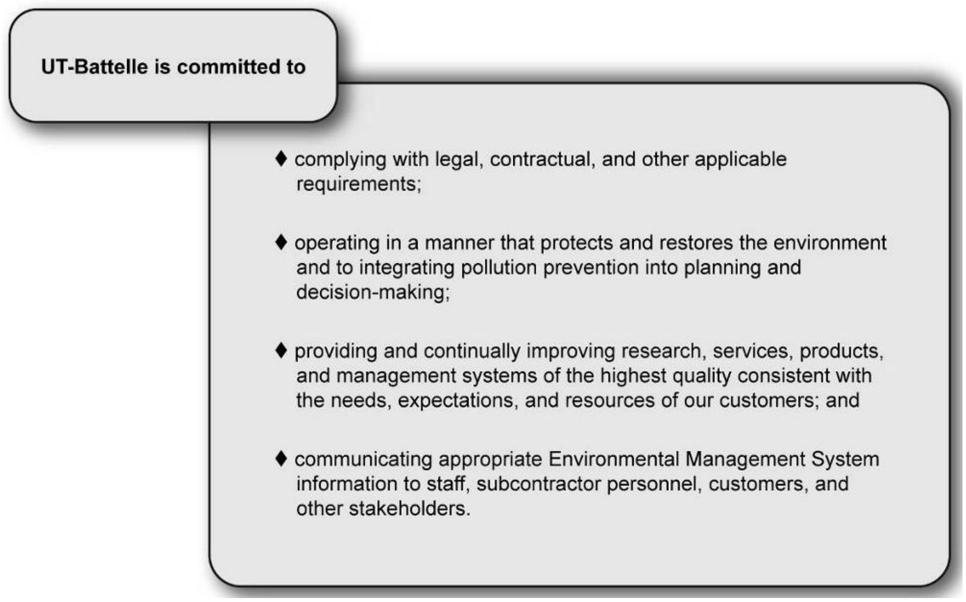

Fig. 5.2. ORNL environmental policy statements.

UT-Battelle, WAI, Bechtel Jacobs Company (BJC),, and Isotek 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. Surveillance audits were conducted in 2008 and 2009. No nonconformities were identified during the most recent surveillance audit. Detailed information on the UT-Battelle EMS is provided in Sects. 5.2.1 through 5.2.1.7. WAI's EMS for activities at the TWPC was registered to the ISO 14001:2004 Standard by NSF International Strategic Registrations, Ltd., in May 2008. NSF International Strategic Registrations, Ltd., conducted a Surveillance Audit for the WAI EMS program in May 2009, and again no nonconformities or issues were identified and several significant practices were noted. Section 5.2.2 describes the TWPC

EMS and associated implementation activities. In June 2009, DOE conducted an external validation audit and concluded "that Isotek Systems, LLC (Isotek) has implemented an Environmental Management System (EMS) that is consistent with the requirements of DOE Order 450 .1 A, Environmental Protection Program."

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.

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 "plan-do-check-act" cycles. 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.

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.

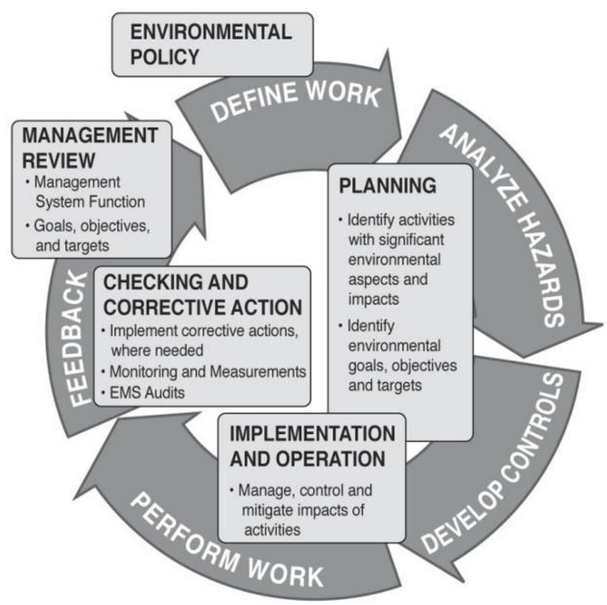

Fig. 5.3. The relationship between the UT-Battelle Environmental Management System and the Integrated Safety Management System.

5.2.1.2 UT-Battelle Policy

The UT-Battelle environmental policy statements are part of the UT-Battelle Policy for ORNL (Fig. 5.2), which 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

UT-Battelle Environmental Aspects

Environmental aspects are elements of an organization's activities, products, or services that can interact with the environment. Environmental aspects associated with UT-Battelle activities, products, and services have been identified 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.

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 laws and 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.

UT-Battelle Objectives and Targets

To improve environmental performance, UT-Battelle has established and implemented objectives, targets, and performance indicators for appropriate 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 mission. These objectives and targets were entered into a commitment tracking system and tracked to completion. These division plans focused on chemical inventory reduction, energy conservation, waste minimization, and recycling. Thirteen EMS Objectives and Targets were identified and accomplished in 2009 and are described in the following:

- **Objective: Reduce environmental impact associated with two division activities (450.1A)**
- **Targets:** Specific line organization targets, actions, responsible persons, and due dates can be found in ACTS (0.19908)

- **Objective: Land and habitat conservation (Performance Track)**
- **Target:** Continue to remove invasive plants and establish and maintain native plants. Treat/restore/maintain 682 acres of land on the ORR by end of 2009

- **Objective: Eliminate photographic hazardous waste generation (Performance Track)**
- **Target:** Eliminate the generation of hazardous photographic waste (ACTS 0.19908.9 and 0.19908.15)

- **Objective: Reduced use of diesel fuel (Performance Track and 430.2B)**
- **Target:** Continue to reduce the use of diesel fuel in vehicles by converting to a biodiesel fuel supply Diesel fuel usage should be reduced by 25% by the end of 2009 (compared to 2005 usage)

- **Objective: Complete plan to implement requirements of DOE Order 430.2B (430.2B)**
- **Target:** Complete executable plan and submit to DOE

- **Objective: Develop measure for evaluating UT-Battelle's contribution to goals in Executive and DOE Orders 450.1A and 430.2B**
- **Target:** Develop a sustainability index that measures UT-Battelle's strategy with respect to the requirements in EO 13423, DOE Order 430.2B, and DOE Order 450.1A

- **Objective: Reduce energy intensity (430.2B)**
- **Target:** By 2015, achieve no less than a 30% energy intensity reduction across the contractor's facility/site in accordance with the Executable Plan

- **Objective: Maximize use of renewable energy (430.2B)**
- **Target:** Maximize installation of on-site renewable energy projects at the contractor's facility/site where technically and economically feasible to acquire at least 7.5% of each site's annual electricity and thermal consumption from on-site renewable sources by FY 2010

- **Objective: Reduce potable water consumption (430.2B)**
- **Target:** Reduce potable water consumption at least 16% relative to the baseline of the facility/site's potable water consumption in FY 2007

- **Objective: Maximize the acquisition and use of environmentally preferable products in the conduct of operations (450.1A)**
- **Target:** See ACTS 9976.5.1 through .12 for a list of FY 2009 actions related to improving UT-Battelle's performance in the area of acquisition and use of environmentally preferable products

- **Objective: Upgrade building management systems (430.2B)**
- **Target:** Improve HVAC control in 4500N, 4500S, 4501/4505, 4508, 5500, and 6000

- **Objective: Advance metering and energy awareness campaign (430.2B)**
- **Target:** Installation of advanced electricity metering system and implementation of Sustainable Energy Education and Communication campaign

- **Objective: Use of reclaimed Fomblin oil (Performance Track)**
- **Target:** Use 100% reclaimed Fomblin oil in nanoscience clean room facility pump

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 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 outlined in Fig. 5.2. Information on UT-Battelle's 2009 compliance status, activities, and accomplishments is presented in Sect. 5.3.

Environmental protection staff provides critical support services to maintain a proper balance between cost and risk in many areas, including the following:

- waste management,
- NEPA compliance,

- air quality compliance,
- water quality compliance,
- U.S. Department of Agriculture (USDA) compliance,
- environmental sampling and data evaluation, and
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) interface.

The UT-Battelle staff also includes experts who provide critical waste management and disposition support services to ORNL research, operations, and support divisions. These 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;
- the hazardous material spill response team, which is the first line of response to hazardous materials spills at ORNL and controls and contains such spills until the situation is stabilized; and
- the Environmental Management Program Office (EMPO) coordinates and directs specific CERCLA decommissioning and demolition work being done on the ORNL site. EMPO activities include developing and implementing interface agreements applicable to multiple contractors, CERCLA Applicable or Relevant and Appropriate Requirements (ARARs), and project work plans.

5.2.1.4 UT-Battelle Sustainable Campus Initiative

"The Sustainable Campus for the Year 2018 Initiative" is an ORNL-wide effort that builds upon the Laboratory's strength as a premier science and technology organization in integrating energy efficiency, cutting-edge technologies, and operational and business processes to achieve sustainability. UT-Battelle implemented this multidisciplinary initiative to provide an overarching support structure to capture current efforts, to accelerate future implementation, and to provide a comprehensive sustainable vision of ORNL in the future. The ultimate goal is to achieve benchmark sustainability in campus operation and in the research, development and deployment of key technologies by 2018. The initiative was launched in October 2008 and continues a modernization program that began in 2002.

A diverse team, representing multiple organizations and areas of expertise, was formed to develop and implement a roadmap to achieve a sustainable campus at ORNL by 2018. Implementation of this roadmap began in 2009. Four components collectively build a base for the roadmap. The first component, foundational methods, includes historically proven methods such as energy efficiency in buildings and processes, zero process water discharge, zero solid waste discharge, zero adverse health effects, recycle and reuse strategies, and employee and family engagement. The second component, known technology, includes recently proven methods such as renewable energy sources, green building design, hybrid vehicles, and certain alternative fuel applications. The third component, leading-edge technology, involves bringing together known technologies in innovative ways and includes methods currently being tested such as solar covered parking with plug-in hybrid electric vehicles (PHEVs), solar application with highly-efficient buildings, innovative transportation technology, advanced building design technologies, and biofuel developments. The fourth component, transformational technology, is forward-thinking high-impact demonstration projects identified by appointed panels of scientists.

Sustainable successes achieved at ORNL during 2009 are discussed in the following sections. For more information see http://sustainability-ornl.org.

5.2.1.4.1 Modernization and Facilities Revitalization

In 1943, more than 6,000 workers began construction of some 150 buildings that became known as ORNL. More than 65 years later, a massive effort to modernize and revitalize the Laboratory continues. Since 2000, more than 1,900,000 ft^2 of aged, expensive-to-maintain buildings has been vacated and some

1,000,000 ft^2 of new and renovated space has been constructed (see Fig. 5.4). 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).

ORNL 2010-G00432/chj

Fig. 5.4. Modernization and facilities revitalization.

Table 5.1. ORNL facilities constructed since 2000

Building number	Building name	Funding source
1521	West End Research Support Facility	DOE
7990	Melton Valley Warehouse	DOE
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

During FY 2009, modernization and revitalization efforts at ORNL provided new facilities, enhanced staff interaction and space utilization, upgraded utility systems, and demolished old, expensive-to-maintain facilities. During the year, ORNL expended approximately $7 million to decrease the backlog of deferred maintenance in mission-critical facilities, to vacate substandard facilities, and to improve quality of remaining facilities.

Bethel Valley East Campus

Construction of the Multiprogram Laboratory Facility (MLF) building began in 2009. The new MLF is located in Bethel Valley on ORNL's East campus, and consists 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.

Critical parking and utility infrastructure projects for the Bethel Valley East Campus were also initiated in 2009. An unprecedented demand for automobile parking, fueled by staffing and subcontractor increases associated with receipt of American Recovery and Reinvestment Act funding, mandates early completion of planned parking lot expansions and construction of a new parking structure.

Other FY 2009 modernization efforts in the Bethel Valley East Campus included initiating the replacement of the 0902 Water Reservoir. This 3 million gallon capacity reservoir that provides potable and fire water to ORNL has been in continuous operation since 1948, and extensive degradation has occurred. In addition projects to upgrade the 6001 Cooling Tower, replace switchgear in Building 4509, and install new smoke detectors in Building 4500 North and South were completed in 2009.

Bethel Valley Central Campus

Much work remains for modernization of the Bethel Valley Central Campus including completion of EM demolition and remediation followed by phased redevelopment of the area. During 2009 construction of an adjoining expansion (to Building 3625) was initiated. The expansion to the Advanced Microscopy Laboratory is located on the southwest side of the existing building to house a number of vibration-sensitive instruments used for materials characterization. UT-Battelle also vacated Building 3025M in support of DOE-EM Program plans for eventual building demolition.

Bethel Valley West Campus

Renovations to existing West Campus facilities continued in 2009 with the construction of a quadrangle, renovation to the Buildings in the 1500 series, and initiation of the construction of several greenhouses (Fig. 5.5). During the year the West End Research Support Facility was completed and placed into service.

ORNL 2010-G00434/chj

Fig. 5.5. Greenhouses.

Chestnut Ridge Campus

Chestnut Ridge infrastructure investment continued in 2009, including approval of a Guest House, construction of three parking areas that provide a total of approximately 240 finished parking spaces, and construction of a cafeteria on the first floor of the Central Laboratory and Office building. The state of Tennessee continued construction of the Joint Institute for Neutron Sciences building.

Melton Valley Campus

Construction of the Melton Valley warehouse was completed in 2009. This facility will provide space to consolidate storage of equipment and materials formerly stored across the ORNL site. In addition, in 2009 construction began on an American Reinvestment and Recovery Act (ARRA)-funded Melton Valley Maintenance Facility which will consolidate maintenance operations in Melton Valley.

Integrated Facilities Disposition Initiative at ORNL

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, 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 (see Fig. 5.6). DOE approved the Alternative Selection and Cost Range Critical Decision-1 for the project in November 2008, and work on the 26-year project continued in 2009 with development of the Critical Decision-2/3 package.

ORNL 2010-G00491/chj

Fig. 5.6. Aggressive demolition.

5.2.1.4.2 Energy Management

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.

Energy Intensity Reduction Performance in Subject Buildings

The Energy Policy Act (EPACT) of 2005 established ambitious goals for 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 with FY 2006 defined as the first performance year. Buildings that have been excluded from these goals at ORNL include 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, ORNL's energy intensity was 364,539 Btu per gross square foot (GSF), as shown in Fig. 5.7, and after a brief plateau has trended downward. ORNL's energy intensity decreased by 5.78% between FY 2005 and FY 2006, 6.31% between FY 2006 and FY 2007, and 1.54% between FY 2007 and FY 2008. The cumulative progress between FY 2003 and FY 2009 represents a 12.8% Btu/GSF reduction in energy intensity. The FY 2009 target reduction was 12%; 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 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 pace to meet the Presidential goal.

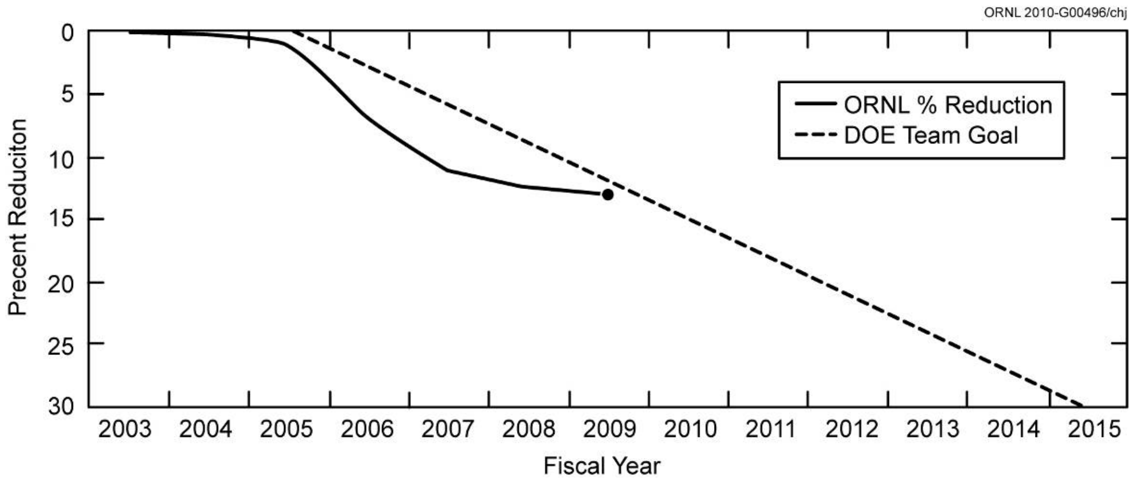

Fig. 5.7. ORNL building energy reduction versus the DOE Transformational Energy Action Management (TEAM) goal.

Energy Savings Performance Contracting

On July 30, 2008, Johnson Controls, Inc. was awarded an Energy Savings Performance Contract (ESPC) 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 executes programs to meet, exceed, and lead in the implementation of the Executive Order 13423 energy, environmental, and transportation goals.

In addition to meeting the goals of the TEAM Initiative, the ESPC supports and modernizes facility infrastructure, provides utility support and capacity, and ensures that mission-related activities can be performed without interruption. ORNL will receive the following specific benefits from this contract.

- Modernization of significant infrastructure improvements to 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 Section 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
- 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 5.2 demonstrates that the ESPC goals meet or exceed TEAM goals. The status of the energy conservation measures (ECMs) is outlined in Table 5.3.

Table 5.2. Energy savings performance contracting goals, 2009

	TEAM[a] 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

[a]TEAM=Transformational Energy Action Management Initiative

Table 5.3. Energy conservation measures status, 2009

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; installation of equipment in the 7000 area is complete; and construction has begun on the new Melton Valley Steam Plant
Building management system upgrade	Design and procurements are finalized and installation of equipment is under way
Advanced electric metering	Design and procurement is complete, and installation of equipment is at 90%
Comprehensive HVAC upgrade	Design is being finalized and procurements have begun
Energy-efficient lighting upgrade	Design, procurements, and construction are complete.
Water conservation	Domestic water projects are complete. The once-through cooling project is designed with completion scheduled for FY 2010

Electric Metering

The EPACT 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.

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 5.4). 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), 38 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 5.4. Electrical 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.

UT-Battelle Employee Energy Conservation Education and Involvement Opportunities

During 2009, UT-Battelle sponsored several events to promote employee awareness of opportunities to conserve energy and promote energy efficiency.

ORNL's Earth Day 2009 celebration, held on Thursday, April 16, 2009, included a slate of activities headlined with a talk by Dr. Mike Sale entitled "Energy, Water, Sustainability, and Responsibility." Other activities included an East Campus Pond tour and an opportunity for staff to exchange a plastic bag for a hot/cold insulated reusable bag. The plastic bags collected were picked up and recycled at no charge by the Knoxville Recycling Coalition. More than 2,000 people attended this event (Fig. 5.8).

ORNL 2010-G00497/chj

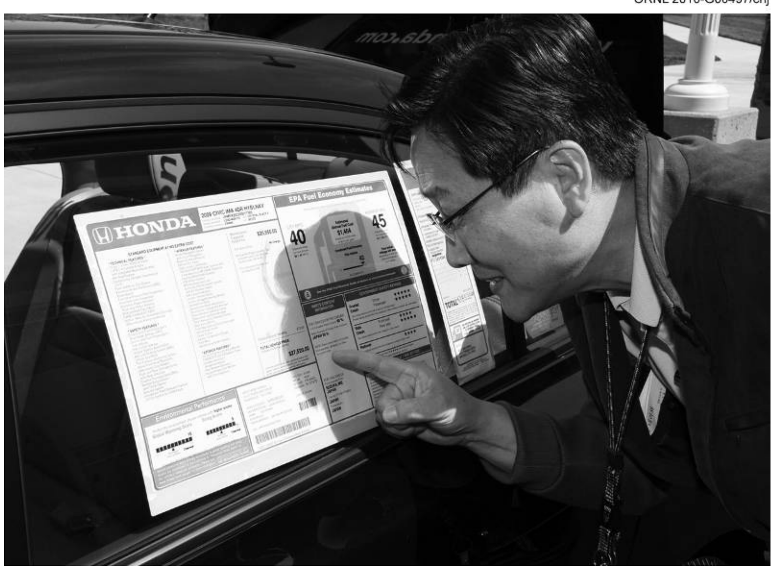

Fig. 5.8. 2009 Earth Day.

UT-Battelle sponsored several events in October in recognition of National Energy Awareness Month, which is 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. This year's Energy Awareness Month theme was "A Sustainable Energy Future: Putting All the Pieces Together."

UT-Battelle and Johnson Controls, Inc., sponsored the 2009 Energy Awareness Celebration on Thursday, January 22 on ORNL's Main Street with information on how to improve energy efficiency in workplaces, homes, and communities. As a part of this celebration, the Sustainable Campus Initiative dedicated a solar array on Bethel Valley Road.

Sustainable Practices

Green building and landscaping as well as energy management efforts are included in all activities at ORNL including research, design, construction, retrofit, operation, and maintenance. One million square feet of LEED-certified campus space provides a multitude of opportunities to perform research on emerging energy-efficient technologies, green construction, and proper operation and maintenance of green facilities. An aggressive commitment to building LEED-certified buildings at ORNL along with the incorporation of other energy-saving measures has added 35% more facility and building area with only a 6% increase in energy consumption when comparing FY 2009 data to a 2000 baseline.

UT-Battelle has also maintained and expanded sustainable landscaping activities at ORNL including native planting on 17 acres at ORNL (see Fig. 5.9) and 307 acres across the ORR and removal of invasive plants from 140 acres at ORNL and 500 acres across the ORR.

ORNL 2010-G00433/chj

Fig. 5.9. Plants and natural landscaping.

Three solar collectors on the ORNL campus provide research opportunities as well as renewable energy to the laboratory. ORNL's first solar collector, an array of 24 solar panels, was originally used as a symbol of alternative energy research and continues to generate renewable electricity. The second solar collector is an 88 m by 3 m (288 ft by 10 ft) collector made up of 168 modules. Designed to provide 51.25 kW at peak power, the array feeds direct current to an inverter, which produces alternating current for the ORNL distribution grid. A total of 88 MWh of direct current is produced annually, or about 70 MWh alternating current (equivalent to the average annual power needs of 5.5 Tennessee homes). This array is designed to be 18.7% efficient and to displace approximately 51,710 kg (114,000 lb) of carbon dioxide every year (more than seven times the amount produced annually by the average American). The electricity added to the grid is used to offset electricity for Buildings 3147 and 3156. The third, most recently installed collector is a single-axis tracking 700-watt total energy concentrator with low-cost, flat, aluminum mirrors that reflect sunlight onto the smaller solar cells in the concentrator. Since only one-third of the area of this array consists of solar cells, the concentrator can produce more energy with fewer expensive solar cells. Research is under way at ORNL to determine how well the array will perform in the naturally hazy atmosphere of East Tennessee.

The large 88 m by 3 m (288 ft by 10 ft) solar collector specifically supports ORNL's aggressive net-zero energy building (NZEB) goal which will transform the four buildings that comprise the ORNL Buildings Technology and Research Integration Center to NZEBs. ORNL accomplished the first step in meeting this goal on October 1, 2009, when ORNL self-declared Building 3156 to be a NZEB with plans under way to transform the remaining buildings. Due to aggressive implementation of energy efficiency measures, Building 3156 decreased its consumption from about 100 MWh/yr to 60 MWh/yr, which is provided by solar power.

Green Transportation

UT-Battelle performs a broad range of green transportation–related research and development activities at ORNL and also embraces current technologies and techniques to reduce fuel consumption. UT-Battelle has implemented a multi-pronged approach to green transportation: (1) encouraging personnel to walk and to ride bikes through innovative campus design, (2) encouraging shared transportation, (3) integrating maximized fuel efficiency features when upgrading roads, (4) continuing the expansion of alternative vehicles and fuel including hybrid vehicles, flex fuel vehicles using E-85, electric vehicles, and diesel vehicles using B20 bio-diesel, and (5) researching and implementing future alternative vehicles and fuel options. These efforts have helped ORNL reduce its fleet from 515 vehicles in 2006 to 476 vehicles in 2009.

In FY 2009, UT-Battelle had a vehicle fleet that included 17 electric vehicles and 41 hybrid cars (see Fig. 5.10). There were also 232 flex fuel vehicles in the fleet (49%) and 66% of new vehicle procurements during the year were flex fuel vehicles. During 2009 a reduction in vehicle emissions was achieved in part due to the use of 50,503 gallons of E85 to fuel the ORNL fleet, which is up from 39,366 gallons in 2008. In addition there are 86 diesel vehicles at ORNL and numerous pieces of equipment that use bio-diesel as opposed to diesel fuel, resulting in additional reductions in emissions. As part of the Sustainable Campus Initiative, the Laboratory is also pursuing the potential use and support of PHEVs in combination with solar-covered parking.

ORNL 2010-G00492/chj

Fig. 5.10. Vehicle fleet.

5.2.1.4.3 Pollution Prevention

UT-Battelle implemented 33 new pollution prevention projects at ORNL during 2009, eliminating more than 255 million kg (~562,000,000 lb) of waste and leading to cost savings/avoidance of more than $8 million (including ongoing reuse/recycle projects). Major 2009 pollution prevention successes at ORNL included source reduction projects such as the elimination of photo processing chemicals, water conservations efforts, and recycling (including radioactive lead, Tyvek, and electronics).

UT-Battelle has implemented numerous water-saving activities during the past several years and has funded additional projects that will reap results in the future. These projects include integration of low-flow fixtures and faucets in new construction and the reuse of rainwater for irrigation. The entire modernized East Campus research complex saves more than 32 million liters (8.5 million gallons) of water per year. In addition to water-savings measures incorporated into new construction, several existing facilities have been retrofitted with a variety of water-saving options, and as a result, a reduction in the use and discharge of an additional 25 million liters (6.5 million gallons) of water per year was realized.

In FY 2009, the use and discharge of water at ORNL was reduced through a variety of water-saving options including (1) replacement of standard-flow plumbing fixtures with low-flow products to reduce domestic water use, (2) replacement and repair of steam traps, (3) aggressive identification and repair of water leaks, (4) the Physics Division's cooling water flow reduction pilot, and (5) the Biological and Environmental Sciences Directorate's ultraviolet (UV) dechlorinator project.

Future identified water reduction projects include the ESPC-funded projects to eliminate once-through cooling water and to install a biomass gasification steam plant (BGSP) at the ORNL steam plant, as well as the expansion of the Physic's Division cooling-water flow reduction pilot. Furthermore, to enhance water use and quality awareness, UT-Battelle holds on-site, Laboratory-wide awareness activities such as Earth Day celebrations and Fix-a-Leak Week and sponsors related educational community outreach activities.

These initiatives have reduced water usage and the associated waste water generation, improved operational efficiency, reduced total regulated air emissions, reduced natural gas and fuel oil use, and resulted in significant cost savings. In FY 2009 alone, water conservation efforts reduced water usage and the associated waste water generation by more than 238 million liters (63 million gallons) per year with an associated cost avoidance of more than $104,700. In the last two fiscal years, UT-Battelle has reduced water usage by 295 million liters (78 million gallons) per year with an associated cost avoidance of more than $342,000. When all identified water conservation efforts are complete, a total of 1 billion liters

(273 million gallons) per year of water usage and associated waste water generation will be eliminated with an associated cost avoidance of more than $5 million, which includes all cost avoidance associated with the BGSP.

During the year UT-Battelle expanded the scope of the recycling program at ORNL with more than 78% of FY 2009–generated materials being diverted for recycle or beneficial use. One successful activity involved “dumpster dives” (see Fig. 5.11) performed by the Sustainable Campus Initiative team during the year to identify viable opportunities for further reductions in waste streams at ORNL. This involves detailed hand sorting and categorization of the contents of dumpsters from targeted buildings. Based on this effort, UT-Battelle targeted recycling and/or reduction of office waste as an area where the diversion of materials from waste streams to beneficial reuse or recycle programs could result in significant reductions in the volume of waste being sent to landfills or disposal facilities. To address this waste stream, centralized recycling locations in hallways and common areas have been replaced by individual containers within offices. Preliminary results indicate this approach has been successful, and similar efforts in other areas will be undertaken during 2010 to further reduce sanitary industrial waste at ORNL.

ORNL 2010-G00493/chj

Fig. 5.11. Pollution prevention.

For more information on these and other ORNL conservation and recycling activities, see http://sustainability-ornl.org.

ORNL Site P2 Awards

- DOE's Environmental Sustainability (EStar) Awards—received for the Sustainable Campus Team and the Net Zero Building (3156). The EStar Awards recognize exemplary environmental sustainability and stewardship practices and excellence in pollution prevention across DOE.

- DOE Office of Science Best in Class Award—On December 31, 2009, ORNL received notification that DOE Office of Science awarded ORNL an Office of Science “Best in Class” Award for environmental sustainability and recognized three other initiatives with “Noteworthy Practices” Awards. Best in Class and Noteworthy Practices Awards were received for accomplishments associated with ORNL’s Net Zero Building (3156), Sustainable Campus Initiative, Information Technology Green IT Initiative, and Green Fleet Program.

- Tennessee Department of Environment and Conservation (TDEC) Tennessee Pollution Prevention Partnership (TP3) Performer Member Flag—UT-Battelle completed the five-project TP3 plan that demonstrates a commitment to preventing pollution of air, land, and water while conserving natural resources.

- Tennessee Chamber of Commerce & Industry Award for Outstanding Achievement in Water Quality and achievement certificate for environmental excellence for the successful completion of several environmental activities at ORNL.

5.2.1.5 Implementation and Operation

Structure and Responsibility

The UT-Battelle Environmental Policy (Fig. 5.2) represents 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.

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
- Notices on *ORNL Today*, an electronic publication which provides current information to ORNL staff on activities, programs, and events at the Laboratory
- EMS brochures and badge cards
- *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, regulators, and stakeholders.

5.2.1.6 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.

5.2.1.7 Checking

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.

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. Should a nonconformance be identified, the ORNL issues management process requires that any regulatory or management system nonconformance be reviewed for cause and corrective and/or preventive action developed. These actions are then implemented and tracked to completion.

The SBMS Assessments 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 the systems are effective and are continually improving.

UT-Battelle also uses the results from numerous external compliance inspections conducted by regulators to verify compliance with 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 2009, an internal audit and an external surveillance audit were conducted and verified that the EMS continued to conform to ISO 14001:2004. In addition the Office of Management and Budget’s Environmental Stewardship Program gave UT-Battelle a green EMS scorecard rating on implementation of EO 13423, Strengthening Federal Environmental, Energy, and Transportation Management, indicating full implementation of EO 13423 requirements. In addition to verifying conformance, these management system assessments also identify continual improvement opportunities.

5.2.2 Environmental Management System for the TRU Waste Processing Center

The EMS for activities at the TWPC was registered to the ISO 14001:2004 Standard by NSF International Strategic Registrations, Ltd., in May 2008. NSF International Strategic Registrations, Ltd., conducted a Surveillance Audit for the WAI EMS program in May 2009, and again no nonconformances or issues were identified and several significant practices were noted. The WAI 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*, and both strive for continual improvement through a “plan-do-check-act” cycle.

The WAI EMS incorporates applicable environmental laws, DOE orders, and other requirements (i.e., directives and federal, state, and local laws) through the *WAI 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. WAI 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.

WAI has established and implemented objectives and measurable performance indicators for the targets associated with the identified significant impacts.

The P2 programs at TWPC involve waste reduction efforts and implementation of sustainable practices that reduce the environmental impacts of the activities conducted at the TWPC. The WAI EMS establishes annual goals and targets to reduce the impact of the TWPC's environmental aspects.

WAI 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. WAI evaluated and put into place during the last part of 2009 a "single stream" recycling program that allows the mixing of multiple types of recyclables and increases the population of recyclable items.

"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 2009, WAI procured environmentally preferable materials totaling approximately $131,000 for use at TWPC.

Several methods are used by WAI 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. WAI also uses the results from numerous external compliance inspections conducted by regulators and contractors to verify compliance with requirements.

5.3 Compliance Programs and Status

During 2009 UT-Battelle, WAI, and Isotek operations were conducted in compliance with contractual and regulatory environmental requirements with the exception of two interrelated exceedances of National Pollutant Discharge Elimination System (NPDES) permit discharge limits. There were no notices of violation or penalties issued by the regulatory agencies. Table 5.5 contains a list of environmental permits that were effective in 2009 at ORNL. Table 5.6 presents a summary of environmental audits conducted at ORNL in 2009.

ORNL does not operate any RCRA Subtitle D disposal facilities. ORNL's industrial solid waste is sent to the Y-12 industrial solid waste disposal landfills. ORNL complies with the requirements by meeting the waste acceptance criteria at the Y-12 facilities.

The following discussions summarize the major environmental programs and activities carried out at ORNL during 2009 and provide an overview of compliance status for the year.

5.3.1 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, WAI, and Isotek maintain 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 5.7 summarizes NEPA activities conducted at ORNL during 2009.

During 2009, UT-Battelle and WAI continued to operate under site-level procedures that provide requirements for project reviews and NEPA compliance. These procedures call 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 non-research activities (e.g., 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

Table 5.5. ORNL environmental permits, 2009

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[a]	DOE	UT-B	UT-B
CAA	Steam Plant	556850	10/21/04	10-21-09[a]	DOE	UT-B	UT-B
CAA	Manipulator Boot Shop	556850	10/21/04	10-21-09[a]	DOE	UT-B	UT-B
CAA	SNS Central Utilities Building Boilers	556850	10/21/04	10-21-09[a]	DOE	UT-B	UT-B
CAA	Surface Coating and Cleaning Operation	556850	10/21/04	10-21-09[a]	DOE	UT-B	UT-B
CAA	SNS and CNF (construction permit)	956542P	10/29/04	03-01-08[a]	DOE	UT-B	UT-B
CAA	SNS Central Laboratory and Office Boilers	556850	10/21/04	10-21-09[a]	DOE	UT-B	UT-B
CAA	EGCR Boilers	556850	10/21/04	10-21-09[a]	DOE	UT-B	UT-B
CAA	Air Stripper (BJC permit)	547563	10/21/04	10-21-09[a]	DOE	BJC	BJC
CAA	HFIR & Radiochemical Engineering Development Center	556850	10/21/04	10-21-09[a]	DOE	UT-B	UT-B
CAA	Off Gas & Hot Cell Ventilation (BJC permit)	547563	10/21/04	10-21-09[a]	DOE	BJC	BJC
CAA	NTRC	0941-02[b]	03/12/09	Annually[a]	DOE	UT-B	UT-B
CAA	TN Operating Permit (emissions source)	057077P	04/13/04	10-31-14[a]	DOE	WAI	WAI
CAA	Radiochemical Development Facility	560898	07/27/09	07-26-14[a]	DOE	Isotek	Isotek
CAA	Biomass Boiler and Melton Valley Steam Plant (construction permit)	962300F	03/27/09	03-01-10[a]	DOE	UT-B	UT-B, JCI
CWA	ORNL NPDES Permit (ORNL sitewide wastewater discharge permit)	TN0002941	07/01/08	07-30-13	DOE	DOE	UT-B, BJC

Table 5.5 (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—SNS	TNR139975	09-30-00	NA	DOE	DOE	UT-B
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	CROET
CWA	TN Operating Permit (sewage)	SOP-02056	02-01-08	12-31-12	DOE	WAI	WAI
CWA	Tennessee General Permit No. TNR10-0000, Stormwater Discharges from Construction Activity—Site Expansion Project	TNR 133560	08-31-09	NA	DOE	WAI	WAI
RCRA	Hazardous Waste Transporter Permit	TN1890090003	01-21-10	01-31-11	DOE	DOE	UT-B, BJC

Table 5.5 (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[c]	DOE/all
RCRA	Hazardous Waste Container Storage and Treatment Units	TNHW-134	09-26-08	09-26-18	DOE	DOE/UT-B	UT-B
RCRA	Hazardous Waste Container Storage and Treatment Units	TNHW-097	09-30-97	09-30-07	DOE	DOE/BJC/ WAI	BJC/WAI

Abbreviations

BJC	Bechtel Jacobs Company
CAA	Clean Air Act
CNF	Central Neutralization Facility
CROET	Community Reuse Organization of East Tennessee
CWA	Clean Water Act
DOE	U.S. Department of Energy
EGCR	Experimental Gas-Cooled Reactor
HFIR	High Flux Isotope Reactor
JCI	Johnson Controls, Inc.
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
WAI	Wastren Advantage Inc.

[a]Continued construction/operation under an expired permit is allowed under air compliance regulations when timely renewal or conversion permit applications are submitted.

[b]Permit issued by Knox County Department of Air Quality Management.

[c]DOE and Oak Ridge Reservation contractors are co-operators of hazardous waste permits.

Table 5.6. Summary of regulatory environmental audits and assessments conducted at ORNL

Date	Reviewer	Subject	Issues
		UT-Battelle	
May 11–14	TDEC, RCRA	TDEC Annual RCRA Inspection	0
July 23	USDA/TNDA	USDA Compliance Inspection	0
September 22	TDEC	CWA NPDES program Inspection	0
September 25	TDEC	RATA for Predictive Emissions	0
November 2–4	TDEC	Annual RCRA inspection at Y-12 Complex	0
December 17	TDEC	Annual CAA inspection	0
		TWPC (WAI)	
May 14	TDEC	TDEC Annual RCRA Inspection	0

Abbreviations

CAA	Clean Air Act
NPDES	National Pollutant Discharge Elimination System
ORNL	Oak Ridge National Laboratory
RATA	Relative Accuracy Test Audit
RCRA	Resource Conservation and Recovery Act
TDEC	Tennessee Department of Environment and Conservation
TNDA	Tennessee Department of Agriculture
TWPC	Transuranic Waste Processing Center
USDA	United States Department of Agriculture

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.

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.

Table 5.7. National Environmental Policy Act (NEPA) activities, 2009

Types of NEPA documentation	Number of instances
ORNL	
Categorical exclusions (CXs) approved	1
Approved under general actions or generic CX documents	59[a]
WAI	
Approved under general actions or generic CX documents	5[a]
Isotek	
Environmental assessment	1

[a]Projects that were reviewed and documented through the site NEPA compliance coordinator.

In 2009, an Environmental Assessment for the Isotek-managed U-233 Material Downblending and Disposition Project (Building 3019 Complex) was completed and a Finding of No Significant Impact under the NEPA process was issued in January 2010.

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). A Section 106 consultation of the Act was completed for the demolition of Buildings 3008, 3012, 3044, 3503, 3504, 3508 and 3592. The State Historic Preservation Officer had no objection to implementing actions for the demolition of these buildings (letter to DOE-ORO, August 20, 2009).

5.3.2 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 TDEC Division of Air Pollution Control. ORNL was issued its first sitewide operating air permit in 2004. To demonstrate compliance with this Title V Major Source Operating Permit, more than 1500 data points are collected and reported every year. In addition, there are 2 continuous monitors for criteria pollutants, 9 continuous samplers for radionuclide emissions, 15 minor radionuclide sources, and numerous demonstrations of compliance with generally applicable air quality protection requirements (asbestos, stratospheric ozone, etc.). TDEC personnel performed an inspection of ORNL on December 17, 2009, to verify compliance with applicable regulations and permit conditions. There were no compliance issues identified. Also, a Knox County Air Quality permit is maintained for the offsite NTRC. An annual compliance report is submitted for this permit. In summary, there were no UT-Battelle, Isotek, or WAI CAA violations or exceedances in 2009. Section 5.4 provides detailed information on 2009 activities conducted at ORNL in support of the CAA.

5.3.3 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 quality 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 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 2009, compliance with the ORNL NPDES Permit was determined by approximately 2,300 laboratory analyses and field measurements. The NPDES permit limit compliance rate for all discharge points for 2009 was nearly 100%, with only one measurement exceeding numeric NPDES permit limits by exceeding a daily-maximum total residual oxidant (TRO) limit. The noncompliance occurred at an instream monitoring point on Fifth Creek, where on February 16, 2009, 0.12 mg/L TRO (chlorine) was measured. The measurement resulted in calculated exceedance of a second, monthly average TRO limit. A dechlorination system at Outfall 265 was repaired to guard against recurrence. Information on the exceedances is provided in Appendix E, Section E.3. The exceedance did not result in any discernable ecological impact. Section 5.5 contains detailed information on the activities and programs carried out in 2009 by UT-Battelle in support of the CWA.

5.3.4 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. TDEC's Bureau of Environment Division of Water Supply Chapter 1200-5-1, Public Water Systems (TDEC 2006), 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 2009, sampling results for ORNL's water system chlorine residual levels, bacterial constituents, disinfectant by-products, and lead and copper were all within acceptable limits. TDEC requires triennial sampling of the ORNL potable water system for lead and copper; the next sampling is scheduled to be performed during June –September 2012.

5.3.5 Resource Conservation and Recovery Act Compliance Status

DOE and the DOE contractors at ORNL were jointly regulated as a large-quantity generator of hazardous waste in 2009 (EPA ID No. TN1890090003), because collectively more than 1,000 kg of hazardous waste per month was generated. This includes hazardous waste that is generated under permitted activities (including repackaging or treatment residuals). At the end of 2009, there were approximately 400 generator accumulation areas for hazardous or mixed waste serving various contractor organizations at ORNL, including UT-Battelle, BJC, Energy Solutions, Isotek, and WAI. DOE and the DOE contractors at ORNL were also jointly regulated as a large quantity handler of universal waste (e.g., fluorescent lamps, batteries, etc.) under the universal waste management standards as more than 5,000 kg of total universal waste was collectively accumulated prior to off-site recycle at any time during 2009. Similarly, DOE and ORNL contractors were collectively regulated as a used oil generator under the used oil management standards in 2009. At the end of 2009, there were approximately 100 used oil areas for management of used oil prior to off-site recycle or disposal.

UT-Battelle and BJC were permitted to transport hazardous wastes and UT-Battelle was registered to operate a transfer facility for temporary (less than 10-day) storage of hazardous wastes transported from off-site locations (such as NTRC). DOE, UT-Battelle, BJC, and WAI were permitted to operate RCRA-permitted hazardous waste treatment and storage facilities (or units). During 2009, 24 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 2007 for TNHW-097).

The RCRA units operate under three permits at ORNL: TNHW-097 (TNHW-145 was issued in early 2010 and replaces the TNHW-097 permit), TNHW-134, and TNHW-121. TNHW-121 is the existing RCRA Hazardous and Solid Waste Amendments permit for the ORR (see Table 5.8). The permits are modified when necessary. Five permit modifications and two temporary authorizations were approved by TDEC in 2009. Two modifications to permit TNHW-134 included removal of Portable Unit 1 and minor changes to the waste analysis plan, training, and inspection logs. Three permit modifications and two temporary authorizations to TNHW-097 were approved by TDEC in 2009. The modifications included removal of WESKEM, LLC as permit co-operator; addition of Portable Unit 1; and for the TWPC, approval of a staging area for loaded and sealed 72-B casks, addition of storage capacity, and addition of size reduction treatment. The temporary authorizations included adding additional storage capacity to four TWPC permitted units and allowing macroencapsulation at an additional location at the TWPC. The renewal application for the TNHW-097 permit submitted in March 2007 was still pending throughout 2009.

TDEC conducted an annual RCRA inspection in May 2009 of ORNL generator areas, battery collection areas, RCRA permitted areas, and RCRA records including required training, generator inspections, permitted facility records, shipments, transfer facility log, the 2008 RCRA Annual Report of Hazardous Waste Activities, and the 2008 Hazardous Waste Reduction Progress Report. All activities and records were found to be in compliance with RCRA regulations and the RCRA permits, and there were no notices of violation or penalties associated with this inspection.

DOE and associated contractors at the NTRC were regulated as a conditionally exempt small-quantity generator in 2009, meaning that less than 100 kg of hazardous waste per month was generated collectively. At the end of 2009, there were three generator accumulation areas in support of operations that generate hazardous wastes and one used oil area for management of recyclable used oil.

There were no hazardous wastes or used oil generated by DOE and contractors at the 0800 Area, the DOE Office of Scientific and Technical Information, ORNL Records, or the Freels Bend Area in 2009.

