

2006
DOE | ORO | 2231

the Oak Ridge
Reservation

ANNUAL SITE ENVIRONMENTAL REPORT



“These stars of earth,
these golden flowers.”

– Henry Wadsworth Longfellow



the Oak Ridge
Reservation

ANNUAL SITE
ENVIRONMENTAL
REPORT
2006

Cover Artwork: Savannah Pressley
Karns Middle School student artist

Layout/Design: Andy Sproles
Communications & External Relations
UT-Battelle

artwork reproduced by DOE with students' permission

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

on the World Wide Web
<http://www.ornl.gov/aser>

Project director
Joan Hughes

Project coordinator
Sharon Thompson

Technical coordinators

Wayne McMahon
Oak Ridge Y-12 Complex

Joan Hughes
Oak Ridge National Laboratory

Mike Coffey
East Tennessee Technology Park

Electronic publisher
Brenda Phillips

Coordinating editor
Walter Koncinski

Graphic artists
Sherri Cotter
Jane Parrott

Project manager, DOE-ORO
David Page

September 2007

Prepared by
Oak Ridge National Laboratory
P.O. Box 2008, Oak Ridge, TN 37831-2008
Managed by UT-Battelle, LLC
for the Department of Energy under Contract No. DE-AC05-00OR22725
and by
the Y-12 National Security Complex
Oak Ridge, TN 37831-8169
Managed by
BWXT Y-12, L.L.C.
for the Department of Energy under Contract No. DE-AC05-00OR22800
and by
East Tennessee Technology Park
P.O. Box 4699, Oak Ridge, TN 37831-4699
Managed by Bechtel Jacobs Company LLC
for the Department of Energy under Contract No. DE-AC05-98OR22700

Contents

| | Page |
|--|-------------|
| Figures | ix |
| Tables..... | xv |
| Acronyms and Abbreviations | xxi |
| Units of Measure and Conversion Factors..... | xxv |
| Acknowledgments..... | xxvii |
| 1. Site and Operations Overview | 1-1 |
| 1.1 Background..... | 1-1 |
| 1.2 Description of Site Locale | 1-1 |
| 1.3 Climate..... | 1-2 |
| 1.4 Regional Air Quality | 1-3 |
| 1.5 Surface Water Setting..... | 1-4 |
| 1.6 Geological Setting | 1-4 |
| 1.7 Description of Site Facilities and Operations | 1-5 |
| 1.7.1 History of the Oak Ridge Reservation..... | 1-5 |
| 1.7.2 The Y-12 National Security Complex | 1-5 |
| 1.7.3 East Tennessee Technology Park..... | 1-7 |
| 1.7.4 Oak Ridge National Laboratory..... | 1-8 |
| 1.7.5 Oak Ridge National Environmental Research Park..... | 1-9 |
| 1.7.6 Oak Ridge Institute for Science and Education | 1-10 |
| 1.7.7 Other Sites..... | 1-10 |
| 2. Environmental Compliance..... | 2-1 |
| 2.1 Introduction | 2-1 |
| 2.2 Compliance Activities | 2-1 |
| 2.2.1 Resource Conservation and Recovery Act | 2-1 |
| 2.2.2 CERCLA..... | 2-7 |
| 2.2.3 RCRA-CERCLA Coordination | 2-7 |
| 2.2.4 Federal Facility Compliance Act | 2-8 |
| 2.2.5 National Environmental Policy Act..... | 2-8 |
| 2.2.6 National Historic Preservation Act | 2-12 |
| 2.2.7 Protection of Wetlands..... | 2-13 |
| 2.2.8 Floodplains Management..... | 2-14 |
| 2.2.9 Endangered Species Protection..... | 2-14 |
| 2.2.10 Environmental Justice..... | 2-16 |
| 2.2.11 Safe Drinking Water Act | 2-18 |
| 2.2.12 Clean Water Act..... | 2-18 |
| 2.2.13 Clean Air Act | 2-23 |
| 2.2.14 Toxic Substances Control Act | 2-25 |
| 2.2.15 Emergency Planning and Community Right-to-Know Act..... | 2-28 |
| 2.2.16 Environmental Occurrences..... | 2-31 |

