



2016

OAK RIDGE RESERVATION
ANNUAL SITE
ENVIRONMENTAL REPORT

Oak Ridge Reservation

**Annual Site
Environmental
Report 2016**

Cover Image
Kelly Roy
Oak Ridge National Laboratory

Design
GLOBAL, Inc

Oak Ridge Reservation Annual Site Environmental Report 2016

on the World Wide Web
[https://doeic.science.energy.gov/
aser/2016-ASER-
Integrated-9-19-2017-DOE-
APPROVAL-COPY.pdf](https://doeic.science.energy.gov/aser/2016-ASER-Integrated-9-19-2017-DOE-APPROVAL-COPY.pdf)

Department of Energy project manager and Oak Ridge Office coordinator
Katatra Vasquez

Technical coordinators

Paula R Roche
Jim Donnelly
Y-12 National Security Complex

Joan Hughes
Walt Doty
Oak Ridge National Laboratory

Mike Coffey
Dennis Mayton
East Tennessee Technology Park

Prepared by
UT-Battelle, LLC
P.O. Box 2008, Oak Ridge, TN 37831-2008
for the US Department of Energy under Contract DE-AC05-00OR22725
and by
Consolidated Nuclear Security LLC
Oak Ridge, TN 37831-8169
under Contract DE-NA0001942
and by
URS | CH2M Oak Ridge LLC
under Contract DE-SC-0004645
and by
GLOBAL, Inc.
under Contract DE-SC0017329

Date of Publication: September 2017

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States; UT-Battelle, LLC; Consolidated Nuclear Security LLC; URS | CH2M Oak Ridge LLC; Global Inc. nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof. The sampling and monitoring results reported herein are not a comprehensive report of all sampling and analysis performed.

Contents

	<i>Page</i>
Figures	vi
Tables	xii
Acronyms and Abbreviations	xvi
Units of Measure and Conversion Factors	xxiv
Acknowledgments	xxvi
Executive Summary	xxvii
Chapter 1 - Introduction to the Oak Ridge Reservation	1-1
1.1 Background	1-1
1.2 History of the Oak Ridge Reservation	1-2
1.3 Site Description	1-2
1.3.1 Location and Population	1-2
1.3.2 Climate.....	1-4
1.3.3 Regional Air Quality	1-4
1.3.4 Surface Water	1-5
1.3.5 Geological Setting	1-5
1.3.6 Natural, Cultural, and Historic Resources	1-6
1.3.7 Wetlands	1-6
1.3.8 Wildlife/Endangered Species.....	1-7
1.3.9 Threatened and Endangered Plants.....	1-13
1.3.10 Historical and Cultural Resources	1-14
1.4 Oak Ridge Sites.....	1-16
1.4.1 Oak Ridge National Laboratory.....	1-16
1.4.2 The Y-12 National Security Complex	1-17
1.4.3 East Tennessee Technology Park	1-18
1.4.4 Environmental Management Waste Management Facility.....	1-19
1.4.5 Oak Ridge Environmental Research Park	1-19
1.4.6 Oak Ridge Institute for Science and Education	1-20
1.4.7 The National Nuclear Security Administration Office of Secure Transportation, Agent Operations Eastern Command.....	1-21
1.5 References	1-21
Chapter 2 - Compliance Summary and Community Involvement	2-1
2.1 Laws and Regulations	2-1
2.2 External Oversight and Assessments	2-1
2.3 Reporting of Oak Ridge Reservation Spills and Releases	2-9
2.4 Notices of Violations and Penalties	2-9
2.5 Community Involvement.....	2-9
2.5.1 Public Comments Solicited	2-10

2.5.2 Oak Ridge Site Specific Advisory Board	2-10
2.5.3 DOE Information Center	2-10
2.6 References.....	2-11
Chapter 3 - East Tennessee Technology Park.....	3-1
3.1 Description of Site and Operations	3-1
3.2 Environmental Management System	3-4
3.2.1 Environmental Stewardship Scorecard.....	3-4
3.2.2 Environmental Compliance	3-8
3.2.3 Environmental Aspects/Impacts	3-8
3.2.4 Environmental Performance Objectives and Targets	3-8
3.2.5 Implementation and Operations	3-9
3.2.6 Pollution Prevention/Waste Minimization	3-9
3.2.7 Competence, Training, and Awareness	3-10
3.2.8 Communication	3-10
3.2.9 Benefits and Successes of Environmental Management System Implementation.....	3-10
3.2.10 Management Review	3-11
3.3 Compliance Programs and Status	3-11
3.3.1 Environmental Permits	3-12
3.3.2 Notices of Violation and Penalties	3-12
3.3.3 Audits and Oversight.....	3-12
3.3.4 National Environmental Policy Act/National Historic Preservation Act	3-14
3.3.5 Clean Air Act Compliance Status.....	3-15
3.3.6 Clean Water Act Compliance Status	3-16
3.3.7 National Pollutant Discharge Elimination System Permit Noncompliances.....	3-16
3.3.8 Safe Drinking Water Act Compliance Status	3-16
3.3.9 Resource Conservation and Recovery Act Compliance Status.....	3-16
3.3.10 Resource Conservation and Recovery Act Underground Storage Tanks.....	3-16
3.3.11 Comprehensive Environmental Response, Compensation, and Liability Act Compliance Status	3-17
3.3.12 East Tennessee Technology Park RCRA-CERCLA Coordination	3-17
3.3.13 Toxic Substances Control Act Compliance Status—Polychlorinated Biphenyls	3-17
3.3.14 Emergency Planning and Community Right-to-Know Act Compliance Status.....	3-18
3.4 Quality Assurance Program	3-18
3.4.1 Integrated Assessment and Oversight Program.....	3-18
3.5 Air Quality Program	3-19
3.5.1 Construction and Operating Permits	3-19
3.5.2 Ambient Air.....	3-27
3.6 Water Quality Program	3-31
3.6.1 NPDES Permit Description	3-31
3.6.2 Storm Water Pollution Prevention Program.....	3-34
3.6.3 Surface Water Monitoring.....	3-54
3.6.4 Groundwater Monitoring.....	3-59
3.7 Biological Monitoring.....	3-71
3.7.1 Bioaccumulation Studies	3-71
3.7.2 Instream Monitoring of Biological Communities	3-77
3.8 Environmental Management and Waste Management Activities.....	3-82
3.8.1 Environmental Remediation Activities	3-82