5.3.6 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 three USTs registered with TDEC under Facility ID Number 0-730089; all three are in service (petroleum) and are state-of-the-art USTs that meet the 1998 standards for new UST installations.

5.3.7 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.

Table 5.8. ORNL Resource Conservation and Recovery Act operating permits, 2009

Permit number	Building/description
	ORNL
TNHW-134	Building 7651 Container Storage Unit
	Building 7652 Container Storage Unit
	Building 7653 Container Storage Unit
	Building 7654 Container Storage Unit
	Portable Unit 2 Storage & Treatment Unit
TNHW-097	Portable Unit 1 Storage & Treatment Unit
	Building 7574 Container Storage Unit
	Building 7576 Container Storage Unit
	Building 7577 Container Storage Unit
	Building 7580 Container Storage Unit
	Building 7823 Container Storage Unit
	Building 7842 Container Storage Unit
	Building 7855 Container Storage Unit
	Building 7860A 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 (WPF) 2 Container Storage Unit
	Building 7880 WPF 4 Container Storage Unit
	Building 7880A WPF 1 (Contact-Handled Storage Area) Container Storage Unit
	WPF 3 (Drum Aging Criteria) Container Storage Unit
	WPF 5 (Container Storage Area) Container Storage Unit
	Building 7880BB WPF 6 (Contact-Handled Marshaling Building) Container Storage Unit
	Building 7880AA WPF 7 (Drum Venting Building) Container Storage Unit
	Macroencapsulation T-1 Treatment Unit
	Amalgamation T-2a Treatment Unit
	Solidification/Stabilization T-3 and T-4a Treatment Unit
	Size Reduction T-5a Treatment Unit
	Oak Ridge Reservation
TNHW-121	Hazardous Waste Corrective Action Permit

[a]Treatment operating units within Building 7880.

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) is operated by the BJC for DOE. Located in Bear Creek Valley, EMWMF 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.

5.3.7.1 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. Annual updates for 2009 for ORNL's Solid Waste Management Units and Areas of Concern were consolidated with updates for ETTP, Y-12, and the ORR and were reported to TDEC, DOE, and EPA Region 4 in January 2010.

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 2010) 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 do not adversely impact future CERCLA environmental remedial actions.

5.3.8 Toxic Substances Control Act Compliance Status

PCB waste generation, transportation, and storage at ORNL are regulated under the EPA ID number TN1890090003. In 2009, UT-Battelle 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 UT-Battelle facilities at Y-12. 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 Table 2.1) 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. In 2009, there were no discoveries of unauthorized uses of PCBs.

5.3.9 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 5.9 describes the main elements of the act. UT-Battelle complied with these requirements in 2009 through the submittal of reports under EPCRA Sections 302, 303, 311, and 312.

ORNL had no releases of extremely hazardous substances, as defined by EPCRA, in 2009.

Table 5.9. Main elements 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/Chemical Inventory	Requires that either material safety data sheets 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

5.3.9.1 Material Safety Data Sheet/Chemical Inventory (Section 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 EPCRA's Section 312 requirements. Of the 101 chemicals identified for CY 2009 on the ORR, 20 were located at ORNL.

Private-sector lessees associated with the reindustrialization effort were not included in the 2009 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.

5.3.9.2 Toxic Chemical Release Reporting (EPCRA Section 313)

DOE submits annual toxic release inventory reports to EPA and TDEC on or before July 1 of each year. The reports cover the previous calendar year and address releases of certain toxic chemicals to air, water, and land as well as waste management, recycling, and pollution prevention activities. Threshold determinations and reports for each of the ORR facilities are made separately. Operations involving toxic release 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 2009, ORNL reported releases of 52,762 lb of nitric acid and 73,041 lb of nitrate compounds (Table 5.10). Of this, 52,668 lb of the nitric acid was not actually released but rather was used for waste treatment at the Process Waste Treatment Complex. This use is considered a "release" under Toxic Release Inventory regulations. The remaining 94 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

Table 5.10. Emergency Planning and Community Right-to-Know Act Section 313 toxic chemical release and off-site transfer summary[a] for ORNL, 2009

Chemical	Year	Quantity (lb)
Nitrate compounds	2008	47,000
	2009	73,041
Nitric acid	2008	25,739
	2009	52,762
Total	2008	72,739
	2009	125,803

[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.

environment. The discharge of nitrate compounds is not regulated in the NPDES permit for the sewage plant.

5.4 Air Quality Program

5.4.1 Construction and Operating Permits

Permits issued by the state of Tennessee convey the clean air requirements that are applicable to ORNL. New projects are governed by construction permits until converted to operating status. The sitewide Title V Major Source Operating Permit includes requirements that are generally applicable to large operations such as a national laboratory, e.g., asbestos and stratospheric ozone, as well as specific requirements directly applicable to individual air emission sources. Source-specific requirements include the National Emission Standards for Hazardous Air Pollutants for Radionuclides (see Sect. 5.4.3), requirements applicable to sources of ambient air criteria pollutants, and sources of other hazardous air pollutants (non-radiological). DOE/UT-Battelle holds a Title V permit for 10 emission sources. In April 2009, an application was submitted to the State of Tennessee to renew this sitewide permit.

At the beginning of 2009, the primary emission points of nonradioactive emissions at ORNL included 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. During 2009, steam plant boilers 1–4 were permanently shut down. All of these units use fossil fuels; therefore, criteria pollutants are emitted. Actual and allowable emissions from the sources are compared in Table 5.11. Actual emissions were calculated from fuel use and EPA emission factors. Boiler 6, a 125-MBtu/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. All UT-Battelle emission sources operated in compliance with Title V permit conditions during 2009.

Table 5.11. Actual versus allowable air emissions from ORNL steam production, 2009

Pollutant	Emissions (tons per year)[a]		Percentage of allowable (%)
	Actual	Allowable	
Sulfur dioxide	9	1277	0.7
Particulate matter	3	71	4.2
Carbon monoxide	35	196	17.9
Volatile organic compounds	2	14	14.3
Nitrogen oxides	74	380	19.5

[a] 1 ton = 907.2 kg.

The permitting and start of construction of the Energy Conservation Measures Project, with the goal of energy savings, was a significant event in 2009. This project includes replacing the existing natural gas/fuel oil fired boilers 1–4 with a biomass gasification system at the ORNL Steam Plant, the installation of additional boilers in remote locations to eliminate the need for steam distribution to those areas, and modifications to the existing natural gas/fuel oil fired boilers 5 and 6. The biomass gasification system, a main component of the overall project, will gasify wood fuel to provide a clean source of steam and will significantly displace fossil fuels used by the existing steam plant and reduce the fossil fuel consumption at ORNL. Also, during 2009, there were three minor modification and two administrative amendment requests pending for the Title V permit.

The minor modification requests were to include the SNS Central Exhaust Facility under the UT-Battelle Title V permit, to transfer ownership of the Radiochemical Development Facility, and to allow an alternative monitoring system for nitrogen oxides.

For state fiscal year 2009, UT-Battelle paid $7,331 in annual emission fees to TDEC. The fees are based on a combination of actual and allowable emissions.

DOE/WAI has an operating air permit for one emission source, a TRU waste processing facility. DOE/Isotek has a Title V Major Source Operating permit for the Radiochemical Development Facility. During CY 2009, no permit limits were exceeded.

5.4.2 NESHAP for Asbestos

There are numerous facilities, structures, components, and various pieces of equipment associated with facilities at ORNL that contain asbestos-containing material (ACM). ORNL's Asbestos Management Program manages the compliance of work activities involving the removal and disposal of ACM and current use of engineering controls and work practices, including inspections and monitoring for proper removal and waste disposal activities of ACM, including notifications to TDEC for all demolition activities and required renovation activities. No releases of reportable quantities of ACM occurred at ORNL during CY 2009.

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).

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:

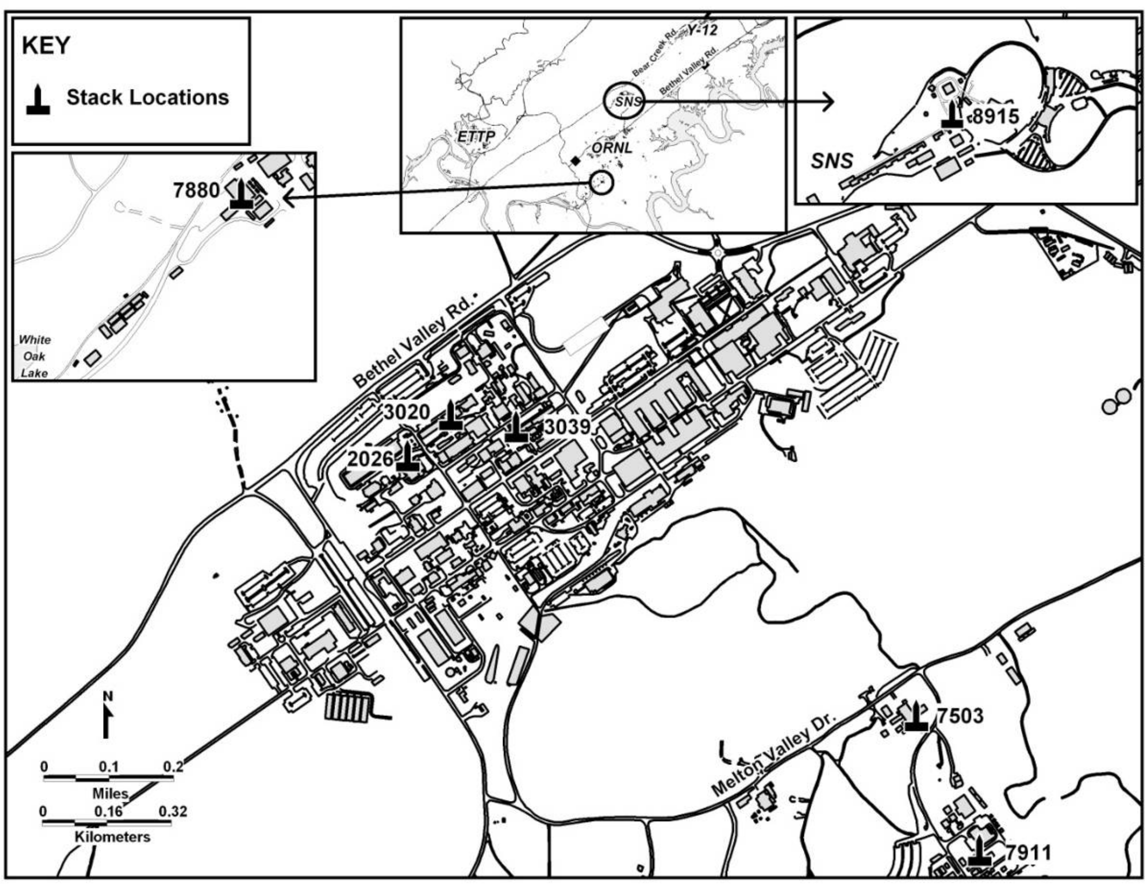

Fig. 5.12. Locations of major radiological emission points at ORNL.

- 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.

In 2009, there were 17 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 and some minor sources. The profiles provide accurate stack flow data for subsequent emission-rate calculations. An annual leak-check program is carried out to verify the integrity of the sample transport system. 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. The sampling system on Stack 7880 requires no other type of radionuclide collection media. 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. A probe-cleaning program for 7880 has established that rinse analysis has historically shown no detectable contamination. Therefore, the frequency of probe rinse collection and analysis is no more often than annually.

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 2009 are presented in Table 5.12. 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.

Historical trends for tritium and ^{131}I are presented in Figs. 5.13 and 5.14, respectively. The tritium emissions for 2009 totaled approximately 163.9 Ci (Fig. 5.13), which is an increase from 2008. The ^{131}I emissions for 2009 totaled 0.17 Ci (Fig. 5.14), which is a significant increase from the past 5 years. Increases in ^{131}I emissions were due to [Please see Pat Scofield].

For 2009, the major offsite dose contributors at ORNL were ^{138}Cs, ^{212}Pb, and ^{41}Ar with dose contributions of approximately 34%, 32%, and 11%, respectively. Emissions of ^{41}Ar result from HFIR operations and research activities and are emitted as a nonadsorbable gas from the 7911 Melton Valley complex stack. Emissions of ^{138}Cs result from research activities in the Radiochemical Engineering Development Center, which also exhausts through the 7911 Melton Valley complex stack. Emissions of ^{212}Pb result from the radiation decay of legacy material stored onsite and contamination areas containing isotopes of ^{228}Th, ^{232}Th, and ^{232}U. Emissions of ^{212}Pb were emitted from the following stacks: 2026, 3020, 3039, 7503, 7856, 7877, 7911, and the Sewage Treatment Plant (STP) Sludge Drier (Fig. 5.15). The calculated radiation dose to the maximally exposed off-site individual from all radiological airborne release points at ORNL during 2009 was 0.3 mrem. This dose is well below the NESHAP standard of 10 mrem and is less than 0.10 % 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.)

Table 5.12. Radiological airborne emissions from all sources at ORNL, 2009 (Ci)[a]

Isotope	Solubility	Stack								
		X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor source	ORNL total
^{225}Ac	M								2.50E–10	2.50E–10
^{228}Ac	M								7.49E–06	7.49E–06
^{110m}Ag	M								1.59E–9	1.59E–09
^{110m}Ag	S					2.25E–06				2.25E–06
^{241}Am	F				5.70E–09	1.15E–06			2.49E–09	1.16E–06
^{241}Am	M	7.68E–08	1.68E–07				1.22E–08		4.34E–08	3.00E–07
^{243}Am	M								6.38E–10	6.38E–10
^{41}Ar	G						8.40E+02	9.53E+00		8.50E+02
^{139}Ba	M						1.01E+00			1.01E+00
^{140}Ba	M						2.56E–04		1.96E–10	2.56E–04
^{140}Ba	S					1.44E–05				1.44E–05
^{7}Be	S			8.29E–06	4.36E–08	1.76E–05			4.62E–07	2.64E–05
^{7}Be	M		9.98E–08						6.01E–03	6.01E–03
^{212}Bi	M								1.58E–08	1.58E–08
^{214}Bi	M								2.61E–06	2.61E–06
^{11}C	G							7.66E+02		7.66E+02
^{14}C	M								1.69E–08	1.69E–08
^{45}Ca	M								8.55E–14	8.55E–14
^{141}Ce	M								9.35E–09	9.35E–09
^{144}Ce	M								2.97E–08	2.97E–08
^{252}Cf[b]	M						7.31E–09		1.67E–11	7.33E–09
^{242}Cm	M								5.65E–08	5.65E–08
^{243}Cm	F					6.30E–07			1.36E–09	6.31E–07
^{243}Cm	M								8.61E–12	8.61E–12
^{244}Cm	F			1.29E–07	3.32E–08	6.30E–07			1.34E–06	2.13E–06
^{244}Cm	M	4.32E–07	2.54E–08				1.12E–08		2.51E–09	4.71E–07
^{245}Cm	M								6.37E–11	6.37E–11
^{248}Cm	M								9.28E–19	9.28E–19
^{57}Co	M								2.09E–06	2.09E–06
^{58}Co	M								3.37E–07	3.37E–07
^{60}Co	M								1.52E–04	1.52E–04
^{60}Co	S			1.57E–06		2.67E–06				4.24E–06

Table 5.12 (continued)

Isotope	Solubility	Stack								
		X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor source	ORNL total
^{51}Cr	M								7.58E–10	7.58E–10
^{134}Cs	F								2.17E–08	2.17E–08
^{134}Cs	S					2.07E–06				2.07E–06
^{135}Cs	F								2.18E–13	2.18E–13
^{137}Cs	F	1.53E–06	1.12E–06				7.77E–06		3.80E–04	3.91E–04
^{137}Cs	S			2.26E–04	7.70E–09	2.46E–06			2.82E–04	5.11E–04
^{138}Cs	F						1.62E+03			1.62E+03
^{253}Es	M								5.35E–11	5.35E–11
^{152}Eu	M								4.28E–09	4.28E–09
^{154}Eu	M								3.94E–09	3.94E–09
^{155}Eu	M								7.25E–10	7.25E–10
^{156}Eu	M								1.38E–16	1.38E–16
^{55}Fe	M								2.30E–07	2.30E–07
^{59}Fe	M								1.17E–10	1.17E–10
^{153}Gd	M								1.06E–13	1.06E–13
^{3}H	S								3.59E–01	3.59E–01
^{3}H	V	1.01E+00		8.37E+00	1.75E+00		7.42E+01	6.61E+01	1.21E+01	1.64E+02
^{181}Hf	M								2.37E–12	2.37E–12
^{203}Hg	M								9.28E–07	9.28E–07
^{166}Ho	M								2.00E–10	2.00E–10
^{124}I	F								5.63E–16	5.63E–16
^{125}I	F							1.53E–01	1.08E–09	1.53E–01
^{126}I	F								6.45E–10	6.45E–10
^{129}I	F								1.07E–03	1.07E–03
^{131}I	F					6.69E–06	1.73E–01		4.95E–07	1.73E–01
^{132}I	F						7.48E–01			7.48E–01
^{133}I	F						5.91E–01			5.91E–01
^{134}I	F						1.00E+00			1.00E+00
^{135}I	F						1.33E+00			1.33E+00
^{192}Ir	M								1.01E–06	1.01E–06

Table 5.12 (continued)

Isotope	Solubility	Stack								
		X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor source	ORNL total
^{40}K	M								3.54E–05	3.54E–05
^{79}Kr	G							1.77E+01		1.77E+01
^{81}Kr	G								5.48E–15	5.48E–15
^{85}Kr	G						1.05E+03		5.53E–07	1.05E+03
^{85m}Kr	G						8.34E+00	5.45E+01		6.28E+01
^{87}Kr	G						8.61E+01	2.36E+01		1.10E+02
^{88}Kr	G						4.78E+01	9.62E+00		5.74E+01
^{89}Kr[c]	G						3.35E+01			3.35E+01
^{140}La	M						1.65E–02		5.89E–10	1.65E–02
^{140}La	S					6.54E–06				6.54E–06
^{54}Mn	S					2.31E–06				2.31E–06
^{54}Mn	M								3.48E–08	3.48E–08
^{93}Mo	M								9.49E–10	9.49E–10
^{99}Mo	M								2.33E–10	2.33E–10
^{13}N	G							1.67E+01		1.67E+01
^{22}Na	M								3.72E–14	3.72E–14
^{92}Nb[d]	M								6.27E–09	6.27E–09
^{93m}Nb	M								2.41E–11	2.41E–11
^{95}Nb	M								5.97E–08	5.97E–08
^{95m}Nb	M								1.84E–12	1.84E–12
^{59}Ni	M								1.06E–07	1.06E–07
^{63}Ni	M								1.34E–07	1.34E–07
^{237}Np	M								4.81E–11	4.81E–11
^{239}Np	M								2.74E–13	2.74E–13
^{191}Os	S			7.42E–04						7.42E–04
^{32}P	M								4.24E–10	4.24E–10
^{33}P	M								5.85E–13	5.85E–13
^{212}Pb	M	4.58E–01	5.45E–01				2.27E–02		9.45E–06	1.03E+00
^{212}Pb	S			9.53E–01	8.74E–02				1.67E–02	1.06E+00
^{210}Po	M								3.00E–14	3.00E–14

Table 5.12 (continued)

Isotope	Solubility	Stack								
		X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor source	ORNL total
^{238}Pu	F			3.40E–08	2.75E–09	1.57E–06			8.98E–10	1.61E–06
^{238}Pu	M	2.92E–08	1.40E–08				2.23E–09		3.30E–07	3.76E–07
^{239}Pu	F			9.30E–07	8.28E–09	6.95E–07			8.60E–10	1.63E–06
^{239}Pu	M	8.14E–08	1.34E–07				2.93E–09		1.98E–09	2.20E–07
^{240}Pu	F					6.95E–07			4.88E–10	6.95E–07
^{240}Pu	M								1.30E–09	1.30E–09
^{241}Pu	M								1.78E–07	1.78E–07
^{242}Pu	M								1.45E–14	1.45E–14
^{228}Ra	M								7.49E–06	7.49E–06
^{88}Rb	M							3.20E+00		3.20E+00
^{188}Re	M								4.15E–07	4.15E–07
^{103}Ru	M								3.50E–09	3.50E–09
^{106}Ru	M								1.01E–05	1.01E–05
^{106}Ru	S					1.97E–05			3.20E–04	3.40E–04
^{35}S	M								1.35E–08	1.35E–08
^{124}Sb	M								1.01E–07	1.01E–07
^{125}Sb	M								2.63E–07	2.63E–07
^{46}Sc	M								6.40E–11	6.40E–11
^{75}Se	F								1.41E–11	1.41E–11
^{75}Se	S			9.19E–05		1.95E–06				9.39E–05
^{113}Sn	M								1.60E–11	1.60E–11
^{119m}Sn	M								1.43E–10	1.43E–10
^{89}Sr	S			1.56E–05	6.90E–09				3.36E–05	4.92E–05
^{89}Sr	M	1.61E–07	8.25E–07				4.31E–06		6.99E–09	5.30E–06
^{90}Sr	M	1.61E–07	8.25E–07				4.31E–06		8.02E–04	8.07E–04
^{90}Sr	S			1.56E–05	6.90E–09	7.86E–06			3.36E–05	5.71E–05
^{179}Ta	M								5.95E–14	5.95E–14
^{182}Ta	M								5.80E–11	5.80E–11
^{99}Tc	M								1.03E–10	1.03E–10
^{99}Tc	S					9.85E–06				9.85E–06

Table 5.12 (continued)

Isotope	Solubility	Stack								
		X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor source	ORNL total
^{99m}Tc	M								2.98E–08	2.98E–08
^{129}Te	M								9.92E–12	9.92E–12
^{129m}Te	M								3.76E–07	3.76E–07
^{228}Th	S	8.59E–09	6.64E–09	2.32E–09	1.02E–09		8.86E–09		5.05E–10	2.79E–08
^{230}Th	F			8.75E–09	4.93E–10				1.08E–09	1.03E–08
^{230}Th	S	4.93E–09	2.46E–09				8.88E–09		1.38E–11	1.63E–08
^{232}Th	F			3.47E–09	2.56E–10				2.14E–10	3.94E–09
^{232}Th	S	1.09E–09	1.87E–09				5.89E–09		1.98E–11	8.87E–09
^{234}Th	S								3.49E–05	3.49E–05
^{232}U	M								2.82E–12	2.82E–12
^{233}U	M								4.62E–10	4.62E–10
^{233}U	S					4.48E–07			2.00E–05	2.05E–05
^{234}U	M	1.10E–07	9.55E–08				6.67E–08		7.16E–10	2.73E–07
^{234}U	S			1.45E–07	1.40E–08	4.48E–07			2.00E–05	2.06E–05
^{235}U	M	9.74E–09	7.97E–09				1.22E–08		1.00E–07	1.30E–07
^{235}U	S			1.43E–08	1.02E–09	9.69E–07			1.16E–06	2.15E–06
^{236}U	M								2.10E–14	2.10E–14
^{236}U	S								1.29E–06	1.29E–06
^{238}U	S			2.56E–08	8.50E–10	9.02E–07			1.94E–06	2.87E–06
^{238}U	M	4.45E–09	9.18E–09				2.53E–08		4.34E–05	4.35E–05
^{181}W	M								1.19E–11	1.19E–11
^{185}W	M								3.57E–08	3.57E–08
^{188}W	M								8.38E–08	8.38E–08
^{125}Xe	G							1.32E+01		1.32E+01
^{127}Xe	G							1.30E+01	6.86E–11	1.30E+01
^{129m}Xe	G								1.45E–10	1.45E–10
^{131m}Xe	G						1.12E+02		9.50E–08	1.12E+02
^{133}Xe	G						1.05E+01		8.92E–09	1.05E+01
^{133m}Xe	G						2.26E+01		5.43E–16	2.26E+01
^{135}Xe	G						5.57E+01			5.57E+01

Table 5.12 (continued)

Isotope	Solubility	Stack								
		X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor source	ORNL total
^{135m}Xe	G						4.08E+01			4.08E+01
^{137}Xe[e]	G						1.17E+02			1.17E+02
^{138}Xe	G						2.18E+02			2.18E+02
^{88}Y	F					3.38E–06				3.38E–06
^{88}Y	M								1.35E–13	1.35E–13
^{91}Y	M								1.60E–08	1.60E–08
^{65}Zn	F					5.22E–06				5.22E–06
^{65}Zn	M								2.35E–10	2.35E–10
^{88}Zr	M								1.08E–13	1.08E–13
^{95}Zr	S					4.47E–06				4.47E–06
^{95}Zr	M								2.67E–08	2.67E–08

[a] 1 Ci = 3.7E+10.
[b] Cf-248 was used as a surrogate for Cf-252.
[c] Kr-88 was used as a surrogate for Kr-89.
[d] Nb-94 was used as a surrogate for Nb-92.
[e] Xe-135 was used as a surrogate for Xe-137.

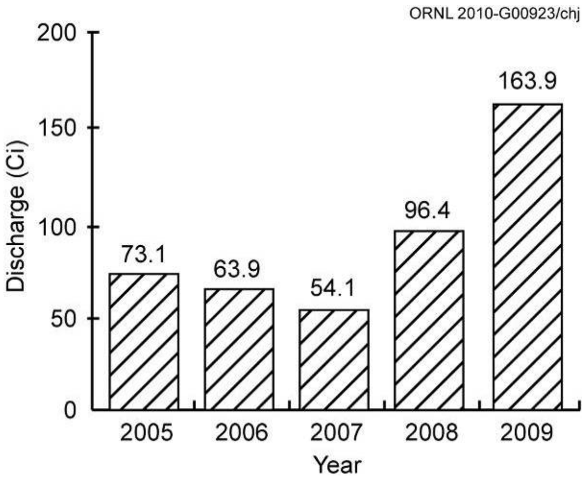

Fig. 5.13. Total discharges of ^{3}H from ORNL to the atmosphere, 2005–2009.

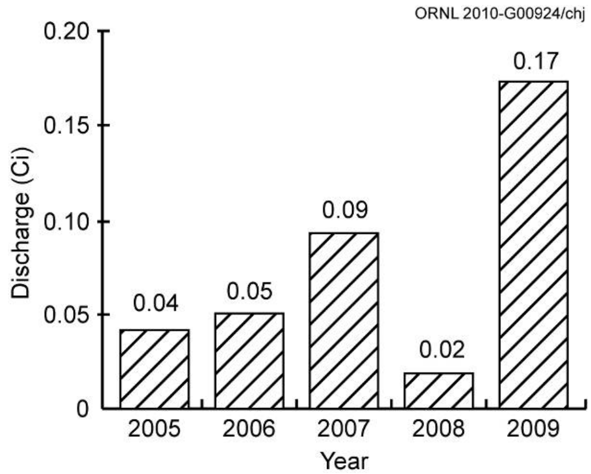

Fig. 5.14. Total discharges of ^{131}I from ORNL to the atmosphere, 2005–2009.

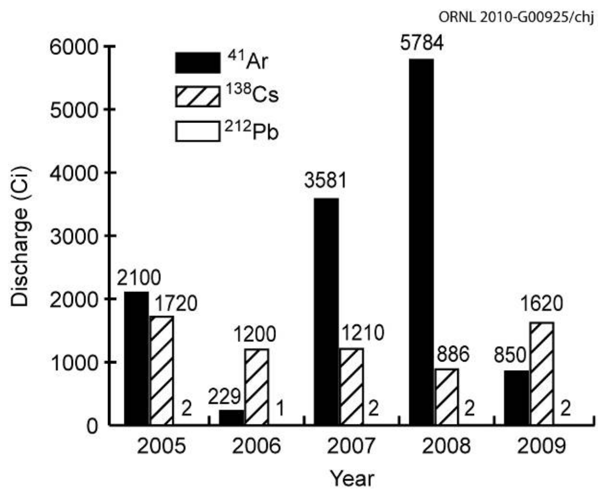

Fig. 5.15. Total discharges of ^{41}Ar, ^{138}Cs, and Pb-212 from ORNL to the atmosphere, 2005–2009.

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 intentionally 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 site perimeter air monitoring (PAM) stations most likely to show impacts of airborne emissions from ORNL and to provide information to support emergency response activities. Four stations, identified as Stations 1, 2, 3, and 7 (Fig. 5.16) make up the ORNL PAM network. Sampling is conducted at each station to quantify levels of tritium; adsorbable gases (e.g., iodine); and gross alpha-, beta-, and gamma-emitting radionuclides (Table 5.13).

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. A charcoal cartridge located behind the glass fiber particulate filter is used to collect adsorbable gases. The charcoal cartridges are changed out and analyzed bi-weekly. A silica-gel column is

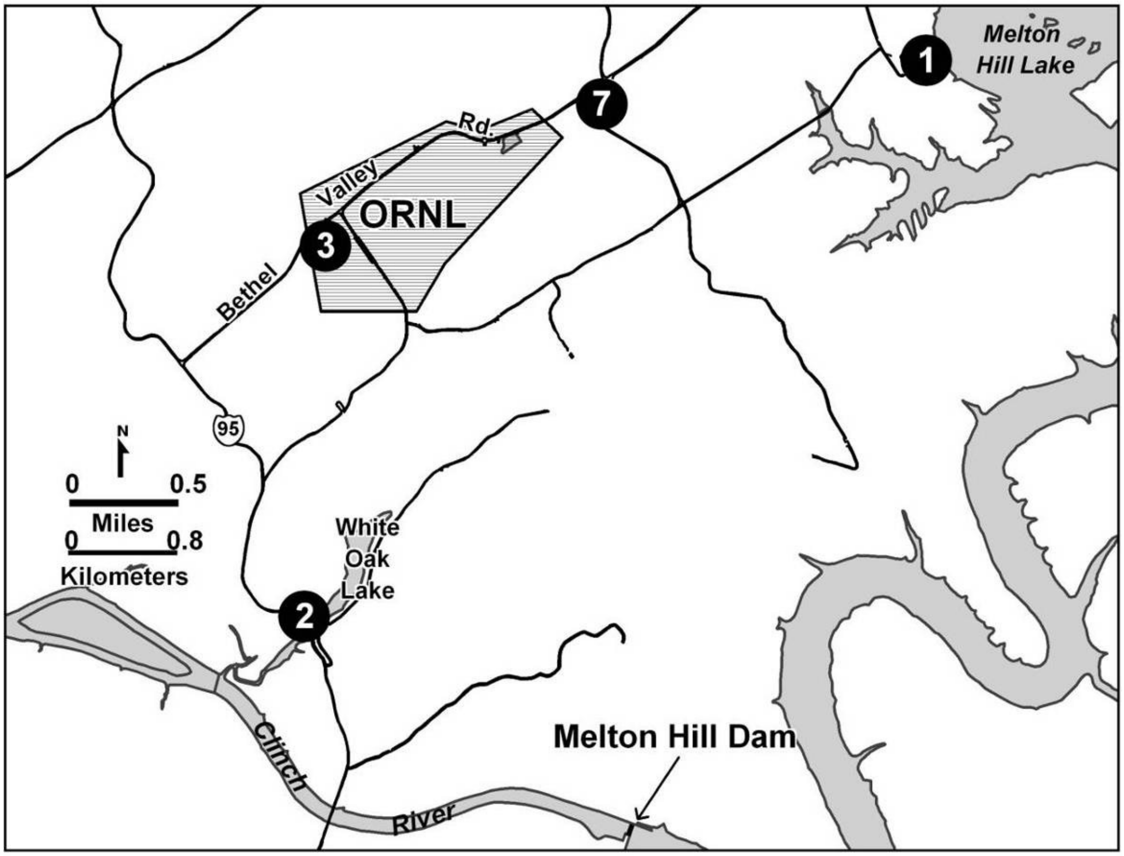

Fig. 5.16. Locations of ambient air monitoring stations at ORNL.

used for collection of tritium as tritiated water. These samples are collected biweekly or weekly, depending on ambient humidity levels, and composited quarterly for tritium analysis.

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 5.13) 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.

5.5 ORNL Water Quality Program

NPDES Permit (TN 0002941), issued to DOE for the ORNL site, was renewed by the state of Tennessee in 2008, and includes requirements for discharging wastewaters from the three ORNL on-site wastewater treatment facilities and for the development and implementation of a Water Quality Protection Plan (WQPP). The permit calls for the WQPP to “establish better linkages between water quality monitoring and detecting and abating water quality and ecological impact.” Rather than prescribing rigid monitoring schedules, the WQPP is flexible, allows an annual assessment of all outfalls, and focuses on significant findings. The goals of the WQPP are to meet the requirements of the NPDES permit, improve the quality of aquatic resources on the ORNL site, prevent further impacts to aquatic resources from current activities, identify the stressors that contribute to impairment of aquatic resources, use available resources efficiently, and communicate outcomes with decision makers and stakeholders.

Table 5.13. Radionuclide concentrations (pCi/mL)[a] measured at ORNL perimeter air monitoring stations, 2009

Parameter	No. detected/ sampled	Concentration		
		Average	Minimum	Maximum
		Station 1		
Alpha	1/1	4.08E–09	*b*	*b*
^{7}Be	1/1	2.48E–08	*b*	*b*
Beta	1/1	1.70E–08	*b*	*b*
^{3}H	2/4	3.26E–05	5.97E–07	1.25E–04[c]
^{40}K	27/27	2.14E–07	1.39E–07	3.4E–07
^{234}U	1/1	5.61E–12	*b*	*b*
^{235}U	0/1	1.65E–13	*b*	*b*
^{238}U	1/1	5.32E–12	*b*	*b*
		Station 2		
Alpha	1/1	4.46E–09	*b*	*b*
^{7}Be	1/1	2.30E–08	*b*	*b*
Beta	1/1	1.75E–08	*b*	*b*
^{3}H	2/4	5.45E–06	1.01E–06	7.77E–06
^{40}K	27/27	2.26E–07	1.04E–07	3.46E–07
^{234}U	1/1	5.78E–12	*b*	*b*
^{235}U	0/1	–1.95E–13	*b*	*b*
^{238}U	1/1	6.79E–12	*b*	*b*
		Station 3		
Alpha	1/1	3.82E–09	*b*	*b*
^{7}Be	1/1	2.31E–08	*b*	*b*
Beta	1/1	1.74E–08	*b*	*b*
^{3}H	2/4	3.73E–06	-6.10E–07	7.64E–06
^{40}K	27/27	2.66E–07	1.81E–07	4.03E–07
^{234}U	1/1	9.81E–12	*b*	*b*
^{235}U	0/1	1.72E–13	*b*	*b*
^{238}U	1/1	1.33E–11	*b*	*b*
		Station 7		
Alpha	1/1	6.12E–09	*b*	*b*
^{7}Be	1/1	2.35E–08	*b*	*b*
Beta	1/1	1.77E–08	*b*	*b*
^{3}H	1/4	3.64E–06	3.67E–07	6.45E–06
^{40}K	27/27	2.53E–07	1.78E–07	3.66E–07
^{234}U	1/1	7.95E–12	*b*	*b*
^{235}U	0/1	3.69E–13	*b*	*b*
^{238}U	1/1	7.53E–12	*b*	*b*

[a]1 pCi = 3.7×10^{-2} Bq.

[b]Not applicable.

[c]High bias to analytical results exists due to analytical issues encountered. However, biased value was reported.

The WQPP was developed by UT-Battelle and approved by TDEC in 2008, and initial rounds of WQPP monitoring were conducted in 2009. The WQPP incorporated several control plans that were required under the previous NPDES permit, including a Biological Monitoring and Abatement Plan (BMAP), a Chlorine Control Strategy, a Storm Water Pollution Prevention Plan, a Best Management

Practices Plan, and a Radiological Monitoring Plan. The WQPP will be reviewed, and if appropriate, revised annually, and submitted to TDEC for review and comment.

To prioritize the stressors and/or contaminant sources that may be of greatest concern to water quality, and to define conceptual models that would guide any special investigations, the WQPP strategy was defined using EPA's Stressor Identification Guidance (EPA 2000). A summary of this process is shown in Fig. 5.17. The Stressor Identification Guidance involves three major steps for identifying the cause of any impairment:

1. list candidate causes of impairment (based on historical data and a working conceptual model),
2. analyze the evidence (using both case study and outside data), and
3. characterize the cause.

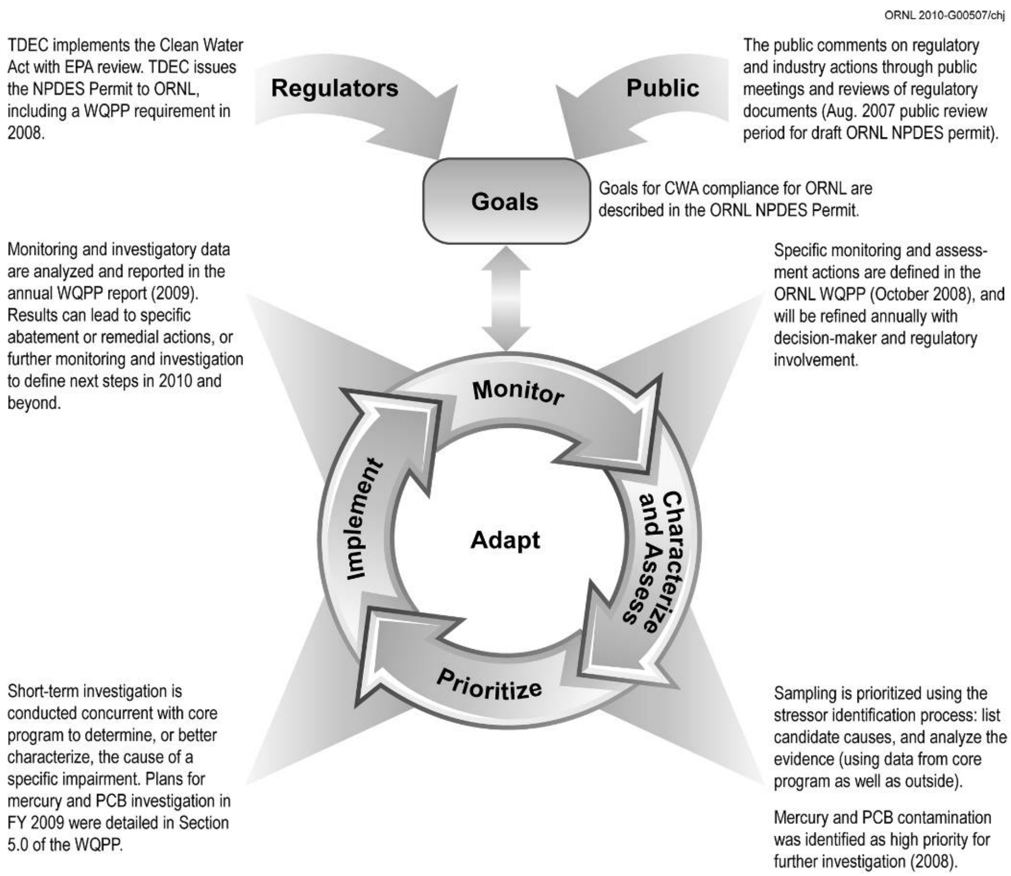

Fig. 5.17. Diagram of the adaptive management framework, with step-wise planning specific to the ORNL Water Quality Protection Plan. Adapted from EPA.

The first two steps of the stressor identification process were initiated in 2009; focusing first on mercury impairment (Fig. 5.18), and then on PCBs, since mercury and PCB concentrations in fish from White Oak Creek (WOC) are at or near human health risk thresholds (e.g., EPA ambient water quality criteria and TDEC fish advisory limits). Some of the major sources of mercury to biota in the WOC watershed are known, providing a good basis from which to define an appropriate conceptual model for mercury contamination in WOC. A list of potential causes of PCB contamination was also developed.

After listing potential causes and analyzing the available evidence on mercury and PCB contamination in the WOC watershed, it was clear that additional investigation was needed to complete the third step of the stressor identification process, "characterizing the cause." Special investigations were

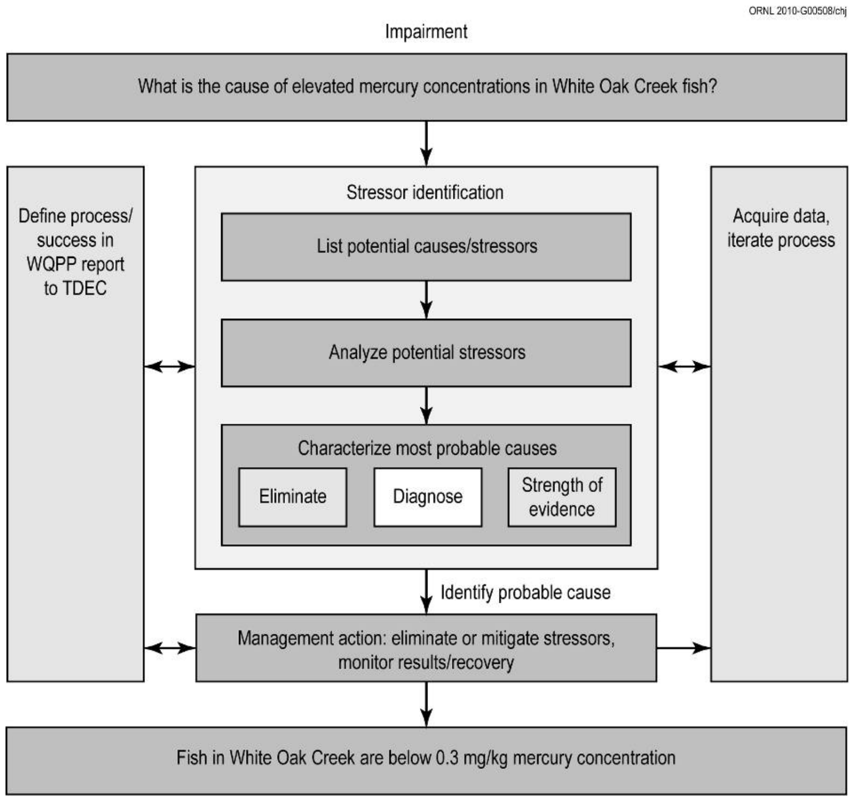

Fig. 5.18. Application of stressor identification guidance to address mercury impairment in the White Oak Creek watershed. Diagram modified from EPA.

designed to identify specific source areas and to revise the conceptual model of the major causes of contamination in the WOC watershed.

At the end of each year, monitoring and investigation data collected under the WQPP will be analyzed, interpreted, reported and compared with past results in the WQPP Annual Report. This information will provide a solid, overall assessment of the status of ORNL's receiving-stream watersheds and the impact of ongoing efforts to protect and restore those watersheds, and will guide efforts to improve the water quality in the watershed.

5.5.1 Treatment Facility Discharges

Three onsite wastewater treatment systems are operated at ORNL to provide appropriate treatment of the various research and development, operational, and domestic wastewaters generated by site staff and activities. All three are permitted to discharge treated wastewater and are monitored under National Pollutant Discharge Elimination System (NPDES) Permit TN 0002941, issued to DOE for the ORNL site by TDEC. These are the ORNL Sewage Treatment Plant (STP-Outfall X01), the Steam Plant Wastewater Treatment Facility (SPWTF - Outfall X02), and the Process Waste Treatment Complex (PWTC - Outfall X12). The ORNL NPDES Permit was renewed in August 2008, and current permit requirements include monitoring the three ORNL wastewater treatment facility effluents for conventional, water-quality-based, and radiological constituents, as well as for effluent toxicity, with numeric parameter-specific compliance limits established by TDEC as determined to be necessary (See Table 5.14 below and Table 2.8 in *Environmental Monitoring on the Oak Ridge Reservation: 2009 Results* (DOE 2009).