| | | |
|--------|--|------|
| 2.2.17 | DOE Order 450.1, Environmental Protection Program | 2-32 |
| 2.2.18 | Release of Property | 2-39 |
| 2.3 | Appraisals and Surveillances of Environmental Programs..... | 2-40 |
| 2.4 | Environmental Permits | 2-40 |
| 2.5 | Notices of Violations and Penalties..... | 2-40 |
| 2.6 | Tennessee Oversight Agreement | 2-41 |
| 3. | Environmental Management and Reservation Activities..... | 3-1 |
| 3.1 | Introduction | 3-1 |
| 3.2 | East Tennessee Technology Park | 3-2 |
| 3.2.1 | Decontamination and Decommissioning | 3-2 |
| 3.3 | Oak Ridge National Laboratory | 3-6 |
| 3.3.1 | Melton Valley Remedial Actions..... | 3-6 |
| 3.3.2 | New Hydrofracture Facility Decontamination and Decommissioning..... | 3-6 |
| 3.3.3 | SWSA Hydrologic Isolation | 3-6 |
| 3.3.4 | Homogeneous Reactor Experiment Ancillary Facilities..... | 3-7 |
| 3.3.5 | Shielded Transfer Tanks | 3-7 |
| 3.3.6 | Liquid Low-Level Waste Pumping Stations..... | 3-8 |
| 3.3.7 | Equipment Storage Yard..... | 3-8 |
| 3.3.8 | Miscellaneous Storage Buildings..... | 3-8 |
| 3.3.9 | Molten Salt Reactor Experiment Fuel and Flush Salts Removal..... | 3-8 |
| 3.3.10 | 22-Trench Area Transuranic Waste Retrieval | 3-8 |
| 3.3.11 | Soils and Sediments Remediation..... | 3-9 |
| 3.3.12 | Pipeline Grouting..... | 3-10 |
| 3.3.13 | Decontamination and Decommissioning Projects | 3-10 |
| 3.3.14 | Remediation of T-1, T-2, and HFIR Tanks Completed | 3-10 |
| 3.3.15 | In Situ Grouting of Trenches 5 and 7 | 3-10 |
| 3.3.16 | Bethel Valley Remediation..... | 3-11 |
| 3.3.17 | Bethel Valley Groundwater Engineering Study Fieldwork Completed..... | 3-11 |
| 3.3.18 | Core Hole 8 Transuranic Waste Removal..... | 3-11 |
| 3.4 | Y-12 National Security Complex | 3-12 |
| 3.4.1 | Upper East Fork Poplar Creek | 3-12 |
| 3.5 | Off-Reservation Activities..... | 3-12 |
| 3.5.1 | David Witherspoon Inc. 901 Site Cleanup | 3-12 |
| 3.6 | Waste Treatment and Disposal | 3-12 |
| 3.6.1 | Tons of Wastes Placed in the EMWMF and Other Landfills | 3-12 |
| 3.6.2 | EMWMF Expansion..... | 3-13 |
| 3.6.3 | Haul Road Completed..... | 3-13 |
| 3.6.4 | Millions of Gallons of Wastewater Treated in 2006..... | 3-13 |
| 3.6.5 | TSCA Incinerator Hazardous Waste Treatment Continues | 3-14 |
| 3.6.6 | Transuranic, Low-Level, and Mixed Waste Operations | 3-14 |
| 3.7 | Public Involvement..... | 3-15 |
| 3.7.1 | Public Input on EM Initiatives..... | 3-15 |
| 4. | ETTP Environmental Monitoring Programs..... | 4-1 |
| 4.1 | ETTP Radionuclide Airborne Effluent Monitoring..... | 4-1 |
| 4.1.1 | Radionuclide Emissions Monitoring Approach..... | 4-1 |
| 4.1.2 | Results..... | 4-3 |
| 4.2 | ETTP Nonradiological Airborne Emissions Monitoring..... | 4-3 |