3.8.2 Reindustrialization.....	3-84
3.9 References.....	3-86
Chapter 4 - The Y-12 National Security Complex.....	4-1
4.1 Description of Site and Operations.....	4-1
4.1.1 Mission.....	4-1
4.1.2 Modernization.....	4-2
4.2 Environmental Management System.....	4-5
4.2.1 Integration with Integrated Safety Management System.....	4-5
4.2.2 Policy.....	4-6
4.2.3 Planning.....	4-7
4.2.4 Implementation and Operation.....	4-10
4.2.5 Checking.....	4-11
4.2.6 Performance.....	4-11
4.2.7 Awards and Recognition.....	4-29
4.3 Compliance Status.....	4-30
4.3.1 Environmental Permits.....	4-30
4.3.2 National Environmental Policy Act/National Historic Preservation Act.....	4-34
4.3.3 Clean Air Act Compliance Status.....	4-36
4.3.4 Clean Water Act Compliance Status.....	4-36
4.3.5 Safe Drinking Water Act Compliance Status.....	4-36
4.3.6 Resource Conservation and Recovery Act Compliance Status.....	4-37
4.3.7 Resource Conservation and Recovery Act–Comprehensive Environmental Response, Compensation, and Liability Act Coordination.....	4-39
4.3.8 Toxic Substances Control Act Compliance Status.....	4-41
4.3.9 Emergency Planning and Community Right-to-Know Act Compliance Status.....	4-41
4.3.10 Spill Prevention, Control, and Countermeasures.....	4-43
4.3.11 Unplanned Releases.....	4-44
4.3.12 Audits and Oversight.....	4-44
4.3.13 Radiological Release of Property.....	4-45
4.4 Air Quality Program.....	4-48
4.4.1 Construction and Operating Permits.....	4-49
4.4.2 Ambient Air.....	4-56
4.5 Water Quality Program.....	4-61
4.5.1 National Pollutant Discharge Elimination System Permit and Compliance Monitoring.....	4-61
4.5.2 Radiological Monitoring Plan and Results.....	4-64
4.5.3 Storm Water Pollution Prevention.....	4-68
4.5.4 Y-12 Complex Ambient Surface Water Quality.....	4-69
4.5.5 Industrial Wastewater Discharge Permit.....	4-70
4.5.6 Quality Assurance/Quality Control.....	4-72
4.5.7 Biomonitoring Program.....	4-72
4.5.8 Biological Monitoring and Abatement Programs.....	4-73
4.6 Groundwater at the Y-12 Complex.....	4-81
4.6.1 Hydrogeologic Setting.....	4-82
4.6.2 Well Installation and Plugging and Abandonment Activities.....	4-85
4.6.3 CY 2016 Groundwater Monitoring.....	4-85
4.6.4 Y-12 Complex Groundwater Quality.....	4-88
4.6.5 Quality Assurance.....	4-106
4.7 Quality Assurance Program.....	4-107

4.8 Environmental Management and Waste Management Activities.....	4-109
4.8.1 Mercury Technology Development Activities for Y-12, East Fork Poplar Creek.....	4-109
4.8.2 Designing the Mercury Treatment Facility	4-109
4.8.3 Waste Management	4-110
4.9 References.....	4-112
Chapter 5 - Oak Ridge National Laboratory	5-1
5.1 Description of Site, Missions, and Operations.....	5-2
5.2 Environmental Management Systems	5-4
5.2.1 UT-Battelle Environmental Management System	5-5
5.2.2 Other Environmental Management System Assessments	5-14
5.3 Compliance Programs and Status	5-15
5.3.1 Environmental Permits	5-16
5.3.2 National Environmental Policy Act/National Historic Preservation Act.....	5-19
5.3.3 Clean Air Act Compliance Status	5-20
5.3.4 Clean Water Act Compliance Status	5-20
5.3.5 Safe Drinking Water Act Compliance Status.....	5-21
5.3.6 Resource Conservation and Recovery Act Compliance Status	5-21
5.3.7 Oak Ridge National Laboratory RCRA-CERCLA Coordination	5-23
5.3.8 Comprehensive Environmental Response, Compensation, and Liability Act Compliance Status	5-23
5.3.9 Toxic Substances Control Act Compliance Status.....	5-24
5.3.10 Emergency Planning and Community Right-to-Know Act Compliance Status	5-24
5.3.11 US Department of Agriculture/Tennessee Department of Agriculture.....	5-25
5.3.12 Wetlands.....	5-26
5.3.13 Radiological Clearance of Property at Oak Ridge National Laboratory.....	5-27
5.4 Air Quality Program	5-30
5.4.1 Construction and Operating Permits	5-30
5.4.2 National Emission Standards for Hazardous Air Pollutants—Asbestos	5-30
5.4.3 Oak Ridge National Laboratory Radiological Airborne Effluent Monitoring	5-30
5.4.4 Stratospheric Ozone Protection	5-45
5.4.5 Ambient Air.....	5-46
5.5 Oak Ridge National Laboratory Water Quality Program	5-46
5.5.1 Treatment Facility Discharges.....	5-49
5.5.2 Residual Bromine and Chlorine Monitoring	5-51
5.5.3 Radiological Monitoring	5-52
5.5.4 Mercury in the White Oak Creek Watershed	5-57
5.5.5 Storm Water Surveillances and Construction Activities	5-60
5.5.6 Biological Monitoring	5-60
5.5.7 Polychlorinated Biphenyls in the White Oak Creek Watershed.....	5-69
5.5.8 Oil Pollution Prevention.....	5-70
5.5.9 Surface Water Surveillance Monitoring.....	5-71
5.5.10 Carbon Fiber Technology Facility Waste Water Monitoring.....	5-73
5.6 Groundwater Monitoring Program	5-74
5.6.1 DOE Office of Environmental Management Groundwater Monitoring	5-74
5.6.2 DOE Office of Science Groundwater Monitoring.....	5-77
5.7 Quality Assurance Program	5-85
5.7.1 Work/Project Planning and Control	5-86
5.7.2 Personnel Training and Qualifications	5-86
5.7.3 Equipment and Instrumentation	5-87

5.7.4 Assessment	5-87
5.7.5 Analytical Quality Assurance	5-88
5.7.6 Data Management and Reporting	5-88
5.7.7 Records Management	5-89
5.8 Environmental Management and Waste Management Activities at Oak Ridge	
National Laboratory	5-89
5.8.1 Oak Ridge National Laboratory Wastewater Treatment	5-89
5.8.2 Oak Ridge National Laboratory Newly Generated Waste Management	5-89
5.8.3 Transuranic Waste Processing Center	5-89
5.9 References	5-90
Chapter 6 - Oak Ridge Reservation Environmental Monitoring Program	6-1
6.1 Meteorological Monitoring	6-1
6.1.1 Description	6-1
6.1.2 Results	6-3
6.2 External Gamma Radiation Monitoring	6-4
6.2.1 Data Collection and Analysis	6-4
6.2.2 Results	6-4
6.3 Ambient Air Monitoring	6-5
6.3.1 Results	6-7
6.4 Surface Water Monitoring	6-10
6.4.1 Oak Ridge Reservation Surface Water Monitoring	6-10
6.4.2 Results	6-10
6.5 Groundwater Monitoring	6-12
6.5.1 Offsite Groundwater Assessment	6-12
6.5.2 Regional-Scale Flow Model	6-12
6.6 Food	6-13
6.6.1 Vegetables	6-13
6.6.2 Milk	6-14
6.6.3 Fish	6-16
6.6.4 White-Tailed Deer	6-18
6.6.5 Canada Geese	6-19
6.6.6 Turkey Monitoring	6-19
6.7 Quality Assurance	6-20
6.8 References	6-20
Chapter 7 Dose	7-1
7.1 Radiation Dose	7-1
7.1.1 Terminology	7-2
7.1.2 Methods of Evaluation	7-2
7.1.3 Current-Year Summary	7-17
7.1.4 Five-Year Trends	7-19
7.1.5 Potential Contributions from Non-DOE Sources	7-19
7.1.6 Doses to Aquatic and Terrestrial Biota	7-20
7.2 Chemical Dose	7-22
7.2.1 Drinking Water Consumption	7-22
7.2.2 Fish Consumption	7-23
7.3 References	7-24