The results of field measurements and laboratory analyses to assess compliance for the parameters required by the NPDES permit, as well as rates of compliance with numeric limits established in the

Table 5.14. National Pollutant Discharge Elimination System (NPDES) compliance at ORNL, 2009

(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	26	100
Ammonia, as N (winter)	13.14	19.78	5.25	7.9		0	26	100
Carbonaceous biological oxygen demand	19.2	28.8	10	15		0	52	100
Dissolved oxygen					6	0	52	100
Escherichia coliform (col/100 mL)			941	126		0	52	100
IC_{25} for *Ceriodaphnia* (%)					15.5	0	2	100
IC_{25} for fathead minnows (%)					15.5	0	2	100
Oil and grease	19.2	28.8	10	15		0	12	100
pH (std. units)				9	6	0	52	100
Total suspended solids	57.5	86.3	30	45		0	52	100
X02 (Coal Yard Runoff Treatment Facility)								
pH (std. units)				9.0	6	0	51	100
Total suspended solids				50		0	6	100
X12 (Process Waste Treatment Complex)								
LC_{50} for *Ceriodaphnia* (%)					100	0	2	100
LC_{50} for fathead minnows (%)					100	0	2	100
Arsenic, total			0.007	0.014		0	6	100
Cadmium, total	1.73	4.60	0.003	0.038		0	6	100
Chromium, total	11.40	18.46	0.22	0.44		0	6	100
Copper, total	13.8	22.53	0.07	0.11		0	6	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	6	100
IC_{25} for *Ceriodaphnia* (%)					30.5	0	2	100
IC_{25} for fathead minnows (%)					30.5	0	2	100

Table 5.14 (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]
Oil and grease	66.7	100	10	15		0	12	100
pH (std. units)				9.0	6.0	0	52	100
Temperature (ºC)				30.5		0	52	100
Instream chlorine monitoring points								
Total residual oxidant			0.011	0.019		2	288	99.3

[a]Percentage compliance 100 – [(number of noncompliances/number of samples) × 100].

[b]Two exceedances at X19 in February 2009.

Abbreviations

LC50 the concentration (as a percentage of full-strength wastewater) that kills 50% of the test species in 48 h.

IC25 inhibition concentration; the concentration as a percentage of full-strength wastewater that caused 25% reduction in survival, reproduction, or growth of the test organisms.

permit, are also provided in Table 5.14. The three ORNL wastewater treatment facilities achieved 100% compliance with permit limits and conditions in 2009.

Effluent toxicity testing provides an assessment of any harmful effects that could occur from the total, combined constituents in the ORNL wastewater treatment facility effluents. The STP and SPWTF have been tested for toxicity to aquatic species under the NPDES Permit every year since 1986, and the PWTC since it went into operation in 1990. Test species have been *Ceriodaphnia dubia*, an aquatic invertebrate, and fathead minnow (*Pimephales promelas*) larvae. These have been tested using EPA chronic and acute test protocols at frequencies ranging from two to four times per year. Test results have been excellent. SPWTF and PWTC effluent have always been shown to be non-toxic. The STP has shown isolated indications of effluent toxicity, but confirmatory tests conducted as required by the permit have confirmed that either the result of the routine test was an anomaly or that the condition of toxicity that existed at the time of the routine test was temporary and of short duration.

Toxicity test requirements under the current NPDES Permit include testing of the STP and PWTC twice per year each, using two test species. The toxicity potential of the SPWTF was mitigated in 2003 by the removal of the ORNL Steam Plant's Coal Yard (the Steam Plant was converted from coal-burning to natural gas), thereby removing the need to treat and discharge coal yard storm water runoff. It was determined by TDEC that toxicity testing of the SPWTF effluent, which now includes only treated boiler blowdown and water-softener regeneration wastewaters from the ORNL Steam Plant, was no longer necessary. In 2009, toxicity test results for the ORNL wastewater treatment facilities were once again favorable, with no indication of toxicity in any of the tests that were conducted (see Table 5.14).

5.5.2 Residual Bromine and Chlorine Monitoring

Chlorine is added to drinking water to disinfect it and to keep it safe for consumption. Chlorine and bromine are added to cooling system water to prevent bacterial growth in the system. When waters are discharged to streams, residual chlorine and bromine can be toxic to fish and other aquatic life. The ORNL NPDES permit controls the discharge of chlorinated and bromated waters, reported as TRO, by limiting the TRO mass loading from outfalls and the TRO concentration instream. Outfalls with lower potential to discharge chlorinated water are generally monitored semiannually; outfalls with known sources that are dechlorinated are monitored more frequently to ensure operational integrity of the dechlorinator. Instream locations are monitored bimonthly.

NPDES permit outfalls are monitored for TRO to ensure effective operation of cooling towers and dechlorination systems and maintenance of water lines. When the permit action level of 1.2 grams per day is exceeded at an outfall, staff investigates and implements treatment and reduction measures. TRO is also monitored at instream points twice per month to verify that releases are not creating adverse conditions for fish and other aquatic life.

Thirty-one individual outfalls were checked for TRO either semiannually, quarterly, monthly, or bimonthly, throughout the year for a total of 259 attempts. Flow was detected 233 times. Table 5.15 lists instances in 2009 where outfalls were found to be in excess of the TRO action level. All cases have been investigated and determined to be from aging, underground water pipes that are leaking drinking water. Two outfalls, 265 and 368, on Fifth Creek exceeded the action level during 2009. There are water line leaks that contributed to a February 2009 exceedance of the TRO limit at X19, an instream monitoring point downstream of the outfalls. The limit is 0.05 mg/L and the measured value was 0.12 mg/L. Four outfalls on WOC exceeded the action level but did not lead to any instream TRO concentration exceedances.

Table 5.15. Outfalls exceeding total residual oxidant (TRO) action level[a] in 2009

Sample date	Outfall	TRO concentration (mg/L)	Flow (gpm)	Load (grams/ day)	Receiving stream	Downstream integration point	Instream TRO point
2/9/2009	265	0.85	20	92.7	Fifth Creek	FFK 0.2	X19
2/9/2009	368	0.8	15	65.4	Fifth Creek	FFK 0.2	X19
4/2/2009	368	0.7	14	53.4	Fifth Creek	FFK 0.2	X19
7/9/2009	368	1.25	9	61.3	Fifth Creek	FFK 0.2	X19
10/5/2009	368	0.85	5	23.2	Fifth Creek	FFK 0.2	X19
2/9/2009	207	0.35	8	15.3	White Oak Creek	WCK 3.9	X21
4/2/2009	207	0.6	3	9.8	White Oak Creek	WCK 3.9	X21
2/16/2009	227	0.85	4	18.5	White Oak Creek	WCK 3.9	X25
2/9/2009	304	0.15	8	6.5	White Oak Creek	WCK 3.9	X21
2/9/2009	312	0.35	4.5	8.6	White Oak Creek	WCK 3.9	X25
4/2/2009	312	0.3	4	6.5	White Oak Creek	WCK 3.9	X25
10/5/2009	312	0.35	5	9.5	White Oak Creek	WCK 3.9	X25

[a]1.2 grams per day.

5.5.3 Cooling Tower Blowdown Monitoring

In 2009, as part of the WQPP at ORNL, cooling tower blowdown effluents were monitored twice (in February and August) for field parameters (pH, conductivity, temperature, and dissolved oxygen) and were monitored once (in August) for chemical oxygen demand, total suspended solids, and total metals. All samples were grab samples.

Fourteen cooling tower/cooling tower systems (Table 5.16) were targeted for monitoring. Of those, three towers (2026, 2535, and 3047) were not operating during any sampling attempts and therefore were not sampled. Three towers (3517, 7902 and 7923) were not operating during the February sampling event but were operating and were sampled during the August sampling event.

Where possible, cooling towers were sampled at the outfalls where blowdown is discharged to the receiving streams. In a few instances, tower water was sampled at the basin under the cooling tower. This was necessary in cases where it was not possible to determine if and when blowdown was present at the outfall. The release of cooling tower blowdown is intermittent, and its presence or absence can be masked when blowdown is commingled with other wastewaters prior to discharge. In some cases, outfall pipes could not be sampled because they were submerged by the receiving stream. Field measurements are presented in Table 5.17. Results for laboratory analyses are presented in Table 5.18.

Table 5.16. Cooling tower/cooling tower systems monitored at ORNL

Cooling tower/ tower system	NPDES outfall receiving blowdown	Sampled location
2026	249	N/A (tower not operating during sampling attempts)
2535	204	N/A (tower not operating during sampling attempts)
2539	204	Tower Basin
3047	367	N/A (tower not operating during sampling attempts)
3517	304	Tower Basin
4510/4521	014	Outfall
5300	363	Outfall
5600	227	Outfall
6001	314	Tower Basin
7619	291	Outfall
7626	191	Outfall
7902	281	Outfall
7923	481	Outfall
8913	435	Outfall

Table 5.17. Field measurements collected in blowdown from ORNL cooling towers

Cooling tower[a]	Sampled location	Date	Flow[b] (gpm)	Conductivity (mS/cm)	Dissolved oxygen (mg/L)	pH (std. unit)	Temperature (deg C)
2539	2539 basin	2/12/2009	Unknown	0.62	6.1	7.9	12.2
2539	2539 basin	8/18/2009	Unknown	0.69	9	7.9	24.2
3517	3517 basin	2/12/2009	Tower was not operating during Feb. sampling attempt				
3517	3517 basin	8/18/2009	Unknown	0.357	8.2	8.1	26.3
5300	Outfall 363	2/12/2009	6	0.71	6.4	8	12
5300	Outfall 363	8/18/2009	6.5	0.838	6.9	8.4	26
5600	Outfall 227	2/12/2009	10	0.83	6.8	8	14.7
5600	Outfall 227	8/18/2009	20	0.49	7	8.4	31.7
6001	6001 basin	2/12/2009	Unknown	1.2	5.9	8.2	23.9
6001	6001 basin	8/18/2009	Unknown	1.19	7.8	8.1	26.2
7619	Outfall 291	2/12/2009	65	0.329	6.8	8.3	8.8
7619	Outfall 291	8/18/2009	0.5	0.271	7	7.6	22.6
7626	Outfall 191	2/12/2009	130	0.407	7.2	7.8	8.8
7626	Outfall 191	8/18/2009	4	0.387	7.1	7.8	23.7
7902	Outfall 281	2/12/2009	Tower was not operating during Feb. sampling attempt				
7902	Outfall 281	8/18/2009	95	1.59	7.3	7.9	27.1
7923	Outfall 481	2/12/2009	Tower was not operating during Feb. sampling attempt				
7923	Outfall 481	8/18/2009	Unknown	1.06	7.7	8.9	28.8
8913	Outfall 435	2/12/2009	90	0.05	6.8	7.3	10.3
8913	Outfall 435	8/18/2009	75	0.419	7.9	8	20.1
4510/4521	Outfall 014	2/12/2009	15	0.98	5.9	9	23.2
4510/4521	Outfall 014	8/18/2009	50	1.17	9	8.2	28

[a]Cooling Towers 2026, 2535, 3047 were not operating during either the February or August sampling attempts and are therefore not included in the table above.

[b]Cooling tower blowdown flow rates are not known for towers that were sampled at the tower basins.

Table 5.18. Results (in mg/L) from laboratory analyses of blowdown from ORNL cooling towers

Date sampled: August 18, 2009

	Cooling tower (sampled location)										
	2539 (2539 basin)	**3517 (3517 basin)**	**5300 (OF 363)**	**5600 (OF 227)**	**6001 (6001 basin)**	**7619 (OF 291)**	**7626 (OF 191)**	**7902 (OF 281)**	**7923 (OF 481)**	**8913 (OF 435)**	**4510/4521 (OF 014)**
Chemical oxygen demand	25.5	J 14.7	30.9	J 12	90.4	J 14.7	J 12	30.9	52.5	J 6.59	174
Total suspended solids	<2	<2	13	2	8	3	<2	<2	<2	2	2
Ag	<0.000619	<0.000619	<0.000619	<0.000619	<0.000619	<0.000619	<0.000619	<0.000619	<0.000619	<0.000619	<0.000619
As	<0.001	<0.001	<0.001	<0.001	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	0.00371
Be	<0.000686	<0.000686	<0.000686	<0.000686	<0.000686	<0.000686	<0.000686	<0.000686	<0.000686	<0.000686	<0.000686
Ca	88.1	45.8	133	57	156	38	52	239	162	40.3	167
Cd	<0.000782	<0.000782	<0.000782	<0.000782	<0.000782	<0.000782	<0.000782	<0.000782	<0.000782	<0.000782	<0.000782
Cr	<0.001	<0.001	0.00109	<0.001	0.132	<0.001	<0.001	0.00135	0.00112	<0.001	<0.001
Cu	0.00594	0.0186	0.0961	0.109	0.428	<0.001	<0.001	0.00271	0.11	<0.001	0.00608
Fe	0.562	<0.0206	0.393	0.0603	0.126	1.19	0.151	0.15	0.146	0.142	0.0207
Mg	24.7	13.5	35.4	15	46.9	10.2	9.69	65.7	47	11	48.2
Mn	0.00719	<0.000953	0.0241	0.00831	0.00943	4.72	0.0355	0.00269	0.0112	0.113	0.0032
Mo	0.795	<0.000931	0.346	1.89	0.67	<0.000931	0.0036	0.00335	0.00187	0.00326	0.819
Ni	0.00278	<0.00138	0.00345	0.00159	0.00489	0.0027	0.00187	0.00558	0.00384	<0.00138	0.00405
Pb	<0.001	<0.001	<0.001	<0.001	0.00223	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sb	<0.00081	<0.00081	<0.00081	<0.00081	<0.00081	<0.00081	<0.00081	0.00223	<0.00081	<0.00081	0.00279
Se	<0.0406	<0.0406	<0.0406	<0.0406	0.0621	<0.0406	<0.0406	<0.0406	<0.0406	<0.0406	<0.0406
Zn	0.158	0.145	0.202	0.0657	0.278	< 0.02	0.0342	0.0742	0.167	0.12	0.218

[a]Towers 2026, 2535, and 3047 were not operating during the time that analytical samples were collected.

[b]Prefix "J" indicates that the value was estimated at or below the analytical detection limit by the laboratory.

The state of Tennessee has established water quality criteria (WQC) for instream temperature as a basis to control the effects of wastewater discharges on receiving waters designated for fish and aquatic life, recreation, domestic water supply, and/or industrial water supply uses. The WQC addresses maximum instream temperature (30.5°C), maximum rate of instream temperature change (2°C per hour), and instream temperature change relative to an upstream control point (3°C). Monitoring of instream temperature in the vicinity of the major cooling water discharges at ORNL was conducted on August 17, 2009. Monitoring was targeted to the third calendar quarter of the year when stream flows are typically low, air and water temperatures are warm and cooling demand is typically at a maximum. Four rounds of grab sample measurements for temperature were collected on the day of monitoring both upstream and downstream of the cooling tower discharges. Individual temperature measurements are presented in Table 5.19. No instream temperature measurement exceeded the maximum criteria of 30.5°C. Upstream to downstream temperature change for the monitored stream reaches were calculated for each of the four rounds of measurements (see Table 5.20). For all rounds, the measured temperature changes across all monitored stream reaches were less than the maximum change criteria of 3°C. The rates of instream temperature change between rounds of measurements were also calculated for each stream reach. No rates of change exceeded the criteria of 2°C per hour (see Table 5.20).

Table 5.19. Field measurements from 2009 instream temperature assessment

Monitoring date: August 17, 2009

Monitoring location	Field measurements							
	Round 1		Round 2		Round 3		Round 4	
	Temp. (deg C)	Time (EDT)	Temp. (deg C)	Time (EDT)	Temp. (deg C)	Time (EDT)	Temp. (deg C)	Time (EDT)
Upstream of Outfall 014	23.3	09:15	24.0	10:58	24.5	13:14	25.2	14:45
Downstream of Outfall 014	23.3	09:13	24.1	10:59	24.5	13:15	25.3	14:46
Upstream of Outfall 227	23.2	09:20	23.2	11:04	24.0	13:11	24.1	14:40
Downstream of Outfall 227	23.1	09:18	23.2	11:05	26.0	13:12	24.7	14:41
Upstream of Outfall 281	21.6	09:40	22.0	10:49	23.2	13:35	23.8	15:15
Downstream of Outfall 281	23.8	09:38	24.0	10:46	25.5	13:36	26.0	15:16
Upstream of Outfall 314	20.0	09:31	20.6	11:12	21.0	13:29	21.8	14:56
Downstream of Outfall 314	22.7	09:30	22.6	11:13	22.8	13:30	23.2	14:58
Upstream of Outfall 363	17.9	09:28	18.1	10:55	18.8	13:20	19.0	14:48
Downstream of Outfall 363	18.0	09:26	18.6	10:54	19.2	13:18	19.2	14:50
Upstream of Outfall 435	16.6	09:31	16.9	11:18	18.0	13:24	18.9	15:04
Downstream of Outfall 435	16.9	09:30	17.5	11:20	18.6	13:25	19.4	15:06

5.5.4 Radiological Monitoring

Beginning in 2009, monitoring of effluents and instream locations for radioactivity that was previously conducted under the ORNL Radiological Monitoring Plan was reorganized under the ORNL WQPP. Monitoring established under the former Radiological Monitoring Plan for instream locations X13, X14, and X15 and the three major treatment facility discharges (Outfalls X01, X02, and X12) continued unchanged under the WQPP, with the exception that an analysis for $^{89/90}Sr$ was added to the monthly monitoring requirements for Outfall X02, the discharge from the SPWTF. Monitoring was adjusted for some category outfalls based on a review of data collected under the previous Radiological Monitoring Plan. Category outfalls are outfalls that discharge effluents with relatively minor constituents that receive little or no treatment prior to discharge. Those adjustments resulted in a net increase in analyses for dry-weather discharges from category outfalls. Sampling of radioactivity in stormwater from individual category outfalls was not conducted in 2009. Table 5.21 details the monitoring frequency and

Table 5.20. Measurements of instream temperature change for stream reaches receiving cooling tower blowdown at ORNL

Monitoring date: August 17, 2009

Stream reach assessed (discharge outfall/cooling system)	Temperature change over length of stream reach (upstream to downstream of cooling system)				Rate of temperature change at downstream end of stream reach between rounds of sampling		
	Round 1 (deg C)	Round 2 (deg C)	Round 3 (deg C)	Round 4 (deg C)	Round 1 to Round 2 (deg C/hour)	Round 2 to Round 3 (deg C/hour)	Round 3 to Round 4 (deg C/hour)
OF 014/ 4510&4521 Cooling System	0.0	0.1	0.0	0.1	0.5	0.2	0.5
OF 227/ 5600 Cooling System	–0.1	0.0	2.0	0.6	0.1	1.3	–0.9
OF 281/ 7902 Cooling System	2.2	2.0	2.3	2.2	0.2	0.5	0.3
OF 314/ 6001 Cooling System	2.7	2.0	1.8	1.4	–0.1	0.1	0.3
OF 363/ 5300 Cooling System	0.1	0.5	0.4	0.2	0.4	0.2	0.0
OF 435/ 8913 Cooling System	0.3	0.6	0.6	0.5	0.3	0.5	0.5

Table 5.21. ORNL National Pollutant Discharge Elimination System Radiological Monitoring Plan

Location	Frequency	Gross alpha/beta[a]	Gamma scan	Tritium	Total rad Sr	Isotopic uranium	Carbon 14	Cm-243/244
Outfall 001	Annually	X						
Outfall 080	Monthly	X	X	X	X			X
Outfall 081	Annually	X						
Outfall 085	Quarterly	X	X	X	X	X		
Outfall 203 [b]	Annually	X	X		X			
Outfall 204	Semiannually	X	X		X			
Outfall 205 [b]	Annually	X						
Outfall 207	Quarterly	X	X		X			
Outfall 211	Annually	X						
Outfall 217	Annually	X						
Outfall 219	Annually	X						
Outfall 234	Annually	X						
Outfall 241	Quarterly	X	X	X	X	X		
Outfall 265	Annually	X						
Outfall 281	Quarterly	X		X				
Outfall 282	Quarterly	X						
Outfall 284 [b]	Annually	X						
Outfall 302	Monthly	X	X	X	X			
Outfall 304	Monthly	X	X	X	X			
Outfall 365	Semiannually	X						
Outfall 368	Annually	X						
Outfall 383	Annually	X		X				
Sewage Treatment Plant (X01)	Monthly	X	X	X	X		X	
Coal Yard Runoff Treatment Facility (X02)	Monthly	X			X			
Process Waste Treatment Complex (X12)	Monthly	X	X	X	X	X		
Melton Branch 1 (X13)	Monthly	X	X	X	X			
WOC (X14)	Monthly	X	X	X	X			
WOD (X15)	Monthly	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]No discharge present.

target analyses for the three treatment facility outfalls, three instream monitoring locations, and 22 category outfalls.

Dry-weather discharges from category outfalls are primarily cooling water, groundwater, and condensate. Low levels of radioactivity can be discharged from category outfalls in areas where groundwater contamination exists and where groundwater enters category outfall collection systems from building and facility sumps, building footer drains, and direct infiltration. In 2009, dry-weather grab samples were collected at 19 of the 22 category outfalls targeted for sampling. The remaining three outfalls were not sampled because there was no discharge present during sampling attempts.

The three treatment facilities monitored were the STP, the SPWTF and the PWTC. Three instream monitoring locations were: X13 on Melton Branch, X14 on White Oak Creek, and X15 at White Oak Dam (WOD) (Fig. 5.19). At each of these treatment facilities and instream monitoring stations, monthly flow-proportional composite samples were collected using dedicated automatic water samplers.

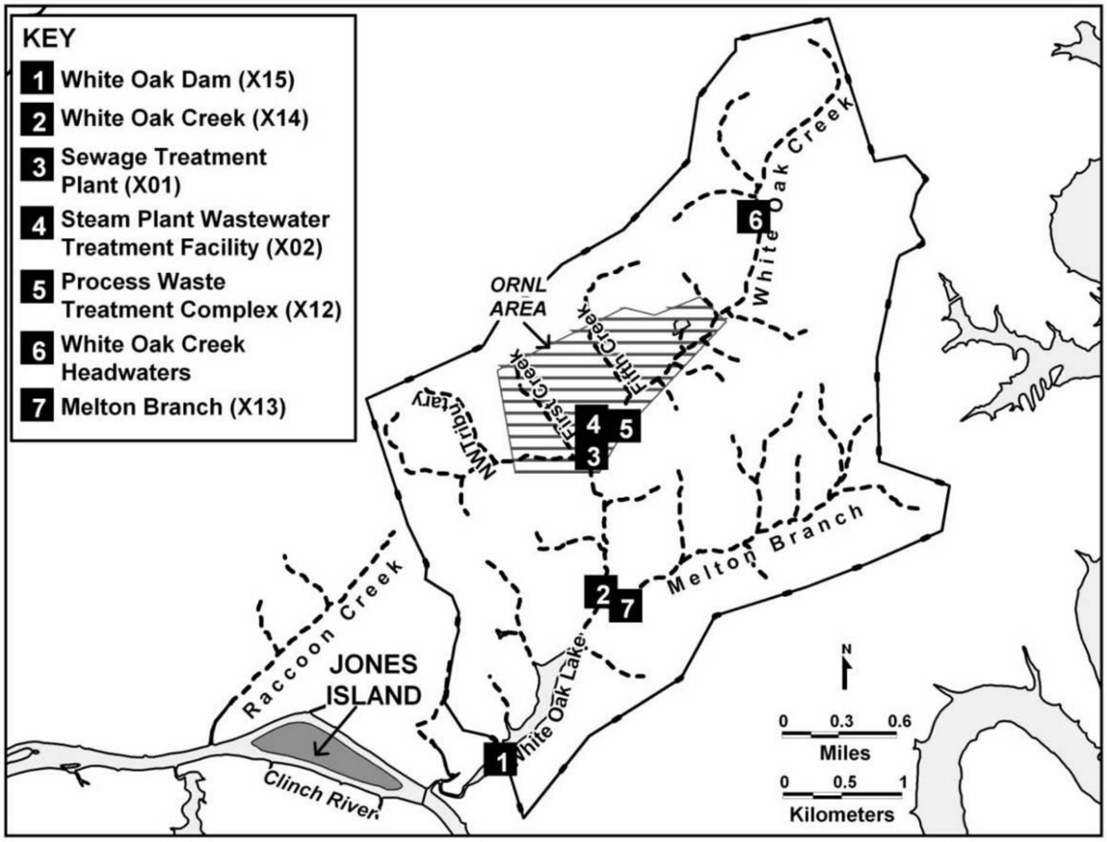

Fig. 5.19. ORNL surface water, National Pollutant Discharge Elimination System, and reference sampling locations.

Expressing radioactivity concentrations as percentage of the DOE DCG values is used in this section as a means of comparing effluent points with different radioisotope signatures. Annual average concentrations were compared with DCG concentrations where applicable (there are no DCGs for gross alpha and gross beta activities) and when at least one individual measurement indicated detectable activity (i.e., at least one individual measurement had a concentration greater than or equal to the measurement's minimum detectable activity [MDA]). For analyses that cannot differentiate between two radioisotopes (e.g., $^{89/90}$Sr), and for radioisotopes that have more than one DCG for different gastrointestinal tract absorption factors, the most restrictive (lowest) DCG was used in the comparisons. DCGs are not intended to be thresholds for instream values as they are for effluents, but are nonetheless useful as a frame of reference. Effluents and instream concentrations are compared to DCGs that were calculated for exposures to humans by ingesting water, but their use in this section does not imply that ORNL effluents or ambient waters are sources of drinking water.

In 2009, there were no measured annual average concentrations of radioactivity that exceeded 100% of DCG concentrations. The annual average concentration of at least one radionuclide exceeded 4% of the relevant DCG concentration in dry-weather discharges from eight NPDES outfalls (080, 085,204, 241, 302, 304, X01, and X12) and at instream sampling locations X13, X14, and X15. Four percent of the DCG is roughly equivalent to the 4-mrem dose limit on which the EPA radionuclide drinking water standards are based (4% of a DCG is a convenient comparison point, but it should not be concluded that ORNL effluents or ambient waters are direct sources of drinking water) (Fig. 5.20).

The total annual discharges (or amounts) 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. 5.21 through 5.25. CY 2009 discharges at White Oak Dam continue to be generally decreased in comparison to years

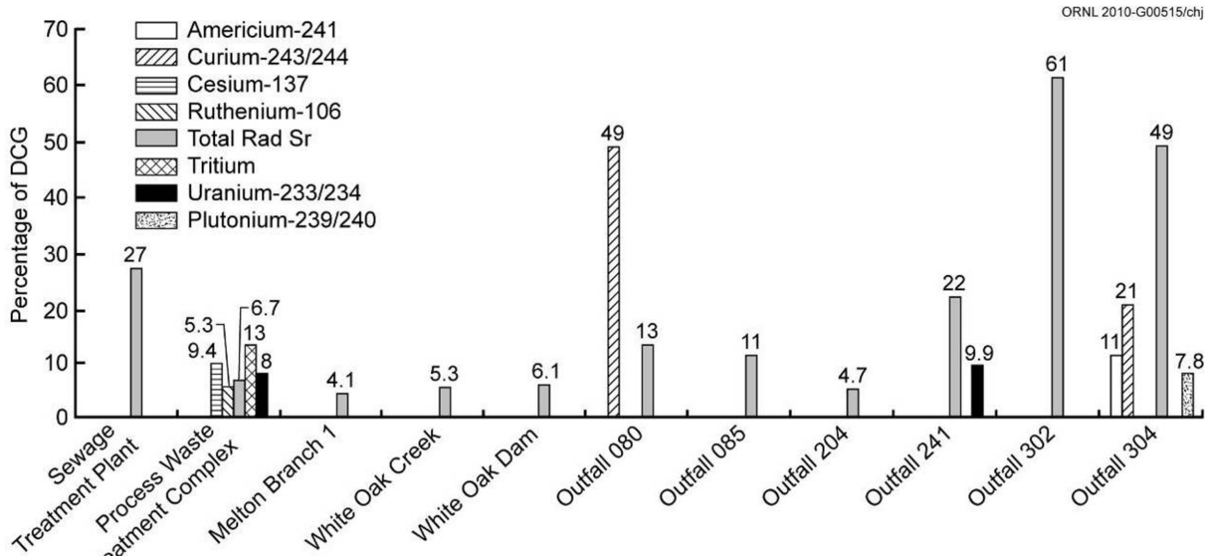

Fig. 5.20. Radionuclides at ORNL sampling sites having average concentrations greater than 4% of the relevant derived concentration guides in 2009.

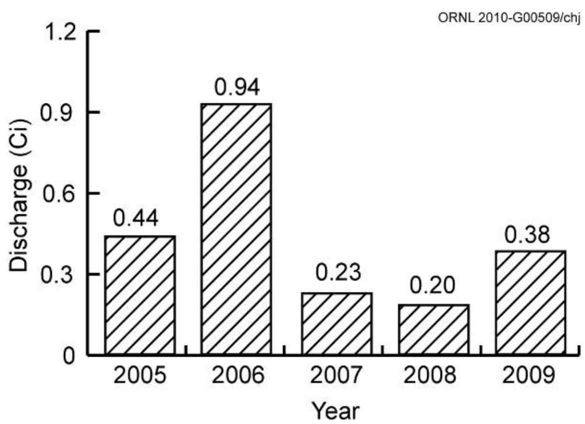

Fig. 5.21. Cesium-137 discharges at White Oak Dam, 2005–2009.

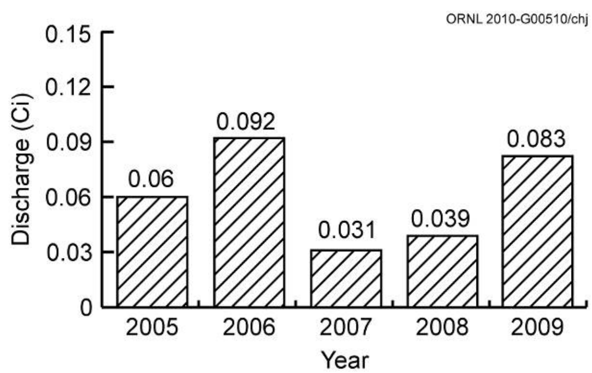

Fig. 5.22. Gross alpha discharges at White Oak Dam, 2005–2009.

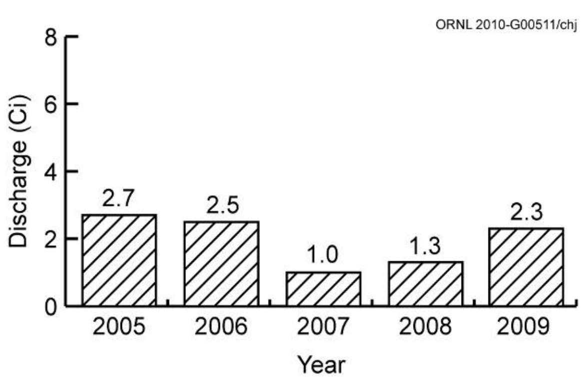

Fig. 5.23. Gross beta discharges at White Oak Dam, 2005–2009.

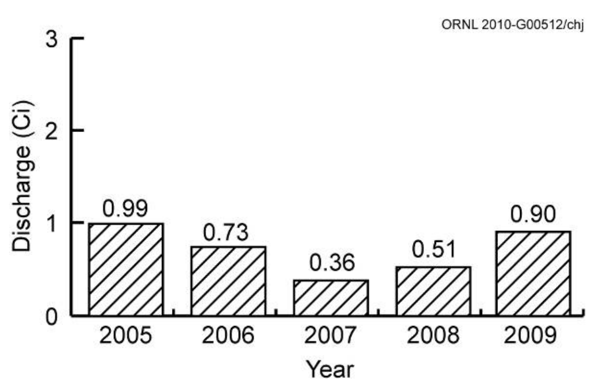

Fig. 5.24. Total radioactive strontium discharges at White Oak Dam, 2005–2009.

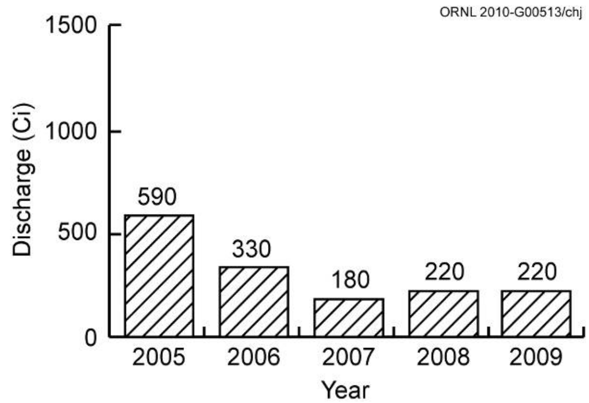

Fig. 5.25. Tritium discharges at White Oak Dam, 2005–2009.

preceding completion of the waste area caps in Melton Valley, though they were somewhat higher than the previous two years, most likely as a result of higher instream flow volume in 2009 as compared to those years (see Fig. 5.26).

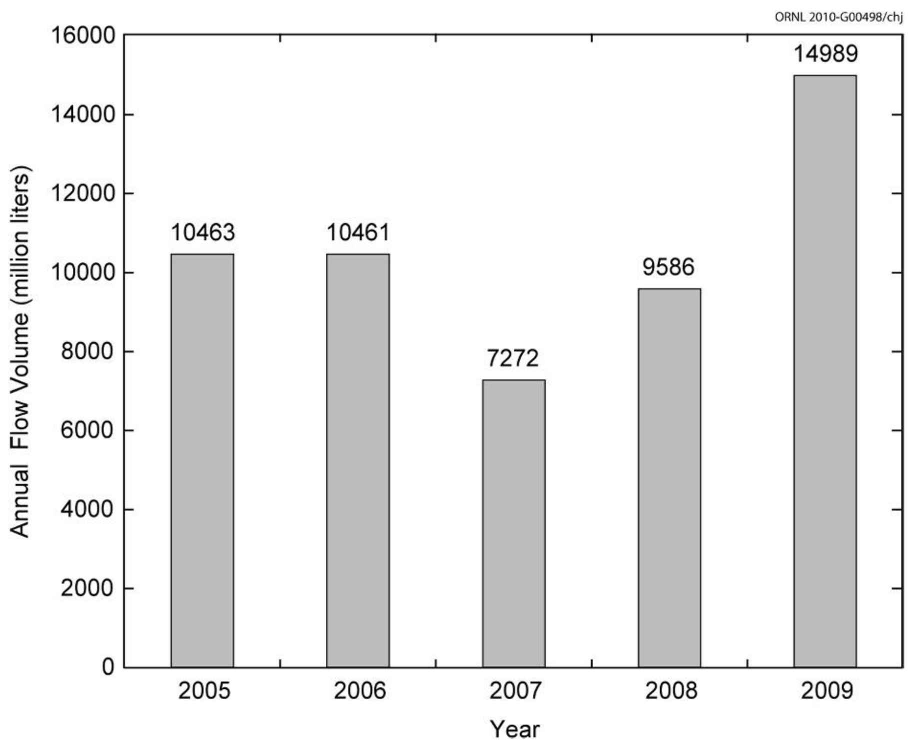

Fig. 5.26. Annual flow volume at White Oak Dam, 2005–2009.

5.5.5 Total Mercury and Methylmercury

Legacy mercury environmental contamination exists at ORNL, due largely to spills and releases that occurred in the 1950s during isotope separation pilot-scale work. Four ORNL facilities were involved, Buildings 3503, 3592, 4501, and 4505, and as a result, mercury is present in soils and groundwater in and around these facilities. Mercury also is present in Fifth Creek and White Oak Creek surface streams that receive surface runoff and groundwater flow from the area of these buildings.

Process wastewater drains and building sumps from Buildings 4501 and 4505, the facilities where most of the ORNL mercury work was conducted, are routed via underground collection-system piping to the ORNL PWTC for treatment to remove constituents including mercury prior to discharge to White Oak Creek. In 2007, another groundwater sump in Building 4501 that had been found to accumulate legacy mercury contamination from building foundation drains was rerouted from storm drain Outfall 211 to the PWTC, and in 2009 a mercury pretreatment unit was installed in Building 4501 to remove most of the mercury from the sump discharge before its routing to the PWTC for final treatment. These recent actions have significantly diminished the release of legacy mercury contamination from the ORNL site to the White Oak Creek watershed (see Fig. 5.27).

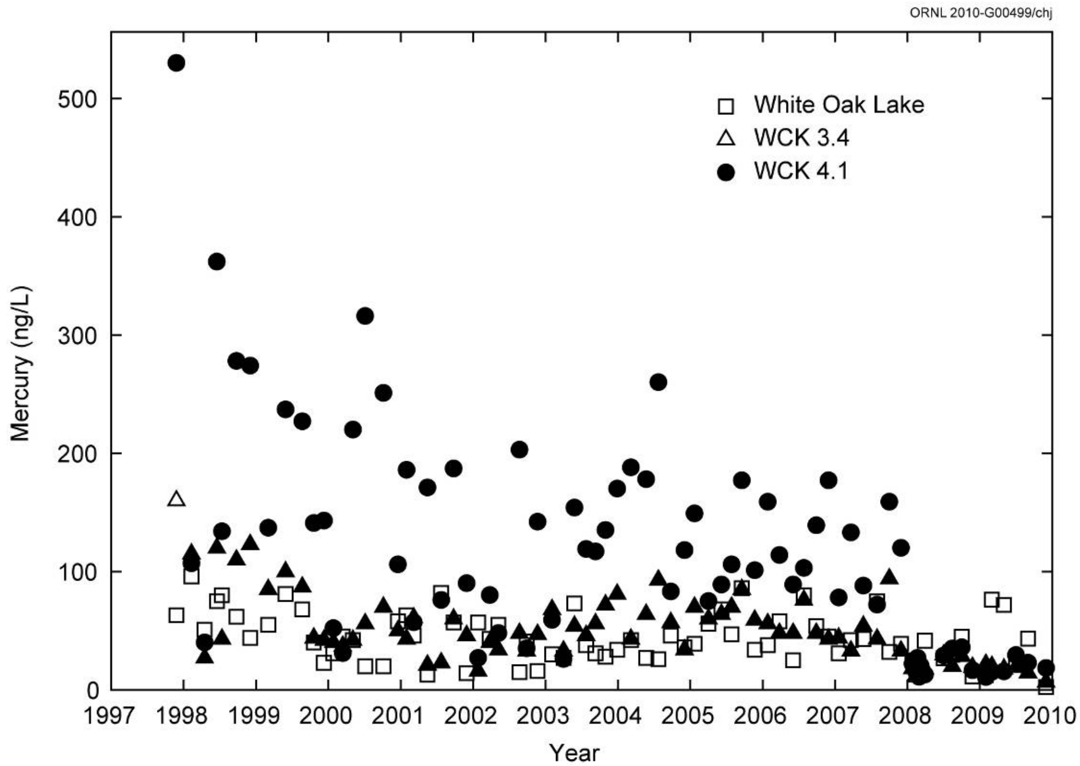

Fig. 5.27. Total aqueous mercury concentrations at sites in White Oak Creek downstream from ORNL, 1998–2009.

For the mercury-investigation component of the WQPP, data collected during initial monitoring may lead to effluent sampling at additional outfalls in future WQPP revisions and are expected to help prioritize future abatement actions and help delineate mercury sources. Depending on the results of the 2009 characterization, follow-up efforts would be narrower in scope, focusing on more precise source identification, mechanism of mercury mobilization, or temporal variability of inputs from the most significant sources.

In 2009, monitoring conducted under the WQPP included spring and fall rounds of dry-weather samples collected and analyzed from a number of instream points in the White Oak Creek watershed upstream, within, and downstream from the ORNL facilities complex and from certain ORNL NPDES outfalls where previous monitoring or site history has shown the potential for effluent mercury. Flow measurements were made for instream and outfall sampling locations, and analyses were conducted for total mercury, dissolved total mercury, methylmercury, and dissolved methyl mercury. Concentration and flux values were measured and calculated. Selected results of the 2009 monitoring are shown in Figs. 5.28 through 5.31, and complete mercury monitoring results can be found in the 2009 Environmental Monitoring Results (DOE 2009).

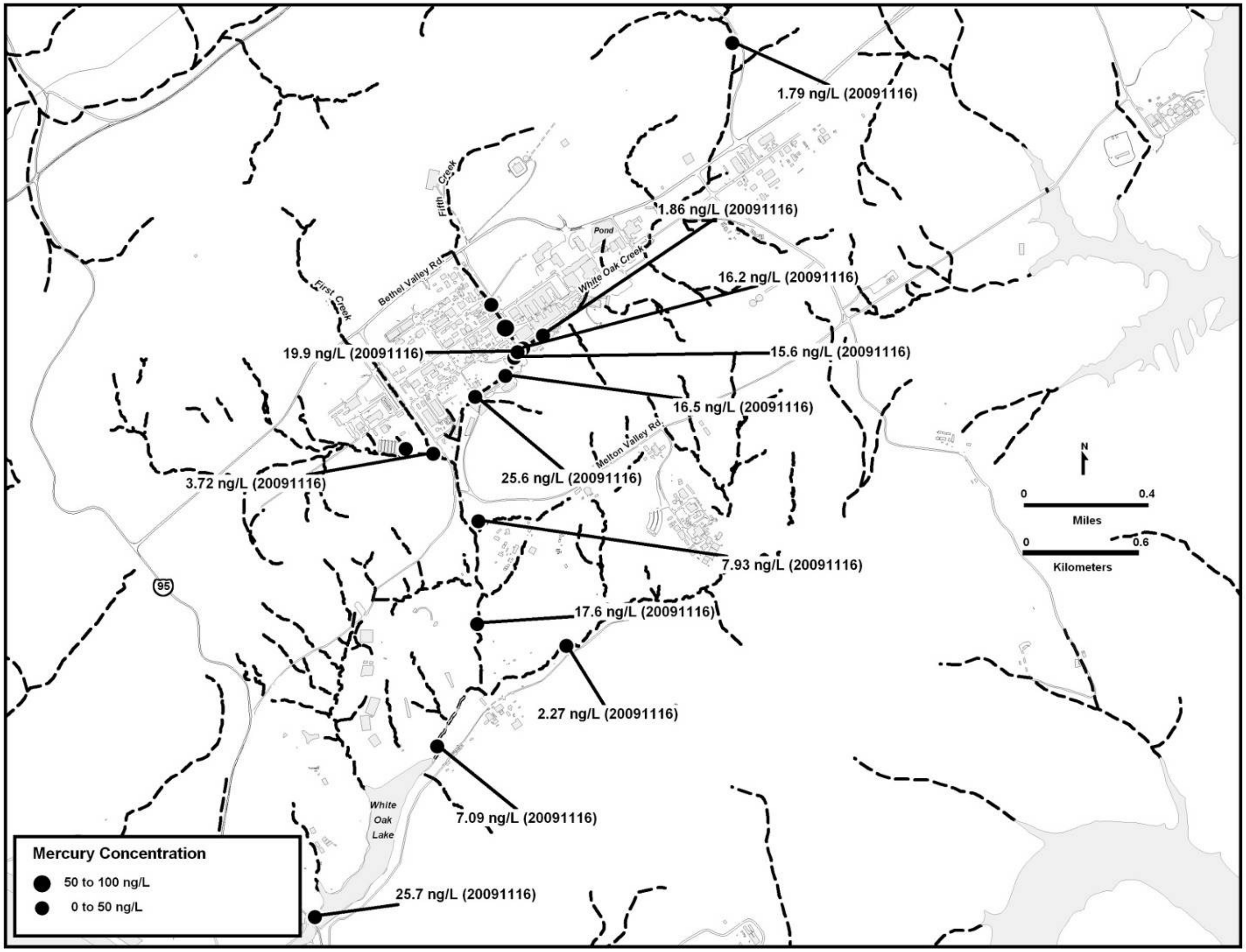

Fig. 5.28. Concentrations of total mercury in the White Oak Creek watershed, November 2009.