Figures

<i>Figure</i>	<i>Page</i>
Chapter 1. Introduction to the Oak Ridge Reservation	
1.1	Location of the Oak Ridge Reservation 1-3
1.2	The Oak Ridge Reservation 1-3
1.3	Oak Ridge Reservation wetlands..... 1-7
1.4	Bald eagle nest on the Oak Ridge Reservation 1-12
1.5	Interesting bird species sighted on the Oak Ridge Reservation in recent years 1-12
1.6	The Oak Ridge National Laboratory 1-16
1.7	Y-12 National Security Complex..... 1-18
1.8	East Tennessee Technology Park 1-19
1.9	The Oak Ridge Environmental Research Park 1-20
Chapter 3. East Tennessee Technology Park	
3.1	East Tennessee Technology Park 3-2
3.2	East Tennessee Technology Park before the start of decontamination and decommissioning activities in 1991. 3-3
3.3	East Tennessee Technology Park in 2016, showing progress in reindustrialization..... 3-3
3.4	Pollution prevention recycling activities related to solid waste reduction at East Tennessee Technology Park in CY 2016. 3-5
3.5	Brightfield 1 Solar Farm..... 3-7
3.6	East Tennessee Technology Park National Pollutant Discharge Elimination System permit compliance since 1999..... 3-11
3.7	East Tennessee Technology Park total on-site ozone-depleting substances inventory, 10-year history. 3-20
3.8	East Tennessee Technology Park ambient air stations K11 and K12 radionuclide monitoring results: 5-year rolling 12-month dose history up through 2016. 3-21
3.9	East Tennessee Technology Park stationary source greenhouse gas emissions tracking history..... 3-23
3.10	East Tennessee Technology Park greenhouse gas emissions trend and targeted reduction commitment..... 3-24
3.11	FY 2016 East Tennessee Technology Park greenhouse gas emissions by scope, as defined in Executive Order 13514..... 3-24
3.12	East Tennessee Technology Park ambient air monitoring station locations 3-28
3.13	East Tennessee Technology Park ambient air monitoring station..... 3-28
3.14	Chromium monitoring results: 5-year history through December 2016. 3-29
3.15	Lead monitoring results: 5-year history through December 2016..... 3-30
3.16	Dose impact results: 5-year history through December 2016. 3-31
3.17	K-731 SwitchHouse and K-732 Switchyard Draining System 3-36
3.18	Mercury concentrations at Surface Water Location K-1700..... 3-43
3.19	Mercury concentrations at outfall 180..... 3-44
3.20	Mercury concentrations at outfall 190..... 3-44
3.21	Mercury concentrations at outfall 05A..... 3-45
3.22	Total chromium sample results for the chromium collection system..... 3-48
3.23	Hexavalent chromium sample results for the chromium collection system 3-48

3.24	Hexavalent chromium results at storm water Outfall 170 during the CERCLA Project test of CWTS.....	3-49
3.25	Hexavalent chromium results at MIK 0.79 during the CERCLA Project test of CWTS.....	3-50
3.26	East Tennessee Technology Park Environmental Monitoring Program surface water monitoring locations.....	3-55
3.27	Annual average percentage of derived concentration standards (DCSs) at surface water monitoring locations, 2016.....	3-56
3.28	Trichloroethene concentrations in Mitchell Branch.....	3-57
3.29	Concentrations of cis-1,2-dichloroethene in Mitchell Branch.....	3-58
3.30	Vinyl chloride concentrations in Mitchell Branch.....	3-58
3.31	Total chromium concentrations at K-1700.....	3-59
3.32	ETTP exit pathways monitoring locations.....	3-60
3.33	VOC concentrations in groundwater at K-1064 Peninsula area.....	3-60
3.34	Chromium concentrations in groundwater in the K-31/K-33 area.....	3-63
3.35	Detected VOC concentrations in groundwater exit pathway wells near K-27 and K-29.....	3-64
3.36	TCE concentrations in selected ETTP K-901 area springs.....	3-66
3.37	History of measured alpha and beta activity in the K-770 area.....	3-67
3.38	VOC concentrations in groundwater at K-1085.....	3-68
3.39	Water bodies at the East Tennessee Technology Park.....	3-72
3.40	Major storm water outfalls and biological monitoring locations on Mitchell Branch.....	3-73
3.41	Asiatic clam (<i>Corbicula fluminea</i>).....	3-74
3.42	Mean total polychlorinated biphenyl (PCB) ($\mu\text{g/g}$, wet wt.; 1993-2016) concentrations in the soft tissues of caged Asiatic clams deployed in Mitchell Branch.....	3-74
3.43	Mean total Mercury (ug/g , wet wt.; 1993-2016) concentrations in the soft tissues of caged Asiatic clams deployed in Mitchell Branch.....	3-75
3.44	Fish bioaccumulation sampling at K-1007-P1 pond.....	3-75
3.45	Mean (+/- standard error) polychlorinated biphenyl (PCB) concentration (ug/g , wet wt.; 1993-2016) redbreast sunfish fillets in Mitchell Branch. (MIK 0.2).....	3-76
3.46	Bluegill sunfish (<i>Lepomis macrochirus</i>).....	3-76
3.47	Mean total Mercury (Hg) concentrations ($\mu\text{g/g}$, wet wt.; 1993-2016) in redbreast sunfish fillets in Mitchell Branch (MIK 0.2), 1989-2016.....	3-77
3.48	Benthic macroinvertebrate sampling in Mitchell Branch.....	3-78
3.49	Mean taxonomic richness in Mitchell Branch, 1987-2016.....	3-79
3.50	Temporal trends in Tennessee Department of Environment and Conservation (TDEC) Benthic Macroinvertebrate Biotic Index (a) and Stream Habitat Index (b) scores for Mitchell Branch, August 2008-2016.....	3-80
3.51	Species richness for fish communities at sites in Mitchell Branch and in reference streams.....	3-81
3.52	Density of fish communities at sites in Mitchell Branch and in reference streams.....	3-81
3.53	East Tennessee Technology Park reindustrialization status, 2016.....	3-85

Chapter 4. The Y-12 National Security Complex

4.1	Age of mission-critical facilities at the Y-12 National Security Complex.....	4-2
4.2	The relationship between the Y-12 Environmental Management System and the Integrated Safety Management System depicted in a "plan-do-check-act" cycle.....	4-6
4.3	Y-12 National Security Complex environment, safety, and health policy.....	4-7
4.4	Cost efficiencies from Y-12 National Security Complex pollution prevention activities.....	4-13
4.5	Y-12 National Security Complex pollution prevention initiatives.....	4-13
4.6	Y-12 donated obsolete security jackets to homeless veterans.....	4-15
4.7	Y-12 National Security Complex recycling results.....	4-15
4.8	Y-12 has achieved a 10% reduction in energy intensity from the FY2015 baseline.....	4-16

4.9	Y-12 National Security Complex water intensity goals	4-25
4.10	Fleet management roadmap.....	4-27
4.11	Tennessee Chamber of Commerce and Industry awards ceremony for Y-12, Montgomery Bell State Park, October 26, 2016.....	4-30
4.12	In a ceremony in Washington, DC, on May 23, 2016, Y-12 received the Electronic Product Environmental Assessment Tool Award Purchaser 2 Star Level Award for Excellence in Green Procurement of Electronics	4-30
4.13	Y-12 National Security Complex path to elimination of its inventory of legacy mixed waste as part of the Oak Ridge Reservation site treatment plan	4-38
4.14	Hazardous waste generation, 2010–2016.....	4-39
4.15	Total curies of uranium discharged from the Y-12 National Security Complex to the atmosphere, 2011–2016	4-53
4.16	Locations of ambient air monitoring stations at the Y-12 Complex.....	4-57
4.17	Temporal trends in mercury vapor concentration for the boundary monitoring stations at the Y-12 Complex, July 1986 to January 2017 [(a) and (b)] and January 1994 to January 2017 for ambient air station 8 [(c)]	4-59
4.18	Major Y-12 National Security Complex National Pollutant Discharge Elimination System (NPDES) outfalls and monitoring locations.....	4-62
4.19	Surface water and sanitary sewer radiological sampling locations at the Y-12 National Security Complex.....	4-66
4.20	Five-year trend of Y-12 National Security Complex releases of uranium to East Fork Poplar Creek	4-67
4.21	Y-12 National Security Complex storm water monitoring locations.....	4-69
4.22	Surface Water Hydrological Information Support System (SWHISS) monitoring locations	4-70
4.23	Locations of biological monitoring sites on East Fork Poplar Creek in relation to the Y-12 National Security Complex.....	4-74
4.24	Locations of biological monitoring reference sites in relation to the Y-12 National Security Complex.....	4-74
4.25	Semiannual average mercury concentration in muscle fillets of redbreast sunfish in East Fork Poplar Creek (EFPC) at EFPC kilometers 23.4 (water) and 24.4 (fish), FY 2016.....	4-76
4.26	Annual mean concentrations of polychlorinated biphenyls (PCBs) in rock bass muscle fillets at East Fork Poplar Creek kilometer 23.4., FY 2016.....	4-77
4.27	(a) Taxonomic richness (mean number of taxa per sample) and (b) density (mean number of taxa per square meter) of the Ephemeroptera, Plecoptera, and Trichoptera (EPT) in the benthic macroinvertebrate communities sampled in the spring from East Fork Poplar Creek and two nearby reference streams (Brushy Fork and Hinds Creek), 1986–2016.....	4-78
4.28	Comparison of mean sensitive species richness (number of species) collected each year from 1985–2016 from four sites in East Fork Poplar Creek and a reference site (Brushy Fork).....	4-79
4.29	Fish density (number of fish per square meter) for two sites in upper East Fork Poplar Creek and a reference site (Brushy Fork) from 1985–2016.....	4-80
4.30	Known or potential contaminant sources for which groundwater monitoring was performed at the Y-12 National Security Complex during CY 2016.	4-81
4.31	Hydrogeologic regimes at the Y-12 National Security Complex and the position of the Maynardville Limestone in Bear Creek Valley.....	4-83
4.32	Groundwater elevation contours and flow directions at the Y-12 National Security Complex	4-84
4.33	Cross section of a typical groundwater monitoring well.	4-85
4.34	Location of Y-12 National Security Complex perimeter/exit pathway well, spring, and surface water monitoring stations.....	4-87

4.35	Groundwater monitoring well sampling at the Y-12 National Security Complex.....	4-88
4.36	Nitrate observed in groundwater at the Y-12 National Security Complex, 2016.	4-91
4.37	Summed volatile organic compounds observed in groundwater at the Y-12 National Security Complex, 2016.....	4-93
4.38	Gross alpha activity observed in groundwater at the Y-12 National Security Complex, 2016.	4-94
4.39	Gross beta activity observed in groundwater at the Y-12 National Security Complex, 2016.	4-95
4.40	Decreasing summed volatile organic compounds (VOCs) observed in exit pathway well GW-722-17 near the New Hope Pond, 2016.	4-96
4.41	Increasing volatile organic compounds observed in groundwater at well GW-627 west and downgradient of the Bear Creek Burial Grounds, 2016.	4-101
4.42	CY 2016 concentrations of selected contaminants in exit pathway monitoring wells in the Bear Creek hydrogeologic regime.....	4-103

Chapter 5. Oak Ridge National Laboratory

5.1	Location of Oak Ridge National Laboratory (ORNL) within the Oak Ridge Reservation and its relationship to other local US Department of Energy facilities	5-2
5.2	Boeing 777-x drill and trim tool at the Guinness World Records Ceremony.	5-4
5.3	Production of lower cost carbon fiber at the Carbon Fiber Technology Facility.....	5-4
5.4	The relationship between the UT-Battelle Environmental Management System and the Integrated Safety Management System.....	5-5
5.5	Avoided costs.	5-8
5.6	ORNL energy use intensity reduction summary.....	5-8
5.7	ORNL water use intensity reduction summary.....	5-9
5.8	Solid waste recycled at Oak Ridge National Laboratory as a result of recycling programs through 2016	5-9
5.9	ORNL-UT-Pellissippi shuttle bus	5-10
5.10	The Open Port Sampling Interfaces for Mass Spectrometry, invented by Gary Van Berkel (left) and Vilmos Kertes, ORNL.....	5-11
5.11	Creek monitoring of wetland mitigation site	5-26
5.12	Locations of major radiological emission points at Oak Ridge National Laboratory	5-31
5.13	Total curies of tritium discharged from Oak Ridge National Laboratory to the atmosphere, 2011–2016.	5-45
5.14	Total curies of ¹³¹ I discharged from Oak Ridge National Laboratory to the atmosphere, 2011–2016.	5-45
5.15	Total discharges of ¹¹ C from Oak Ridge National Laboratory to the atmosphere, 2011–2016.....	5-45
5.16	Diagram of the adaptive management framework with step-wise planning specific to the Oak Ridge National Laboratory Water Quality Protection Plan (WQPP).....	5-49

5.17	Application of stressor identification guidance to address mercury impairment in the White Oak Creek watershed.....	5-49
5.18	Selected surface water, National Pollutant Discharge Elimination System, and reference sampling locations at Oak Ridge National Laboratory	5-54
5.19	Outfalls and instream locations at Oak Ridge National Laboratory with average radionuclide concentrations greater than 4% of the relevant derived concentration standards in 2016.	5-55
5.20	Cesium-137 discharges at White Oak Dam, 2011–2016.	5-56
5.21	Gross alpha discharges at White Oak Dam, 2011–2016.	5-56
5.22	Gross beta discharges at White Oak Dam, 2011–2016.	5-57
5.23	Total radioactive strontium discharges at White Oak Dam, 2011–2016.	5-57
5.24	Tritium discharges at White Oak Dam, 2011–2016.	5-57
5.25	Annual flow volume at White Oak Dam, 2011–2016.....	5-57
5.26	Total aqueous mercury concentrations at sites in White Oak Creek downstream from Oak Ridge National Laboratory, 1998–2016.	5-58
5.27	Total mercury concentration and flux at selected Oak Ridge National Laboratory instream locations, 2009 through 2016.	5-59
5.28	Mean concentrations of mercury (\pm standard error, N = 6) in muscle tissue of sunfish and bass from White Oak Creek [White Oak Creek kilometers (WCKs) 3.9 and 2.9] and White Oak Lake (WCK 1.5), 1998–2016.....	5-61
5.29	Mean total polychlorinated biphenyl (PCB) concentrations (\pm standard error, N = 6) in fish fillets collected from the White Oak Creek watershed, 1998–2016.....	5-62
5.30	Temporal trends in Tennessee Department of Environment and Conservation Biotic Index Scores for White Oak Creek watershed, August 2006–August 2015.	5-63
5.31	Benthic macroinvertebrate communities in First Creek: (a) total taxonomic richness (mean number of all taxa/sample) and (b) taxonomic richness of the pollution intolerant taxa, Ephemeroptera, Plecoptera, and Trichoptera [(EPT); mean number of EPT taxa/sample], April sampling periods, 1987–2015.	5-64
5.32	Benthic macroinvertebrate communities in Fifth Creek: (a) total taxonomic richness (mean number of all taxa/sample) and (b) taxonomic richness of the pollution intolerant taxa, Ephemeroptera, Plecoptera, and Trichoptera [(EPT); mean number of EPT taxa/sample], April sampling periods, 1987–2015.	5-65
5.33	Benthic macroinvertebrate communities in White Oak Creek: (a) total taxonomic richness (mean number of all taxa/sample) and (b) taxonomic richness of the pollution intolerant taxa, Ephemeroptera, Plecoptera, and Trichoptera [(EPT); mean number of EPT taxa/sample], April sampling periods, 1987–2015.....	5-66
5.34	Benthic macroinvertebrate communities in lower Melton Branch: (a) total taxonomic richness (mean number of all taxa/sample) and (b) taxonomic richness of the pollution intolerant taxa, Ephemeroptera, Plecoptera, and Trichoptera [(EPT); mean number of EPT taxa/sample], April sampling periods, 1987–2015.....	5-67
5.35	Fish species richness (number of species) in upper White Oak Creek and lower Melton Branch compared with two reference streams (Brushy Fork and Mill Branch) 1985–2016.	5-68
5.36	Locations of monitoring points for First Creek source investigation.....	5-69
5.37	Oak Ridge National Laboratory surface water sampling locations.....	5-72
5.38	UT-Battelle exit pathway groundwater monitoring locations at Oak Ridge National Laboratory, 2016.	5-78
5.39	Groundwater monitoring locations at the Spallation Neutron Source, 2016.	5-83
5.40	Simple hydrograph of spring discharge vs. time after initiation of rainfall.	5-84