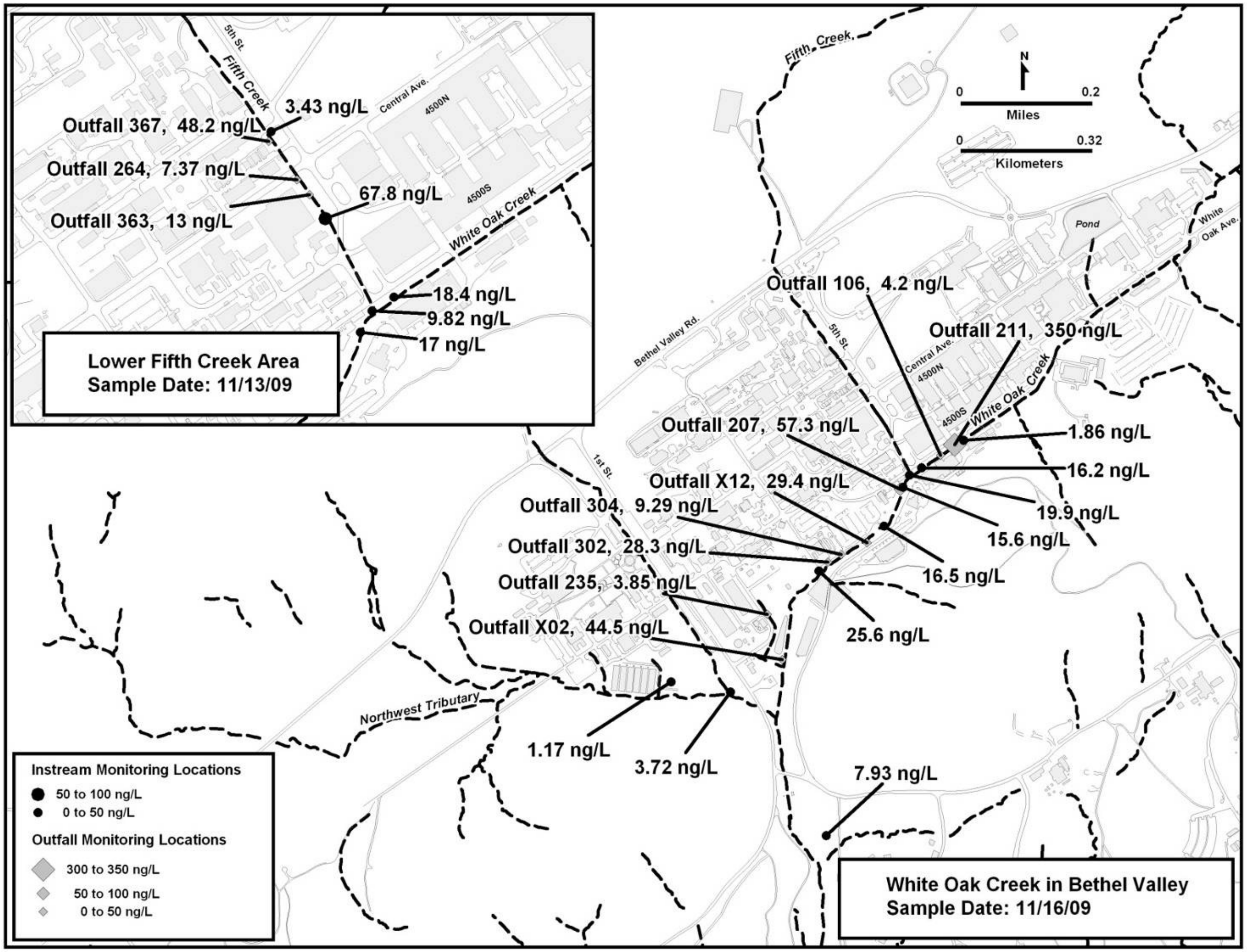

Fig. 5.29. Concentrations of total mercury in Bethel Valley reaches of White Oak Creek, November 2009.

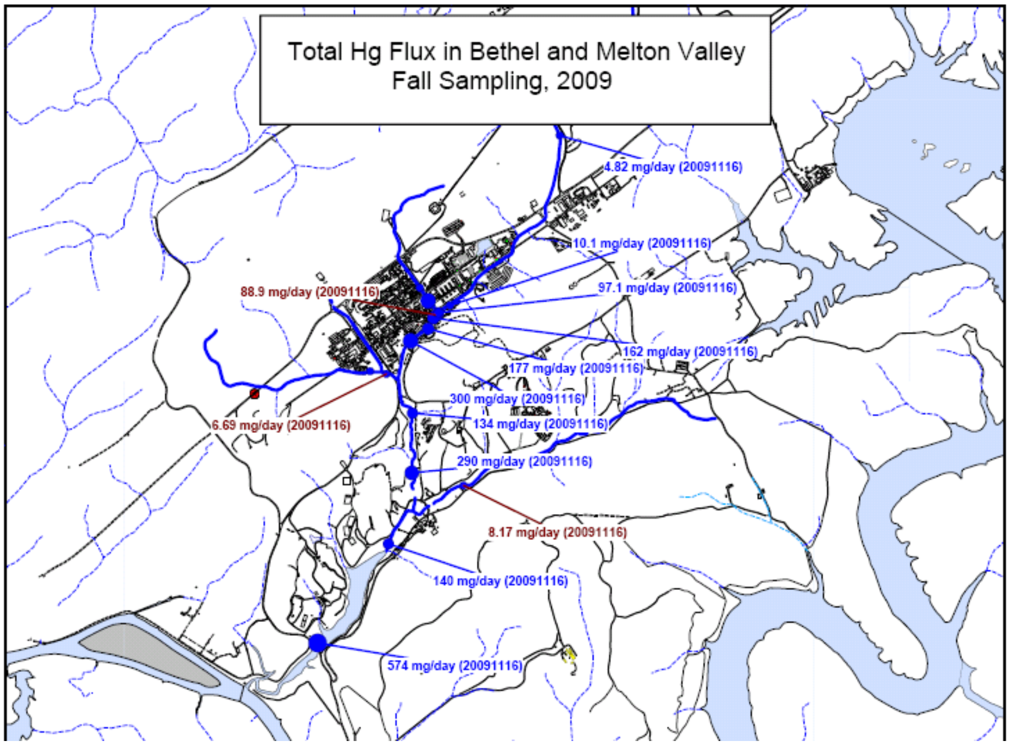

Fig. 5.30. Flux of total mercury in the White Oak Creek watershed, November 2009.

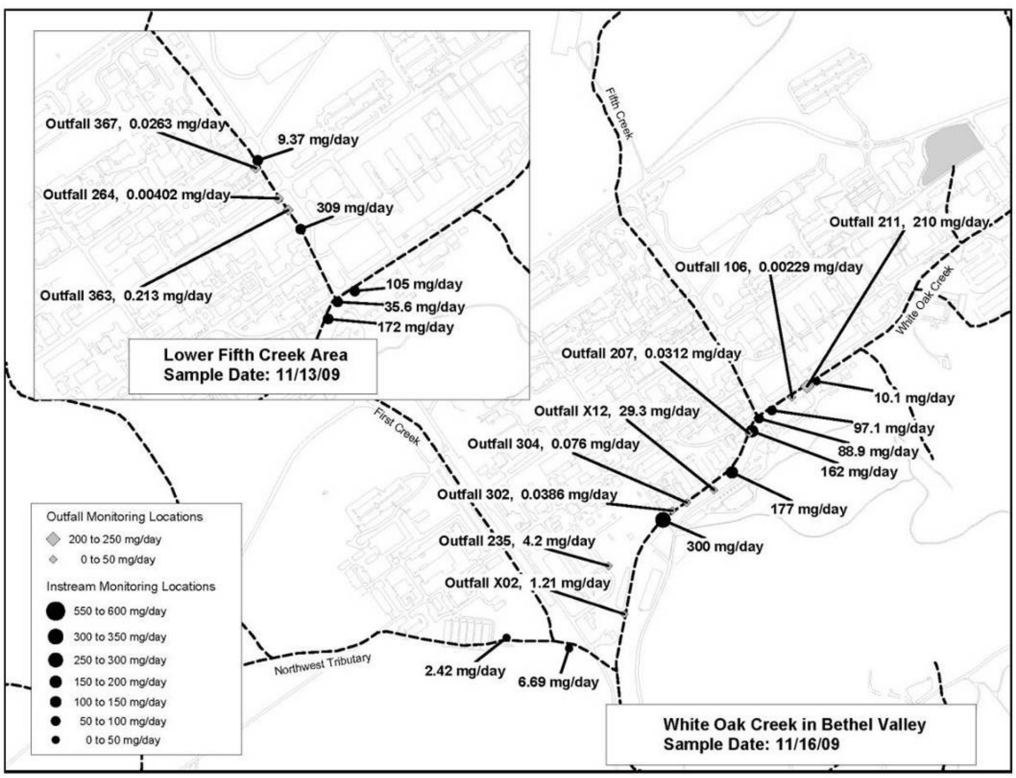

Fig. 5.31. Flux of total mercury in Bethel Valley reaches of White Oak Creek, November 2009.

Monitoring results for 2009 indicated that mercury concentrations at all instream locations were below the Tennessee water quality criterion for recreational use, 51 ng/L (parts per trillion), with a few stream reaches showing higher mercury concentrations and/or fluxes than the rest (Fig. 5.28 and Fig. 5.30). These areas of interest included Outfall 211 and the area downstream from that outfall in White Oak Creek; a particular reach of Fifth Creek; and White Oak Creek downstream of its confluence with Fifth Creek (Fig. 5.29 and Fig. 5.31).

Methylmercury values were typically less than 1% of the total mercury concentrations and fluxes monitored in the same locations. Dissolved methylmercury was only detected at a few of the monitoring locations; overall much less methylmercury than total mercury, both in dissolved and undissolved analyses, was detected.

For 2010, WQPP mercury investigative efforts will focus on one or more of the areas of interest that were identified in the 2009 monitoring. A subset of the 2009 characterization-monitoring protocol will also be conducted in 2010, to maintain ongoing data on the presence of mercury in the White Oak Creek watershed.

5.5.6 Ambient Dry and Wet Weather Monitoring

In 2009, the ORNL WQPP included an objective to characterize water quality at some of the same instream locations where biological communities (fish and benthic macroinvertebrates) are monitored. These locations, where both biological and water quality data were collected, are referred to in the WQPP as integration points. Monitoring sites included seven integration points within or downstream of industrialized areas and four water quality reference locations upstream of the majority of process and stormwater discharges from those industrialized areas (see Fig. 5.32). The purpose of generating a

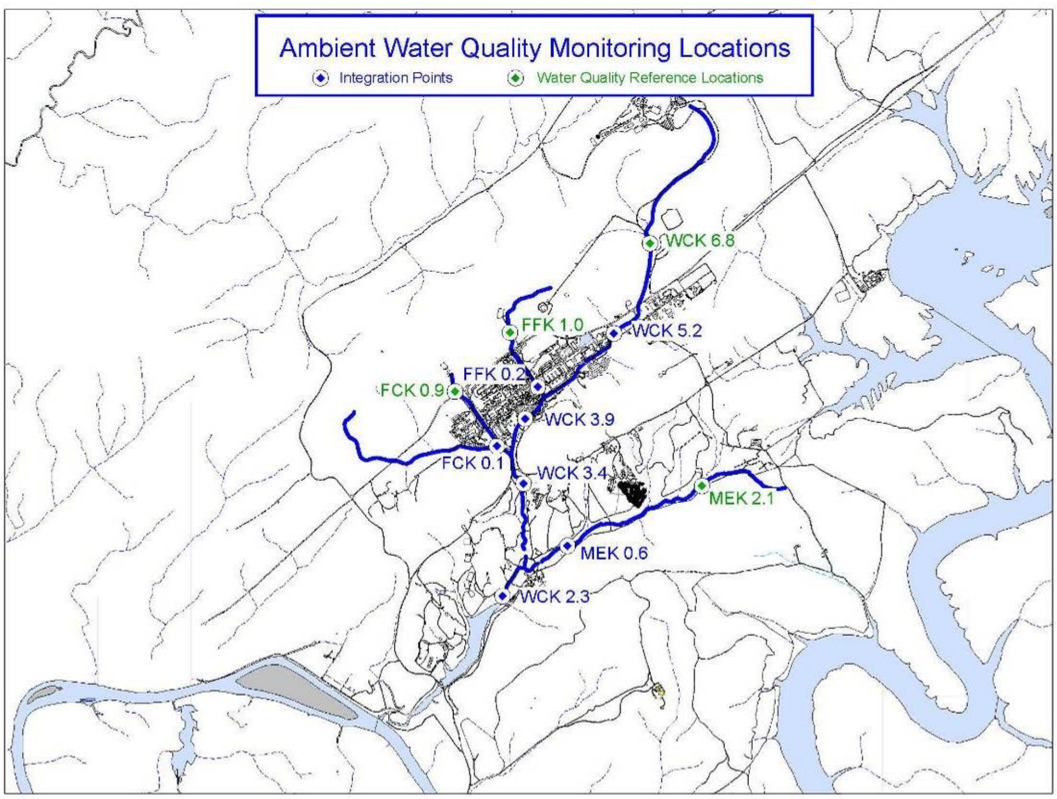

Fig. 5.32. Locations of ambient water quality monitoring integration points and reference locations at ORNL.

database of water quality conditions at locations where biological community health is monitored was to support one of the overall objectives of the WQPP: to discover the reasons for biological community impairment and to ultimately eliminate or reduce those impairments.

In 2009, each location was monitored four times during dry-weather baseflow conditions and two times during wet-weather storm runoff conditions. Samples were collected for solids (suspended and dissolved) and metals (total and dissolved). Nutrients (total phosphorus, Kjeldahl nitrogen, nitrate+nitrite nitrogen, and ammonia) were collected for the sampling events within the growing season (two of the dry-weather sampling events and one of the wet-weather sampling events). Dry-weather samples were 24-hour time-proportional composite samples, and wet-weather samples were flow-proportional composite samples of up to 6 hours duration. Field measurements (conductivity, dissolved oxygen, flow, pH, and temperature) were performed on grab samples during each sampling event. Results are presented in the 2009 Environmental Monitoring Results (DOE 2009). These results are being used to guide future efforts under the WQPP, and along with data from future sampling, should prove useful in determining causes of biological community impairments in the WOC watershed. The data suggest that areas warranting additional study under the WQPP are instream concentrations of nutrients and metals, and additional sampling of those parameters is planned for 2010.

5.5.7 Stormwater Surveillances and Construction Activities

Figure 5.33 depicts the location of construction sites that were considered significant in 2009 because of the need to be covered under the General TN NPDES Permit for Construction Activities and/or an

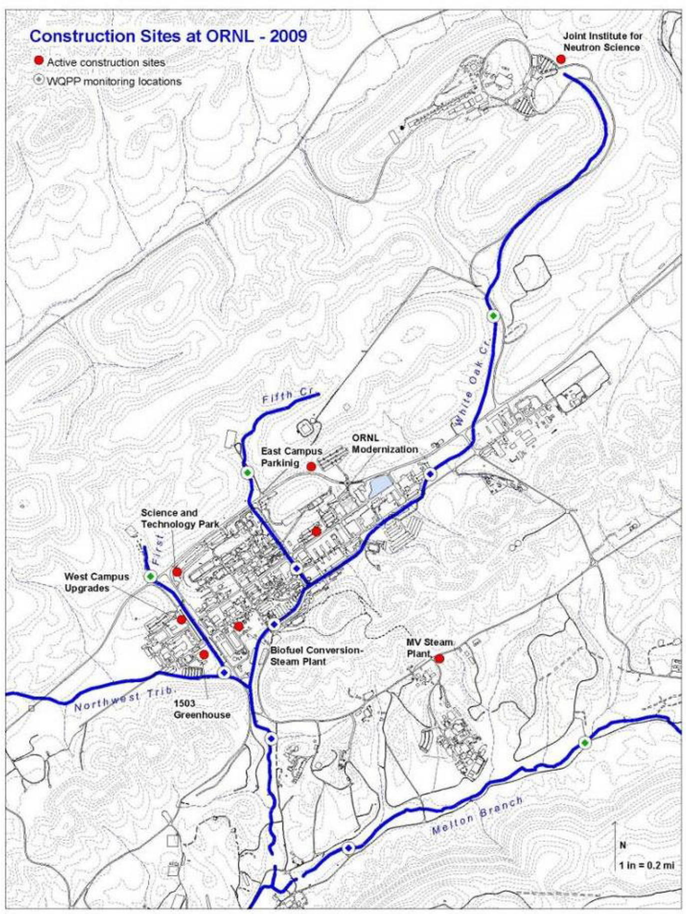

Fig. 5.33. Active construction sites and WQPP monitoring locations at ORNL, 2009.

Aquatic Resource Alteration Permit or because they had a footprint of greater than 1 acre. (Construction areas that are part of CERCLA remediation follow substantive requirements of the appropriate water pollution control permits, but are not required to obtain official permit coverage). Three of these sites were inspected in 2009 to evaluate overall effectiveness of the best management practices in use. In general, while some short-term impacts to receiving streams may have been noted, no long-term adverse impacts were observed.

NPDES outfall drainage areas were also inspected twice in 2009. Land use within drainage areas is typical of office/industrial settings with surface features including laboratories, support facilities, paved areas, and grassy lawns. Outdoor material storage is most prevalent in the 7000 Area on the east end of the main ORNL facility (where most of the craft and maintenance shops are located), with other smaller outdoor storage areas located throughout the facility in and around loading docks and material delivery areas at laboratory and office buildings. The types of materials stored outside include metal items (sheeting, pipes, and parts); equipment awaiting use, disposal, or repair; construction material; and de-icer product. Flaking paint on some buildings (slated to be dismantled in the near future) also poses a potential mobile storm water pollutant source.

Some construction activities are performed by third-party contractors working as tenants under agreement with other local, state, and federal agencies on the DOE reservation. There are mechanisms in place for ensuring effective storm water controls at these third-party sites, one of which includes staff from UT-Battelle acting as points-of-contact for communication interface on environmental, spill/emergency response, and other key issues.

Instream locations identified under the WQPP were monitored twice in 2009 in storm conditions. A more detailed description of the WQPP wet-weather monitoring scenario can be found in Sect. 5.5.6.

5.5.8 Biological Monitoring

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 at a level that will impact fish and aquatic life or violate the recreational criteria 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 2009. 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 2009. Long-term trends in waterborne mercury in the WOC system downstream of ORNL are shown in Fig. 5.27. Waterborne mercury downstream of ORNL declined abruptly in 2008 and remained low in 2009 as a result of rerouting highly contaminated sump water in Building 4501 to the PWTC in December 2007. The mean total mercury concentration at White Oak Creek kilometer (WCK) 4.1 was 18.6 ± 2.7 ng/L in 2009 compared with 108 ± 33 ng/L in 2007. The decrease was also apparent but less pronounced at WCK 3.4, with mercury averaging 16.6 ± 2.2 ng/L in 2009 versus 49 ± 23 ng/L in 2007. In addition to being significantly lower than levels in 2007, mercury levels at these two sites were also slightly lower than in 2008. A pretreatment system for the sump water started operation on October 22, 2009, which removes almost all of the mercury prior to sending the water to the PWTC. This system reduces the mercury concentration in the influent and effluent of the PWTC. Average aqueous mercury concentration at the White Oak Dam was 38.0 ± 12.7 ng/L in 2009, a level similar to results reported in recent years.

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 2009 (Fig. 5.34). Mercury concentrations in redbreast sunfish at WCK 3.9 (a site

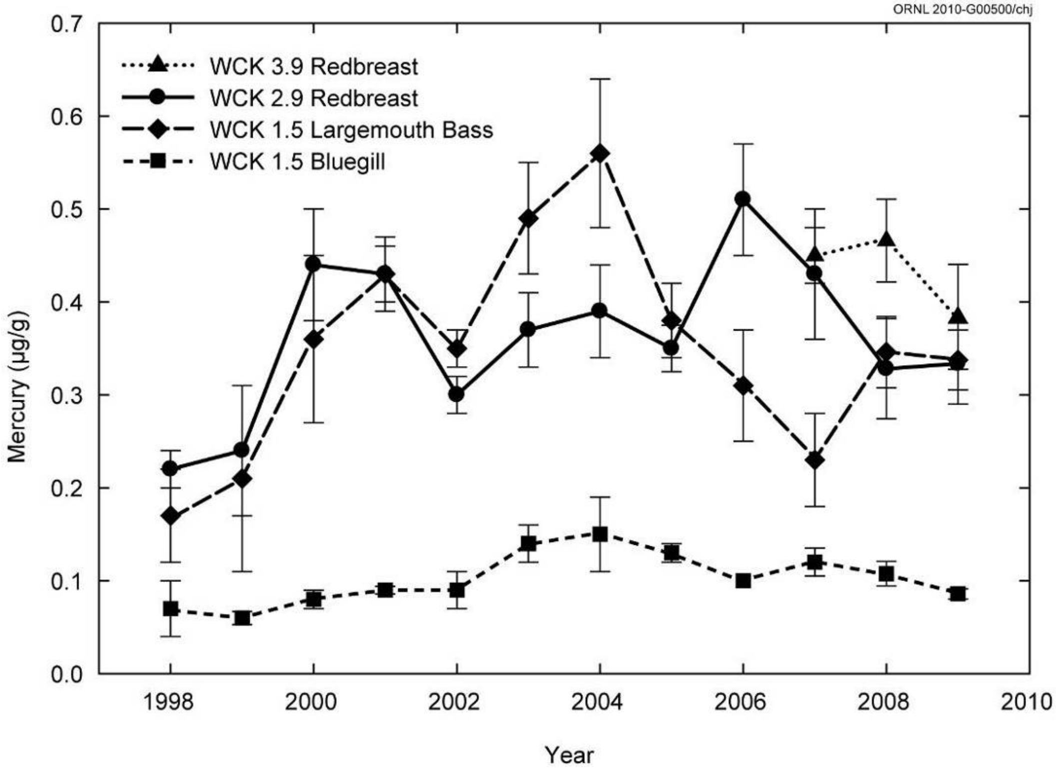

Fig. 5.34. Mean concentrations of mercury (µg/g, ± standard error, N = 6) in muscle tissue of sunfish and bass from White Oak Creek (WCK 3.9, WCK 2.9) and White Oak Lake (WCK 1.5), 1998–2009. WCK = White Oak Creek kilometer

sampled for the first time in 2007) averaged 0.38 µg/g in 2009, significantly lower than in previous years. Mean PCB concentrations in redbreast sunfish at WCK 3.9 were also significantly lower in 2009 (0.30 µg/g) than in 2008 (0.66 µg/g). This apparent decrease may be because the fish collected in 2009 were significantly (approximately 20% by weight) smaller than in 2008. In contrast, mean PCB concentrations in fish from WCK 2.9 increased from 0.26 in 2008 to 0.43 µg/g in 2009 despite no difference in the average size of the fish collected between the two years (Fig. 5.35).

Benthic Macroinvertebrate Communities. Monitoring of benthic macroinvertebrate communities in WOC, First Creek, and Fifth Creek continued in 2009. 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). 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. 5.36, 5.37, and 5.38). Relative to reference sites, the metrics 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. Reductions in metric values observed at FFK 0.2 in 2008 persisted in 2009, providing stronger evidence that an additional stress (or stresses) occurred after April 2007. In 2008, FCK 0.1 had exhibited reductions in metric values comparable to those at FFK 0.2, but increases in metric values in 2009 indicate that the change in 2008 was either a response to a limited but significant disturbance associated with facility

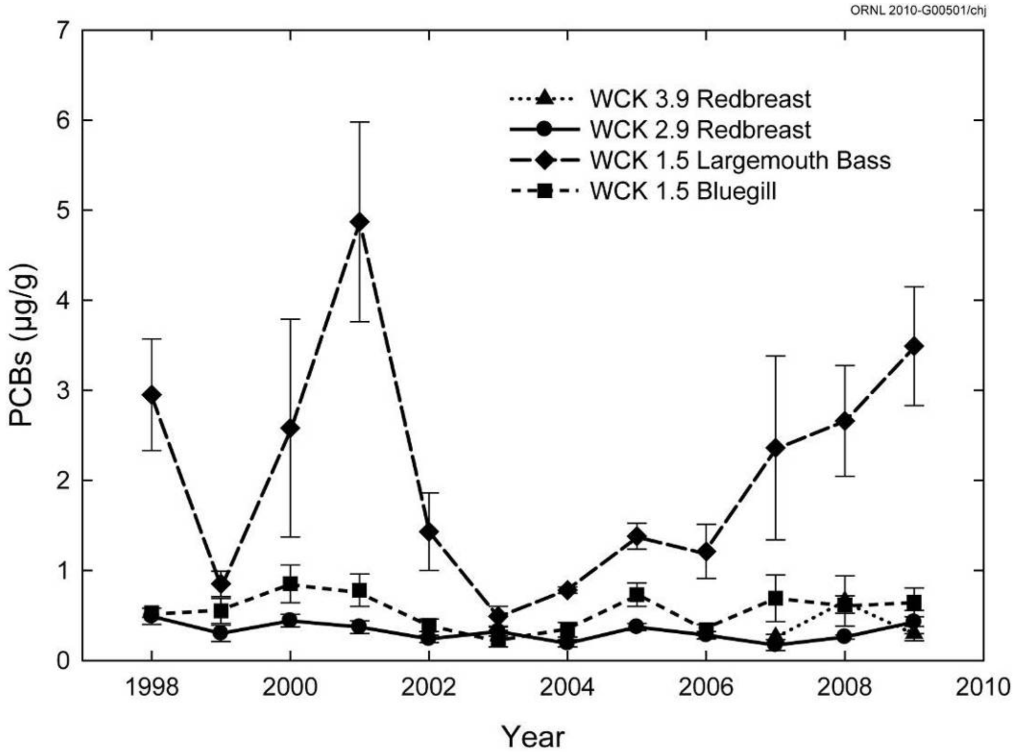

Fig. 5.35. Mean polychlorinated biphenyl (PCB) concentrations (µg/g, ± standard error N=6) in fish fillet collected from the White Oak Creek watershed, 1998–2009. WCK = WOC kilometer.

operations or just natural annual variation. Changes in the macroinvertebrate communities in WOC (WCK 3.9 and WCK 2.3, Fig. 5.38) and lower Melton Branch (MEK 0.6, Fig. 5.39) 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, 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) sources.

Fish Communities

Monitoring fish communities in WOC and major tributaries continued in 2009. 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 2009 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. A project to introduce missing species into the watershed was initiated in 2008 and increased richness was observed in most of WOC during 2009, except a section where episodic fish kills occurred in 2008 as a result of several acute toxic releases over a few months. The mortality in 2008 impacted richness values in 2009 as the site is isolated from downstream areas of colonization richness often takes several years to rebound. The initial success of the

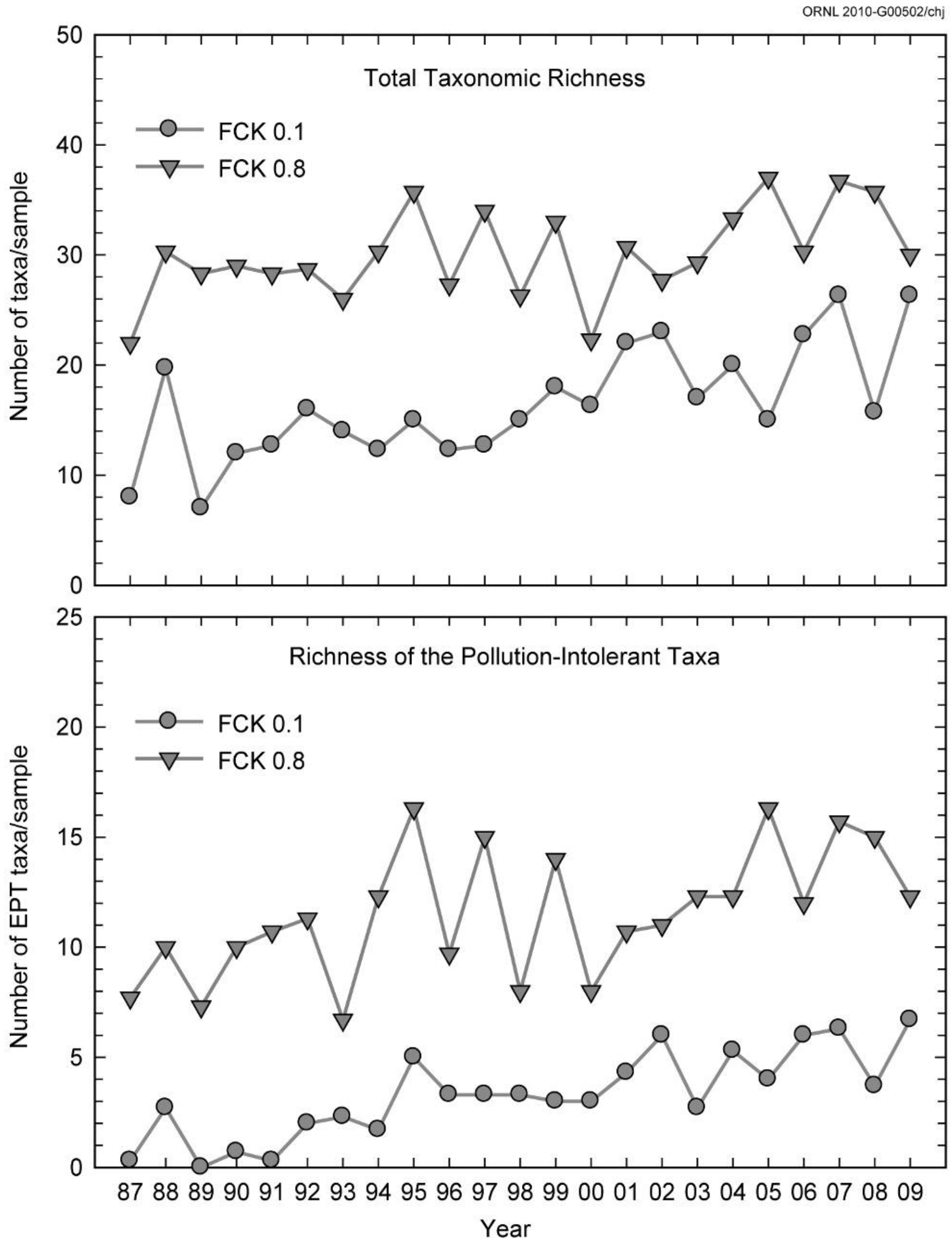

Fig. 5.36. Taxonomic richness (top) and richness of the pollution-intolerant taxa (bottom) of the benthic macroinvertebrate community in First Creek, April sampling periods, 1987−2009. FCK = First Creek kilometer; EPT = *Ephemeroptera, Plecoptera*, and *Trichoptera*; FCK 0.8 = reference site.

introductions in much of 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 2009 relative to reference streams or upstream sites, especially in Fifth Creek where the fish community decreased from multiple species down to limited richness at very low abundances (Fig. 5.40).

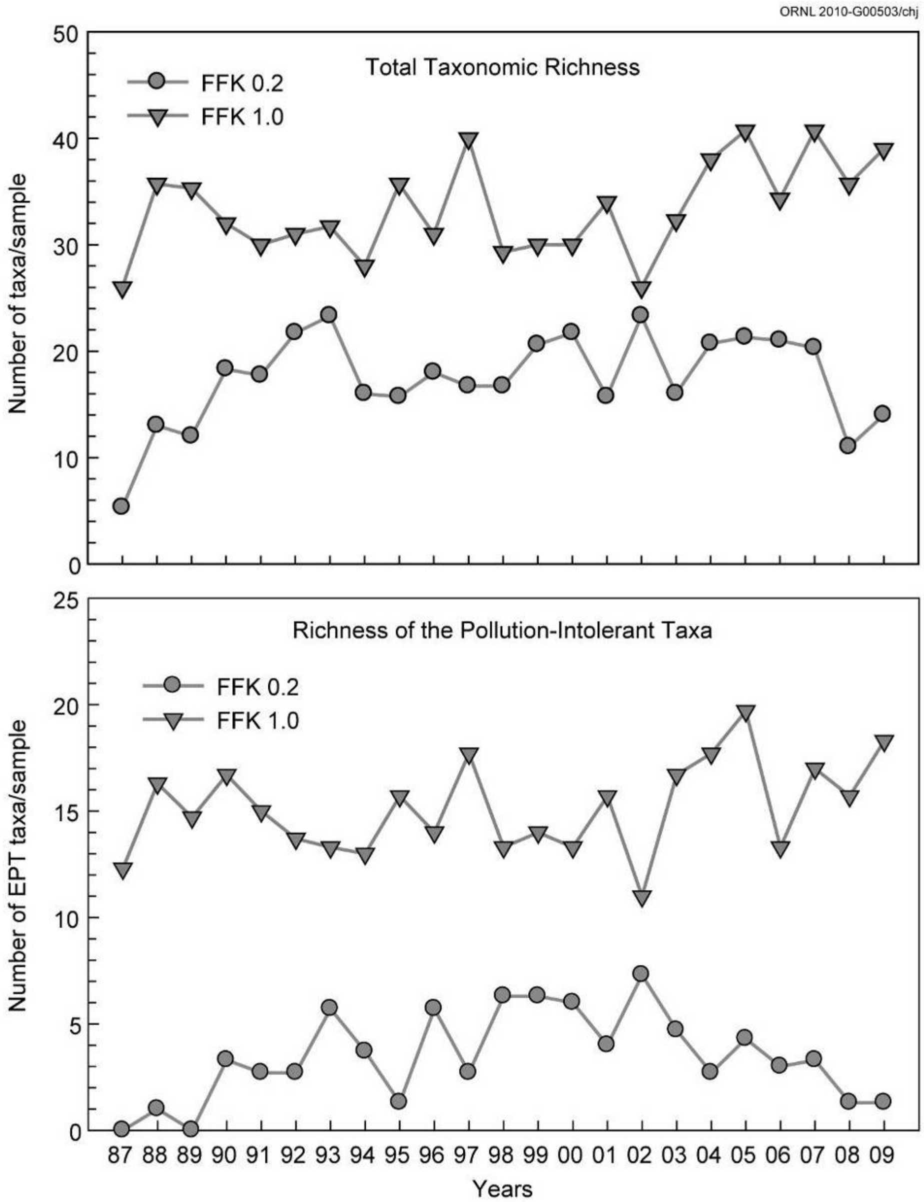

Fig. 5.37. Taxonomic richness (top) and richness of the pollution-intolerant taxa (bottom) of the benthic macroinvertebrate community in Fifth Creek, April sampling periods, 1987–2009. FFK = Fifth Creek kilometer; EPT = *Ephemeroptera, Plecoptera,* and *Trichoptera*; FFK 1.0 = reference site.

5.5.9 PCBs in the WOC Watershed

Bioaccumulation monitoring has shown that PCBs are not discharged from ORNL outfalls into the WOC watershed at levels detected by standard analytical methods, but largemouth bass collected from White Oak Lake continue to have tissue PCB concentrations higher than those recommended by TDEC and EPA for frequent consumption. While past monitoring efforts were instrumental in establishing a baseline for PCBs, focus has historically been on PCB levels in fish related to consumption advisories. These studies were not designed to identify specific stream reaches contributing to PCB bioaccumulation.

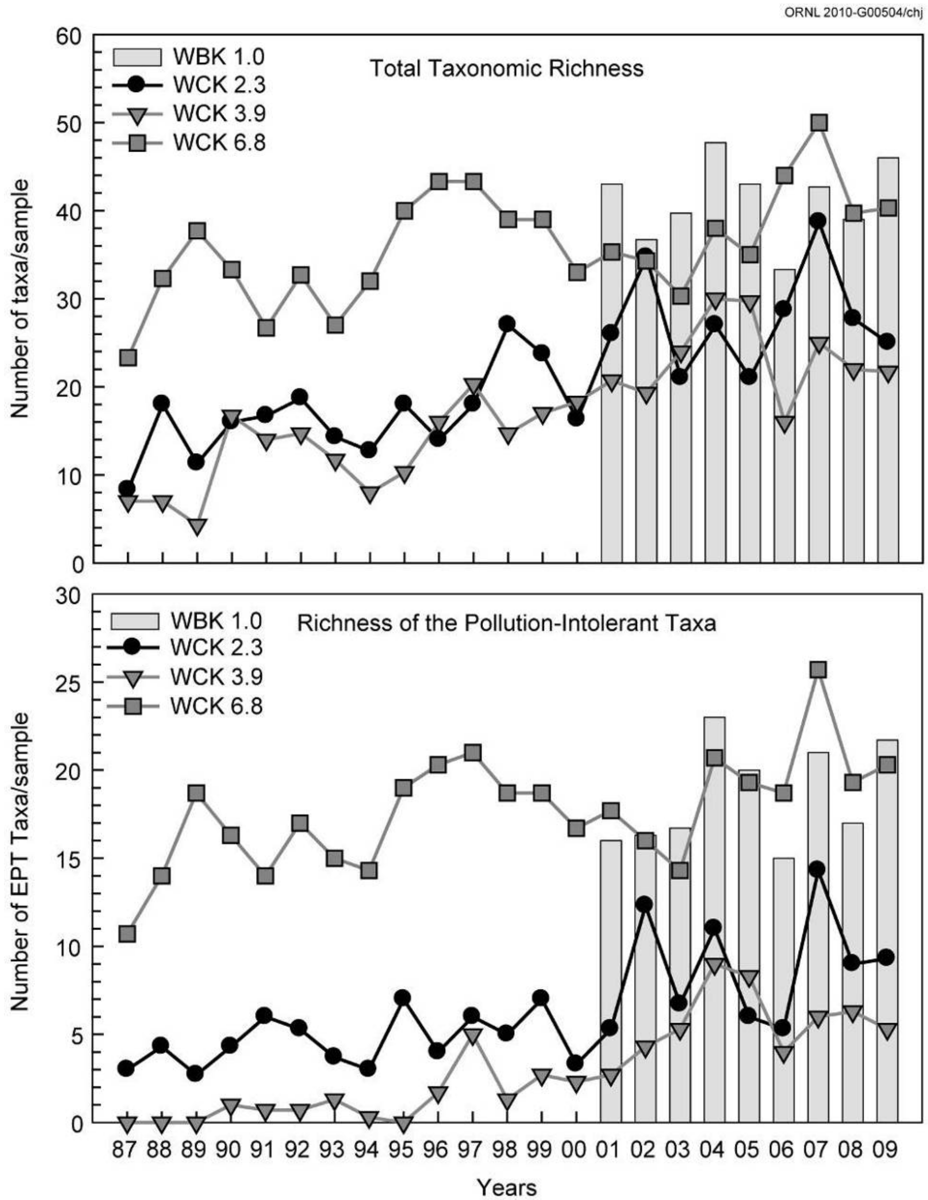

Fig. 5.38. Taxonomic richness (top) and richness of the pollution-intolerant taxa (bottom) of the benthic macroinvertebrate communities in White Oak Creek, April sampling periods, 1987–2009. WCK = White Oak Creek kilometer; WBK = Walker Branch kilometer; EPT = *Ephemeroptera, Plecoptera*, and *Trichoptera*; WBK 1.0 = reference site.

In 2009, the focus of PCB monitoring at ORNL under the BMAP was on the identification of the stream reaches in the White Oak Creek watershed where PCB sources are likely to contribute to bioaccumulation in fish. Key integration points within the watershed were identified and monitoring results from impacted sites were compared to reference sites in each of the streams on the main ORNL campus and Melton Valley to assess bioaccumulation potential.

The mobility of the fish populations used in traditional bioaccumulation monitoring studies precludes the possibility of source identification. Therefore, the source identification task involved the use of semi-permeable membrane devices (SPMDs) to assess the chronic, low-level discharges of PCBs at critical sites on the reservation. SPMDs are essentially oil-filled plastic sleeves in which PCBs are soluble.

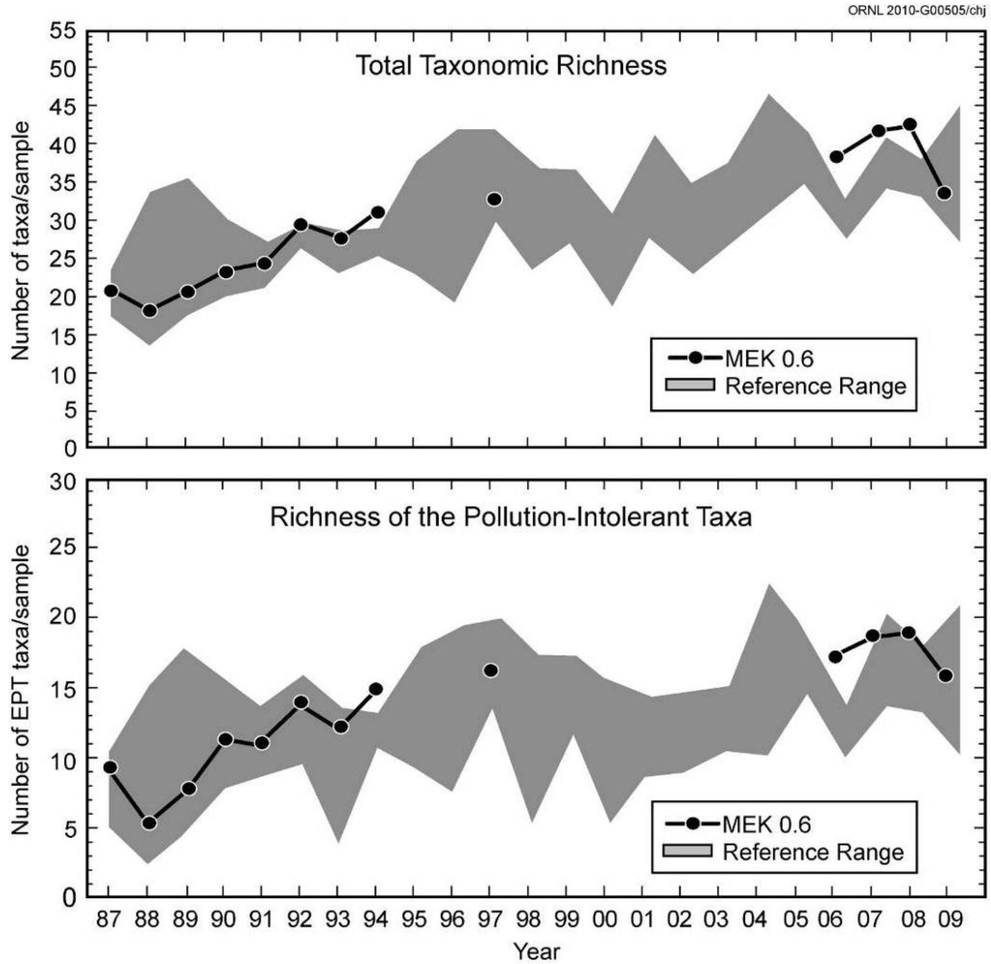

Fig. 5.39. Taxonomic richness (top) and richness of the pollution-intolerant taxa (bottom) of the benthic macroinvertebrate community in lower Melton Branch, April sampling periods, 1987−2009. MEK = Melton Branch kilometer; EPT = *Ephemeroptera*, *Plecoptera*, and *Trichoptera*. Reference range is between 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).

Because SPMDs remain submerged at a given site for 4 weeks and have a high affinity for PCBs, a time-integrated, semi-quantitative index of the mean PCB concentration in the overlying water during the deployment period is provided. SPMDs also have advantages over “snapshot” water concentration analyses. The long deployment period enables the distinction between the relative PCB inputs at sites whose aqueous PCB concentrations are below detection limits (Fig. 5.41).

The SPMD results in this study provide information on the relative contributions of various stream reaches within the ORNL campus. Results clearly show the influence of ORNL activities, as SPMDs deployed at reference sites upstream and downstream of the plant had background levels of PCBs, while all sites within the plant had elevated levels. By far, the highest levels were seen at First Creek, indicating that this creek may be critical in introducing PCBs to White Oak Creek, exacerbating bioaccumulation in fish in this watershed (Table 5.22). Future source identification studies will therefore be refined to focus on First Creek inputs.