Chapter 6. Oak Ridge Reservation Environmental Monitoring Program

6.1	The Oak Ridge Reservation meteorological monitoring network, including sonic detection and ranging (SODAR) devices.....	6-3
6.2	External gamma radiation monitoring locations on the Oak Ridge Reservation.....	6-4
6.3	Oak Ridge Reservation ambient air station.....	6-6
6.4	Locations of Oak Ridge Reservation perimeter air monitoring stations.....	6-6
6.5	Oak Ridge Reservation surface water surveillance sampling locations.....	6-11
6.6	Milk-sampling locations in the vicinity of the Oak Ridge Reservation.....	6-15
6.7	Fish-sampling locations for the Oak Ridge Reservation Surveillance Program.....	6-17

Chapter 7. Dose

7.1	Nuclides contributing to the effective dose at the Y-12 National Security Complex.....	7-6
7.2	Nuclides contributing to effective dose at Oak Ridge National Laboratory.....	7-7
7.3	Nuclides contributing to effective dose at East Tennessee Technology Park.....	7-7

Tables

<i>Table</i>	<i>Page</i>
Chapter 1. Introduction to the Oak Ridge Reservation	
1.1 Animal species of special concern reported on the Oak Ridge Reservation	1-8
1.2 Vascular plant species listed by state or federal agencies and sighted/reported on or near the Oak Ridge Reservation, 2016.....	1-13
Chapter 2. Compliance Summary and Community Involvement	
2.1 Applicable environmental laws/regulations and 2016 status	2-2
2.2 Summary of regulatory environmental evaluations, audits, inspections, and assessments conducted at Oak Ridge Reservation, 2016	2-9
Chapter 3. East Tennessee Technology Park	
3.1 East Tennessee Technology Park Environmental Permits, 2016	3-13
3.2 Regulatory oversight, assessments, inspections, and site visits at East Tennessee Technology Park, 2016.....	3-14
3.3 East Tennessee Technology Park UCOR emergency reciprocating internal combustion engine air permit compliance demonstration, 2016	3-26
3.4 Radionuclides in ambient air at East Tennessee Technology Park, January 2016 through December 2016	3-30
3.5 Representative outfalls	3-32
3.6 Storm water Outfall 170 for chromium monitoring	3-32
3.7 Storm water composite sampling for radiological discharges.....	3-35
3.8 Analytical results for radiological monitoring at ETTP storm water outfalls in 2016	3-35
3.9 Radionuclides released to off-site waters from the ETTP storm water system in 2016 (Ci).....	3-35
3.10 Storm water sampling to support D&D of the K-27 building	3-39
3.11 Results over screening levels for Building K-27 D&D monitoring	3-40
3.12 Quarterly ⁹⁹ Tc sampling at Outfall 190	3-41
3.13 Mercury sampling at storm water outfalls sampled during previous NPDES permit	3-42
3.14 Quarterly NPDES/SWPP Program mercury monitoring results—CY 2015 and 2016.....	3-42
3.15 NPDES permit renewal sampling-mercury results	3-45
3.16 PCB samples collected as part of the FY 2016 SWPP Program	3-46
3.17 Analytical results from CY 2016 SWPP Program PCB sampling	3-46
3.18 Monitoring requirements-Mitchell Branch subwatershed total and hexavalent chromium sampling locations.....	3-47
3.19 NPDES permit renewal sampling conducted in CY 2016	3-50
3.20 Analytical results exceeding screening levels for NPDES permit renewal sampling— CY 2016	3-51
3.21 Analytical results from flow-proportional composite sampling.....	3-53
3.22 Analytical results for Outfall 100 and K-1007-B Weir sampling conducted on December 2, 2016.....	3-54
3.23 Analytical results for Outfall 100 and K-1007-B Weir sampling conducted on December	

	13, 2016	3-54
3.24	VOCs detected in groundwater in the Mitchell Branch Exit Pathway	3-62

Chapter 4. The Y-12 National Security Complex

4.1	FY 2016 sustainability goals and status	4-19
4.2	Y-12 National Security Complex greenhouse gas emissions summary	4-28
4.3	Y-12 National Security Complex environmental permits, 2016	4-31
4.4	Y-12 National Security Complex Resource Conservation and Recovery Act post-closure status for former treatment, storage, and disposal units on the Oak Ridge Reservation	4-40
4.5	Emergency Planning and Community Right-to-Know Act Section 313 toxic chemical release and off-site transfer summary for the Y-12 National Security Complex, 2015 and 2016	4-43
4.6	Summary of external regulatory audits and reviews, 2016	4-45
4.7	Summary of materials released in 2016	4-45
4.8	DOE O 458.1 preapproved authorized limits	4-46
4.9	Actual versus allowable air emissions from the Y-12 National Security Complex Steam Plant, 2016	4-50
4.10	Greenhouse gas emissions from Y-12 National Security Complex stationary fuel combustion sources	4-55
4.11	Summary of data for the Y-12 National Security Complex ambient air monitoring program for mercury for CY 2016	4-58
4.12	National Pollutant Discharge Elimination System compliance monitoring requirements and record for the Y-12 National Security Complex, January through December 2016	4-63
4.13	Radiological parameters monitored at the Y-12 National Security Complex, 2016	4-65
4.14	Summary of Y-12 National Security Complex radiological monitoring plan sample requirements and 2016 results	4-66
4.15	Release of uranium from the Y-12 National Security Complex to the off-site environment as a liquid effluent, 2011–2016	4-67
4.16	Y-12 National Security Complex discharge point SS6, Sanitary Sewer Station 6, January through December 2016	4-71
4.17	Y-12 National Security Complex Biomonitoring Program summary information for outfalls 200 and 135 in 2016	4-73
4.18	Summary of groundwater monitoring at the Y-12 Complex, 2016	4-86
4.19	Description of waste management units and underground storage tanks included in groundwater monitoring activities, upper East Fork Poplar Creek hydrogeologic regime, 2016	4-89
4.20	Description of waste management units included in 2016 groundwater monitoring activities, Bear Creek hydrogeologic regime	4-98
4.21	Nitrate and uranium concentrations in Bear Creek	4-100
4.22	Description of waste management units included in groundwater monitoring activities, Chestnut Ridge hydrogeologic regime, 2016	4-104