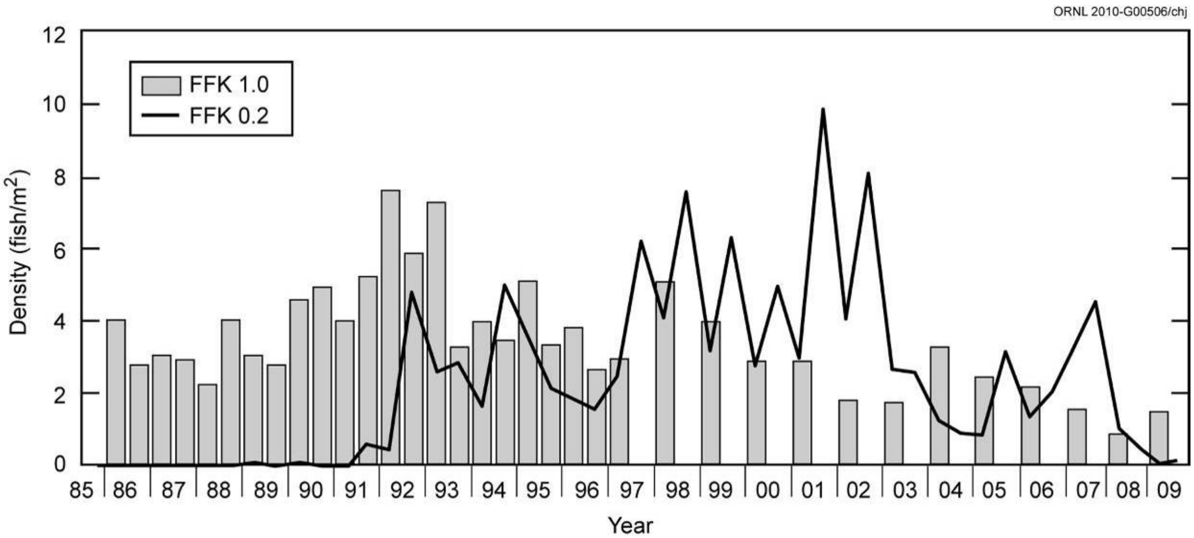

Fig. 5.40. Density estimates of fish communities in Fifth Creek, 1985–2009.

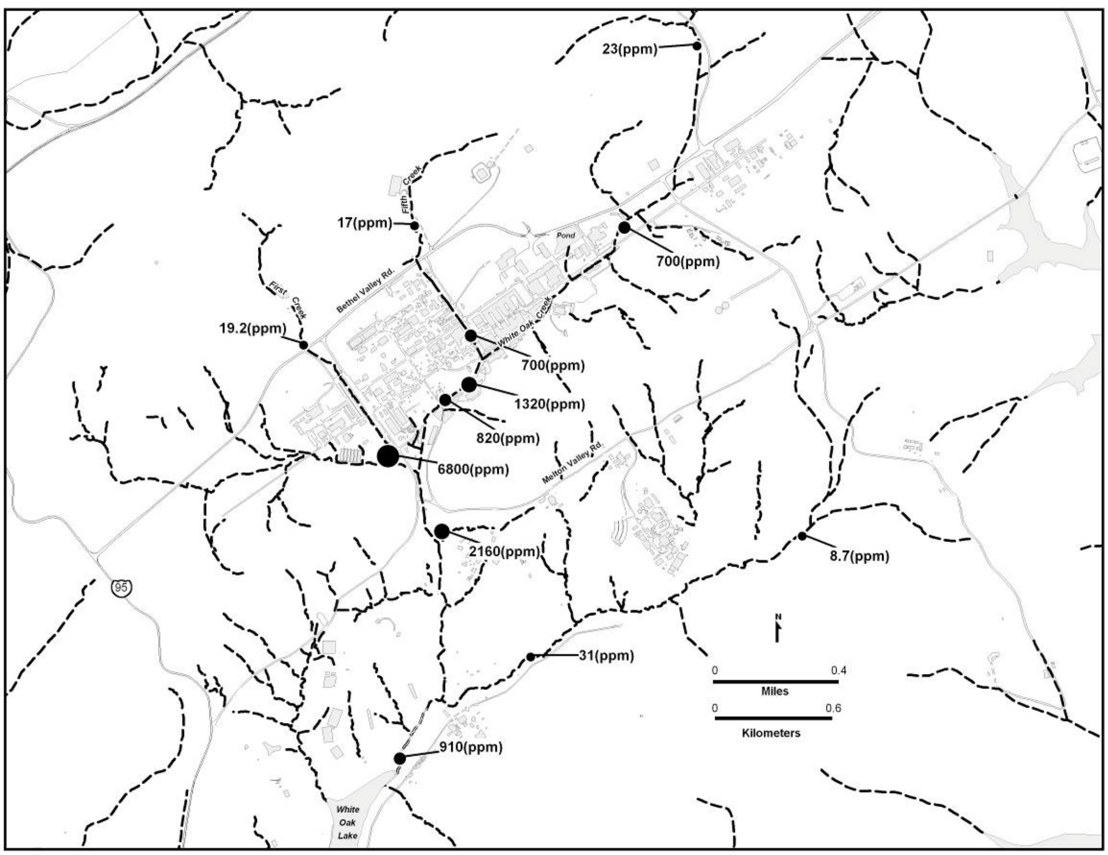

Fig. 5.41. Total polychlorinated biphenyl concentrations (parts by million) by semi-permeable membrane devices, sample collection date: July 14, 2009.

Table 5.22. PCB concentrations in semi-permeable membrane devices at monitoring locations in the White Oak Creek watershed

Samples recovered on July 14, 2009, after 4 weeks

ORNL stream	Location name	Location type	Total PCBs (ppm)
White Oak Creek	WCK 5.2	Integration point	700
White Oak Creek	WCK 3.9	Integration point	820
White Oak Creek	WCK 3.4	Integration point	2160
White Oak Creek	WCK 2.3	Integration point	910
White Oak Creek	WCK 4.1	Integration point	1320
First Creek	FCK 0.1	Integration point	6800
Fifth Creek	FFK 0.2	Integration point	700
Melton Branch	MEK 0.6	Integration point	31
White Oak Creek	WCK 6.8	Reference site	23
Fifth Creek	FFK 1.0	Reference site	17
First Creek	FCK 0.9	Reference site	19.2
Melton Branch	MEK 2.1	Reference site	8.7

5.5.10 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 spill prevention, control, and countermeasures (SPCC) plan to minimize the potential for oil discharges. Each facility on the ORR implements a site-specific SPCC plan. The NTRC, which is located off the ORR, also has a SPCC plan covering the oil inventory at its location. There were no regulatory or permitting actions related to oil pollution prevention at ORNL in 2009.

5.5.11 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. 5.42).

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 White Oak Lake at WOD are also checked for volatile organic compounds (VOCs), PCBs, and metals. Table 5.23 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.

Radionuclides were detected above MDAs at all of the 12 surface water locations in 2009. 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

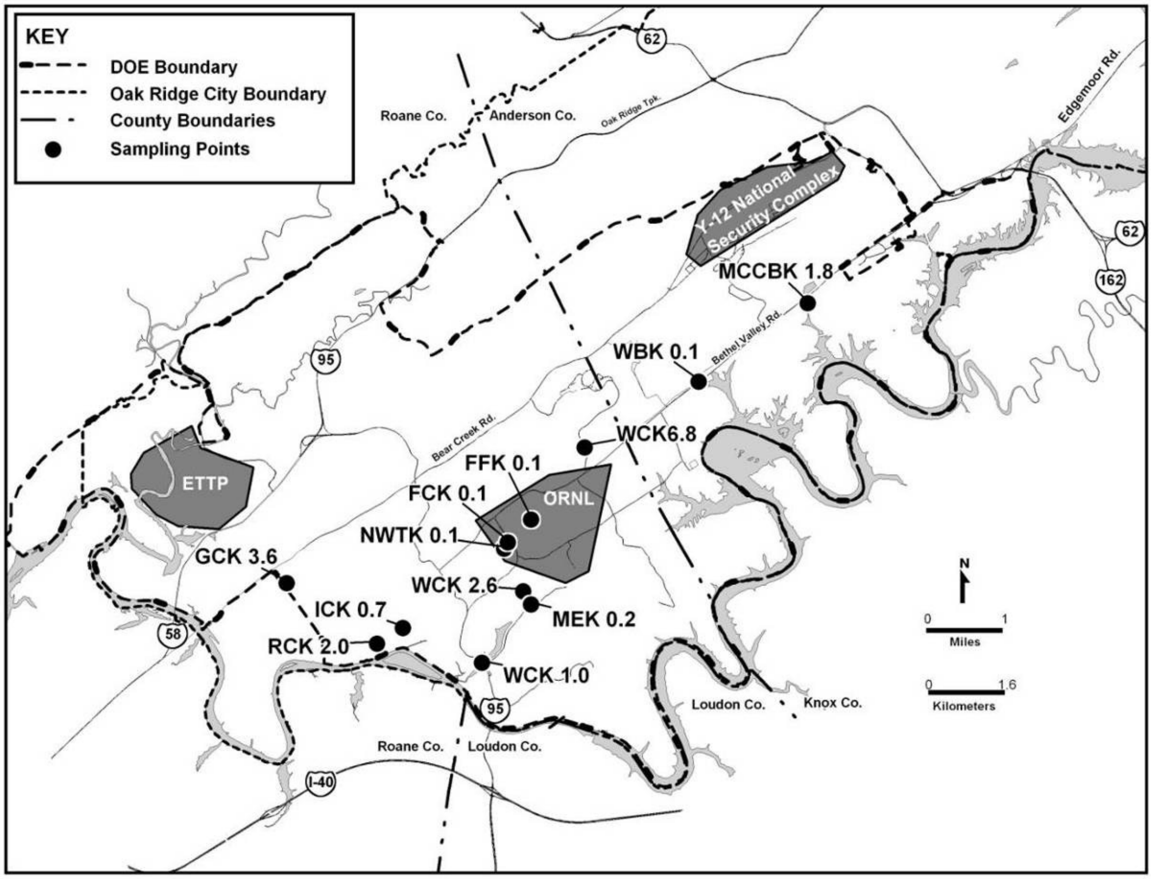

Fig. 5.42. ORNL surface water sampling locations.

in mid-1990s; future remedial actions in those areas are planned and, until completion, little change in surface water contaminant conditions is expected. The results from 2009 sampling at those locations are consistent with historical data and with the processes or legacy activities nearby or upstream from these locations. The VOC chloroform continues to be detected at WOC at WOD. 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.

5.5.12 Sediment Monitoring

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. 5.43). 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. 5.44). These samples are filtered, and the residue (settleable solids) is analyzed for gross alpha, gross beta, and gamma emitters.

Table 5.23. ORNL surface water sampling locations, frequencies, and parameters, 2009

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, tritium, 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, tritium, 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, tritium, field measurements[b]
WCK 6.8	WOC upstream from ORNL	Quarterly (Feb., May, Aug., Nov.)	Gross alpha, gross beta, total radioactive strontium, gamma scan, tritium, 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, tritium, 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, tritium, 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, tritium, 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, tritium, field measurements[b]

[a]Locations identify bodies of water and locations on them (e.g., WCK 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	Raccoon Creek kilometer
WBK	Walker Branch kilometer
WCK	White Oak Creek (WOC) kilometer

[b]Field measurements consist of dissolved oxygen, pH, and temperature.

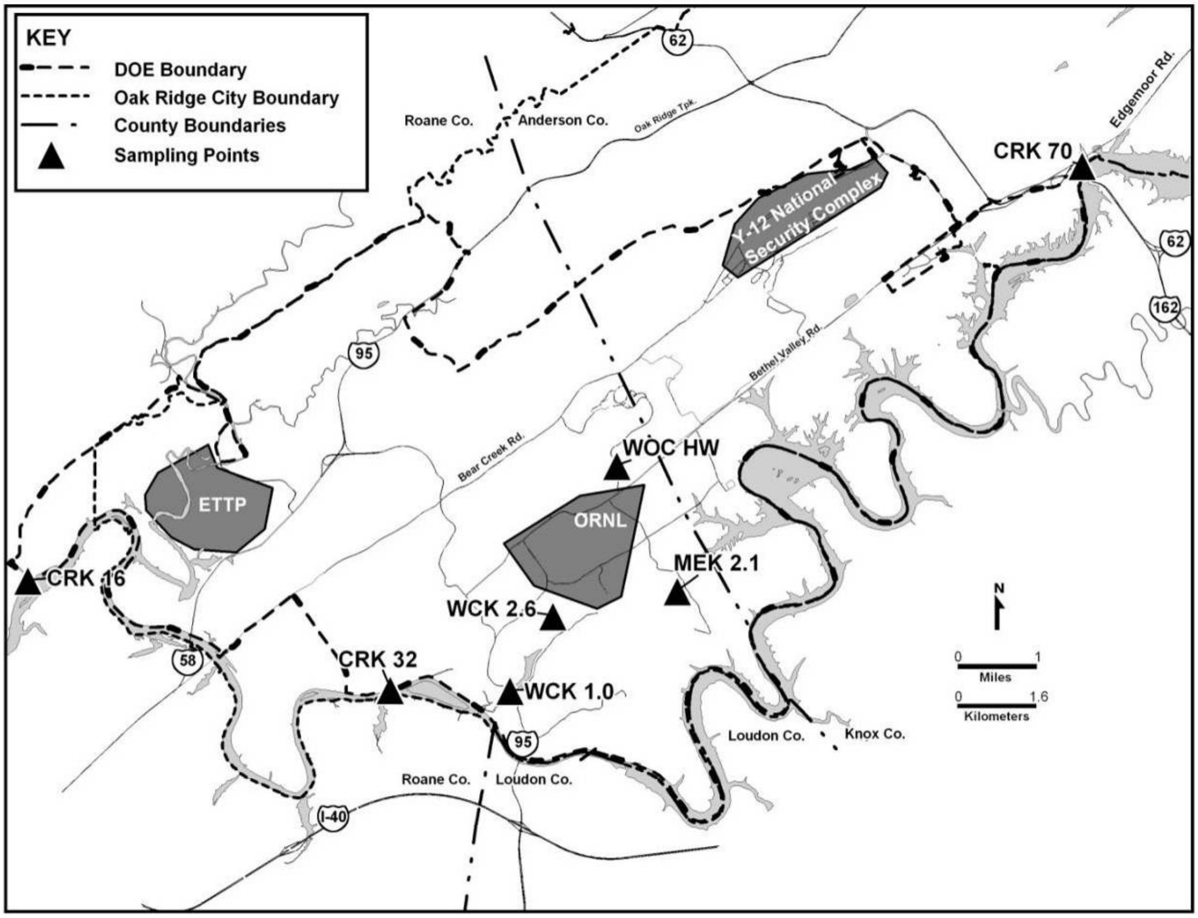

Fig. 5.43. ORNL sediment sampling locations.

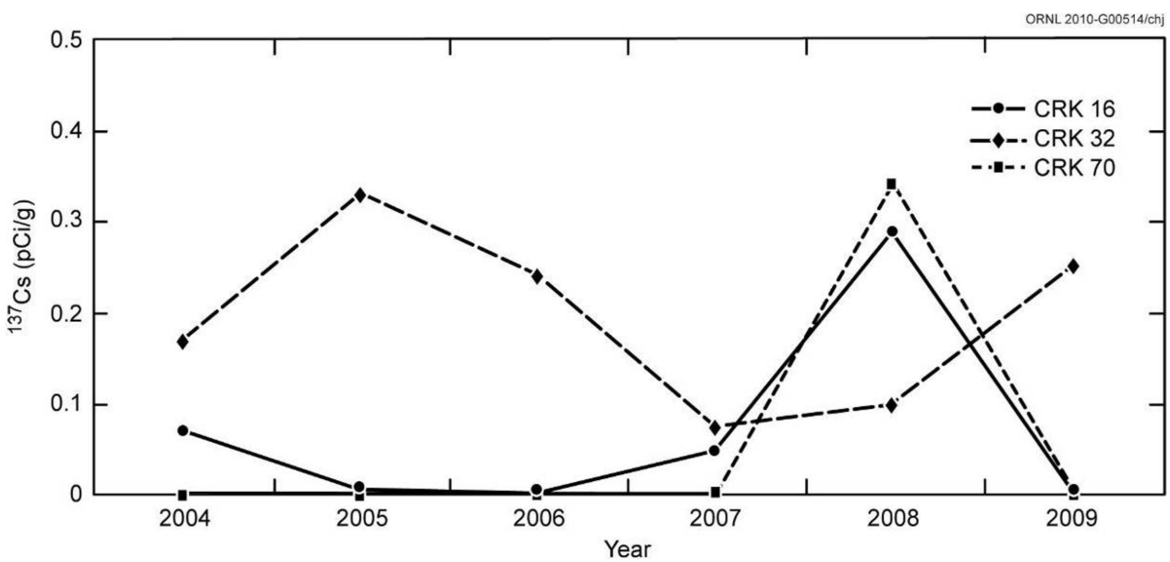

Fig. 5.44. ORNL sediment sampling results for ^{137}Cs, 2004–2009.

Potassium-40, a naturally occurring radionuclide, was detected in sediments at all three locations. The only man-made radionuclide detected in sediments was ^{137}Cs downstream from ORNL at CRK 32. Figure 5.44 shows 6 years of ^{137}Cs results in sediment.

Sampling for heavy rain event settleable solids took place in January and December 2009. Radionuclide concentrations for alpha, beta, and ^{137}Cs were higher at the downstream location, WCK 1.0, than those observed at upstream locations.

5.6 Groundwater Protection Program

As in years past, groundwater monitoring at ORNL was conducted under two sampling programs in 2009: DOE Environmental Management (EM) monitoring and DOE Office of Science (OS) surveillance monitoring. The EM groundwater monitoring program was performed by BJC. The OS groundwater monitoring surveillance program was conducted by UT-Battelle.

Results from the 2009 surveillance monitoring effort at exit pathway monitoring points indicate a continued decrease in trend in concentrations of radionuclides such as ^{3}H, total radioactive strontium, and gross beta activity at WOC Area Discharge wells. Where comparisons could be performed, upper tolerance limits estimated for metals such as iron, manganese, and aluminum are within range or below those upper tolerance limits estimated for groundwater in similar bedrock environments at ORNL. Where these metals are present, it is likely that they are sorbed onto suspended solids in the groundwater samples collected given that groundwater samples are not filtered prior to analysis. Overall, 2009 contaminant concentrations in groundwater observed in other watershed or sub-watershed discharge areas are consistent with observations described in past ASERs. Similar conclusions can be drawn for 2009 SNS results. Based on the results of the 2009 monitoring effort, there is no indication that current OS operations are significantly impacting groundwater at ORNL.

5.6.1 DOE-EM Groundwater Monitoring

Monitoring was performed as part of an ongoing comprehensive CERCLA cleanup effort in Bethel and Melton Valleys at ORNL, the two administrative watersheds at the ORNL site. Groundwater monitoring for baseline and trend evaluation in addition to measuring effectiveness of completed CERCLA remedial actions is conducted by the Water Resources Restoration Program (WRRP). The WRRP has been managed by BJC for the DOE-EM program since its inception and is the vehicle for the EM program to carry out the monitoring requirements outlined in CERCLA decision documents. The results of CERCLA monitoring for the ORR for fiscal year 2009, including the monitoring at ORNL, are evaluated and reported in the *2010 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE 2010) as required by the Federal Facilities Agreement for the ORR. The monitoring results and remedy effectiveness evaluations for Bethel and Melton Valley are reported in Sections 2 and 3, respectively, in the 2010 Remediation Effectiveness Report.

The WRRP also conducts groundwater monitoring at SWSA 6 and submits the required annual groundwater monitoring report to TDEC in response to RCRA Permit.

Groundwater monitoring conducted by the EM program at ORNL includes routine sampling and analysis of groundwater from 27 wells in Bethel Valley. In Melton Valley, where CERCLA remedial actions were completed in 2006 for the extensive waste management areas, the groundwater monitoring program includes monitoring groundwater levels in 80 wells to evaluate the effectiveness of hydrologic isolation of buried waste units. Additionally, groundwater is sampled and analyzed for a wide range of general chemical and contaminant parameters in 46 wells within the interior portion of the closed waste management area.

Exit pathway groundwater monitoring conducted by the EM program includes sampling at six multiport monitoring wells in western Melton Valley (wells 4537, 4538, 4539, 4540, 4541, 4542) and 1 multiport well (4579) in western Bethel Valley.

5.7.1.1 Summary of EM Groundwater Monitoring -- FY 2009

Bethel Valley

The only element of Bethel Valley Record of Decision remedy that requires groundwater monitoring that was complete prior to FY 2009 is the containment pumping to control and treat discharges from the Core Hole 8 plume in the central campus area of ORNL. The original action for this plume was a CERCLA Removal Action that was implemented in 1995. The remedy had performed well until the latter portion of FY 2008 when conditions changed and ^{90}Sr and $^{233/234}$U concentrations in monitoring wells and the groundwater collection system began increasing. Leaking utility water lines near the source area are suspected to have increased the mass of contaminants feeding the plume. Increased infiltration of plume water into storm drains has allowed increased contaminant flux to First Creek, a tributary of White Oak Creek. During FY 2009 the remedy did not meet its performance goal which is a reduction of ^{90}Sr in White Oak Creek. DOE is in the process of modifying the groundwater collection system to increase the plume containment effectiveness.

Monitoring of groundwater contaminants in other areas of Bethel Valley showed that contaminant levels are generally stable.

Monitoring of well 4579 in the western exit pathway of Bethel Valley detected ^{90}Sr in bedrock at levels greater than the MCL effective dose equivalent (8 Ci/L). The multizone monitoring well was installed to monitor a known seepage pathway between Solid Waste Storage Area 3 and the headwater of Raccoon Creek. Monitoring of surface water in Raccoon Creek has been conducted for many years and ^{90}Sr activity in the stream have fluctuated. In FY 2009 the average ^{90}Sr activity in the Raccoon Creek surface water was less than MCL effective dose equivalent.

Melton Valley

The Record of Decision for Interim Actions in Melton Valley established goals for reduction of contaminant levels in surface water, groundwater level fluctuation reduction goals within hydrologically isolated areas, and minimization of the spread of groundwater contamination. Remedy effectiveness groundwater monitoring in Melton Valley includes groundwater level monitoring in wells within and adjacent to hydrologically isolated shallow waste burial areas and groundwater quality monitoring in selected wells adjacent to buried waste areas.

Groundwater level monitoring is showing that the hydrologic isolation component of the Melton Valley remedy is effectively minimizing the infiltration of percolation water from contacting buried waste and is reducing contaminated leachate formation. FY 2009 was the first year to experience above-average annual rainfall since the remedy was completed in 2006 which provided a good stress test on the hydrologic isolation remedy components. In a few areas groundwater level within capped areas continue to respond to groundwater fluctuations imposed from areas outside the caps however the contact of groundwater with buried waste is minimal. Overall the hydrologic isolation systems are performing as designed.

Groundwater quality monitoring in the interior of Melton Valley shows that in general groundwater contaminant concentrations are declining or are stable following remedial actions.

Monitoring of groundwater in the Melton Valley exit pathway has detected the presence of site related contaminants in groundwater near the Clinch River. Low concentrations of ^{90}Sr, tritium, uranium, and volatile organic compounds have been detected in a number of the multizone sampling locations. Groundwater in the exit pathway wells has high alkalinity and sodium and exhibits elevated pH. Because of the detection of site related contaminants near the DOE site boundary additional groundwater monitoring wells are being installed offsite, on the western side of the Clinch River to enable sampling and analysis of groundwater to determine if site related contaminants have migrated beneath the river.

5.6.2 Office of Science Groundwater Monitoring

DOE Order 450.1A is the primary requirement for a sitewide 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 OS groundwater surveillance monitoring program are reported in the following sections.

Exit pathway and active sites groundwater surveillance monitoring points sampled during 2009 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 OS, federal drinking water standards and Tennessee water quality criteria for domestic water supplies (TDEC 2009) 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.

5.6.2.1 Exit Pathway Monitoring

During 2009, exit pathway groundwater surveillance monitoring was performed in accordance with the *UT-Battelle Sampling and Analysis Plan for Surveillance Monitoring of Exit Pathway Groundwater at Oak Ridge National Laboratory* (Bonine 2009). Groundwater exit pathways at ORNL include areas from watersheds or sub-watersheds where groundwater discharges to the Clinch River/Melton Hill Reservoir to the west, south, and east of the main campus of ORNL. The exit pathway monitoring points were chosen based on hydrologic features, screened intervals (for wells), and locations relative to discharge areas proximate 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 geographic expediency. The Southern Discharge Area Exit Pathway was carved from the East End Discharge Area Exit Pathway. Fig. 5.45 shows the locations of the exit pathway monitoring points sampled in 2009.

The five zones include:

- the WOC Discharge Area Exit Pathway,
- the 7000/Bearden Creek Watershed Discharge Area Exit Pathway,
- the East End Discharge Area Exit Pathway,
- the Northwestern Discharge Area Exit Pathway, and
- the Southern Discharge Area Exit Pathway.

Unfiltered samples collected from the UT-Battelle exit pathway groundwater surveillance monitoring points in 2009 were analyzed for VOCs, semi-volatile organic compounds, metals (including mercury), and radionuclides (including gross alpha/gross beta activity, gamma emitters, total radioactive strontium, and tritium). Under the monitoring strategy outlined in the Exit Pathway Sampling and Analysis Plan (Bonine 2009), samples were collected semiannually during the wet and dry seasons in 2009.

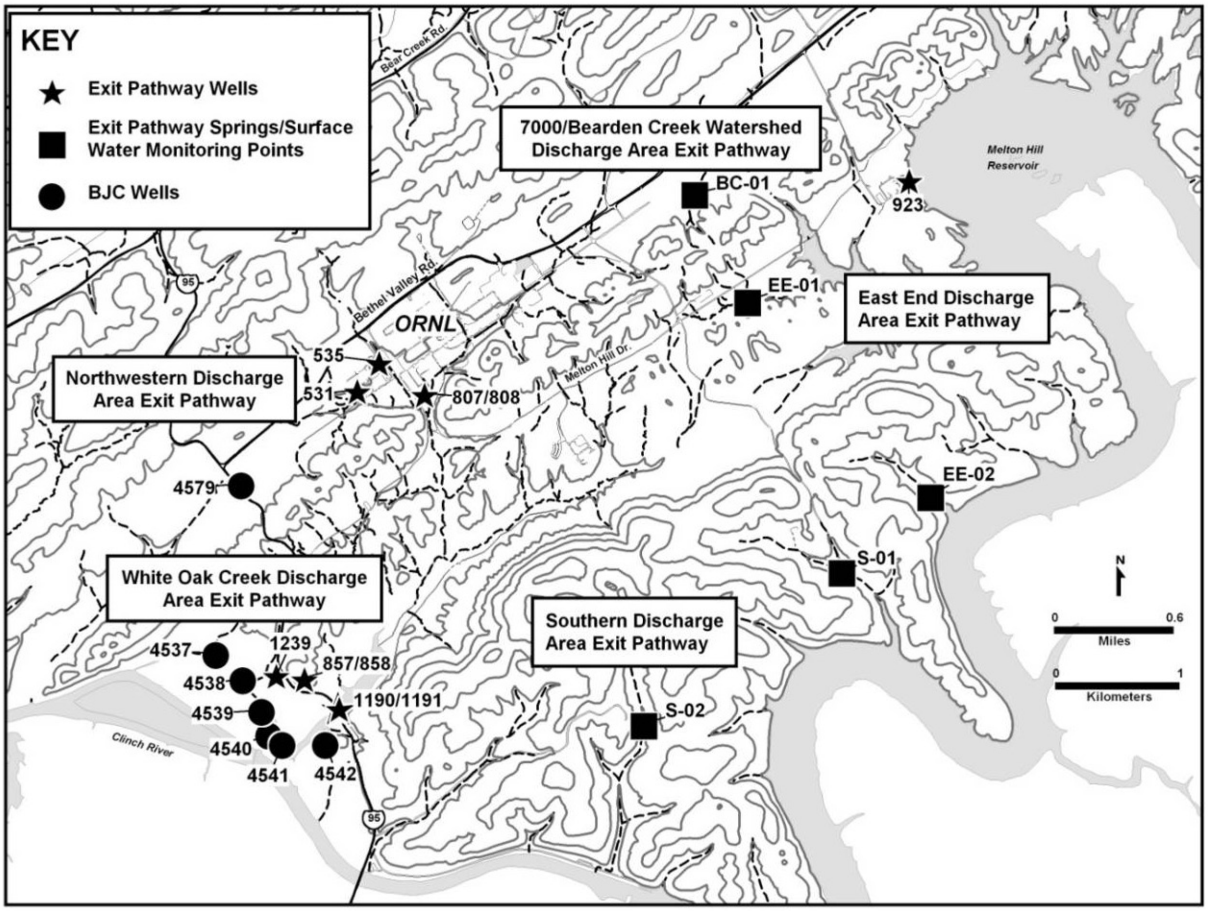

Fig. 5.45. UT-Battelle exit pathway groundwater monitoring locations at ORNL, 2009.

5.6.2.1.1 Exit Pathway Monitoring Results

Statistical trend analyses were performed on exit pathway monitoring data sets containing data exceeding reference standards in 2009. The bases used for the trend analyses were the historical data collected from the late 1980s through 2009. Trend analyses were not performed on data sets that were reported as being "undetected" by the laboratory, even when minimum detection limits exceeded reference standards (i.e., semi-volatile organic compounds atrazine, benzo(a)pyrene, hexachlorobenzene, and pentachlorophenol) and were not performed on parameters for which there are no reference standards or where data densities were insufficient. Only those parameters that exhibited statistically significant (80% to 99% confidence levels) upward or downward trends are reported. Where data densities for monitoring points were sufficient, 95% upper tolerance limits (UTLs) were estimated for specific metal data sets that have historically exceeded reference standards. These UTLs were compared against UTLs estimated for those metals in the different groundwater regimes identified for ORNL. Where data densities were insufficient to estimate UTLs, no comparison was made. Samples were not collected at BC-01 or S-01 during the dry season due to a lack of water flow at these locations. Samples were collected at all other monitoring points during both the wet and dry seasons. Groundwater sampling results that exceeded reference standards as well as those that were detected in 2009 may be found in the 2009 Environmental Monitoring Results (DOE 2009).

WOC Discharge Area Exit Pathway Results

Monitoring wells 857, 858, 1190, 1191, and 1239 were sampled during April as well as in August and September 2009. 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 the WOC Discharge Area wells. A statistically significant downward trend exists for all three radiological constituents at both sampling locations. Aside from the radionuclides that were detected above reference standard concentrations, the following radionuclides were detected at low levels in WOC Discharge Area wells: gross beta activity, ^{214}Bi, and ^{3}H in well 857; gross beta activity and ^{40}K in well 858; ^{214}Bi and ^{214}Pb in well 1190; and gross alpha activity, ^{214}Bi, and ^{214}Pb in well 1191.

As in past years, iron, manganese, and aluminum exceeded reference standards in WOC Discharge Area wells during 2009. Aluminum was found to exceed its reference standard in well 857 in addition to iron and manganese in wells 1190 and 1191. Statistical trend analyses of metals data for these wells show a statistically significant historical increase in aluminum and manganese in wells 857 and 1191, respectively and a statistically significant historical decrease in manganese and iron in wells 1190 and 1191, respectively. Further statistical analyses of historical iron, manganese, and aluminum data from these wells indicate the 95% UTLs are within the range or below those estimated for the transition limestone-shale/shale-dominated groundwater clusters established for ORNL (Wolf et al. 1996). The transition limestone-shale/shale-dominated groundwater clusters were used for comparison because the WOC Discharge Area wells are screened in strata dominated by shale but interbedded with limestones. Table 5.24 provides a comparison for these UTLs.

Table 5.24. Comparison of WOC discharge area groundwater and shale-dominated groundwater upper tolerance limits (UTLs)

Metal	WOC discharge area estimated 95th UTL (mg/L)	Transition limestone-shale groundwater estimated 95th UTL (mg/L)	Shale-dominated groundwater estimated 95th UTL (mg/L)
Iron	9.19	8.0	50
Manganese	0.35	2.6	16
Aluminum	1.11	3.2	2.8

It is likely that the metals are sorbed onto suspended solids in the groundwater samples collected contributing to the exceedance of the reference standards used for comparison. Other metals were detected at low concentrations in groundwater samples collected from WOC Discharge Area wells; these results can be found in the 2009 Environmental Monitoring Results (DOE 2009).

Detection limits for several semi-volatile organic compounds (atrazine, benzo(a)pyrene, hexachlorobenzene, and pentachlorophenol) 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, 1190, and 1191 and was detected in well 1239. Bis(2-ethylhexyl) phthalate was also found in laboratory blank samples from wells 857, 858, and 1239. Given its presence in laboratory blanks, the source of bis(2-ethylhexyl) phthalate may have been due to laboratory cross-contamination of sample aliquots collected from wells 1190, 1191, and 1239. Departing from past year observations, diethyl phthalate was not detected in samples collected from WOC Discharge Area wells in 2009.

Low concentrations of volatile organics were also detected in WOC Area Discharge wells in 2009. Low levels of acetone were detected in wells 1190 and 1191, while a low estimated concentration of carbon disulfide was reported for a sample collected from well 1190. Subsequent to collection of the 2009 groundwater samples, acetone was found to be present in the deionized water used in preparing blank samples. This source of deionized water is no longer used for blank samples or for decontamination of sampling equipment.

7000/Bearden Creek Watershed Discharge Area Exit Pathway Results

Wells 1198 and 1199 were not sampled during 2009 because detailed geotechnical and environmental characterization of the Multiprogram Computational and Data Center site located east of the 7000 area revealed that neither is located in the groundwater discharge zone for the 7000/Bearden Creek Watershed Discharge Area.

Spring/seep BC-01 was sampled during the wet season in March 2009, but could not be sampled during the dry season due to the lack of water flow from the spring/seep.

No radionuclides were detected in BC-01. Iron and aluminum were detected at concentrations greater than reference standards in 2009. These metals are most likely sorbed onto suspended solids in the groundwater samples collected contributing to the exceedance of the reference standards. Other metals were detected at low concentrations in groundwater samples collected from this discharge area in 2009 and results are provided in the 2009 Environmental Monitoring Results (DOE 2009).

Detection limits for the semi-volatile organic compounds (atrazine, benzo(a)pyrene, hexachlorobenzene, and pentachlorophenol) exceeded reference standards. No volatile organic compounds were detected in BC-01.

East End Discharge Area Exit Pathway Results

Well 923 was sampled in April and August 2009. Wells EE-01 and ED-02 were sampled in March and August 2009. 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, EE-02, and well 923. Additionally, low concentrations of ^{214}Bi and ^{214}Pb were detected in EE-02.

Iron, manganese, and aluminum exceeded reference standards in EE-01 and EE-02, and iron and manganese exceeded reference standards in well 923. A statistically significant historical increase in manganese is observable in the EE-01 data set. It is likely that iron, manganese, and aluminum are sorbed onto suspended solids in the groundwater samples collected contributing to the exceedance of the reference standards. Other metals were detected at low concentrations in groundwater samples collected from East End Discharge Area in 2009; these results can be viewed in the 2009 Environmental Monitoring Results (DOE 2009).

Detection limits for several undetected semi-volatile organic compounds (atrazine, benzo(a)pyrene, hexachlorobenzene, and pentachlorophenol) exceeded reference standards. Bis(2-ethylhexyl) phthalate was detected in one sample collected from well 923. Plastic well casing materials used in the construction of the well may explain the presence of the phthalate in the sample. A low estimated concentration of bis(2-ethylhexyl) phthalate was also detected in a sample collected from EE-01 during 2009. No other organic compounds were detected in samples collected from the East End Discharge Area.

Northwestern Discharge Area Exit Pathway Results

Wells 807 and 808 were added to the Northwest Discharge Area Exit Pathway in 2009. These wells are located down gradient of many of the facilities located in the ORNL Main Campus. They are also located near the water gap through Haw Ridge and are used to monitor a localized groundwater exit pathway from the ORNL Main Campus into Melton Valley.

Wells 807 and 808 were sampled in April and August 2009 as was well 531. Well 535 was sampled in early June and September 2009 due to continued access restrictions associated with construction activities related to ORNL campus upgrades.

No radiological parameters exceeded their reference standards at any Northwestern Discharge Area monitoring point in 2009. However, gross beta activity was detected in low concentrations in well 531 and ^{214}Bi, ^{214}Pb, and ^{3}H were detected in well 535. Gross beta activity, total radioactive strontium, ^{3}H, and ^{214}Bi were detected in well 807 while gross beta activity and ^{40}K were detected in low concentrations in well 808.

Iron and aluminum concentrations exceeded reference standards in well 531. However, statistical analyses of historical data for both metals exhibit statistically significant decreasing trends in concentrations. Iron, manganese, and aluminum also exceeded reference standards in well 535, and analyses of historical data for iron and manganese exhibit statistically significant increasing trends at well 535. Additionally, iron and manganese exceeded reference standards in well 807 with historical concentration data for iron exhibiting a statistically significant increasing trend. It is likely that these metals are sorbed onto suspended solids in the samples contributing to the exceedance of the reference standards. Other metals were detected at low concentrations in groundwater samples collected from Northwestern Discharge Area in 2009 and results are provided in the 2009 Environmental Monitoring Results (DOE 2009). Detection limits for several undetected semi-volatile organic compounds (atrazine, benzo(a)pyrene, hexachlorobenzene, and pentachlorophenol) exceeded reference standards. Diethyl phthalate was detected at a low, estimated concentration in a sample collected from well 535. Plastic well casing materials used in the construction of the well may explain the presence of the phthalate in the sample. Toluene was also detected at low, estimated concentrations in samples collected from well 535 in 2009.

Southern Discharge Area Exit Pathway Results

Monitoring point S-01 was sampled by UT-Battelle in March 2009, but no samples were collected during the dry season sampling event (August 2009) because the monitoring point was dry. Monitoring point S-02 was sampled in March and August 2009.

No radiological parameters exceeded reference standards at either monitoring point; however, low concentrations of ^{214}Bi and ^{214}Pb were detected in the sample collected from S-01, and gross alpha and beta were detected in samples collected from S-02.

Concentrations reported for iron, aluminum, manganese, and lead concentrations exceeded reference standards at S-02 during 2009. It is likely that these metals are sorbed onto suspended solids in the groundwater samples collected contributing to the exceedance of the reference standards. Other metals were detected at low concentrations in groundwater samples collected from Southern Discharge Area in 2009; these results can be viewed in the 2009 Environmental Monitoring Results (DOE 2009).

Detection limits for several undetected semi-volatile organic compounds (atrazine, benzo(a)pyrene, hexachlorobenzene, and pentachlorophenol) exceeded reference standards. Acetone was detected in a blank sample associated with samples collected from S-02. Subsequent to collection of the 2009 groundwater samples, acetone was found to be present in the deionized water used in preparing blank samples. This source of deionized water is no longer used for blank samples or for decontamination of sampling equipment.

5.6.2.2 Active Sites Monitoring

5.6.2.2.1 Active Sites Monitoring—HFIR

Surveillance monitoring of the HFIR site detected a subsurface release of ^{3}H from a process waste drain in the autumn of 2000. At that time, reactor systems were shut down so that the release site could be identified and repaired. The process waste drain was found to be the source of the release and was repaired, ending the release of the ^{3}H to the subsurface. From 2000–2007, monitoring of HFIR-site wells and subsurface drains was conducted to determine the size and scope of the ^{3}H plume that was created by the release. This groundwater monitoring approach was conducted by the UT-Battelle Research Reactor Division (RRD). The main mass of the ^{3}H plume was observed to move from the release area to the south-southeast toward a tributary to Melton Branch and Melton Branch, itself. RRD discontinued routine monitoring in 2007 based on a history of zero detectable subsurface releases of ^{3}H from the process waste drain and observations of steep downward trends in ^{3}H concentration reductions in samples collected from monitoring sites down gradient of the release site. The expectation is that ^{3}H concentrations should continue to decrease with the possibility of additional precipitation-driven concentration spikes or drought-induced ^{3}H concentration stagnation. Although RRD has ceased monitoring the ^{3}H plume, ^{3}H monitoring at HFIR has continued under the auspices of the *ORNL Radiological Monitoring Plan*. Please refer to Sect. 5.5 for results of 2009 ^{3}H monitoring at HFIR. 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 2009 at the SNS site. The 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 2009 under the draft *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, and 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 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 that break out 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. Locations were chosen based on hydrogeological factors and proximity to the beam line. Figure 5.46 shows the locations of the specific monitoring points sampled during 2009.

Because of the presence of karst geomorphic features at the SNS site, sampling of the seeps/springs was performed quarterly 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). Given their fate and transport characteristics, ^{3}H and ^{14}C are the principal groundwater constituents of concern at the SNS site. In 2009, samples were collected on a quarterly basis for ^{3}H and

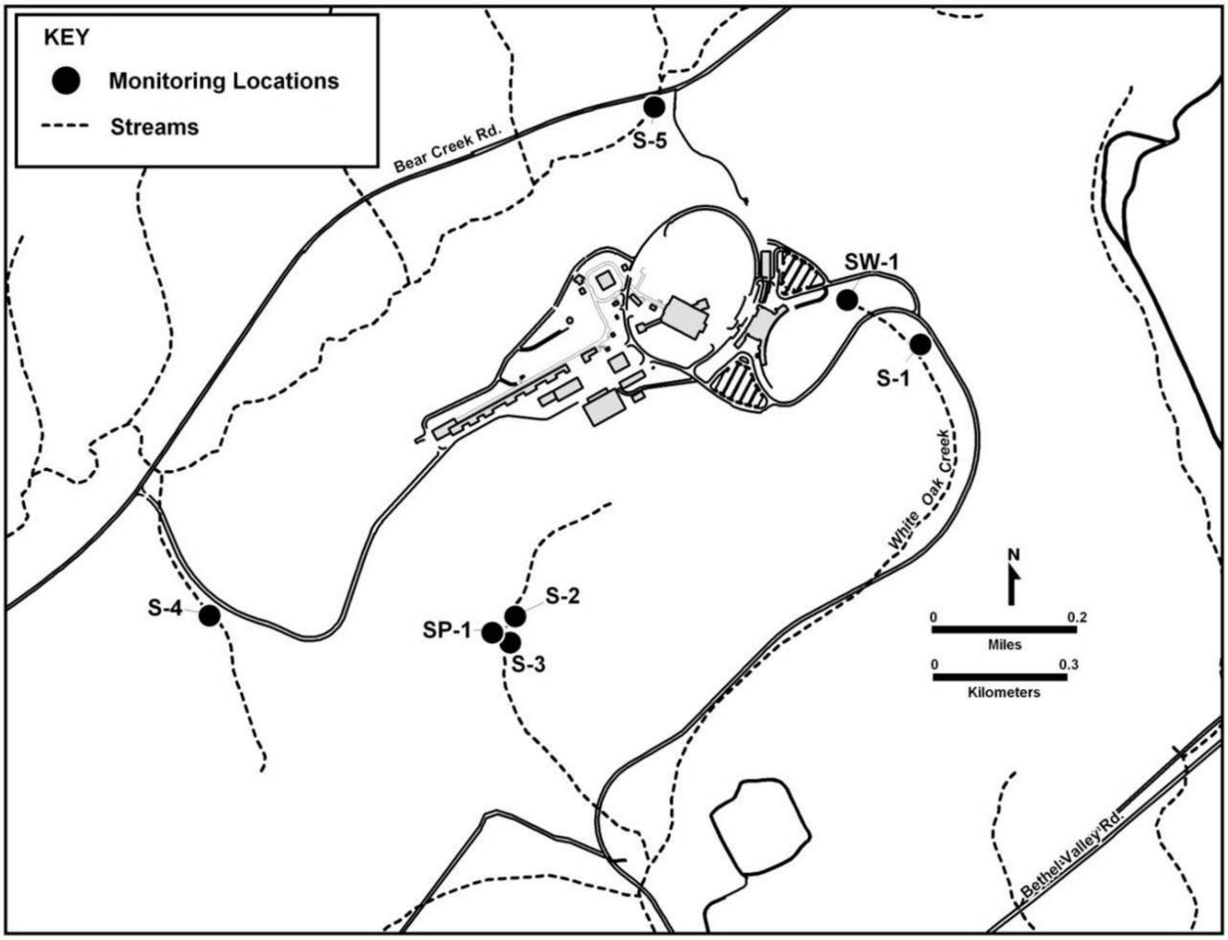

Fig. 5.46. Groundwater monitoring locations at the Spallation Neutron Source, 2009.