Chapter 5. Oak Ridge National Laboratory

5.1	Summary of regulatory environmental audits, evaluations, inspections, and assessments conducted at Oak Ridge National Laboratory, 2016	5-16
5.2	Environmental permits in effect at ORNL in 2016	5-17
5.3	National Environmental Policy Act activities, 2016	5-19
5.4	Oak Ridge National Laboratory Resource Conservation and Recovery Act operating permits, 2016	5-22
5.5	Main elements of the Emergency Planning and Community Right-to-Know Act	5-25

5.6	Excess items requested for release and/or recycling, 2016.....	5-29
5.7	Radiological airborne emissions from all sources at ORNL, 2016 (Ci)	5-34
5.8	Radionuclide concentrations (pCi/mL) measured at Oak Ridge National Laboratory air monitoring station 7, 2016	5-46
5.9	National Pollutant Discharge Elimination System compliance at Oak Ridge National Laboratory, January through December 2016	5-50
5.10	Outfalls exceeding total residual oxidant NPDES permit action level in 2016	5-52
5.11	Radiological monitoring conducted under the Oak Ridge National Laboratory Water Quality Protection Plan, 2016	5-53
5.12	First Creek and WOC PCB source assessment, September 2016	5-70
5.13	Oak Ridge National Laboratory surface water sampling locations, frequencies, and parameters, 2016	5-73
5.14	Industrial and Commercial User Waste Water Discharge Permit compliance at the Oak Ridge National Laboratory Carbon Fiber Technology Facility, 2016.....	5-73
5.15	Scheduled 2016 exit pathway groundwater monitoring.....	5-79
5.16	2016 exit pathway groundwater monitoring—results of trend analyses for parameters exceeding reference standards	5-80
5.17	2016 exit pathway groundwater monitoring results—detected radiological parameters	5-80
5.18	Analytical results for parameters detected in samples collected at the Spallation Neutron Source during 2016 (pCi/L)	5-85

Chapter 6. Oak Ridge Reservation Environmental Monitoring Program

6.1	Oak Ridge Reservation meteorological towers	6-2
6.2	External gamma (exposure rate) averages for the Oak Ridge Reservation, 2016	6-5
6.3	Average radionuclide concentrations at Oak Ridge Reservation perimeter air monitoring stations, 2016	6-7
6.4	Oak Ridge Reservation surface water sampling locations, frequencies, and parameters, 2016.....	6-12
6.5	Concentrations of radionuclides detected in vegetables, 2016 (pCi/kg)	6-13
6.6	Concentrations of radionuclides detected in raw milk, 2016	6-15
6.7	Tissue concentrations in catfish and sunfish for detected mercury, PCBs, and detected radionuclides, 2016	6-17

Chapter 7. Dose

7.1	Emission point parameters and receptor locations used in the dose calculations.....	7-3
7.2	Meteorological towers and heights used to model atmospheric dispersion from source emissions	7-5
7.3	Calculated radiation doses to maximally exposed off-site individuals from airborne releases, 2016	7-6
7.4	Calculated collective effective doses from airborne releases, 2016	7-6
7.5	Hypothetical effective doses from living near the Oak Ridge Reservation, Oak Ridge National Laboratory, and the East Tennessee Technology Park ambient air monitoring stations, 2016	7-8
7.6	Summary of annual maximum individual (mrem) and collective (person-rem) effective doses (EDs) from waterborne radionuclides, 2016.....	7-13
7.7	Summary of maximum estimated effective doses to an adult by exposure pathway	7-18
7.8	Trends in effective dose (mrem).....	7-19
7.9	Chemical hazard quotients and estimated risks for drinking water, 2016.....	7-23
7.10	Chemical hazard quotients and estimated risks for carcinogens in fish, 2016	7-24

Appendices

- A Glossary
- B Climate Overview of the Oak Ridge Area
- C Reference Standards and Data for Water
- D National Pollution Discharge Elimination System Noncompliance Summaries for 2016
- E Radiation
- F Chemicals

Acronyms and Abbreviations

A	AAS	ambient air (monitoring) station
	ABC	aluminum beverage can (recycling)
	ACHP	Advisory Council on Historic Preservation
	ACO	Analytical Chemistry Organization (Y-12 Complex)
	ACM	asbestos-containing material
	AFV	alternative fuel vehicle
	AGL	above ground level
	ALARA	as low as reasonably achievable
	AMP	asset management program
	ANSI	American National Standards Institute
	ANSI/HPS	ANSI Health Physics Society (standard)
	AOC	area of concern
	AOEC	Agent Operations Eastern Command (NNSA OST)
	ARAP	Aquatic Resource Alteration Permit
	ARAR	applicable or relevant and appropriate requirement
	ASER	<i>Oak Ridge Reservation Annual Site Environmental Report</i>
	ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	ambient water quality criterion	
B	BCG	biota concentration guide
	BCK	Bear Creek kilometer
	BFK	Brushy Fork kilometer
	BMAP	Biological Monitoring and Abatement Program
	BRW	bedrock well
C	C&D	construction and demolition
	CAA	Clean Air Act
	CAP-88	Clean Air Assessment Package (software)
	CAS	condition assessment survey
	CCA	chromated copper arsenate (as in CCA Type C pressure-treated wood)
	CCR	climate change resiliency
	CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
	CEUSP	Consolidated Edison Uranium Solidification Project
	CFL	Computers for Learning
	CFR	<i>Code of Federal Regulations</i>
	CFTF	Carbon Fiber Technology Facility

	CH	contact-handled
	CNF	Central Neutralization Facility
	CNS	Consolidated Nuclear Security, LLC
	CO ₂ e	CO ₂ equivalent
	COC	contaminant of concern
	COR	City of Oak Ridge
	CPU	central processing unit
	CRK	Clinch River kilometer
	CROET	Community Reuse Organization of East Tennessee
	CRT	cathode ray tube (also display devices, especially computers incorporating cathode ray tubes)
	CWA	Clean Water Act
	CWTS	Chromium Water Treatment System (ETTP)
	CX	categorical exclusion
	CY	calendar year
D		
	D&D	decontamination and decommissioning
	DAC	derived air concentration
	DCA	dichloroethane
	DCE	dichloroethene/dichloroethylene
	DCS	derived concentration standard
	DNAPL	dense nonaqueous phase liquid
	DOE	US Department of Energy
	DOE ORO	DOE Oak Ridge Office
E		
	EA	environmental assessment
	EC&P	environmental compliance and protection
	ECD	Environmental Compliance Department (Y-12)
	ECM	energy conservation measure
	ED	effective dose
	EFK	East Fork Poplar Creek kilometer
	EFPC	East Fork Poplar Creek
	EISA	Energy Independence and Security Act
	EM	environmental management
	EMMIS	Environmental Monitoring Management Information System (Y-12)
	EMS	environmental management system
	EMWMF	Environmental Management Waste Management Facility
	ENIGMA	Ecosystems and Networks Integrated with Genes and Molecular Assemblies
	EO	executive order
	EOC	Emergency Operations Center
	EPA	US Environmental Protection Agency
	EPCRA	Emergency Planning and Community Right-to-Know Act