^{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

Sampling at the SNS site occurred during March, June, September, and November 2009, and the sampling results were compared to reference standards. Gross alpha activity was detected above the applicable reference standard in the base flow sample collected from S-5 in March 2009. No other SNS sample results exceeded reference standard values in 2009. Low concentrations of gross alpha activity were detected in samples collected from S-1 and SW-1 during base flow conditions in March. In addition, low concentrations of gross beta activity were detected in samples collected from S-2 and S-5 during base flow conditions in March 2009. Carbon-14 was detected in a sample collected during base flow condition at monitoring point S-4 in March 2009. Low concentrations of ^{3}H were detected numerous times during 2009. The following is a summary of the locations, flow conditions, and dates for the ^{3}H detections.

1. S-1 – (a) during falling limb flow conditions in March; (b) during base flow, rising limb, and falling limb flow conditions in September; and c) during rising limb flow conditions in November
2. S-2 – (a) during base flow, rising limb, and falling limb flow conditions in September and (b) during rising limb flow conditions in November
3. S-4 – during rising limb flow conditions in November
4. S-5 – (a) during base flow and rising limb flow conditions in September and (b) during rising limb flow conditions in November
5. SW-1 – during rising limb flow conditions in September and November

SNS groundwater monitoring results are found in the 2009 Environmental Monitoring Results (DOE 2009).

5.7 U.S. Department of Agriculture/Tennessee Department of Agriculture

In 2009, UT-Battelle personnel had 10 domestic soil agreements for receipt of or movement of quarantined soils, two soil permits for receipt of or movement of nondomestic soils (from outside the continental United States), and six other 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.

All activities conducted under soil compliance agreements and soil permits were in compliance with the applicable regulations.

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;
- perform work planning: analyze hazards and define controls;
- execute work, and
- provide feedback.

In addition, EP&WSD has approved project-specific standard operating procedures for all activities controlled and maintained through the ORNL Integrated Document Management System.

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.

Likewise, the TWPC Training and Qualification program provides employees 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 the Integrated Document Management System, 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. Standard operating procedures for sampling 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 activities that have been performed conform to expectations and requirements. External assessments are scheduled based on requests from auditing agencies. Table 2.1 presents a listing of environmental audits and assessments performed at ORNL in 2009 and information on the number of findings identified. 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.

The TWPC performs independent audits, surveillances, and internal management assessments to verify that requirements have been accurately specified and activities that have been performed conform to expectations and requirements. Environmental personnel conduct internal assessments of TWPC procedural compliance, environmental compliance, and EMS implementation. Corrective actions, if required, are documented and tracked in the TWPC Issues Management Database.

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. UT-Battelle uses a competitive award system to select laboratories that are contracted under basic ordering agreements to perform analytical work to characterize ORNL environmental samples. The DOE Environmental Management Consolidated Audit Program performs oversight of subcontracted commercial laboratories. 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 that monitor the performance of all subcontracted laboratories and verify that 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 office areas and the ORNL Inactive Records Center, and destroying records.

The TWPC maintains all 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 at ORNL

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 has become one of the world's most modern campuses for scientific discovery in materials and chemical sciences, nuclear science, energy research, and supercomputing. However, among all this modern infrastructure are large contaminated areas that resulted from years of former operations and waste storage. The EM Program has divided ORNL into two major cleanup areas: Bethel Valley and Melton Valley. The Bethel Valley area includes the principal research facilities, and the Melton Valley area was used for reactors and waste management. The following sections summarize some of the 2009 EM activities undertaken at ORNL. More detailed information is available in the *FY 2009 Cleanup Progress Annual Report to the Oak Ridge Community* (DOE 2009a).

Tank W1-A Remediation Planned

An area of groundwater contamination resulting from Tank W-1A, called the Core Hole 8 plume, has been the focus of DOE coordinated actions to minimize the release of contaminants since late 1994.

Remediating Tank W-1A has been on hold pending funding, but in FY 2009 it was identified as a project that would receive ARRA funds.

The Core Hole 8 plume, located in the central portion of the ORNL main plant area, emanates from contaminated soil surrounding Tank W-1A in the North Tank Farm and migrates westward to a nearby creek. The principal plume contaminants are strontium-90 and uranium isotopes.

Planning activities in 2009 focused on characterizing the extent and types of contamination as well as excavation, packaging, and waste transportation considerations. The project is scheduled to be completed in 2011.

Decommissioning of Non-Reactor Facilities

In FY 2009, DOE prepared a remedial design report/remedial action work plan (RDR/RAWP) for decontamination and decommissioning (D&D) of non-reactor facilities and legacy material removal in the Bethel Valley Watershed at ORNL. The RDR/RAWP addresses D&D of approximately 180 facilities including:

- near-term projects funded by ARRA that are planned for completion in 2011, and
- other (non-ARRA-funded) facility D&D and legacy material removal scope planned for implementation during a 20-plus-year period.

Initiation of Demolition Plans for Building 3026 C&D

In 2009, demolition was initiated on one of the highest hazard excess facilities at ORNL: the 3026 C&D Radioisotope Development Laboratory. This building—one of the original Manhattan Project facilities—had a footprint of approximately 20,000 ft^2 and contained several hot cells and associated pipes and ducts that were highly contaminated. The wooden structure in which the hot cells were located had deteriorated significantly over the years, and a roof failure in 2007 damaged the fire suppression sprinkler system, requiring deactivation. This presented potential fire hazards to nearby facilities and the potential for contaminant release if a fire occurred in the facility. DOE determined that the resulting risks warranted implementing a time-critical removal action for the 3026 C&D wooden structure.

In 2009, a high-priority, accelerated project plan was developed by UT-Battelle and approved by DOE to prepare for demolition of the wooden structure. The Waste Handling Plan and associated sampling and analysis plan/quality assurance project plan was prepared, reviewed, and approved by EPA and TDEC. The facility’s structural condition was assessed, and shoring was installed to ensure safe access for workers to most areas of the facility. The facility was surveyed to establish baseline hazardous material conditions so that appropriate worker protection measures could be identified and implemented. Samples and analytical data were developed, and a waste profile was prepared and approved for disposal of the majority of demolition debris at the EMWMF as well as disposal of selected items off-site. Associated cell piping and ductwork were treated with stabilizing agents to minimize the potential for release of contaminants during the demolition process. The facility was disconnected from utility systems (water, steam, air, and ventilation). A subcontract was established with Clauss Construction, LLC, to demolish the wooden structure. The activities required to prepare for final demolition were initiated and included removal of asbestos-containing materials (floor tile, transite, thermal insulation); removal of hazardous materials, such as lead shielding, light bulbs, mercury switches, and oils; and removal of hot cell piping and ductwork. At the end of FY 2009, final preparations were in progress to begin shipping and disposing of asbestos-containing debris at the EMWMF. Demolition of the 3026 C&D wooden structure was completed in early FY 2010. A follow-on project is planned to be initiated later in FY 2010 to demolish the remaining 3026 hot cell structures.

Planning for Demolition of "2000 Complex" Facilities

In 2009, planning began for the demolition of the 2000 Complex at ORNL, located in the northwest corner of the central campus area. The complex consisted of 8 facilities encompassing about 60,000 ft^2 used to support ORNL research projects in the late 1940s. The complex is in severe disrepair and has been vacant for approximately 6 years. A high-priority, accelerated project plan was developed by UT-Battelle in 2009 and approved by DOE. The demolition will be conducted in two phases with the first phase (2000 Complex East) consisting of six buildings (2001, 2019, 2024, 2087, 2088, and 2092) and the second phase (2000 Complex West) consisting of the 2000 and 2034 buildings.

The Waste Handling Plan and associated Sampling and Analysis Plan/Quality Assurance Project Plan are in development, with approval anticipated in early FY 2010. Demolition of the 2000 Complex East buildings is expected to be completed by the spring of 2010. Demolition of the 2000 Complex West facilities is expected to be completed in the late fall of 2010.

Bethel Valley Burial Grounds Remediation

In 2009, DOE prepared a RDR/RAWP that presents the design for hydrologic isolation of buried waste at the Bethel Valley Burial Grounds at ORNL. The RDR/RAWP addresses remediation of two former waste sites that are sources of contaminant release: Solid Waste Storage Area (SWSA) 1 in Central Bethel Valley and SWSA 3 in West Bethel Valley.

The RDR/RAWP also addresses contaminated areas in the vicinity of the two SWSAs. The Bethel Valley Burial Grounds remediation project is planned to be performed with ARRA funding and completed in 2011.

Soil and Sediment Remediation

The ORNL Soils and Sediment Project will complete removal of contaminated soils and sediments to protect workers and groundwater as specified in the Bethel Valley Interim Record of Decision.

The RAWP for the project provides the approach that will be followed to characterize soils and sediments to ensure that the soil cleanup requirements for Bethel Valley are met. The initial draft of the RAWP was submitted to the regulators in 2008, and a revised draft was submitted in 2009. Officials are working to resolve regulator comments and finalize the RAWP by early FY 2010.

Field sampling activities for this area are planned to be started in FY 2010. Additional workshops on the remaining areas will also be conducted in FY 2010.

5.10 ORNL Waste Management

5.10.1 ORNL Wastewater Treatment

At ORNL, approximately 131 million gal of wastewater were treated and released at the PWTC in 2009. In addition, the liquid low-level waste (LLW) evaporator at ORNL treated 141,000 gal of waste. The waste treatment activities supported both EM and Office of Science mission activities, ensuring that wastewaters for both programs' activities are managed in a safe and compliant manner.

5.10.2 ORNL Newly Generated Waste Management

ORNL is the largest, most diverse Office of Science Laboratory in the DOE Complex. Although much effort is expended to prevent pollution and eliminate waste generation, some waste streams are generated as a byproduct of performing research and operational activities and must be managed to ensure the environment is protected from associated hazards. UT-Battelle, LLC, as the prime contractor for the management of ORNL, is responsible for the management of wastes generated from research and development activities as well as the wastes generated from the operations of the R&D facilities.

Wastes generated from ongoing research and operational activities are termed "newly generated waste." At ORNL, newly generated wastes consist of chemical waste streams, waste containing or contaminated with radioactivity, and chemical waste that also contains radioactivity (known as mixed waste). The majority of ORNL's newly generated radioactive waste meets the definition of low-level radioactive waste, but ORNL does generate a small quantity of waste classified as TRU waste. Most of ORNL's newly generated radioactive waste contains very small quantities of radioactivity, and can be handled without special-handling protocols (this waste is known as contact-handled [CH] waste). However, some wastes generated in the ORNL's nuclear facilities contain enough radioactivity to require special-handling procedures such as transport in special casks that provide shielding of the radioactivity (this waste is known as remote-handled [RH] waste). Less than 5% of the ORNL's newly generated radioactive waste meets the criteria of being RH waste.

Beginning October 1, 2008, ORNL became fully responsible for disposition of almost all of its newly generated waste. Prior to that date, waste management responsibilities at ORNL were a shared responsibility between the DOE Office of Science (and its prime contractor, UT-Battelle) and DOE-EM (and its prime contractor, BJC). DOE initiated the transfer of most waste management responsibilities back to ORNL on October 1, 2008, to give waste generators across ORNL incentive to find new ways of doing business to eliminate and/or reduce waste generation. When 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. Waste management responsibility is currently shared only for those waste streams that are still both being generated by DOE-SC and DOE-EM activities at ORNL (e.g., TRU waste, and certain liquid and gaseous waste streams that can be treated by the on-site ORNL liquid and gaseous waste system operated by DOE-EM and its contractors).

The transition of waste management responsibilities at ORNL that took effect the beginning of FY 2009 went smoothly, and ORNL newly generated waste continues to be safely and effectively dispositioned using a combination of commercial waste vendors and government-owned waste disposal sites. ORNL maintains contracts with a variety of commercial waste vendors to provide for the required transport, treatment, and safe disposal of hazardous, mixed, and some radioactive waste streams. The other radioactive waste streams from ORNL are dispositioned at the National Nuclear Security Administration's (NNSA's) Nevada Test Site, for which ORNL is an approved waste generator. Standard industrial waste generated by ORNL is dispositioned in DOE's ORR industrial waste landfills located near Y-12. Finally, certain waste streams generated from environmental remediation projects at ORNL may also be dispositioned in the Oak Ridge EMWMF located near Y-12, if approved by regulatory agencies in accordance with the Oak Ridge Federal Facilities Agreement.

ORNL management of newly generated waste is fully regulated by a number of federal and state laws and associated regulations. In Oak Ridge, most of these regulations are implemented by the State of Tennessee, with TDEC overseeing waste management activities. ORNL waste management officials routinely meet with TDEC DOE Oversight Division staff to brief them on the status of waste management activities, and compliance audits of waste management activities are routinely performed by TDEC. ORNL's radioactive waste activities are performed under the authority of DOE's Radioactive Waste Management Order (DOE Order 435.1), with which ORNL fully complies. Radioactive waste activities are routinely reviewed with DOE officials to ensure the requirements of the radioactive waste order are being met.

5.10.3 TRU Waste Processing Center

TRU waste-processing activities carried out for DOE in 2009 by WAI address the three remaining waste streams stored at ORNL—CH solids/debris, 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 in December 2005, and RH-TRU processing started in May 2008. During CY 2009, 380 m^3 of CH waste and 18.8 m^3 of RH waste was processed. In CY 2009, 102.7 m^3 of CH waste and 5.5 m^3 of RH waste was shipped off-site.

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Best Management Practices Plan

Bethel Valley Interim ROD

Biological Monitoring and Abatement Plan (BMAP)

CERCLA

Chlorine Control Strategy

Clean Air Act

DOE Order 435.1

DOE Order 450.1a

Emergency Planning and Community Right-to-Know Act

EPA Method 2

Executive Order 13423, “Strengthening Federal Environmental, Energy, and Transportation Management”

FFA

FONSI for 3019 Complex

Integrated Safety Management Description Plan

NTRC SPCC Plan

Oil Pollution Act of 1990

ORNL Ozone Plan

ORNL SPCC Plan

QAPP (Bldg. 3206)

Radiological Monitoring Plan

RDR/RAWP for D&D?

Sampling and Analysis Plan (Bldg. 3206)

SARA

Sect. 311 of the CWA

Storm Water Pollution Prevention Plan

Subtitle I of RCRA (40 CFR 280)

TDEC Rule 1200-1-15

Tennessee Drinking Water Regulations

The Energy Policy Act (EPACT) of 2005

Title III of SARA

Title VI CAA

Toxic Chemical Release Reporting Annual Report

WAI Contract Requirements Document and Regulatory Management Plan

Waste Handling Plan (Bldg. 3206)

WQPP

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 Chapter 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 Towers MT3 and MT9, where data are collected at 15 and 33 m. Additionally, at selected towers, data are collected at the 30-, 33-, 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 East Tennessee Technology Park (ETTP), and at MT2 and MT4 (as of 2010) at Oak Ridge National Laboratory (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).

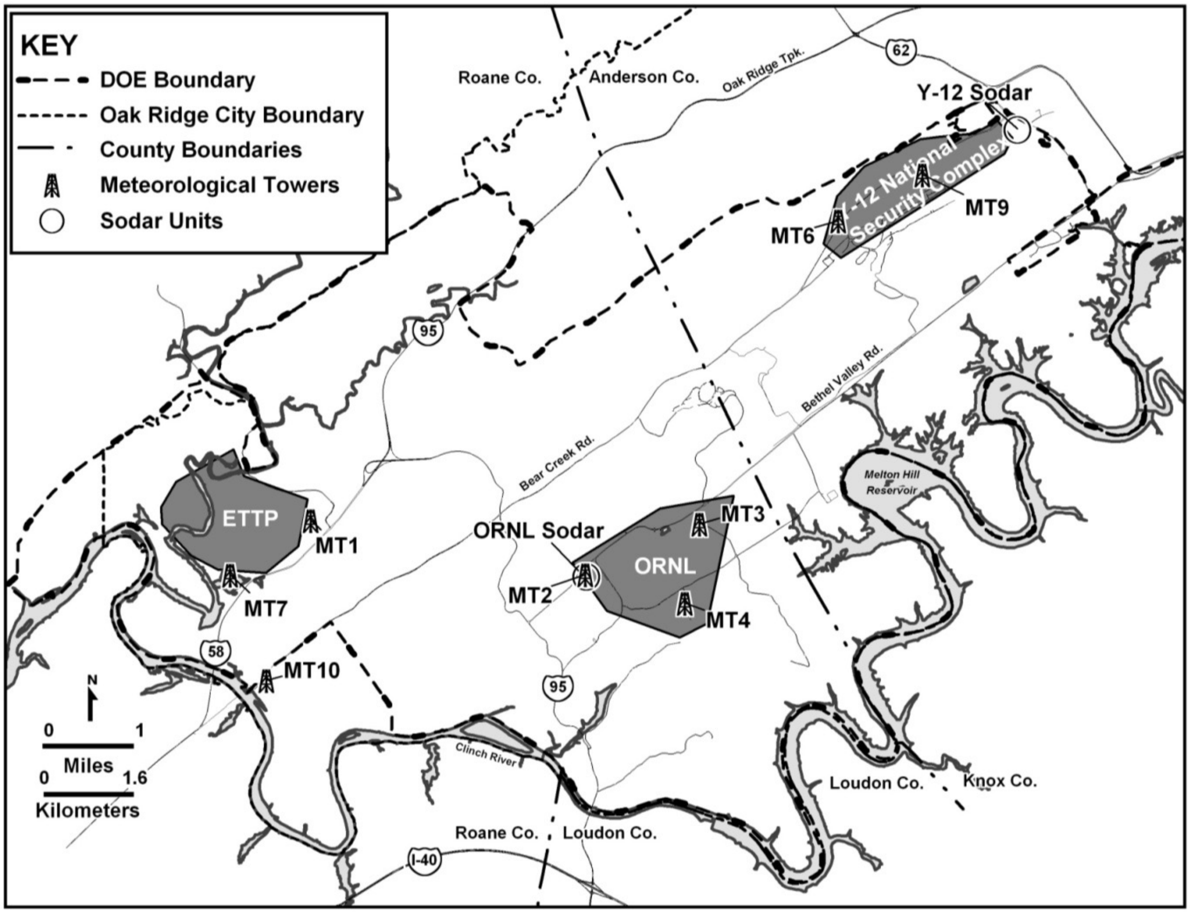

Fig. 6.1. The ORR meteorological monitoring network (Sodar: sonic detection and ranging wind profiler).

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	15, 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.

On the ORR, low-speed winds dominate near the surface. This characteristic is typical of most near-surface measurements (as influenced by nearby ridges and mountains). Winds sometimes accelerate at ridgetop level, particularly when winds are not exactly 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 at Oak Ridge (town site) during 2009 (1,544 mm) was 17.6% above the long-term average of 1,313 mm. This marks the first year of above-average precipitation since 2004.

The average data recovery rates (a measure of acceptable data) across locations used for modeling during 2009 were greater than 96.3% for ORNL sites (Towers MT2, MT3, MT4, and MT10); greater than 97.9% for ETTP sites (Towers MT1 and MT7); and 99.7% for Y-12 sites (Towers MT6 and MT9). Nearly all data recovery exceeded the required 90% per quarter recovery rate. Those that did exceed the requirement (Tower A 10-m temperature for 2009 Quarters 1 and 2 and Tower C 100-m wind speed during 2009 Quarter 4) were corrected with accepted substitution data from nearby sites.

6.2 External Gamma Radiation Monitoring

Table 6.2 summarizes the data collected at each station during the year. The mean observed exposure rate for the reservation network for 2009 was 7.7 μR/h, which is slightly higher than the annual average of 6.7 μR/h observed at the reference location. 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.

Table 6.2. External gamma averages for the ORR, 2009

Monitoring location	Number of data values collected	Measurement (μR/h)[a]		
		Min	Max	Mean
39	52	8.4	9.0	8.7
40	52	5.5	8.6	7.7
42	52	5.9	7.1	6.7
46	52	7.8	9.1	8.8
48	52	6.0	8.1	6.6
52	52	5.6	7.4	6.7

[a]To convert microroentgens per hour (μR/h) to milliroentgens per year, multiply by 8.760.

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.

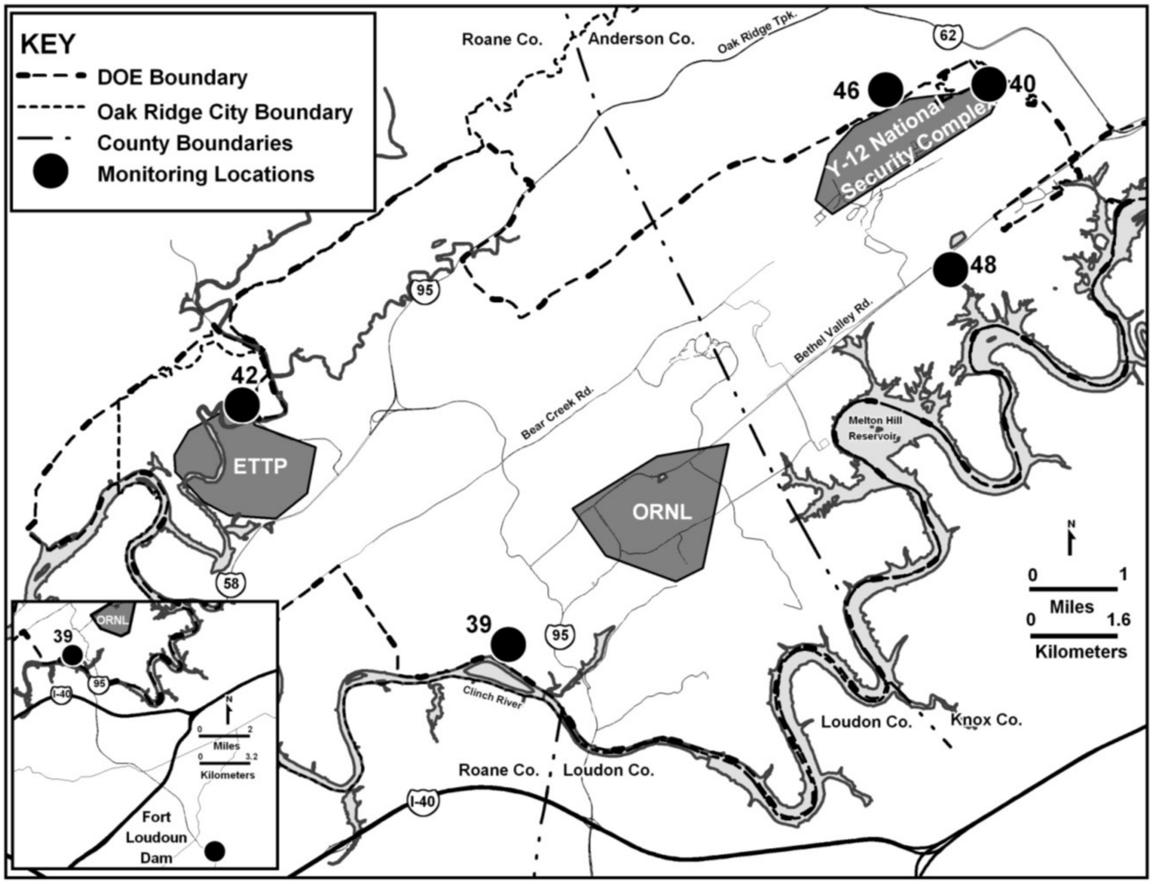

Fig. 6.2. External gamma radiation monitoring locations on the ORR.

6.2.2 Results

Table 6.2 summarizes the data collected at each station during the year. Values in this table have previously been presented as dose rates but this year are reported as exposure rates, in μR/h, to more accurately present actual measured values. The mean observed exposure rate for the reservation network for 2009 was 7.7 μR/h, and the average at the reference location was 6.7 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 by each installation to measure radiological parameters directly in the ambient air adjacent to the facilities. Ambient air monitoring conducted at site levels is discussed in Chapters 3, 4, and 5. 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.

An ORR ambient air monitoring program is also conducted as a complement to the individual site programs and for purposes of assessing the impacts of ORR operations on an integrated basis. This program is discussed in detail in the following sections.

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 2009 to quantify levels of alpha-, beta-, and gamma-emitting radionuclides.

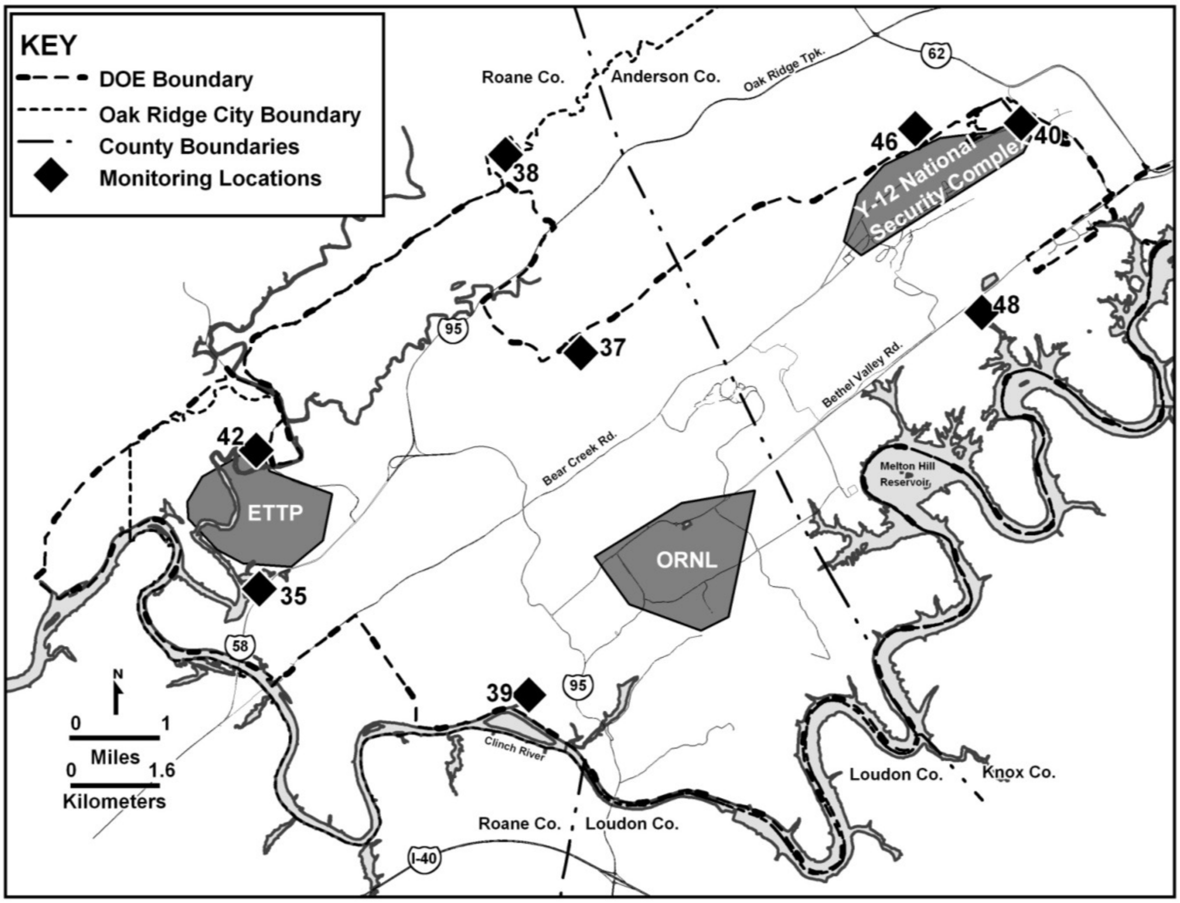

Fig. 6.3. Locations of ORR perimeter air monitoring stations.

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 using high-volume air samplers. The filters are collected weekly, composited quarterly, and then submitted to an analytical laboratory to quantify gross alpha and beta activity and to determine concentrations of specific isotope of interest on the ORR. 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.

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 the appropriate derived concentration guide (DCG). DCGs serve as standard reference values for conducting environmental protection programs at DOE sites. All radionuclide concentrations measured at the ORR ambient air stations during 2009 were less than 1% of applicable DCGs, indicating that activities on the reservation are not adversely affecting local air quality. 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 or ^{40}K. The concentrations of ^{3}H, ^{234}U, ^{235}U, and ^{238}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 2005 through 2009.

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 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 U.S. Environmental Protection Agency radionuclide drinking water standards are based.

6.4.2 Results

Comparison of 2009 surface water sample results from locations upstream of DOE inputs with results from surface water samples obtained downstream of DOE inputs shows no statistically significant difference for any of the radionuclides; none of the radionuclides at any location were detected above 4% of the respective DCG or the 4-mrem dose limit which is the maximum contaminant limit (MCL) for beta and photon emitters in community drinking water systems (CFR 2005).

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.

Table 6.3. Average radionuclide concentrations at ORR perimeter air monitoring stations, 2009

Parameter	No. detected/ no. total	Concentration (pCi/mL)[a]		
		Average	Minimum	Maximum
		Station 35		
^{7}Be	4/4	2.79E–08	1.73E–08	3.85E–08
^{40}K	0/4	1.85E–10	1.04E–11	4.56E–10
^{3}H	1/4	4.03E–06	6.78E–07	8.02E–06
^{234}U	4/4	1.30E–11	5.29E–12	2.24E–11
^{235}U	2/4	5.17E–13	–6.30E–14	9.06E–13
^{238}U	4/4	5.62E–12	2.60E–12	7.96E–12
		Station 37		
^{7}Be	4/4	2.90E–08	1.82E–08	3.54E–08
^{40}K	0/4	3.18E–10	–6.78E–11	5.37E–10
^{3}H	2/4	2.68E–05	–6.12E–07	9.26E–05
^{234}U	4/4	4.37E–12	3.64E–12	5.82E–12
^{235}U	1/4	3.54E–13	1.86E–13	6.31E–13
^{238}U	4/4	3.63E–12	2.22E–12	5.31E–12
		Station 38		
^{7}Be	4/4	2.94E–08	2.40E–08	4.32E–08
^{40}K	0/4	–8.39E–11	–3.00E–10	5.92E–11
^{3}H	0/4	2.07E–06	3.14E–08	4.38E–06
^{234}U	4/4	4.10E–12	3.20E–12	5.54E–12
^{235}U	1/4	2.42E–13	6.10E–14	4.02E–13
^{238}U	4/4	3.18E–12	2.20E–12	5.00E–12
		Station 39		
^{7}Be	4/4	2.65E–08	2.09E–08	3.78E–08
^{40}K	0/4	1.35E–10	5.01E–12	2.37E–10
^{3}H	1/4	1.03E–06	–3.99E–06	6.14E–06
^{234}U	4/4	2.61E–12	1.28E–12	3.76E–12
^{235}U	0/4	1.06E–13	0	2.19E–13
^{238}U	4/4	2.76E–12	2.22E–12	3.48E–12
		Station 40		
^{7}Be	4/4	2.71E–08	1.41E–08	5.01E–08
^{40}K	0/4	–1.34E–10	–3.34E–10	–9.65E–12
^{3}H	1/4	9.65E–06	–1.39E–08	2.84E–05
^{234}U	4/4	1.20E–11	6.40E–12	2.12E–11
^{235}U	2/4	3.55E–13	2.20E–13	5.21E–13
^{238}U	4/4	2.97E–12	1.78E–12	4.44E–12
		Station 42		
^{7}Be	4/4	2.85E–08	2.24E–08	3.31E–08
^{40}K	0/4	–1.39E–10	–5.00E–10	3.90E–10
^{3}H	1/4	3.83E–06	1.14E–06	6.73E–06
^{234}U	4/4	1.60E–11	6.08E–12	2.94E–11
^{235}U	2/4	5.11E–13	1.66E–13	8.16E–13
^{238}U	4/4	3.70E–12	3.16E–12	4.61E–12
		Station 46		
^{7}Be	4/4	2.85E–08	2.01E–08	4.65E–08
^{40}K	0/4	1.76E–10	–2.68E–10	4.71E–10
^{3}H	1/4	1.29E–05	4.94E–07	3.63E–05
^{234}U	4/4	7.38E–12	3.34E–12	1.33E–11
^{235}U	2/4	3.42E–13	1.28E–13	5.90E–13
^{238}U	4/4	2.87E–12	2.14E–12	4.43E–12

Table 6.3 (continued)

Parameter	No. detected/ no. total	Concentration (pCi/mL)[a]		
		Average	Minimum	Maximum
		Station 48		
^{7}Be	4/4	3.16E–08	1.65E–08	4.72E–08
^{40}K	0/4	–8.51E–11	–3.72E–10	1.75E–10
^{3}H	0/4	1.94E–06	–4.36E–07	4.95E–06
^{234}U	3/4	2.36E–12	5.64E–13	3.41E–12
^{235}U	0/4	9.73E–14	0	2.13E–13
^{238}U	4/4	2.39E–12	1.44E–12	3.89E–12
		Station 52		
^{7}Be	4/4	3.40E–08	2.51E–08	4.89E–08
^{40}K	0/4	7.22E–11	–5.66E–11	2.96E–10
^{3}H	0/4	1.52E–06	–1.15E–06	3.07E–06
^{234}U	4/4	2.37E–12	1.07E–12	2.94E–12
^{235}U	0/4	1.43E–13	–7.74E–14	3.59E–13
^{238}U	4/4	2.18E–12	1.67E–12	2.68E–12

[a]Units are picocuries per milliliter.

6.5.1 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.

6.5.1.1 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 radionuclides ^{7}Be and ^{40}K. Concentrations of radionuclides detected above MDA are shown in Table 6.6.

6.5.2 Milk

Ingestion is one of the pathways of exposure to radioactivity for humans. Radionuclides can be transferred from the environment to people via food chains such as the grass-cow-milk pathway. Milk is a potentially significant source to humans of some radionuclides deposited from airborne emissions because of the relatively large surface area that a cow can graze daily, the rapid transfer of milk from producer to consumer, and the importance of milk in the diet.

The milk-sampling program resumed in 2009 after a dairy was identified in Claxton. The 2009 milk-sampling program consisted of grab samples collected every other month from the Claxton location and two reference locations, one in Maryville and one in Louisville (Fig. 6.5). Milk samples are analyzed for gamma emitters and for total radioactive strontium (^{89}Sr + ^{90}Sr) by chemical separation and low-background beta counting. Liquid scintillation is used to analyze for ^{3}H.

6.5.2.1 Results

Concentrations of radionuclides detected above MDA in milk are presented in Table 6.7. Total radioactive strontium (^{89}Sr + ^{90}Sr) was detected once at the Claxton location, resulting in a low estimated dose. Each of the sampled locations is remote from the DOE facilities and very unlikely to be impacted by DOE activities.

Table 6.4. Uranium concentrations in ambient air on the ORR

Isotope	Concentration (pCi/mL)[a]				
	2005	2006	2007	2008	2009
			Station 35		
^{234}U	1.24E–11	1.43E–11	1.28E–11	6.58E–12	1.30E–11
^{235}U	1.10E–12	1.09E–12	6.88E–13	3.85E–13	5.17E–13
^{238}U	2.16E–11	1.94E–11	1.87E–11	8.29E–12	5.62E–12
			Station 37		
^{234}U	8.01E–12	4.52E–12	6.02E–12	3.81E–12	4.37E–12
^{235}U	9.22E–13	5.83E–13	5.09E–13	3.37E–13	3.54E–13
^{238}U	1.01E–11	6.84E–12	1.28E–11	4.34E–12	3.63E–12
			Station 38		
^{234}U	6.21E–12	5.69E–12	6.93E–12	3.5E–12	4.10E–12
^{235}U	5.72E–13	4.72E–13	4.74E–13	4.38E–13	2.42E–13
^{238}U	7.50E–12	8.28E–12	1.41E–11	3.57E–12	3.18E–12
			Station 39		
^{234}U	4.58E–12	4.46E–12	4.05E–12	2.76E–12	2.61E–12
^{235}U	5.74E–13	4.08E–13	3.86E–13	1.66E–13	1.06E–13
^{238}U	4.40E–12	4.51E–12	4.44E–12	2.88E–12	2.76E–12
			Station 40		
^{234}U	2.85E–11	2.07E–11	2.25E–11	1.68E–11	1.20E–11
^{235}U	1.43E–12	1.22E–12	1.01E–12	9.24E–13	3.55E–13
^{238}U	8.73E–12	6.65E–12	1.15E–11	5.79E–12	2.97E–12
			Station 42		
^{234}U	7.51E–12	1.01E–11	6.57E–12	4.25E–12	1.60E–11
^{235}U	4.58E–13	3.55E–13	4.66E–13	4.13E–13	5.11E–13
^{238}U	1.03E–11	9.68E–12	1.18E–11	3.72E–12	3.70E–12
			Station 46		
^{234}U	1.82E–11	1.07E–11	1.12E–11	9.39E–12	7.38E–12
^{235}U	1.10E–12	4.14E–13	7.18E–13	5.68E–13	3.42E–13
^{238}U	1.04E–11	7.01E–12	1.24E–11	6.35E–12	2.87E–12
			Station 48		
^{234}U	7.63E–12	5.50E–12	7.84E–12	4.08E–12	2.36E–12
^{235}U	5.01E–13	2.49E–13	5.53E–13	2.7E–13	9.73E–14
^{238}U	6.60E–12	4.15E–12	9.84E–12	3.6E–12	2.39E–12
			Station 52		
^{234}U	5.03E–12	3.52E–12	3.74E–12	2.86E–12	2.37E–12
^{235}U	5.31E–12	–6.54E–14	7.20E–14	3.2E–13	1.43E–13
^{238}U	3.95E–12	3.69E–12	3.94E–12	2.4E–12	2.18E–12

[a] 1 pCi = 3.7×10^{-2} Bq.

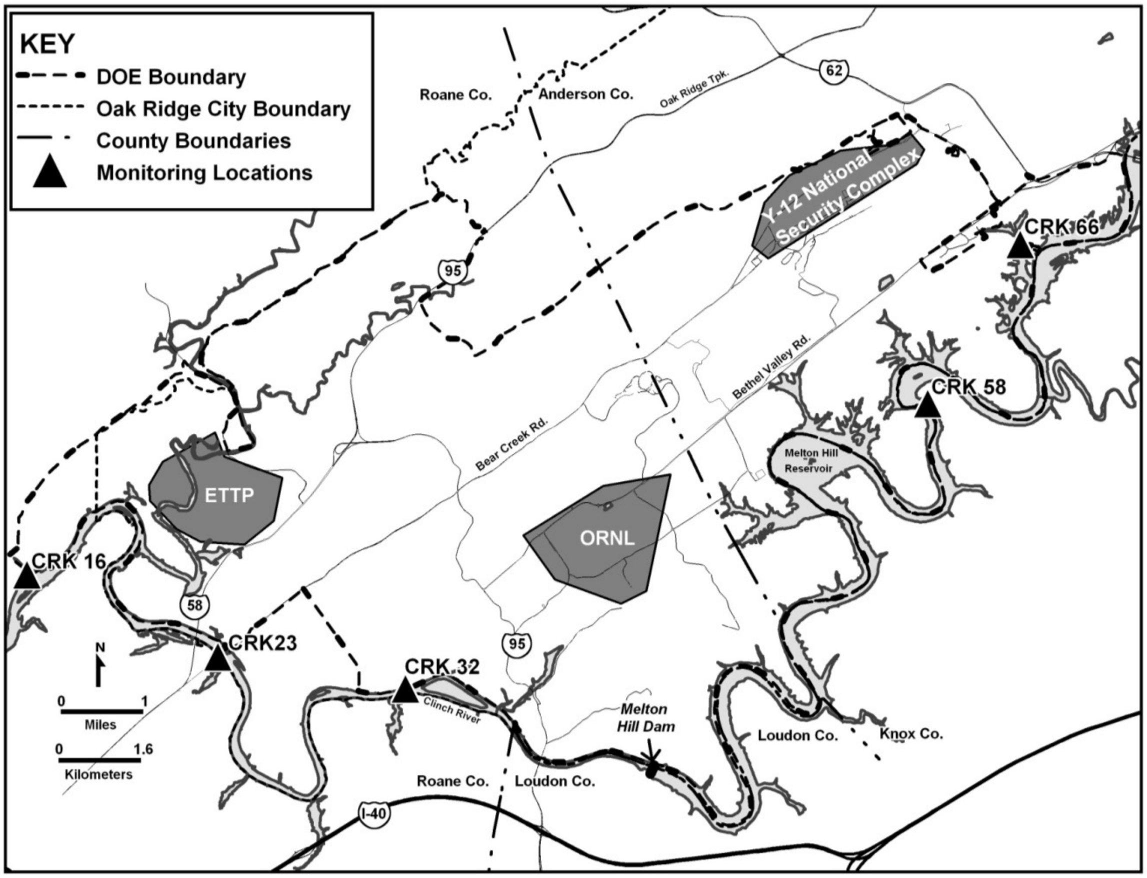

Fig. 6.4. ORR surface water surveillance sampling locations.

Table 6.5. ORR surface water sampling locations, frequencies, and parameters, 2009

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 the Clinch River with the Tennessee River, Watts Bar Reservoir).

[b]Field measurements consist of dissolved oxygen, pH, and temperature.

Table 6.6. Concentrations of radionuclides detected in vegetables, 2009 (pCi/kg)[a]

Location	Gross alpha	Gross beta	^{7}Be	^{40}K	^{234}U	^{235}U	^{238}U
			Lettuce				
East of ORR (Claxton vicinity)	0.000040	0.0029	0.0011	0.0048	0.0000073	*b*	0.0000092
North of ETTP	0.000057	0.0036	*b*	0.0045	0.0000048	*b*	*0.0000052*
Northeast of Y-12, Scarboro #2	*b*	0.0030	*b*	0.0052	0.0000028	*b*	0.0000031
North of Y-12	0.000067	0.0041	*b*	0.0063	0.000014	*b*	0.000014
Southwest of ORNL, Lenoir City #1	0.000071[c]	0.0042	*b*	0.0051	0.0000093	*b*	0.0000092
Southwest of ORNL, Lenoir City #2	0.000080	0.0034	*b*	0.0055	*b*	*b*	*b*
Reference Location, Maryville	0.000038	0.0029	*b*	0.0038	0.0000037	*b*	*b*
			Tomato				
East of ORR (Claxton vicinity)	0.00040[d]	0.00069	*b*	*b*	*b*	*b*	0.0000022
North of ETTP	0.00026	0.00057	*b*	*b*	0.0000044	*b*	*b*
Northeast of Y-12, Scarboro #2	*b*	0.00047	*b*	0.0025	*b*	0.0000023	*b*
North of Y-12	0.00021	0.00073	*b*	0.0015	0.0000048	*b*	*b*
Southwest of ORNL, Lenoir City #1	*b*	0.00074	*b*	*B*	0.0000085	*b*	*b*
Southwest of ORNL, Lenoir City #2	0.000015[e]	0.00071	*b*	0.0019	*b*	*b*	*b*
Reference Location, Maryville	*b*	0.00061	*b*	0.0020	*b*	*b*	0.0000026
			Turnips				
East of ORR (Claxton vicinity)	*b*	0.0015	*b*	0.0025	*b*	*b*	0.0000025
North of ETTP	0.000022	0.0017	*b*	0.0026	*b*	*b*	*b*
Northeast of Y-12, Scarboro #2	0.00020[f]	0.0017	*b*	0.0033	*b*	*b*	*b*
North of Y-12	0.000017	0.0019	*b*	0.0023	*b*	*b*	*b*
Southwest of ORNL, Lenoir City #1	0.00011	0.00223	*b*	0.0028	*b*	*b*	*b*
Southwest of ORNL, Lenoir City #2	*b*[g]	0.0023	*b*	0.0025	*b*	*b*	*b*
Reference Location, Maryville	0.000022[h]	0.0020	*b*	*B*	*b*	*b*	*b*

[a]Detected radionuclides are those at or above minimum detectable activity. 1 pCi = 3.7 × 10^{-2} Bq.

[b]Value was not above minimum detectable activity.

[c]Additional analyses were conducted to identify the alpha activity: $^{239/240}$Pu was detected at 0.0000061pCi/kg; of ^{241}Am, ^{242}Cm, ^{244}Cm, ^{237}Np, ^{238}Pu, ^{228}Th, ^{230}Th, and ^{232}Th, none were above minimum detectable activity.