	EPEAT	Electronic Product Environmental Assessment Tool
	EPT	ephemeroptera, plecoptera, and trichoptera (taxa)
	EPSD	Environmental Protection Services Division (UT-Battelle)
	ES&H	environment, safety, and health
	ESPC	Energy Savings Performance Contract
	ESS	Environmental Surveillance System (ORNL)
	ETTP	East Tennessee Technology Park
	EV	electric vehicle
F	FAR	Federal Acquisition Regulation
	FCK	First Creek kilometer
	FEMP	Federal Energy Management Program
	FFA	Federal Facility Agreement (for the Oak Ridge Reservation)
	FFCA	Federal Facilities Compliance Agreement
	FFK	Fifth Creek kilometer
	FONSI	finding of no significant impact
	FWS	US Fish and Wildlife Service
	FY	fiscal year
	FYNSP	Future Years Nuclear Security Plan
G	GET	general employee training
	GHG	greenhouse gas
	GI	green infrastructure
	GI/LID	green infrastructure/low impact development
	GM	Geiger–Müller tube for detection of ionizing radiation
	GP	guiding principle
	GSA	General Services Administration
	GSF	gross square feet
H	HAP	hazardous air pollutant
	HCN	hydrogen cyanide
	HEMSF	high-energy mission-specific facility
	HEPA	high-efficiency particulate air
	HEU	highly enriched uranium
	HFIR	High Flux Isotope Reactor
	HPSB	high-performance sustainable building
	HQ	hazard quotient
	HVAC	heating, ventilation, and air conditioning
	HVC	Hardin Valley Campus
I	IC ₂₅	inhibition concentration (the concentration of effluent that causes a 25% reduction in survival, reproduction, and/or growth of monitored species)

	ID	identification (number)
	IDMS	Integrated Document Management System (UT-Battelle)
	ILA	industrial, landscaping, and agricultural
	ISMS	Integrated Safety Management System
	ISO	International Organization for Standardization
	Isotek	Isotek Systems LLC
J		
	JCI	Johnson Controls, Inc.
L		
	LCD	liquid crystal display
	LEDP	Laboratory Equipment Donation Program
	LEED	Leadership in Energy and Environmental Design
	LEP	life extension program
	LID	low impact development
	LIMS	Laboratory Information Management System (Y-12 Complex)
	LLW	low-level waste
M		
	M&E	material and equipment
	M&TE	measurement and test equipment
	MACT	Maximum Achievable Control Technology
	MARSAME	<i>Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual</i>
	MARSSIM	<i>Multi-Agency Radiation Survey and Site Investigation Manual</i>
	MCK	McCoy Branch kilometer
	MCL	maximum contaminant level
	MDA	minimum detectable activity
	MDF	Manufacturing Demonstration Facility
	MEI	maximally exposed individual
	MEK	Melton Branch kilometer
	MIK	Mitchell Branch kilometer
	MOA	memorandum of agreement
	MSL	mean sea level
	MT	meteorological tower (when followed by a numeral as in “MT2”)
	MTF	Mercury Treatment Facility
N		
	NAAQS	National Ambient Air Quality Standards
	NEPA	National Environmental Policy Act
	NESHAPs	National Emission Standards for Hazardous Air Pollutants
	NHPA	National Historic Preservation Act
	NIST	National Institute of Standards and Technology
	NNSA	National Nuclear Security Administration
	NNSS	Nevada National Security Site

	NOV	notice of violation
	NPDES	National Pollutant Discharge Elimination System
	NPL	National Priorities List (EPA)
	NPO	NNSA Production Office
	NPS	US National Park Service
	NRHP	National Register of Historic Places
	NSC	National Security Complex
	NSF-ISR	NSF International Strategic Registrations, Ltd.
	NTRC	National Transportation Research Center
	NWSol	North Wind Solutions, LLC
O	ODS	ozone-depleting substance
	O&M	operations and maintenance
	OMP	operational monitoring plan
	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	Oak Ridge Office (DOE)
	ORPS	Occurrence Reporting and Processing System
	ORR	Oak Ridge Reservation
	ORR-PCB-FFCA	Oak Ridge Reservation Polychlorinated Biphenyl Federal Facilities Compliance Agreement
	ORSSAB	Oak Ridge Site Specific Advisory Board
	ORWMA	Oak Ridge Wildlife Management Area
	OS	Office of Science (DOE)
P	P2/WMin	pollution prevention/waste minimization
	PAM	perimeter air monitoring (station)
	Pantex	Pantex Plant
	PCB	polychlorinated biphenyl
	PCE	tetrachloroethene
	PEMS	Predictive Emissions Monitoring System
	PHEV	plug-in hybrid electric vehicle
	PM	particulate matter
	PM ₁₀	particulate matter with an aerodynamic diameter $\leq 10 \mu\text{m}$
	PM _{2.5}	fine particulate matter with an aerodynamic diameter $\leq 2.5 \mu\text{m}$
	PSS	plant shift superintendent
	PUE	power usage effectiveness
	PWTC	Process Waste Treatment Complex

Q	QA	quality assurance
	QAS	quality assurance system
	QC	quality control
	QMS	quality management system
R		
R	R2	responsible recycling
	RA	remedial action
	R&D	research and development
	rad-NESHAPs	National Emission Standards for Hazardous Air Pollutants for radionuclides
	RATA	relative accuracy test audit
	RCRA	Resource Conservation and Recovery Act
	RCW	recirculating cooling water
	REC	renewable energy credit (also renewable energy certificate)
	REDC	Radiochemical Engineering Development Center
	RESRAD	residual radioactivity
	RH	remote-handled
	RI	remedial investigation
	RI/FS	remedial investigation/feasibility study
	RICE	reciprocating internal combustion engine
	RMP	risk management plan
	ROD	record of decision
	RQ	reportable quantity (CERCLA)
RSI	Restoration Services, Inc.	
S		
S	S&M	surveillance and maintenance
	SAP	sampling and analysis plan
	SARA	Superfund Amendments and Reauthorization Act
	SBMS	Standards-Based Management System (UT-Battelle)
	SCP	standards and calibration program
	SD	storm water outfall/storm drain
	SDWA	Safe Drinking Water Act
	SHPO	State Historic Preservation Office (Tennessee)
	SIC	Standard Industrial Classification (code)
	SNAP	Significant New Alternatives Program (EPA)
	SNS	Spallation Neutron Source
	SODAR	sonic detection and ranging
	SOF	sum of fractions
	SPCC	spill prevention, control, and countermeasures (plan)
	SPMD	semipermeable membrane device
	SSP	site sustainability plan
	SSPP	Strategic Sustainability Performance Plan (DOE)

	STP	sewage treatment plant
	SVOC	semivolatile organic compound
	SWEIS	sitewide environmental impact statement
	SWHISS	Surface Water Hydrological Information Support System (Y-12 Complex)
	SWMU	solid waste management unit
	SWPP	storm water pollution prevention
	SWPPP	Storm Water Pollution Prevention Plan
	SWSA	solid waste storage area
T		
	T&D	transmission and distribution
	TCA	trichloroethane
	TCE	trichloroethene/trichloroethylene
	TDEC	Tennessee Department of Environment and Conservation
	TEMA	Tennessee Emergency Management Agency
	TMDL	total maximum daily load
	TMSP	Tennessee Stormwater Multi-Sector General Permit
	TOA	Tennessee Oversight Agreement
	TRI	toxic (chemical) release inventory
	TRO	total residual oxidant
	TRU	transuranic
	TSC	Technical Support Center
	TSCA	Toxic Substances Control Act
	TSS	total suspended solids
	TVA	Tennessee Valley Authority
	TWA	time-weighted average
	TWPC	Transuranic Waste Processing Center
	TWRA	Tennessee Wildlife Resources Agency
U		
	UCOR	URS CH2M Oak Ridge LLC
	UMC	unnneeded materials and chemicals
	UMS	Utilities Management System (Y-12 Complex)
	UNW	unconsolidated well
	UPF	Uranium Processing Facility (Y-12 Complex)
	USDA	US Department of Agriculture
	UST	underground storage tank
	UT-Battelle	UT-Battelle, LLC (partnership between University of Tennessee and Battelle Memorial Institute formed to manage ORNL for DOE)
V		
	VOC	volatile organic compound

W	WCK	White Oak Creek kilometer
	WEMA	west end mercury-use area (Y-12)
	WOC	White Oak Creek
	WOD	White Oak Dam
	WPB	waste-processing building
	WQC	water quality criterion
	WQPP	water quality protection plan
	WRRP	Water Resources Restoration Program
	WSR	waste services representatives
Y	Y-12/Y-12 Complex	Y-12 National Security Complex

Units of Measure and Conversion Factors*

Units of measure and their abbreviations			
acre	acre	millicurie	mCi
becquerel	Bq	milligram	mg
British thermal unit	Btu	milliliter	mL
centimeter	cm	millimeter	mm
curie	Ci	million	M
day	day	millirad	mrad
degrees Celsius	°C	millirem	mrem
degrees Fahrenheit	°F	milliroentgen	mR
disintegrations per minute	dpm	millisievert	mSv
foot	ft	minute	min
gallon	gal	nanogram	ng
gallons per minute	gal/min	nephelometric turbidity unit	NTU
gram	g	parts per billion	ppb
gray	Gy	parts per million	ppm
gross square feet	gsf	parts per trillion	ppt
hectare	ha	picocurie	pCi
hour	h	pound	lb
inch	in.	pound mass	lbm
joule	J	pounds per square inch	psi
kilocurie	kCi	pounds per square inch gage	psig
kilogram	kg	quart	qt
kilometer	km	rad	rad
kilowatt	kW	roentgen	R
liter	L	rem	rem
megajoule	MJ	roentgen equivalent man	rem
megawatt	MW	second	s
megawatt-hour	MWh	sievert	Sv
meter	m	standard unit (pH)	SU
microcurie	μCi	ton, short (2,000 lb)	ton
microgram	μg	yard	yd
micrometer	μm	year	year

Quantitative prefixes			
exa	× 10 ¹⁸	atto	× 10 ⁻¹⁸
peta	× 10 ¹⁵	femto	× 10 ⁻¹⁵
tera	× 10 ¹²	pico	× 10 ⁻¹²
giga	× 10 ⁹	nano	× 10 ⁻⁹
mega	× 10 ⁶	micro	× 10 ⁻⁶
kilo	× 10 ³	milli	× 10 ⁻³
hecto	× 10 ²	centi	× 10 ⁻²
deka	× 10 ¹	decic	× 10 ⁻¹

*Due to differing permit reporting requirements and instrument capabilities, various units of measurement are used in this report. The provided list of units of measure and conversion factors is intended to help readers make approximate conversions to other units as needed for specific calculations and comparisons.

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 (US liquid)	× 0.946	L	L	× 1.057	qt (US liquid)
gal	× 3.7854118	L	L	× 0.264172051	gal
Concentration					
ppb	× 1	µg/kg	µg/kg	× 1	ppb
ppm	× 1	mg/kg	mg/kg	× 1	ppm
ppb	× 1	µg/L	µg/L	× 1	ppb
ppm	× 1	mg/L	mg/L	× 1	ppm
Weight					
lb	× 0.4536	kg	kg	× 2.205	lb
lbm	× 0.45356	kg	kg	× 2.2046226	lbm
ton, short	× 907.1847	kg	kg	× 0.00110231131	ton, short
Temperature					
°C	°F = (9/5) °C + 32	°F	°F	°C = (5/9) (F—32)	°C
Activity					
Bq	× 2.7 × 10 ⁻¹¹	Ci	Ci	× 3.7 × 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	× 1,000	pCi	pCi	× 0.001	nCi
mCi/km ²	× 1	nCi/m ²	nCi/m ²	× 1	mCi/km ²
dpm/L	× 0.45 × 10 ⁹	µCi/cm ³	µCi/cm ³	× 2.22 × 10 ⁹	dpm/L
pCi/L	× 10 ⁻⁹	µCi/mL	µCi/mL	× 10 ⁹	pCi/L
pCi/m ³	× 10 ⁻¹²	µCi/cm ³	µCi/cm ³	× 10 ¹²	pCi/m ³

Acknowledgments

The US Department of Energy (DOE) is responsible for producing this document. DOE acknowledges with deep appreciation the efforts of the following individuals, who provided valuable resources, information, technical data, and management, administrative, field, or other support for the Oak Ridge Reservation Annual Site Environmental Report for 2016.

ENVIRONMENTAL MANAGEMENT

Carrie Barber
Betsy Brucken
Mark Cleveland
Kevin Crow
Christa Davis
Katie Davis
Howell Estes
Steve Foster
Justin Frazer
Glen Galen
Sherry Gibson
Stephen Goodpasture
Kevin Ironside
Charles Justice
Richard Ketelle
Rodney Kingrea
Jeff Maddox
Bruce McElhoe
Jeff Murphy
Tony Poole
Gill Salade
Cheryl Saylor
Eileen Shea
Adam Smith
Wesley White
Steven Wood

ORSSAB

Spencer Gross

ORNL

Betsy Brucken
Kevin Birdwell
Terry Bonine
Jason Case
Gary Chadwick
Cheri Lee Cross
Kathleen Davidson
Jim Eaton
Rich Franco

Taylor Fry
Neil Giffen
Wes Goddard
Mark Greeley
Scott Gregory
Julia Hancock
Jamie Herold
Joan Hughes
Trent Jett
Regis Loffman
Diane Maddox
Jeff Maddox
Terry Mathews
Robert McManamay
Lori Muhs
Teresa Nichols
Todd North
Anne Ostergaard
Mitch Parker
Mark Peterson
Kelly Roy
Kyle Rutherford
Ernest Ryan
Denise Saunders
Pat Scofield
Jeff Shelton
Jeff Sickau
Elizabeth Wright
Linda Smith
George Stephens
Sam Thomas
Charlie Valentine

Y-12 COMPLEX

Gary Beck
Betsy Brucken
Vickie Brumback
Jeff Bruner
Mark Burdette
Durand Carmany
Sara Cornwell
Terry Cothron

Laura Cunningham
Jennifer Dixon
Stan Duke
Beth Eckerman
Steve Field
Michelle Fine
Steven Foster
Daniel Gelb
Kim Hanzelka
Clarence Hill
William Hurst
Steve Jones
Cheryl LaBorde
Wesley Long
Stacey Loveless
Jimmy Massey
Wayne McMahon
Jane Nations
Terry Nore
Aprell Patterson
Mark Peterson
Tony Poole
Sandra Reagan
Randy Redmond
Craig Schwartz
Beth Schultz
Charlie Sexton
Mark Shedden
Brad Skaggs
Johnny Skinner
Tim Tharp
Brenda Vann
Lance Voss
Jeanette Widman
Mick Wiest
Rebekah Young