[d]Additional analyses were conducted to identify the alpha activity, and none were above minimum detectable activity: ^{241}Am, ^{242}Cm, ^{244}Cm, ^{237}Np, ^{238}Pu, $^{239/240}$Pu , ^{228}Th, ^{230}Th, and ^{232}Th.

[e]Additional analyses were conducted to identify the alpha activity: ^{241}Am was detected at 0.0000042 pCi/kg and ^{242}Cm was detected at 0.000013 pCi/kg; of ^{244}Cm, ^{237}Np, ^{238}Pu, $^{239/240}$Pu , ^{228}Th, ^{230}Th, and ^{232}Th none were above minimum detectable activity.

[f]Additional analyses were conducted to identify the alpha activity, and none of the following were above minimum detectable activity: ^{241}Am, ^{242}Cm, ^{244}Cm, ^{237}Np, ^{238}Pu, $^{239/240}$Pu , ^{228}Th, ^{230}Th, and ^{232}Th.

[g]Additional analyses were conducted to identify the alpha activity: ^{232}Th was detected at 0.0000029 pCi/kg; of ^{241}Am, ^{242}Cm, ^{244}Cm, ^{237}Np, ^{238}Pu, $^{239/240}$Pu , ^{228}Th, and ^{230Th}, none were above minimum detectable activity.

[h]Additional analyses were conducted to identify the alpha activity, and none of the following were above minimum detectable activity: ^{241}Am, ^{242}Cm, ^{244}Cm, ^{237}Np, ^{238}Pu, $^{239/240}$Pu , ^{228}Th, ^{230}Th, and ^{232}Th.

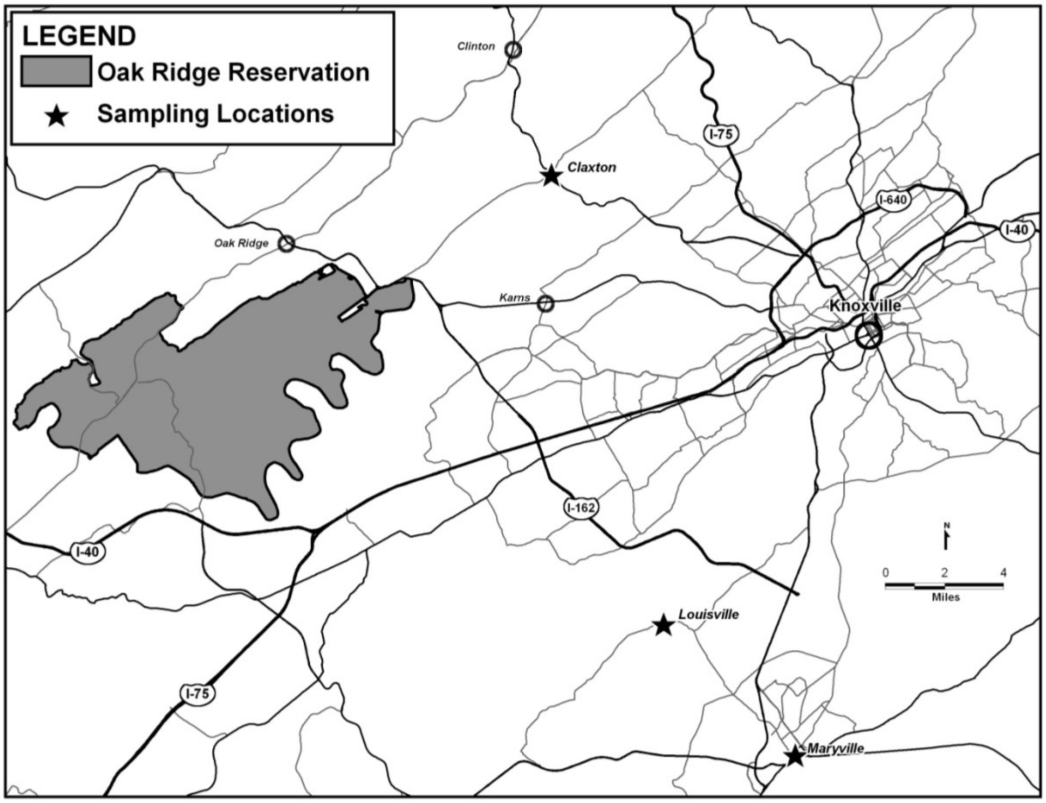

Fig. 6.5. Milk sampling locations in the vicinity of the ORR.

Table 6.7. Concentration of radionuclides detected in raw milk, 2009

Analysis	No. detected/ no. total	Detected concentration (pCi/L)[a]			Standard error of mean
		Max	Min	Avg	
		Claxton			
Potassium-40	6/6	1400[b]	1000[b]	1200[b]	51
Total rad Sr	1/6	2.4[b]	0.26	1.2[b]	0.3
		Combined Reference locations			
Potassium-40	12/12	1400[b]	1200[b]	1300[b]	18

[a]Detected radionuclides are those above minimum detectable activity.
1 pCi = 3.7 H 10^{12} Bq.

[b]Individual and average concentrations significantly greater than zero at the 95% confidence level..

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 potential exposure pathway is monitored by collecting fish from three locations on the Clinch River annually and analyzing edible fish flesh for specific contaminants. The locations are as follows (Fig. 6.6):

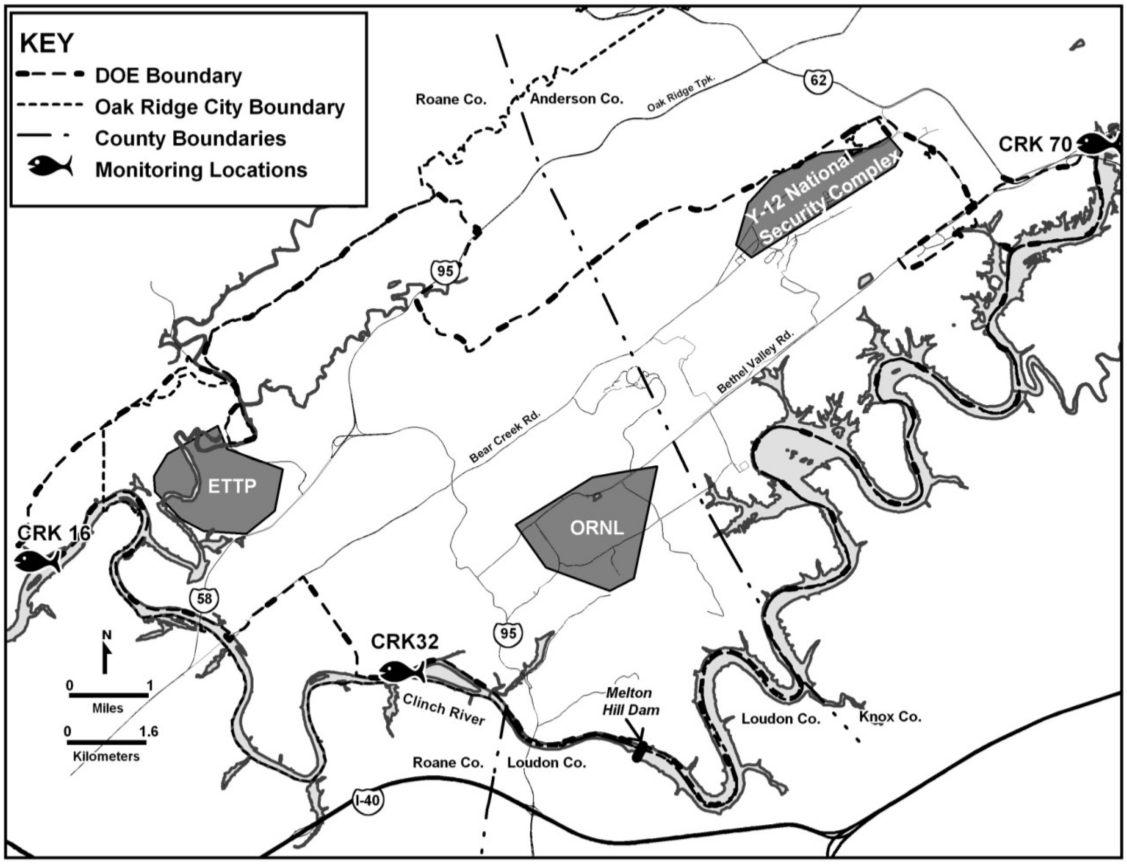

Fig. 6.6. Fish sampling locations for the ORR.

- 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).

Sunfish (*Lepomis macrochirus*, *L. auritus*, and *Ambloplites rupestris*) and catfish (*Ictalurus punctatus*) are collected from each of the three locations to represent both top-feeding and bottom-feeding-predator species. In 2008, a composite sample for each of these species at each location was analyzed for selected metals, polychlorinated biphenyls (PCBs), ^{3}H, gross alpha, gross beta, gamma-emitting radionuclides, and total radioactive strontium. In order to accurately estimate exposure levels to consumers, only edible portions of the fish were submitted for analyses.

It should be noted that the Tennessee Department of Environment and Conservation (TDEC) issues advisories for consumption of certain species of fish caught in specified Tennessee waters. These advisories apply to fish that could contain potentially hazardous contaminants. A "do not consume" advisory has been issued by TDEC for catfish in the Melton Hill Reservoir in its entirety, and not just in those areas that could be impacted by ORR activities, because of PCB contamination. Similarly, a precautionary advisory for catfish in the Clinch River arm of Watts Bar Reservoir has been issued because of PCB contamination (TDEC 2008).

6.6.1 Results

Detected PCBs, mercury, and radionuclides are shown in Table 6.8. PCBs and mercury were detected in both sunfish and catfish at all three locations in 2009. Aroclor-1260 was detected in both species at all locations while Aroclor-1254 was observed in the catfish samples from each location (Aroclor-1260 and -1254 are PCBs). These results are consistent with the TDEC advisories discussed above.

Table 6.8. 2009 tissue concentrations in catfish and sunfish for mercury, detected PCBs, and detected radionuclides[a]

Parameter	Catfish[b]	Sunfish[b]
Clinch River downstream from all DOE ORR inputs (CRK 16)		
Metals (mg/kg)		
Mercury	0.073	0.097
Pesticides and PCBs (μg/kg)		
PCB-1254	69	U[13]
PCB-1260	95	29
Radionuclides (pCi/g)[c]		
Alpha activity	0.0097	0.026*
Beta activity	1.4*	1.5*
Potassium-40	3.3*	2.9*
Clinch River downstream from ORNL (CRK 32)		
Metals (mg/kg)		
Mercury	0.084	0.022
Pesticides and PCBs (μg/kg)		
PCB-1254	130	U[11]
PCB-1260	270	18
Radionuclides (pCi/g)[c]		
Alpha activity	0.1*	0.0088
Beta activity	1.4*	0.97*
Potassium-40	4.0*	2.8*
Clinch River (Solway Bridge) upstream from all DOE ORR inputs (CRK 70)		
Metals (mg/kg)		
Mercury	0.038	0.021
Pesticides and PCBs (μg/kg)		
PCB-1254	15	U[9.7]
PCB-1260	62	40
Radionuclides (pCi/g)[c]		
Alpha activity	0.18*	–0.0037
Beta activity	2.3*	1.0*
Potassium-40	3.2*	4.0*
Strontium-90	0.2*	0.01*

[a]Only parameters that were detected for at least one species are listed in the table. The sampling and analysis plan contains a complete list of analyses performed.

[b]Prefix "U" indicates that the value was undetected at the analytical detection limit.

[c]Radionuclide concentrations significantly greater than zero are identified by an asterisk (*). Detected radionuclides are those at or above MDA.

CRK = Clinch River kilometer

MDA = minimum detectable activity

PCB = polychlorinated biphenyl

Radiological analyses for fish tissues sampled in 2009 showed only two instances of statistical differences (at the 95% confidence level) in radionuclide levels when comparing results from the two areas that could potentially be affected by ORR activities with those from the upstream, non-DOE-impacted location. While no significant differences were observed in gross alpha levels in sunfish at any location, the alpha activity in catfish was slightly higher at the upstream reference location (unaffected by DOE activities) than at either of the two downstream locations. Gross beta activity detected in sunfish at CRK 16, downstream of all reservation sources, was slightly higher than levels observed at either of the other two locations, but no statistical differences were observed in beta results for catfish. There were no other statistical differences in radionuclide concentrations in upstream and downstream locations, indicating that DOE activities on the ORR are not significant contributors to public radiological dose.

6.7 White-Tailed Deer

The twenty-fourth annual deer hunts managed by DOE and the Tennessee Wildlife Resources Agency (TWRA) were held on the ORR during the final quarter of 2009. 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 2009 hunts were held on three weekends. Shotgun/muzzleloader and archery hunts were held October 24–25, November 14–15, and December 5–6. In 2009, 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 354 deer. From the total deer harvest, 214 (60.5%) were bucks and 140 (39.5%) were does. The heaviest buck had ten antler points and weighed 189 lb. The greatest number of antler points found on one buck was 28. The heaviest doe weighed 117 lb.

Since 1985 10,699 deer have been harvested. Of these only 197 (1.84%) have been retained as a result of potential radiological contamination. The heaviest buck was 218 lb (harvested in 1998); the average weight is 85.9 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.

The wildlife administrative release limits associated with deer, turkey, and geese harvested on the ORR are conservative and were established based on as-low-as-reasonably-achievable (ALARA) principles to ensure that doses to consumers of wildlife harvested on the reservation are managed and controlled to levels well below regulatory dose thresholds. The ALARA concept is not a dose limit but rather a philosophy that has the objective of maintaining exposures to worker, members of the public, and the environment ALARA below regulatory limits. The administrative release limit of 5 pCi/g for ^{137}Cs is based on the assumption that one person consumes all of the meat from a maximum-weight deer, goose or turkey. This limit ensures that members of the public who harvest wildlife on the reservation will not receive significant radionuclide doses from this consumption pathway. Similarly, the gross beta count administrative limit of 2.5 times background is near the detection limit for field measurements.

6.7.1 Results

In the 2009 hunts, 354 deer were harvested on the ORR, and 2 (0.56%) were retained for exceeding the administrative release limits [1.5 times the background for beta activity in bone (~20 pCi/g) or 5 pCi/g of ^{137}Cs in edible tissue]. The two retained deer exceeded the limit for beta-particle activity in bone. The average weight of the released deer was 86.8 lb; the maximum weight was 189 lb. The average ^{137}Cs concentration in the released deer was 0.6 pCi/g, and the maximum ^{137}Cs concentration in the released deer was 1.2 pCi/g.

Total field-dressed weight of the released deer was 30,557 lb. It is assumed that 55% of the field weight is edible meat; therefore, the total harvest of edible meat (352 released deer) is estimated to be 16,806 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 ORR operations because open hunts for Canada geese are held on the 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 for noninvasive gross radiological surveys.

From the roundup, 63 geese were subjected to live whole-body gamma scans. The geese were collected from ORNL (19), Y-12 (24), and Clark Center Park (20). None exceeded the administrative release limits.

The same ^{137}Cs release administrative limit as applied to deer is also applied to geese. For ^{137}Cs , the administrative release limit of 5 pCi/g assumes one person consumes all of the meat from a maximum-weight goose. The administrative limits were established to keep doses ALARA and to be consistent among harvested wildlife.

6.8.1.1 Results

The average ^{137}Cs concentration in the released geese was about 0.25 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 0.93 pCi/g. The average weight of the geese screened during the roundup was 7.9 lb, and the maximum goose weight was 11.5 lb. No geese were sacrificed for radiological analyses in 2009.

6.8.2 Turkey Monitoring

Two wild turkey hunts managed by DOE and TWRA were held on the reservation (April 4 and 5 and April 18 and 19, 2009). Hunting was open for both shotguns and archery. Thirty-six turkeys were harvested, of which 7 (19.4%) were juveniles and 29 (80.6%) were adults. The average turkey weight was about 19.3 lb. The largest tom weighed 25.7 lb. The longest beard was 11.9 inches, and the average was 9.0 inches. The longest spur was 1.5 in. and the average was 0.8 in.

Since 1997, 546 turkeys have been harvested. Of these, only three (0.55%) have been retained because of potential radiological contamination. The heaviest turkey was 25.7 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.

The same ^{137}Cs release administrative limits as applied to deer and geese are also applied to turkey. For ^{137}Cs, the administrative release limit of 5 pCi/g assumes one person consumes all of the meat from a maximum-weight turkey. The administrative limits were established to keep doses ALARA and to be consistent between harvested wildlife.

6.8.2.1 Results

In 2009, none of the 36 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 0.14 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 9.7 lb of meat. Based on the individual weights, the total harvest of edible meat (36 released birds) is estimated to be about 347.2 lb. No turkeys were sacrificed for radiological analyses in 2009.

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 whose members represent DOE, UT-Battelle, B&W Y-12, and BJC. 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

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CFR. 2005. Code of Federal Regulations: Title 40: Protection of the Environment, 40 CRF 141.66, December.

TDEC. 2008. *The Status of Water Quality in Tennessee*. 305b Report. Tennessee Department of Environment and Conservation, Division of Water Pollution Control, Nashville, Tennessee. April.

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 0.3 mrem from radionuclides emitted to the atmosphere from all of the sources on the ORR in 2009; 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 2 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 0.02 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 3.2 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 ORR facilities during 2009. 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 a 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 2009 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 software program (CAP-88) 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. CAP-88 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 third year CAP-88 has been used. The program uses 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 ED 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).

A total of 33 emission points on the ORR, each of which includes one or more individual sources, was modeled during 2009. The total includes 3 (2 combined) points at the Y-12 Complex, 24 points at ORNL, and 6 points at ETTP. Table 7.1 lists the emission-point parameter values and receptor locations used in the dose calculations.

Meteorological data used in the calculations for 2009 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 2009, rainfall, as averaged over the four rain gauges located on the ORR, was 163.4 cm. The average air temperature was 14.2°C, and the average mixing-layer height was 568.8 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 (NESHAPs) 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.

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 13,340 m southwest of the main Y-12 National Security Complex release point, about 5,240 m west-southwest of the 7911 stack at ORNL, and about 5,270 m south-southeast of the Toxic Substances Control Act (TSCA) Incinerator (stack K-1435) at the ETTP. This individual could have received an ED of about 0.3 mrem, which is well below the NESHAPs 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

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	4350	SW	4350	SW
X-2000 Lab Hoods	15	0.5	0	Ambient	4770	SW	4770	SW
X-3000 Lab Hoods	15	0.5	0	Ambient	5100	SW	5100	SW
X-4000 Lab Hoods	15	0.5	0	Ambient	5270	SW	5270	SW
X-6000 Lab Hoods	15	0.5	0	Ambient	5970	SW	5970	SW
X-7000 Lab Hoods	15	0.5	0	Ambient	5290	SW	5290	SW
X-2026	22.9	1.05	9.27	Ambient	4820	SW	4820	SW
X-2099	3.66	0.178	16.67	Ambient	4810	SW	4810	SW
X-2523	7	0.3	6.25	Ambient	4670	SW	4670	SW
X-3018	61	4.11	0.23	Ambient	NA		NA	
X-3020	61	1.22	15.65	Ambient	5000	SW	5000	SW
X-3039	76.2	2.44	12.6	Ambient	5070	SW	5070	SW
X-3074 Group	4	0.25	0	Ambient	NA		NA	
X-3544	9.53	0.279	18.52	Ambient	4810	SW	4810	SW
X-3608 Air Stripper	10.97	2.44	0.57	Ambient	4930	SW	4930	SW
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	5550	SW	5550	SW
X-7503	30.5	0.91	10.27	Ambient	5330	SW	5330	SW
X-7830 Group	4.6	0.248	8.5	Ambient	3920	WSW	3920	WSW
X-7855 TRU Bunker	1.0	0.32	0.44	Ambient	4350	SW	4350	SW
X-7856-CIP	18.29	0.483	12.38	Ambient	3970	WSW	3970	WSW
X-7877	13.9	0.406	13.56	Ambient	3890	WSW	3890	WSW
X-7880	27.7	1.52	0	Ambient	3970	WSW	3970	WSW
X-7911	76.2	1.52	12.91	Ambient	5240	WSW	5240	WSW
X-7935								
7935 Bldg Stack	12.57	0.51	11.6	Ambient	NA		NA	
7935 Glove Box	5.5	0.2	6.5	Ambient	NA		NA	
X-7966	6.096	0.292	11.58	Ambient	5330	SW	5330	SW
X-8915	24.38	1.219	5.83	Ambient	8070	SW	8070	SW
X-Decon Areas	15	0.5	0	Ambient	5310	SW	5310	SW
X-STP	7.6	0.203	10.21	Ambient	4590	SW	4590	SW
K-1407-U CNF	7.16	1.22	0.625	Ambient	450	WSW	5700	SSE
K-1423 SWR	7.62	0.71	12.8	Ambient	110	SE	5920	SE
K-1435 Incinerator	30.5	1.37	6.18	80.01	1000	W	5270	SSE
K-1435-C Tanks	18.29	0.2	0	Ambient	970	W	5270	SSE

Table 7.1 (continued)

Source ID	Stack height (m)	Stack diameter (m)	Effective exit gas velocity (m/s)	Exit gas temperatu re (°C)	Distance (m) and direction to the maximally exposed individual[a]			
					Plant maximum		Oak Ridge Reservation maximum	
Y-Monitored	20	0.5	0	Ambient	2270	NE	13340	SW
Y-Room Exhaust	20	0.5	0	Ambient	2270	NE	13340	SW
Y-Unmonitored Processes	20	0.5	0	Ambient	2270	NE	13340	SW
Y-Unmonitored Lab Hoods	20	0.5	0	Ambient	2270	NE	13340	SW

[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. Meteorological towers and heights used to model atmospheric dispersion from source emissions

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	60	K-1435 Incinerator
MT7	10	K-1407-U, K-1423-SWR, K-1435-C WFT,K-2500-HA, K-2500-HD, and K1093
		Oak Ridge National Laboratory
MT4	10	X-7830, X-7966, X-7935, X-7855
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.

about 17 person-rem, which is approximately 0.005 % 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 99%) 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 6% of the collective ED for the ORR.

The maximally exposed individual for ORNL was located at a residence about 5,070 m southwest of the 3039 stack and 5,240 m west-southwest of the 7911 stack. This individual could have received an ED

Table 7.3. Calculated radiation doses to maximally exposed off-site individuals from airborne releases, 2009

Plant	Effective dose, mrem (mSv)	
	At plant max	At Oak Ridge Reservation max
Oak Ridge National Laboratory	0.3 (0.003)[a]	0.3 (0.003)
East Tennessee Technology Park	0.06 (0.0006)[b]	0.007 (0.00007)
Y-12 National Security Complex	0.1(0.001)[c]	0.01(0.0001)
Entire Oak Ridge Reservation	*D*	0.3(0.003)[e]

[a]The maximally exposed individual was located 5070 m SW of X-3039 and 5240 m WSW of X-7911.

[b]The maximally exposed individual was located 1000 m W 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, 2009 (updated 6/16/10)

Plant	Collective effective dose[a]	
	Person-rem	Person-Sv
Oak Ridge National Laboratory	15	0.15
East Tennessee Technology Park	0.9	0.09
Y-12 National Security Complex	1	0.01
Entire Oak Ridge Reservation (ORR)	17	0.17

[a]Collective effective dose to the 1,040,041 persons residing within 80 km of the ORR (based on 2000 census data).

of about 0.29 mrem from ORNL emissions. Radionuclides contributing 1% or more to the dose include ^{41}Ar (9%), ^{212}Pb (27%), ^{138}Cs (30%), ^{125}I (15%), ^{11}C (6%), ^{129}I (4%), ^{138}Xe (1.5%), and ^{88}Kr (1%). The contribution of ORNL emissions to the collective ED to the population residing within 80 km of the ORR was calculated to be about 14.8 person-rem, approximately 88% of the collective ED for the ORR.

The maximally exposed individual for the ETTP was located at a business about 1000 m west of the TSCA Incinerator stack. The ED received by this individual was calculated to be about 0.06 mrem. About 66% of the dose is from ingestion and inhalation of plutonium isotopes (^{238}Pu, ^{239}Pu, ^{240}Pu), 17% of the dose is from uranium radioisotopes (^{234}U, ^{235}U, ^{238}U), about 3% is from ^{3}H, and 9% is from ^{241}Am. The contribution of ETTP emissions to the collective ED to the population residing within 80 km of the ORR was calculated to be about 0.9 person-rem, or approximately 5% of the collective ED for the reservation.

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 0.001 and 0.7 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 0.05 and 0.3 mrem/year. As shown in Table 7.5, EDs calculated using CAP-88 tend to be higher than or equivalent to EDs calculated using measured air concentrations, with the exception of the estimated doses at PAM 37.

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

Table 7.5. Hypothetical effective doses from living at the Oak Ridge Reservation and the East Tennessee Technology Park ambient-air monitoring stations, 2009 (updated 6/16/10)

Station	Calculated effective doses			
	Using air monitor data		Using CAP-88[a] and emission data	
	mrem/year	mSv/year	mrem/year	mSv/year
35	0.04	0.0004	0.1	0.001
37	0.7	0.007	0.1	0.001
38	0.07	0.0007	0.08	0.0008
39	0.001	0.00001	0.3	0.003
40	0.1	0.001	0.3	0.003
42	0.04	0.0004	0.09	0.0009
46	0.09	0.0009	0.1	0.001
48	0.02	0.0002	0.2	0.002
52	0.08	0.0008	*B*	*b*
K2	0.04	0.0004	0.09	0.0009
K6	0.02	0.0002	0.05	0.0005
K9	0.02	0.0002	0.05	0.05
K11	0.09	0.0009	0.1	0.001

[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.

was 0.08 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.

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 0.001 mrem/year, which is less than the ED of 0.3 mrem/year calculated at the PAM 40 air monitor station using CAP-88. PAM 39 is located closer in but near the maximally exposed individual location for ORR/ORNL; the ED calculated using measured air concentrations was 0.001 mrem/year, which was considerably less than the 0.3 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 0.045 mrem/year (half of 0.09 mrem/year to account for the business receptor), which is similar to the ETTP maximally exposed individual annual dose of 0.06 mrem estimated using CAP-88.

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) the 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 with and without 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 allows the potential radiation doses to be bounded. 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 2009, 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 3×10^{-9} mrem. The collective ED to the 30,514 persons who drink water from the city of Oak Ridge water plant could have been 5×10^{-8} person-rem. If naturally occurring radionuclides are included, individual and collective EDs could have been 0.9 mrem and 14 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 0.0005 mrem; the collective dose to the 52,706 persons who drink water from this plant could have been 0.01 person-rem. If naturally occurring radionuclides are included, the EDs could have been 0.9 mrem and 24 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 843 workers who drink water from this plant could have been about 0.08 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 0.03 mrem; the collective dose to the 24,804 persons who drink water from these plants could have been about 0.4 person-rem. If naturally occurring radionuclides are included, the EDs could have been 0.6 mrem and 7 person-rem.

Lower system. Several water treatment plants are located on tributaries of Watts Bar Lake and Chickamauga Lake. Persons drinking water from these plants could not have received EDs greater than the 0.03 mrem calculated for drinking Kingston and Rockwood water. The collective dose to the 275,183 persons who drink water within the lower system could have been about 4 person-rem. If naturally occurring radionuclides are included, the EDs could have been about 0.6 mrem and 63 person-rem.

Poplar Creek/Lower East Fork Poplar Creek. There are no drinking water intake locations on Poplar Creek or on Lower East Fork 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 2009 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 0.5 mrem. The collective ED to the 242 persons who could have eaten such fish could have been 0.04 person-rem. If naturally occurring radionuclides are included, the EDs could have been 4 mrem and 0.3 person-rem.

Melton Hill Lake. An avid fish consumer who ate fish from Melton Hill Lake could have received an ED of about 0.0007 mrem. The collective ED to the 2,179 persons who could have eaten such fish could be about 0.0005 person-rem. If naturally occurring radionuclides are included, the EDs could have been 1 mrem and 0.9 person-rem.

Upper Clinch River. An avid fish consumer who ate fish from the Upper Clinch River could have received an ED of about 1 mrem. The collective ED to the 470 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 7 mrem and 1 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 0.8 mrem. The collective ED to the 1,097 persons who could have eaten such fish could have been about 0.3 person-rem. If naturally occurring radionuclides are included, the EDs could have been 9 mrem and 3 person-rem.

Upper Watts Bar Lake. An avid fish consumer who ate fish from Upper Watts Bar Lake could have received an ED of about 0.2 mrem. The collective ED to the 3,136 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 3 mrem and 3 person-rem.

Lower system. An avid fish consumer who ate fish from the lower system could have received an ED of about 0.2 mrem. The collective ED to the 28,600 persons who could have eaten such fish could have been about 2 person-rem. If naturally occurring radionuclides are included, the EDs could have been 3 mrem and 21 person-rem.

Poplar Creek/Lower East Fork 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 1 mrem. Assuming 100 people could have eaten fish from Lower East Fork Poplar Creek and 100 from

Poplar Creek, the collective ED could have been about 0.04 person-rem. If naturally occurring radionuclides are included, the EDs could have been 2 mrem and 0.07 person-rem.

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 2009, 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 0.0004 mrem. The collective ED to the 10,412 other users could have been 0.0007 person-rem. If naturally occurring radionuclides are included, individual and collective EDs could have been 0.003 mrem and 0.007 person-rem, respectively.

Melton Hill Lake. An individual other user of Melton Hill Lake could have received an ED of about 0.0004 mrem. The collective ED to the 24,294 other users could have been about 0.002 person-rem. If naturally occurring radionuclides are included, the EDs could have been 0.002 mrem and 0.02 person-rem.

Upper Clinch River. An other user of the upper Clinch River could have received an ED of about 0.2 mrem. The collective ED to the 3,774 other users could have been about 0.04 person-rem. If naturally occurring radionuclides are included, the EDs could have been 0.3 mrem and 0.06 person-rem.

Lower Clinch River. An other user of the lower Clinch River could have received an ED of about 0.1 mrem. The collective ED to the 8,807 other users could have been about 0.4 person-rem. If naturally occurring radionuclides are included, the EDs could have been 0.2 mrem and 0.6 person-rem.

Upper Watts Bar Lake. An other user of upper Watts Bar Lake could have received an ED of about 0.05 mrem. The collective ED to the 25,163 other users could have been about 0.5 person-rem. If naturally occurring radionuclides are included, the EDs could have been 0.09 mrem and 0.8 person-rem.

Lower system. An other user of the lower system could have received an ED of about 0.05 mrem. The collective ED to the 413,330 other users could have been about 4 person-rem. If naturally occurring radionuclides are included, the EDs could have been 0.09 mrem and 6 person-rem.

Poplar Creek/Lower East Fork Poplar Creek. An other user of Lower East Fork Poplar Creek, above its confluence with Poplar Creek, could have received an ED of about 0.03 mrem. The collective ED to the 200 other users of Poplar Creek and Lower East Fork Poplar Creek could have been about 0.001 person-rem. If naturally occurring radionuclides are included, the EDs could have been 0.04 mrem and 0.001 person-rem.

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 2 mrem to a person obtaining his or her full annual complement of drinking water and fish from and participating in other water uses on Upper Clinch River. The maximum collective ED to the 50-mile population could be as high as 12 person-rem. These are small percentages of individual and collective doses attributable to natural background radiation, about 0.7 % of the average individual background dose of 300 mrem/year and 0.004% of the 312,012 person-rem that this population received from natural sources of radiation.

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	0.000000003	0.5	0.0004	0.5
Collective ED	0.00000005	0.04	0.0007	0.04
Melton Hill Lake (CRK 58, Knox County Water Plant)				
Individual ED	0.0005	0.0007	0.0004	0.002
Collective ED	0.01	0.00005	0.002	0.02
Upper Clinch River (CRK 23, Gallaher Water Plant, CRK 32)				
Individual ED	0.2	1.2	0.2	2
Collective ED	0.08	0.2	0.04	0.3
Lower Clinch River (CRK 16)				
Individual ED	NA[d]	0.8	0.1	0.9
Collective ED	NA[d]	0.3	0.4	0.6
Upper Watts Bar Lake, Kingston Municipal Water Plant				
Individual ED	0.03	0.2	0.05	0.3
Collective ED	0.4	0.3	0.5	1
Lower system (Lower Watts Bar Lake and Chickamauga Lake)				
Individual ED	0.03	0.2	0.05	0.3
Collective ED	4	2	4	9
Lower East Fork Poplar Creek and Poplar Creek				
Individual ED	NA[d]	1.0	0.03	1
Collective ED	NA[d]	0.04	0.001	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

During 2009, milk samples were collected from two “locations”: a nearby dairy and a composite of several reference locations. Significant concentrations of ^{40}K were detected in all samples and radioactive strontium was detected in one of six samples from the nearby dairy. Potential EDs attributable to ^{40}K at both “locations” were about 9 mrem/year. The dose due to strontium at the nearby dairy was about 0.04 mrem.

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 7Be and 40K also are emitted from the ORR. Dose estimates are based on hypothetical consumption rates of vegetables that contain statistically significant amounts of detected radionuclides that could have come from the ORR. Based on a nationwide food consumption survey (EPA 1997), a hypothetical home gardener was assumed to have eaten 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 0.02 and 0.4 mrem, depending on garden location. Of this total, between 0 and 0.1 mrem could have come from eating tomatoes, between 0.006 and 0.4 mrem from eating lettuce, and between 0 and 0.06 mrem from eating turnips. The highest dose to a gardener could have been about 0.4 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 0.03 mrem, 0.02 mrem from tomatoes and 0.01 mrem from lettuce.

An example of a naturally occurring and fertilizer-introduced radionuclide is 40K, which is specifically identified in the samples and accounts for most of the beta activity found in them. The presence of 40K in the samples adds, on average, between 3 and 4 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 90Sr and 210Po, a hypothetical home gardener could have received an additional ED of between 4 and 55 mrem. Of this total, between 0 and 54 mrem could have come from eating tomatoes, between 0.9 and 3 mrem from eating lettuce, and between 0.2 and 10 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 (e.g., ^{210}Po), not radionuclides discharged from the ORR. Excess beta activity was detected at only two locations, one of which was the distant garden.

Tomato samples at two locations, lettuce samples at one location, and turnip samples at three locations were analyzed for an additional suite of alpha-emitting nuclides. For tomatoes, results of the additional sampling had no effect on one sample and caused the estimated dose to increase by a factor of 4.7 over the dose attributed to radionuclides in the normal sampling menu for the other location. For lettuce, the additional sampling caused the estimated dose to increase by a factor of 12 over normal sampling at the one sampled location. For turnips, the additional sampling had no effect at two locations and increased the estimated dose by a factor of 6.8 over the dose estimated using the normal sampling menu.

7.1.2.3.3 Hay

No hay samples were collected in 2009 (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 2009 on the Oak Ridge Wildlife Management Area, which is part of the ORR (see Sect. 6.7). During the hunts, 354 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; these samples were field-counted for radioactivity to ensure that the deer met wildlife release criteria (less than 20 pCi/g of beta-particle activity in bone or 5 pCi/g of ^{137}Cs in edible tissue). Two deer exceeded the limit for beta-particle activity in bone and were confiscated. The remaining 352 deer were released to the hunters.

The average ^{137}Cs concentration in tissue of the 352 released deer, as determined by field counting, was 0.6 pCi/g; the maximum ^{137}Cs concentration in a released deer was 1.2 pCi/g. Many of the ^{137}Cs concentrations were less than minimum detectable levels. Of the released deer, the average weight was 86.8 lb and the maximum weight was 189 lb. The EDs attributed to field-measured ^{137}Cs concentrations and actual field weights of the released deer ranged from about 0.01 to 1.7 mrem.

Also evaluated were potential doses attributed to deer that might have moved off the ORR and been harvested elsewhere. In this scenario, an individual who consumed one hypothetical average-weight (86.8 lb) deer (assuming 55% field weight is edible meat) containing the 2009 average field-measured concentration of ^{137}Cs (0.6 pCi/g) could have received an ED of about 0.7 mrem. The maximum field-measured ^{137}Cs concentration was 1.2 pCi/g, and the maximum deer weight was 189 lb. A hunter who consumed a hypothetical deer of maximum weight and ^{137}Cs content could have received an ED of about 3 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 2009 detected analytical ^{90}Sr result (0.07 pCi/g, which was at the minimum detectable level) is estimated to be about 2 mrem.

Tissue samples collected in 2009 from 14 deer (12 released and 2 retained) were subjected to laboratory analysis. Requested radioisotopic analyses included ^{137}Cs, ^{90}Sr, and ^{40}K radionuclides. Comparison of the field results to analytical ^{137}Cs concentrations found that the field concentrations were greater than or essentially equal to the analytical results and all were less than the administrative limit of 5 pCi/g. The ^{90}Sr concentrations analyzed in these tissue samples were in most cases less than the minimum detectable levels. Using ^{137}Cs and ^{90}Sr (at maximum measured concentrations and excluding ^{40}K, a naturally occurring radionuclide) analytical tissue data and actual deer weights, the estimated doses for the 14 deer (both retained and released) ranged between 0.09 to 2 mrem.

The maximum ED to an individual consuming venison from two or four deer was also evaluated. There were about 35 hunters/households who harvested 2 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 0.4 to 2.8 mrem.

The collective ED from eating all the harvested venison from ORR with a 2009 average field-derived ^{137}Cs concentration of 0.6 pCi/g and average weight of 86.8 lb is estimated to be about 0.2 person-rem.

7.1.2.3.5 Canada Geese

During the 2009 goose roundup, 63 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 0.25 pCi/g, with maximum ^{137}Cs concentration in the released geese of 0.93 pCi/g. Most of the ^{137}Cs concentrations were below minimum detectable activity levels. The average weight of the geese screened during the roundup was about 7.9 lb and the maximum 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 7.9 lb and an average ^{137}Cs concentration of 0.25 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 0.93 pCi/g and the maximum weight of 11.5 lb was about 0.1 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 a 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 hypothetical geese of maximum weight with the highest measured concentration of ^{137}Cs, that person could have received an ED of about 0.3 mrem.

No geese tissue samples were analyzed in 2008 and 2009. 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 below 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 2009, one April 5–6 and the other April 12–13. Thirty-six birds were harvested, and none were retained. The average ^{137}Cs concentration measured in the released turkeys was 0.1 pCi/g, and the maximum ^{137}Cs concentration was 0.14 pCi/g. The average weight of the turkeys released was about 19.3 lb. The maximum turkey weight was about 25.7 lb.

The EDs attributed to field-measured ^{137}Cs concentrations and actual field weights of the released turkeys ranged from about 0.0005 to 0.03 mrem. Potential doses were also evaluated for turkeys that might have moved off the ORR and been harvested elsewhere. In this scenario, if a person consumed a wild turkey with an average weight of 19.3 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 0.14 pCi/g and the maximum weight of 25.7 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 2009.

The collective ED from consuming all the harvested wild turkey meat (36 birds) with an average field-derived ^{137}Cs concentration of 0.1 pCi/g and average weight of 19.3 lb is estimated to be about 0.0008 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 2009 averaged about 7.7 μR/h and ranged from 5.5 to 9.1 μR/h. These exposure rates correspond to an average ED rate of about 48 mrem/year and a range of 34 to 57 mrem/year. At the remote PAM, the exposure rate averaged 6.7 μR/h (approximately 41 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.

Direct radiation monitoring is no longer conducted for the UF_6 cylinder storage yards and the K-770 Scrap Yard at ETTP. These former sources of direct radiation 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 2009, that person could have received a total ED of about 5 mrem. Of that total, 0.3 mrem would have come from airborne emissions and 2 mrem from waterborne emissions, (0.2 mrem from drinking water, 1.2 mrem from consuming fish, and 0.2 mrem from other water uses along the upper Clinch River).

Table 7.7. Summary of maximum potential effective doses to an adult by exposure pathway

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	0.3	0.003	0.3	17	0.17	1,040,041[b]	
Liquid effluents:							
Drinking water	0.2	0.0002	0.2	0.08	0.0008	384,050[c]	
Eating fish	1.2	0.0012	1.2	0.2	0.002	40,554[d]	
Other activities	0.2	0.0002	0.2	0.04	0.0004	485,981[d]	
Eating deer	3[e]	0.003	3	0.2	0.002	352	
Eating geese	0.1[f]	0.0001	0.1	*g*	*g*		
Eating turkey	0.04[h]	0.00004	0.04	0.0008	0.000008	36	
Direct radiation	0.4[i]	0.0004	0.4				
All pathways	5	0.005		18	0.	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, a combination of the heaviest deer harvested and the highest measured concentrations of ^{137}Cs in released deer on the ORR in 2009; 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 the 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.

This dose is about 2% of the annual dose (300 mrem) from background radiation. The ED of 5 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.

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 2009 maximum ED should not have exceeded about 5 mrem, or about 5% of the limit given in DOE Order 5400.5. (For further information, see Sects. F.5.6 through F.5.12 in Appendix F, which summarize 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 17 person-rem. This dose is about 0.005% of the 312,012 person-rem that this population received from natural sources during 2009.

7.1.4 Five-Year Trends

Dose equivalents associated with selected exposure pathways for the years from 2006 to 2009 are given in Table 7.8.

Table 7.8. Trends in effective dose (mrem)[a] for selected pathways

Pathway	2005	2006	2007	2008	2009
All air	0.9	0.8	0.3	0.4	0.3
Fish consumption (Clinch River)	0.3	0.7	0.9	0.6	0.2
Drinking water (Kingston)	0.03	0.02	0.04	0.05	0.03
Direct radiation (Clinch River)	0.4	0.5[b,c]	0.4[d]	0.4[d]	0.4[d]
Direct radiation (Poplar Creek)	1[b]	0.8[b]	NA[d]	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 (updated 6/21/10)

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 NESHAPs 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. Nine facilities responded to the DOE request. Based on these responses, no member of the public should have received an annual ED greater than 10 mrem due to airborne releases from these facilities. One facility used Level 1 of Comply, which states only that the facility is in compliance and the annual dose is less than 10 mrem; three other facilities stated estimated annual doses from airborne emissions at about 3E-4 mrem, 1.2 mrem, and 9.13E-4 mrem, respectively. Therefore, doses from airborne emissions from both non-DOE and DOE sources should be less than 10 mrem. A maximally exposed individual dose of about 20 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 this facilities 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 (Versions 1.21 and 1.5), 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 biota dose evaluation tool and uses the screening (i.e., biota concentration guides [BCGs]) and analysis methods in the technical standard. The BCG is the limiting concentration of a radionuclide in sediment or water that would not cause dose limits for protection of aquatic biota populations to be exceeded.

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 present both internal and external dose hazards. 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 11 different instream sampling locations:

- Melton Branch (Melton Branch kilometer [MEK] 0.2),
- White Oak Creek (White Oak Creek kilometers [WCK] 1.0, 2.6, and 6.8),
- First Creek,
- Fifth Creek,
- Raccoon Creek,
- Northwest Tributary, and
- Clinch River (CRKs 23, 32, and 66).

All locations, except First Creek, WCK 1.0, and WCK 2.6 passed the initial screening phase (comparison of maximum radionuclide water concentrations to default BCGs). For Fifth Creek, WCK 1.0 (White Oak Creek at the dam) and WCK 2.6, average concentrations were used, and 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 (which was also used for First 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 11 sampling locations.

At the Y-12 Complex, doses to aquatic organisms were estimated from surface water concentrations at five different instream sampling locations:

- Surface Water Hydrological Information Support System Station 9422-1 (Station 17),
- Outfall 200,
- Discharge Point S24, Bear Creek at Bear Creek kilometer (BCK) 9.4,
- Discharge Point S17 (unnamed tributary to the Clinch River), and
- Discharge Point S19 (Rogers Quarry).

Discharge Points S17 and S19 passed the general screening phase (maximum water concentrations and default parameters for BCGs). Surface Water Hydrological Information Support System 9422-2 and Discharge Point S24 passed using average water concentrations. This resulted in absorbed dose rates to aquatic organisms below the DOE aquatic dose limit of 1 rad/d at all five Y-12 locations.

At ETTP, doses to aquatic organisms were estimated from surface water concentrations at 11 different instream sampling locations:

- Mitchell Branch at K1700, MIKs 0.45, 0.59, 0.74, 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, in accordance with requirements in DOE Order 450.1, the terrestrial organism assessment was conducted using the RESRAD-Biota code (Versions 1.21 and 1.5), 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 with soil presenting 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.

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 Conasauaga soils, and the other sampling location was near Bearden Creek, which represents 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 (collected on the confluence of Melton Branch and White Oak Creek and collected on the White Oak Creek floodplain upstream from White Oak Dam), samples taken at all other soil sampling locations passed either the initial-level screening (comparison of maximum radionuclide soil concentrations to default BCGs) or second-level screening, for which BCG 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 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) records of decisions.

White-footed mice (*Peromyscus leucopus*), deer mice (*Peromyscus maniculatus*) and hispid cotton rats (*Sigmodon hispidus)* were selected for sampling since they live and forage in these areas, are food for other mammals, and have relatively small home ranges. Biota sampling in the White Oak Creek floodplain was conducted in 2009. The biota sampling locations were at confluence of Melton Branch and White Oak Creek and in the floodplain upstream of White Oak Lake. In addition, biota samples were collected at a background location (Gum Hollow). A gridded area was established in each sampling area. The biota sampling areas were in similar locations and areas as the soil sampling areas. There were three composite samples associated with each sampling area and approximately 25 mice were collected per site.

The maximum radionuclide tissue concentrations and maximum soil radionuclide concentrations for each sample location were used to estimate the terrestrial dose. The tissue concentrations are used to estimate the internal dose. To evaluate the external dose, the soil concentrations previously collected were also included in the dose assessment. The external dose was the primary contributor to the total dose. For White Oak Creek, ^{137}Cs was the major contributor to the total dose (0.023 rad/day) with ^{90}Sr and ^{40}K and as secondary contributors (7.0E-4 and 5.97E-4 rad/day, respectively). For Melton Branch, ^{137}Cs was the major contributor to dose (0.009 rad/day) with ^{90}Sr and ^{40}K as secondary contributors (8.2E-4 and 7.8E-4 rad/day, respectively). For the background location, Gum Hollow, ^{40}K was the major contributor to dose (7.4E-4 rad/day) with ^{238}U as the secondary dose contributor (3.5E-4 rad/day). Based on measured concentrations in soil and tissue, the absorbed doses to the mice and voles analyzed along the confluence of Melton Branch and White Oak Creek and in the floodplain upstream of White Oak Lake were less than 0.1 rad/day.

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). The hazard quotient is a ratio that compares the estimated exposure dose or intake to the reference dose (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 $10P^{-4P}$ to $10P^{-6P}$. A risk value greater than $10P^{-5P}$ 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, 2009

Chemical	Hazard quotient[a]	
	CRK 23[b]	CRK 16[c]
Arsenic		B 0.008
Barium	B 0.005	B 0.005
Beryllium		
Boron	B 0.002	B 0.002
Cadmium	B 0.008	B 0.007
Chromium	B 0.02	B 0.004
Copper	B 0.0007	B 0.0005
Lead	B 0.1	B 0.1
Manganese	0.008	0.009
Nickel	B 0.002	B 0.001
Selenium	B 0.003	
Vanadium	B 0.002	B 0.002
Zinc	0.0006	B 0.0001
Risk for carcinogens		
Arsenic		B 2E-5
1,2 Dichloroethane	J1E-06[a]	

Abbreviations:

CRK = Clinch River kilometer

[a]Melton Hill Reservoir near the water intake for ETTP.

[b]Clinch River downstream of all U.S. Department of Energy inputs.

[c]A prefix “B” is used with a metal or anion and is the same as “J.” A prefix “J” indicates the value was estimated at or below the analytical detection limit by the laboratory.

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 (which are PCBs, also referred to as PCB-1254 and -1260). An HQ greater than 1 for Aroclor-1254 was estimated in catfish at two locations (CRKs 16 and 32). An HQ greater than 1 for Aroclor-1260 was estimated in catfish at three locations (CRKs 16, 32, and 70).

For carcinogens, risk values at or greater than 10^{-5} were calculated for the intake of Aroclor-1254 found in catfish collected at all three locations. For sunfish and catfish, risk values at or 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 (TWRA 2009).

Table 7.10. Chemical hazard quotients and estimated risks for carcinogens in fish, 2009[a] *(updated 4/28/10)*

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	0.1	0.1	0.2	0.2	0.2	0.2
Barium	0.0006	0.0003	0.0002	0.00006	0.00007	0.00006
Beryllium						
Boron	< 0.0002	0.0003	0.0003	0.0002	0.0004	0.0002
Cadmium	0.01	0.02	0.01	0.02	0.02	<0.01
Chromium	0.02	0.03	0.02	0.02	0.02	0.02
Copper	0.006	0.005	0.005	0.005	0.003	0.006
Lead		<0.2			0.3	
Manganese	0.003	0.003	0.002	0.0009	0.0009	0.001
Mercury	0.06	0.06	0.3	0.1	0.2	0.2
Nickel	< 0.0009	0.001	0.002	0.001	<0.0009	
Selenium	0.2	0.2	0.2	0.1	0.1	0.1
Silver						
Strontium	0.002	0.0009	0.0004	0.0001	0.00007	0.00008
Thallium	0.1		0.1	0.09	0.08	0.07
Uranium	0.00007	0.00007	0.0002	0.00005	0.00007	0.07
Vanadium			0.001	<0.001		0.00005
Zinc	0.04	0.03	0.03	0.02	0.02	0.02
Hazard quotient for pesticides and Aroclors						
Aroclor-1254				0.6	5	2.8
Aroclor-1260	1.6	0.7	1.2	2.7	11	4
Risks for carcinogens						
Aroclor-1254				1E–5	9E–5	5E–5
Aroclor-1260	3E–5	1E–5	2E–5	4E–4	2E–4	7E–4
PCBs (mixed)[e]	3E–5	1E–5	2E–5	5E–4	3E–4	1E–4

CRK=Clinch River kilometer

[a]A prefix “<” 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

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Do we need to add these:

CAP-88PC Version 3
40 CFR 61, Subpart H
Federal Guidance Report (FGR) Number 13 (EPA 1999)
Various DOE Orders

Appendix A. Errata

Appendix A. Errata

Errata in the *Oak Ridge Reservation Annual Site Environmental Report* for 2008 (DOE/ORO/2296).

Cross references Section 5.8.1 throughout the report to were in error. Ignore references to this section.

On page 2-4 of Table 2.1, report section 5.2.1.9 cited for DOE Order 435.1 should be changed to section 5.2.1.3.4.2.

The following map, showing ORNL sediment-sampling locations, was mistakenly omitted from the report. The callouts to Figure 5.36 in Sect. 5.5.8 refer to it. All preceding and subsequent figure callouts in Chapter 5 correctly refer to the figures in it.

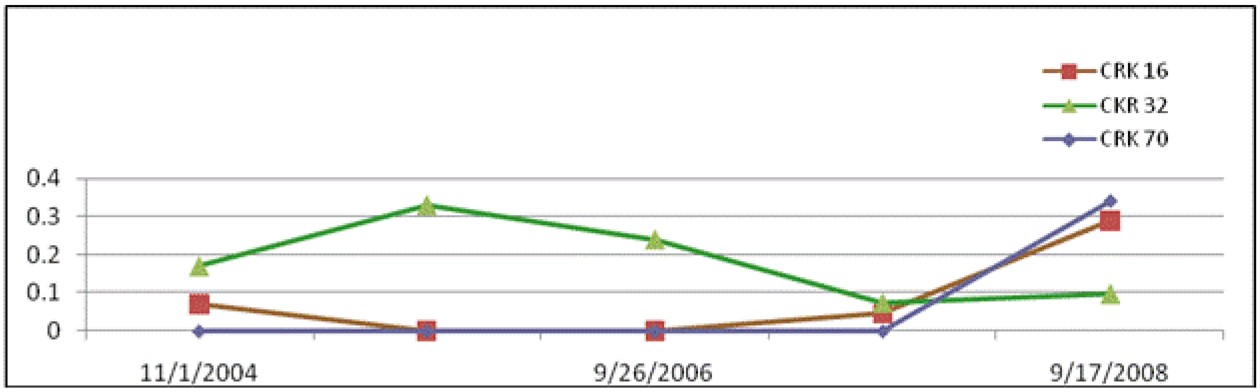

Fig. 5.36. Cesium-137 (pCi/g) in sediments, 2004–2008.

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.

flux — A flow or discharge of a substance (in units of mass, radioactivity, etc.) per unit time.

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.

laboratory blank — An analyte-free matrix to which all reagents are added in the same volumes or proportions as used in sample processing. The laboratory blank should be carried through the complete sample preparation and analytical procedure. The laboratory blank is used to document contamination resulting from the analytical process.

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.

upper tolerance limit (UTL) —The upper endpoint of an interval which contains a specified fraction of a population with a specified probability (confidence level). Data points or calculated values which fall above a UTL indicate the existence of a statistical difference which is not explained by inherent random variation.

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

Appendix C. Climate Overview for the Oak Ridge Area

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 a wide range of seasonal temperatures. 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 into the Great Valley). 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. Most of these changes appear to be 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 ENSO and PDO 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 10–30 years. All of these patterns can collectively modulate regional temperature and precipitation trends with respect to East Tennessee (especially the AMO). The AMO shifted from a cold to warm sea surface temperature phase (mid-1990s) but may be shifting back to a cool phase as of 2009–2010. The PDO appears to have entered a cool sea surface temperature phase since about 2000. Also, the ENSO pattern has more frequently brought about warmer Eastern Pacific sea surface temperatures in the last couple of decades. Additionally, some evidence exists that human-induced climate change may be producing some effects (via land cover change, soot and aerosols, and to a lesser extent, greenhouse gases). Largely due to the effects of the AMO and ENSO, Oak Ridge climate warmed about 1.2ºC (34ºF) during the 1990s but has stabilized near the 1990s values since then (little warming has occurred since 2000). The recent warming appears to have lengthened the growing season [i.e., the period with temperatures above 0ºC (32ºF)] 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 ORR (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 or during strong cold air advection), 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 nighttime 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.

Annual wind roses for each of the eight Oak Ridge Reservation meteorological towers during 2009 (Towers MT1, MT2, MT3, MT4, MT6, MT7, MT9, and MT10) have been compiled. These can be viewed online at http://www.ornl.gov/~das/web/RECWX7.HTM. 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 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 [0.254 cm/h (< 0.10 in./h)], moderate [0.254–0.762 cm/h (0.10–0.30 in./h)], and heavy [0.762 cm/h (> 0.30 in./h)].

C.3 Temperature and Precipitation

Temperature and precipitation normals (1980–2009) and extremes (1948–2009) and their durations for the city of Oak Ridge are summarized in Table C.1. Decadal temperature and precipitation averages for the four decades from 1970 through 2009 are given in Table C.2. Hourly freeze data (1985–2009) 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 40 years. In general, temperatures in Oak Ridge rose in the 1990s but have leveled off during the 2000s. Based on average decadal temperatures, temperatures have risen 2.5ºF or 1.4ºC between the decades of the 1970s and the 2000s from 13.7 to 15.2ºC (56.8 to 59.3ºF). More detailed 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 2.1ºC (3.8ºF) and 1.9ºC (3.5ºF), respectively. This significant increase is probably dominated by the effects of the Atlantic Multidecadal Oscillation (AMO). Also, 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 of these factors, Oak Ridge temperatures have warmed more dramatically during these months. Spring temperatures (March–April) have risen by about 1.4ºC (2.5ºF). Summer and fall temperatures exhibit temperature rises of 1.6ºC (2.8ºF) and 1.4ºC (2.5ºF), respectively. December temperatures changed the least +0.1ºC (+0.2ºF). Most of these average increases were driven by significant increases in minimum daily temperatures. Overall, annual minimum temperatures seem to have increased more dramatically by 1.7ºC (3.1ºF) than maximum temperatures (by 1ºC (1.9ºF). For the most recent decade (2000s), August average temperatures are now warmer than those of July.

Decadal precipitation averages suggest some important changes in precipitation patterns in Oak Ridge over the period of the 1970s to 2000s. 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 2.54 cm/month (1 in./month). Conversely, the late summer and early fall months (August through October) have seen slight decreases in precipitation [about 1.27 cm/month (0.50 in./month)]. However, 2009 has been a notable exception to this trend. Overall, annual precipitation during the 2000s is consistent with the 30-year average [around 132 cm (52 in.)]. The year 2007 was the driest year on record in Oak Ridge [91.1 cm (35.87 in.)] which was the heart of a 4-year period of below average precipitation (2005–2008). The year 2009 had precipitation that was more than 17% above normal. These statistics encompass the period from 1948 to 2009.

The previously discussed increase in winter temperatures apparently affected monthly and annual snowfall amounts until recently. During the 1970s and 1980s, snowfall averaged about 25.4–28 cm (10–11 in.) annually in Oak Ridge. However, during the most recent decade (2000s), snowfall has averaged only 6.6 cm (2.6 in). This decrease seems to have occurred largely since the mid-1990s. Snowfall during 2008 totaled only 2.0 cm (0.8 in). However, snowfall during 2009 and 2010 (through February) have begun to increase again with totals of 10.2 and 15.2 cm (4.0 and 6.0 in.), respectively.

Wind roses for Tower MT2 ("C") during light, moderate, heavy, and all precipitation events (during the decade of 1998 to 2007) have been compiled. These may be viewed online at http://www.ornl.gov/~das/web/RECWX7.HTM. The precipitation classes are defined by the National Weather Service as follows:

- light: trace to 0.254 cm/h (0.10 in./h)
- moderate: 0.28 to 0.762 cm/h (0.11 to 0.30 in./h)
- heavy: more than 0.762 cm/h (0.30 in./h)

Table C.1. Climate normals (1980–2009) and extremes (1948–2009) for Oak Ridge, Tennessee (Town Site), with 2009 comparisons

Monthly variables	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Temperature, °C (°F)													
30-Year Average Max	8.3 (47.0)	11.2 (52.2)	16.4 (61.5)	21.4 (70.6)	25.8 (78.5)	29.8 (85.6)	31.5 (88.7)	31.2 (88.1)	27.7 (81.9)	21.9 (71.4)	15.6 (60.1)	9.6 (49.3)	20.9 (69.6)
2009 Average Max	7.4 (45.3)	11.2 (52.1)	16.4 (61.6)	21.4 (70.6)	25.1 (77.1)	30.7 (87.2)	29.3 (84.8)	30.0 (86.0)	26.2 (79.2)	19.2 (66.6)	16.7 (62.0)	8.4 (47.2)	20.2 (68.3)
62-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	-2.2 (28.1)	-0.7 (30.8)	3.0 (37.4)	6.7 (44.1)	12.5 (54.5)	17.1 (62.8)	19.6 (67.3)	19.1 (66.4)	15.2 (59.4)	8.4 (47.1)	3.1 (37.5)	-0.9 (30.4)	8.4 (47.2)
2009 Average Min	-2.7 (27.1)	0.0 (32.0)	4.8 (40.6)	7.9 (46.3)	14.3 (57.8)	18.9 (66.1)	18.5 (65.3)	19.3 (66.8)	17.9 (64.3)	9.2 (48.5)	4.3 (39.7)	0.0 (32.0)	9.4 (48.9)
62-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	3.1 (37.6)	5.3 (41.5)	9.7 (49.5)	14.4 (58.0)	19.2 (66.5)	23.5 (74.3)	25.6 (78.0)	25.2 (77.3)	21.5 (70.7)	15.2 (59.3)	9.3 (48.8)	4.4 (39.9)	14.7 (58.5)
2009 Average	2.9 (37.2)	6.2 (43.1)	10.6 (51.1)	14.9 (58.8)	19.7 (67.5)	24.9 (76.9)	23.9 (75.1)	24.7 (76.4)	22.1 (71.8)	14.2 (57.6)	10.5 (50.9)	4.2 (39.6)	14.9 (58.8)
2009Dep from Average	-0.2 (-0.4)	0.9 (1.6)	0.9 (1.6)	0.4 (0.8)	0.6 (1.0)	1.4 (2.6)	-1.6 (-2.9)	-0.5 (-0.9)	0.6 (1.1)	-0.9 (-1.7)	1.2 (2.1)	-0.2 (-0.3)	0.2 (0.4)
30-year average heating degree days, °C (°F)[a]													
	468 (842)	366 (659)	267 (480)	128 (231)	36 (65)	2 (3)	0	0	14 (25)	113 (204)	268 (482)	429 (773)	2091 (3763)
30-year average cooling degree days, °C (°F)[a]													
	0	0	2 (4)	15 (28)	66 (118)	161 (290)	228 (410)	215 (387)	108 (195)	18 (32)	1 (2)	0	815 (1466)
Precipitation, mm (in.)													
30-Year Average	119.7 (4.71)	122.5 (4.82)	115.6 (4.55)	113.1 (4.45)	114.1 (4.49)	96.3 (3.79)	131.4 (5.17)	81.6 (3.21)	96.6 (3.80)	71.1 (2.80)	119.7 (4.71)	131.1 (5.16)	1313 (51.66)
2009	148.4 (5.48)	87.1 (3.43)	110.3 (4.34)	96.0 (3.78)	147.6 (5.81)	149.1 (5.87)	150.4 (5.92)	116.1 (4.57)	139.2 (5.48)	146.9 (5.78)	66.6 (2.62)	207.6 (8.17)	1565.4 (61.61)
2009 Dep from Average	28.7 (1.13)	-35.3 (-1.39)	-5.3 (-0.21)	-17.0 (-0.67)	33.5 (1.32)	52.8 (2.08)	19.1 (0.75)	34.6 (1.36)	42.7 (1.68)	75.7 (2.98)	-53.1 (-2.09)	76.5 (3.01)	252.8 (9.95)
62-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)
62-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)
62-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	68.6 (2.7)	71.1 (2.8)	27.9 (1.1)	7.6 (0.3)	0	0	0	0	0	0	Trace	38.1 (1.5)	213.4 (8.4)
2009 Totals	25.4 (1.0)	25.4 (1.0)	0	Trace	0	0	0	0	0	0	0	50.8 (2.0)	101.6 (4.0)
62-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)
62-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 ≥ 32C	0	0	0	0.2	0.8	7.7	14.7	13.3	4.2	0	0	0	40.9
2009 Max ≥ 32 C	0	0	0	0	0	7	1	7	0	0	0	0	15
30-Year Min ≤ 0C	21.5	16.7	10.9	2.8	0	0	0	0	0	1.8	10.5	18.8	83.0
2009 Min ≤ 0C	21	16	7	1	0	0	0	0	0	0	3	9	64
30-Year Max ≤ C	2.6	0.9	0.2	0	0	0	0	0	0	0	0	1.5	5.2
2009 Max ≤ 0C	2	1	0	0	0	0	0	0	0	0	0	0	3
Days w/Precip													
30-Year Avg ≥ 0.01 in.	11.5	11.0	11.9	10.6	11.7	10.9	12.3	9.6	8.5	8.4	9.6	11.7	127.7
2009 Days ≥ 0.01 in.	12	10	12	12	18	12	13	12	17	14	6	11	149
30-Year Avg ≥ 1.00 in.	1.3	1.4	1.2	1.2	1.2	1.0	1.4	0.8	1.3	0.9	1.5	1.6	14.8
2009 Days ≥ 1.00 in.	1	1	1	2	1	1	1	1	1	1	1	3	15

Table C.2. Decadal climate change (1970–2009) for Oak Ridge, Tennessee (Town Site) with 2009 comparisons

Monthly variables	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Temperature, °C (°F)													
1970-1979 Avg Max	6.6 (43.8)	9.7 (49.5)	15.6 (60.1)	21.4 (70.6)	24.8 (76.7)	28.5 (83.3)	30.0 (85.9)	29.7 (85.5)	26.8 (80.2)	20.8 (69.4)	14.5 (58.2)	10.0 (49.9)	19.9 (67.8)
1980-1989 Avg Max	6.9 (44.4)	10.2 (50.3)	15.9 (60.7)	21.0 (69.8)	25.6 (78.1)	29.8 (85.7)	31.6 (88.8)	30.7 (87.3)	27.1 (80.8)	21.3 (70.3)	15.6 (60.2)	8.6 (47.5)	20.3 (68.6)
1990-1999 Avg Max	9.4 (48.8)	12.3 (54.1)	16.2 (61.2)	21.9 (71.3)	26.2 (79.1)	29.7 (85.5)	32.1 (89.8)	31.4 (88.6)	28.4 (83.2)	22.6 (72.8)	15.2 (59.4)	10.4 (50.8)	21.3 (70.4)
2000-2009 Avg Max	8.8 (47.9)	11.2 (52.1)	17.0 (62.7)	21.4 (70.6)	25.8 (78.4)	29.8 (85.6)	30.8 (87.5)	31.4 (88.5)	27.6 (81.8)	21.8 (71.2)	15.9 (60.6)	9.8 (49.6)	21.0 (69.7)
Change (70s vs. 00s)	2.2 (5.1)	1.5 (2.6)	1.4 (2.6)	0.0 (0.0)	1.0 (1.7)	1.3 (2.3)	0.8 (1.6)	1.4 (2.5)	0.8 (1.6)	1.0 (1.8)	1.4 (2.4)	-0.2 (-0.3)	1.1 (1.9)
2009 Avg Max	7.4 (45.3)	12.4 (54.4)	16.4 (61.6)	21.4 (70.6)	25.1 (77.1)	30.7 (87.2)	29.3 (84.8)	30.0 (86.0)	26.2 (79.2)	19.2 (66.6)	16.7 (62.0)	8.4 (47.2)	20.2 (68.3)
1970-1979 Avg Min	-3.4 (25.8)	-2.4 (27.6)	3.0 (37.4)	6.7 (44.1)	11.6 (52.8)	15.7 (60.2)	18.3 (64.9)	18.1 (64.6)	15.5 (59.9)	7.5 (45.5)	2.6 (36.8)	-0.8 (30.5)	7.7 (45.8)
1980-1989 Avg Min	-4.1 (24.7)	-2.1 (28.3)	1.7 (35.0)	6.0 (42.9)	11.4 (52.4)	16.2 (61.2)	19.0 (66.2)	18.4 (65.1)	14.4 (57.9)	7.5 (45.4)	3.1 (37.5)	-2.3 (27.8)	7.4 (45.3)
1990-1999 Avg Min	-0.9 (30.3)	0.0 (32.0)	2.9 (37.1)	7.2 (45.0)	12.5 (54.5)	17.2 (63.0)	20.0 (67.9)	18.9 (66.1)	15.1 (59.2)	8.2 (46.8)	2.2 (36.0)	0.1 (32.2)	8.6 (47.6)
2000-2009 Avg Min	-1.4 (29.5)	0.0 (32.0)	4.4 (39.9)	8.6 (47.5)	13.6 (56.4)	18.0 (64.3)	20.0 (67.9)	20.0 (68.0)	16.1 (61.0)	9.5 (49.0)	3.9 (39.0)	-0.4 (31.4)	9.4 (48.9)
Change (70s vs. 00s)	2.0 (3.7)	2.4 (4.4)	1.4 (2.5)	1.9 (3.4)	2.0 (3.6)	2.3 (4.1)	1.7 (3.0)	1.9 (3.4)	0.6 (1.1)	2.0 (3.5)	1.3 (2.2)	0.4 (0.9)	1.7 (3.1)
2009 Avg Min	-2.7 (27.1)	-0.4 (31.3)	4.8 (40.6)	7.9 (46.3)	14.3 (57.8)	18.9 (66.1)	18.5 (65.3)	19.3 (66.8)	17.9 (64.3)	9.2 (48.5)	4.3 (39.7)	0.0 (32.0)	9.7 (49.5)
1970-1979 Avg	1.6 (34.9)	3.7 (38.6)	9.3 (48.8)	14.1 (57.4)	18.1 (64.7)	22.1 (71.8)	24.1 (75.4)	23.9 (75.0)	21.1 (70.0)	14.2 (57.5)	8.6 (47.5)	4.6 (40.3)	13.8 (56.8)
1980-1989 Avg	1.4 (34.6)	4.1 (39.3)	8.8 (47.9)	13.5 (56.4)	18.5 (65.3)	23.0 (73.4)	25.3 (77.5)	24.6 (76.2)	20.8 (69.4)	14.4 (57.9)	9.4 (48.8)	3.1 (37.7)	13.9 (57.0)
1990-1999 Avg	4.2 (39.6)	6.2 (43.1)	9.6 (49.2)	14.5 (58.2)	19.4 (66.8)	23.5 (74.3)	26.0 (78.9)	25.2 (77.4)	21.9 (71.4)	15.5 (59.8)	8.8 (47.8)	5.3 (41.5)	15.0 (59.0)
2000-2009 Avg	3.7 (38.7)	5.6 (42.1)	10.7 (51.3)	15.3 (59.6)	19.7 (67.5)	23.9 (75.1)	25.4 (77.7)	25.7 (78.3)	21.9 (71.4)	15.6 (60.1)	9.9 (49.8)	4.7 (40.5)	15.2 (59.3)
Change (70s vs. 00s)	2.1 (3.8)	1.9 (3.5)	1.4 (2.5)	1.2 (2.2)	1.6 (2.8)	1.8 (3.3)	1.3 (2.3)	1.8 (3.3)	0.8 (1.4)	1.4 (2.6)	1.3 (2.3)	0.1 (0.2)	1.4 (2.5)
2009 Avg	1.2 (34.1)	6.1 (42.9)	10.6 (51.1)	14.9 (58.8)	19.7 (67.5)	24.9 (76.9)	23.9 (75.1)	24.7 (76.4)	22.1 (71.8)	14.2 (57.6)	10.5 (50.9)	4.2 (39.6)	14.8 (58.6)
Precipitation, mm (in.)													
1970-1979 Avg	143.4 (5.65)	94.6 (3.72)	169.4 (6.67)	118.3 (4.66)	149.8 (5.89)	120.5 (4.74)	130.4 (5.13)	109.8 (4.32)	107.2 (4.22)	99.8 (3.93)	129.6 (5.10)	145.3 (5.72)	1516.4 (59.68)
1980-1989 Avg	100.4 (3.95)	109.1 (4.29)	112.6 (4.43)	88.8 (3.49)	110.6 (4.35)	84.1 (3.31)	120.4 (4.74)	82.6 (3.25)	108.9 (4.29)	79.8 (3.14)	128.0 (5.04)	107.6 (4.23)	1236.2 (48.66)
1990-1999 Avg	141.4 (5.57)	136.5 (5.37)	149.0 (5.86)	126.3 (4.97)	113.4 (4.47)	110.0 (4.33)	134.8 (5.31)	83.6 (3.29)	71.9 (2.83)	67.3 (2.65)	109.8 (4.32)	161.0 (6.34)	1429.4 (56.26)
2000-2009 Avg	116.9 (4.60)	121.8 (4.80)	115.6 (4.55)	125.0 (4.92)	117.8 (4.64)	95.2 (3.75)	138.9 (5.47)	78.4 (3.09)	108.8 (4.28)	74.0 (2.91)	121.4 (4.78)	124.4 (4.90)	1333.4 (52.48)
Change (70s vs. 00s)	-26.5 (-1.04)	27.2 (1.07)	-43.8 (-1.72)	6.7 (0.26)	-32.0 (-1.26)	-25.3 (-1.00)	8.5 (0.33)	-31.4 (-1.24)	1.6 (0.06)	-25.8 (-1.02)	-8.2 (-0.32)	-20.9 (-0.82)	-183.0 (-7.20)
2009 Totals	148.4 (5.84)	87.1 (3.43)	110.3 (4.34)	96.0 (3.78)	147.6 (5.81)	149.1 (5.87)	150.4 (5.92)	116.1 (4.57)	139.2 (5.48)	146.9 (5.78)	66.6 (2.62)	207.6 (8.17)	1565.4 (61.61)
Snowfall, cm (in.)													
1970-1979 Avg	11.1 (4.4)	12.5 (4.9)	4.2 (1.7)	0.2 (0.1)	0	0	0	0	0	0	0.5 (0.2)	4.4 (1.8)	351 (13.8)
1980-1989 Avg	11.3 (4.5)	8.8 (3.5)	2.2 (0.9)	2.2 (0.9)	0	0	0	0	0	0	0	7.5 (3.0)	328 (12.9)
1990-1999 Avg	6.8 (2.7)	7.8 (3.1)	8.1 (3.2)	Trace	0	0	0	0	0	0	0.3 (0.1)	3.1 (1.2)	109 (4.3)
2000-2009 Avg	2.1 (0.8)	4.5 (1.8)	Trace	Trace	0	0	0	0	0	0	Trace	1.7 (0.7)	-242 (-9.5)
Change (70s vs. 00s)	-9.0 (-3.6)	-8.0 (-3.1)	-4.2 (-1.7)	-0.2 (-0.1)	0	0	0	0	0	0	-0.5 (-0.2)	-2.7 (-1.1)	
2009 Totals	2.5 (1.0)	1.0 (0.4)	0	Trace	0	0	0	0	0	0	0	5.1 (2.0)	20.3 (0.8)

Table C.3. Hourly Sub-freezing Temperature Data for Oak Ridge, Tennessee, 1985–2009

Number of hours at or below 0, -5, -10, and -15 (°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
2009	238	93	29	0	178	64	5	0	55	15	0	5	0	0	0	0	0	8	0	0	178	22	0	0	662	194	34	0
Avg.	239	73	16	3	155	38	7	1	68	7	1	12	0	0	0	8	0	69	4	0	203	46	7	1	755	168	31	5

[a]Source: 1985–2009 National Oceanic and Atmospheric Administration Atmospheric Turbulence and Diffusion Division KOQT Station, Automated Surface Observing System.

The meteorological record from Tower C was used because it is centrally located within the ORR.

Hourly values of subfreezing temperatures in Oak Ridge are presented in Table C.3 for the years 1985 through 2009. 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 500–700 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), with “D” being 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 (7.2ºF) 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.

Wind roses for ORNL Tower MT2 at 30 m (98.4 ft) with respect to Stability A through G during 2009 have been compiled and may be viewed at http://www.ornl.gov/~das/web/RECWX7.HTM. Stability 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 east north east directions (likely down valley "cold air" drainage flow).

C.5 References

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Appendix D. Reference Standards and Data for Water

Table D.1. Reference standards for radionuclides in water

Parameter[a]	National primary drinking water standard[b]	4% of DCG[c]	DCG[d]
^{241}Am		1.2	30
^{214}Bi		24,000	600,000
^{109}Cd		400	10,000
^{143}Ce		1,200	30,000
^{60}Co		200	5,000
^{51}Cr		40,000	1,000,000
^{137}Cs		120	3,000
^{155}Eu		4,000	100,000
Gross alpha[e]	15		
Gross beta (mrem/year)	4[f]		
^{3}H	20,000[g]	80,000	2,000,000
^{131}I		120	3,000
^{40}K		280	7,000
^{237}Np		1.2	30
^{234m}Pa		2,800	70,000
^{238}Pu		1.6	40
$^{239/240}Pu$		1.2	30
^{226}Ra	5[h]	4	100
^{228}Ra	5[h]	4	100
^{106}Ru		240	6,000
^{90}Sr	8[g]	40	1,000
^{99}Tc		4,000	100,000
^{228}Th		16	400
^{230}Th		12	300
^{232}Th		2	50
^{234}Th		400	10,000
Thorium, natural		2	50
^{234}U		20	500
^{235}U		24	600
^{236}U		20	500
^{238}U		24	600
Uranium, natural		24	600
Uranium, total[i] (µg/L[j])	30	20	500

[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 (continued)

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 (continued)

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)			
Glyphosate	700 (E1, T)			
Heptachlor (c)	0.4 (E1, T)	0.52	0.0038	0.00079, 0.00079
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, 280
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, wade-able 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

Table D.2 (continued)

Chemical	TDEC and EPA Drinking Water Standards[a]	TDEC Fish and Aquatic Life Criteria		TDEC Recreation Criteria Water + Organisms, Organisms Only[b]
		Maximum	Continuous	
Toluene	1000 (E1, T)			1300, 15,000
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 2009

Appendix E. National Pollutant Discharge Elimination System Noncompliance Summaries for 2009

E.1 Y-12 Complex

National Pollutant Discharge Elimination System (NPDES) permit excursion occurred when the measured cadmium monthly average at Outfall 200, 0.00162 mg/L, exceeded the permit limit of 0.001 mg/L on April 4, 2009. At the time of the reading there were no observed adverse effects on the receiving stream.

E.2 East Tennessee Technology Park

In January 2009, the East Tennessee Technology Park (ETTP) had one NPDES noncompliance at storm water outfall 340 located near the southwest corner of the K-25 building. Storm water outfall 340 receives surface runoff and roof drainage from the west wing of the K-25 building. Sampling subcontractor personnel obtained a pH reading of 9.1 standard units at the designated NPDES monitoring location while collecting routine NPDES permit compliance data. The permitted pH range is 4.0 to 9.0 standard units. The elevated pH reading may have been related to the sealing of the storm drain inlets, causing the backup of storm water into debris piles that had accumulated in the vicinity of the inlets. This backup may have caused the pH to be raised by contact of the storm water with concrete powder and other residues generated during the demolition of the K-25 building. Also, the elevated pH may have been caused by a cementitious material, used to seal the gap between the metal plate and the storm drain inlet, that may have broken apart due to heavy truck traffic and fallen into the storm drain inlet. Corrective action included identification of all storm water inlets that may have defective seals; removal of building debris and sealing material from storm water inlets with failed seals; the resealing of damaged storm water inlets with 4000-psi (pounds per square inch) concrete instead of flowable fill; placement of jersey bouncers over storm drain inlets to prevent future damage due to truck traffic; continued routine inspections of the storm drain inlets for damage; and modification of the Storm Water Pollution Prevention Plan (STP3) and the changing of storm water control measures as necessary for demolition activities. No threat to human health or the environment occurred as a result of this event, and no fish kills or other adverse impacts to the biota were observed.

E.3 Oak Ridge National Laboratory

An NPDES permit-limit nonconformance occurred at an instream monitoring point for total residual oxidant [(TRO) chlorine/bromine] on Fifth Creek within the ORNL main campus, where on February 16, 2009, 0.12 mg/L TRO was measured, compared to a daily maximum permit limit of 0.019 mg/L. The measurement resulted in a calculated exceedance of a second monthly average limit at that same monitoring point. No harm to aquatic species was seen as a result of this incident. A dechlorination system at Outfall 265 on Fifth Creek, which dechlorinates a potable/cooling water source to Fifth Creek, had malfunctioned and was determined to be the source of the chlorine that was detected in Fifth Creek. The unit was repaired, and there has been no recurrence since February 2009.

Appendix F. Radiation

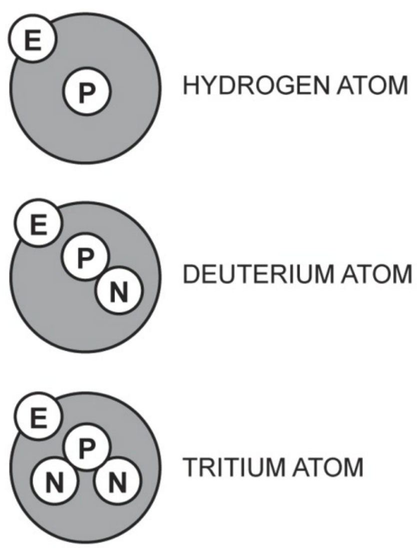
Appendix F. Radiation

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 and 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.

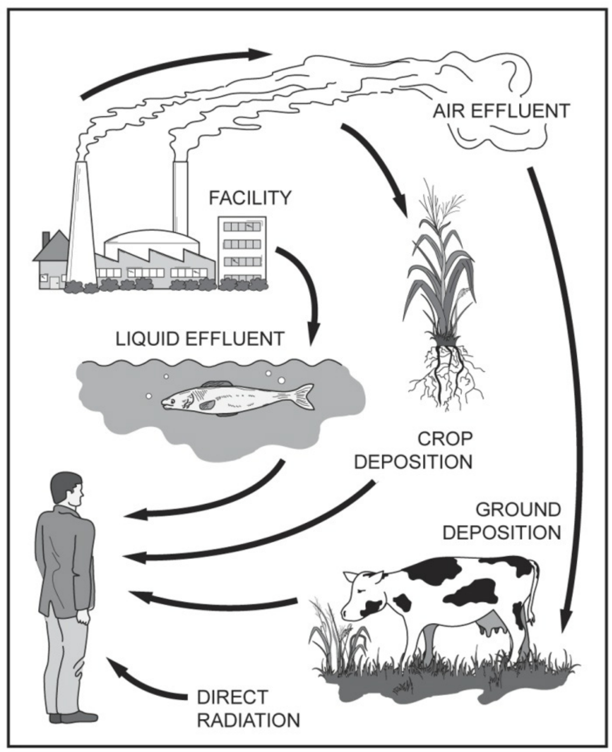


Fig. F.2. Examples of radiation pathways.

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, 1 curie equals 3.7×10^{10} (37,000,000,000) atomic disintegrations per second (dps). In the international system of units, 1 dps equals 1 Becquerel (Bq).

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. The effective dose (ED) 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. In addition, the ED is based on the latest lung model, gastrointestional absorption fractions, and biokinetic models used for selected elements. Specific types of EDs are defined as follows:

- committed ED—the weighted sum of the committed ED in specified tissues in the human body during the 50-year period following intake; and
- collective E—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 ED, which is the ED that will be received during a specified time (50 years) from radionuclides taken into the body in the current year, and the ED 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 ED 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 ED (rem) resulting from intake (by inhalation and ingestion) of a unit activity (1.0 µCi) of a radionuclide. The second gives the ED 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

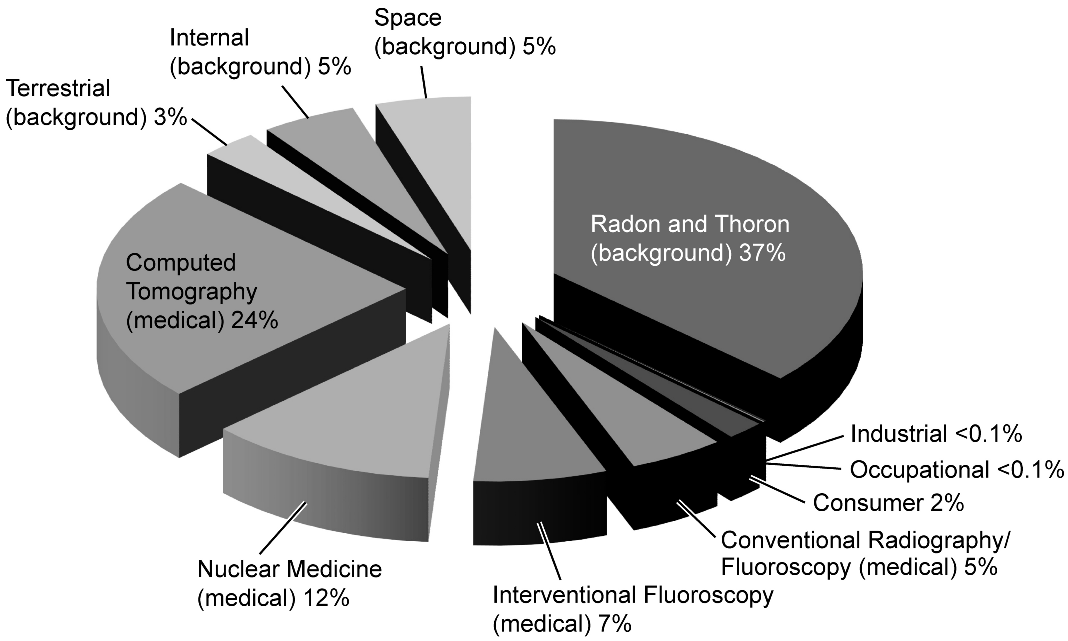


Fig. F.3. All exposure categories for collective effective dose (percent) for 2006.

(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.

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 (liters per year) to the downstream water body flow (liters per 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 (curies per year) or (2) activities per unit volume of water (curies per liter) plus the total volume of water discharged per year (liters per year). Radionuclide concentrations in the receiving water body are calculated simply by dividing the measured discharge activities (curies per year) by the total annual flow of the receiving water body (liters per 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), and

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. 6.6), 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, CRK 70				
Fish[b]		0.5		0.5
Water[c]	3E-09	0.0	0.0004	0.0004
Maximum	3E-09	0.5	0.0004	0.5
Melton Hill Lake, CRK 58				
Water[c]	4E-09	0.0	0.0004	0.0004
Discharge[d]	0.0005	0.0007	0.00004	0.001
Maximum	0.0005	0.0007	0.0004	0.002
Upper Clinch River, CRK 23, Gallaher Water Plant, CRK 32				
Fish[b]		0.03		0.03
Water[c]	0.2	1.2	0.2	1.6
Discharge[d]	0.02	0.06	0.008	0.09
Maximum	0.2	1.2	0.2	1.6
Lower Clinch River, CRK 16				
Fish[b]		0.0		0.0
Water[c]	NA[e]	0.8	0.1	0.9
Discharge[d]	NA[e]	0.04	0.005	0.05
Maximum	NA[e]	0.8	0.1	0.9
Upper Watts Bar Lake, Kingston Municipal Water Plant				
Water[c]	0.03	0.2	0.05	0.3
Discharge[d]	0.005	0.01	0.002	0.02
Maximum	0.03	0.2	0.05	0.3
Lower System (Lower Watts Bar Lake and Chickamauga Lake)				
Water[c]	0.03	0.2	0.05	0.3
Discharge[d]	0.005	0.01	0.002	0.02
Maximum	0.03	0.2	0.05	0.3
Poplar Creek				
Water[c]	NA[e]	0.06	0.007	0.07
Discharge[d]	NA[e]	0.3	0.007	0.3
Maximum	NA[e]	0.3	0.007	0.3

[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), and
$DC_{T,ing}$	=	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
$DC_{i,WS}$	=	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

$$C_{i,shore} = C_{W,i} * F_{i,W\text{-}S} * T_{1/2,i} * (1 - \text{EXP}[-\lambda_{r,i} * 365 * t_{S\text{-}W}]) ,$$

where

$C_{W,i}$ = 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 the variation in dose based on method used to estimate dose.

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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			
Arsenic	3.0E–04	RfD	Aroclor-1016	7.0E–05	RfD
			Aroclor-1254	2.0E-05	RfD
	1.5E+00	SF	Aroclor-1260	2.0E–05	RfD[b]
Barium	2.0E–01	RfD	PCBs (mixed)	2.0E+00	SF[c]
Beryllium	2.0E–03	RfD	1,2-Dichloroethane	9.1E-02	SF
Boron	2.0E–01	RfD			
Cadmium	5.0E–04	RfD			
Chromium VI	3.0E–03	RfD			
Cobalt					
Lead	1.4E–04	*d,e*			
Lithium					
Magnesium					
Manganese	1.4E–01	RfD			
Mercury	3.0E–04	RfD[f]			
Molybdenum	5.0E–03	RfD			
Nickel	2.0E–02	RfD			
Selenium	5.0E–03	RfD			
Silicon					
Silver	5.0E–03	RfD			
Strontium	6.0E–01	RfD			
Thallium	5.7E–05	*d,g*			
Titanium					
Uranium	3.0E–03	RfD			
Vanadium	9.0E–03	RfD			
Zinc	3.0E–01	RfD			

[a]RfD: reference dose (mg/kg-day); SF: slope factor (risk per mg/kg-day).

[b]The RfD for Aroclor-1254 is also used for Aroclor-1260.

[c]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.

[d]The water quality criteria (WQC) are given in units of micrograms per liter. To convert the concentration to an RfD (mg/kg-day), 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.

[e]This value is based on the 2008 Tennessee WQC (TDEC 2008) for lead for domestic water supplies which reflects the maximum contaminant level value (5 µg/L).

[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]This value is based on the 2008 Tennessee WQC (TDEC 2008) 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), and

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), and

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), and

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), and

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

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