| | | |
|--------|--|------|
| 4.3 | Liquid Discharges—ETTP Radiological Monitoring Summary | 4-3 |
| 4.3.1 | Sample Collection and Analytical Procedure | 4-3 |
| 4.3.2 | Results..... | 4-4 |
| 4.4 | Nonradiological Liquid Discharges—ETTP Surface Water Effluents..... | 4-5 |
| 4.4.1 | Results..... | 4-6 |
| 4.5 | Storm Water Pollution Prevention Program..... | 4-6 |
| 4.5.1 | Storm Water Monitoring Strategy | 4-6 |
| 4.5.2 | ETTP Water Quality Program Monitoring Program Results | 4-8 |
| 4.5.3 | Radiological Monitoring of Storm Water Discharges | 4-9 |
| 4.5.4 | Nonradiological Monitoring of Storm Water Discharges..... | 4-10 |
| 4.6 | ETTP Biological Monitoring and Abatement Program..... | 4-10 |
| 4.6.1 | BMAP Toxicity Monitoring..... | 4-10 |
| 4.6.2 | BMAP Bioaccumulation Studies..... | 4-11 |
| 4.6.3 | BMAP Ecological Surveys of Instream Communities..... | 4-13 |
| 4.7 | ETTP Ambient Air Monitoring..... | 4-14 |
| 4.7.1 | Results..... | 4-17 |
| 4.7.2 | Criteria Pollutant Levels..... | 4-17 |
| 4.7.3 | Hazardous Air Pollutant Carcinogenic Metal Levels | 4-18 |
| 4.7.4 | Radionuclide Levels..... | 4-18 |
| 4.7.5 | Organic Compound Levels..... | 4-20 |
| 4.7.6 | Five-Year Trends | 4-20 |
| 4.8 | ETTP Surface Water Monitoring | 4-20 |
| 4.9 | ETTP Groundwater Monitoring..... | 4-22 |
| 4.10 | ETTP Direct Radiation | 4-22 |
| 4.11 | Modernization and Reindustrialization | 4-23 |
| 5. | ORNL Environmental Monitoring Programs | 5-1 |
| 5.1 | ORNL Radiological Airborne Effluent Monitoring | 5-1 |
| 5.1.1 | Sample Collection and Analytical Procedure | 5-1 |
| 5.1.2 | Results..... | 5-3 |
| 5.2 | ORNL Nonradiological Airborne Emissions Monitoring | 5-3 |
| 5.2.1 | Results..... | 5-8 |
| 5.3 | ORNL Ambient Air Monitoring | 5-9 |
| 5.3.1 | Results..... | 5-9 |
| 5.4 | ORNL NPDES Summary | 5-9 |
| 5.4.1 | NPDES Permit Monitoring..... | 5-9 |
| 5.4.2 | Results and Progress in Implementing Programs and Corrective Actions: ORNL Sink and Drain Survey Program..... | 5-19 |
| 5.5 | ORNL Wastewater Biomonitoring..... | 5-19 |
| 5.6 | ORNL Biological Monitoring and Abatement Program | 5-20 |
| 5.6.1 | Bioaccumulation Studies | 5-20 |
| 5.7 | ORNL Surface Water Monitoring at NPDES Reference Location | 5-25 |
| 5.8 | ORNL Surface Water Surveillance Monitoring..... | 5-26 |
| 5.8.1 | Results | 5-27 |
| 5.9 | ORNL Sediment | 5-29 |
| 5.9.1 | Results..... | 5-30 |
| 5.10 | Groundwater Monitoring at ORNL..... | 5-31 |
| 5.10.1 | Background | 5-31 |
| 5.10.2 | Exit Pathway Monitoring | 5-35 |
| 5.10.3 | Active Sites Monitoring – HFIR and SNS | 5-35 |
| 5.10.4 | Monitoring Results..... | 5-40 |

| | | |
|--------|--|------|
| 5.11 | Modernization and Reindustrialization Activities at ORNL | 5-44 |
| 5.12 | Spallation Neutron Source | 5-45 |
| 6. | Y-12 Environmental Monitoring Programs | 6-1 |
| 6.1 | Y-12 Complex Radiological Airborne Effluent Monitoring | 6-1 |
| 6.1.1 | Sample Collection and Analytical Procedure | 6-1 |
| 6.1.2 | Results..... | 6-2 |
| 6.2 | Y-12 Complex Nonradiological Airborne Emissions Monitoring..... | 6-2 |
| 6.2.1 | Results..... | 6-3 |
| 6.3 | Y-12 Complex Ambient Air Monitoring | 6-4 |
| 6.3.1 | Mercury..... | 6-4 |
| 6.3.2 | Fluorides | 6-6 |
| 6.4 | Liquid Discharges—Y-12 Complex Radiological Monitoring Summary | 6-7 |
| 6.4.1 | Results..... | 6-10 |
| 6.5 | Nonradiological Liquid Discharges—Y-12 Complex Surface Water and Liquid Effluents | 6-10 |
| 6.5.1 | Sanitary Wastewater..... | 6-14 |
| 6.5.2 | Storm Water | 6-14 |
| 6.5.3 | Results and Progress in Implementing Corrective Actions..... | 6-14 |
| 6.5.4 | Flow Management (or Raw Water)..... | 6-21 |
| 6.5.5 | Mercury Removal from Storm Drain Catch Basins..... | 6-21 |
| 6.6 | Biomonitoring Program | 6-21 |
| 6.7 | Biological Monitoring and Abatement Programs..... | 6-23 |
| 6.7.1 | Bioaccumulation Studies..... | 6-23 |
| 6.7.2 | Benthic Invertebrate Surveys | 6-25 |
| 6.7.3 | Fish Community Monitoring..... | 6-27 |
| 6.8 | Y-12 Complex Ambient Surface Water Monitoring..... | 6-28 |
| 6.9 | Y-12 Sediment Sampling..... | 6-30 |
| 6.10 | Groundwater Monitoring at the Y-12 Complex | 6-30 |
| 6.10.1 | Hydrogeologic Setting..... | 6-34 |
| 6.10.2 | Well Installation and Plugging and Abandonment Activities..... | 6-34 |
| 6.10.3 | CY 2006 Groundwater Monitoring Program..... | 6-36 |
| 6.10.4 | Y-12 Groundwater Quality..... | 6-36 |
| 6.11 | Modernization Activities at the Y-12 National Security Complex..... | 6-54 |
| 6.11.1 | Infrastructure Reduction..... | 6-54 |
| 6.11.2 | New Construction..... | 6-54 |
| 6.11.3 | Operating Lease Project | 6-55 |
| 7. | ORR Environmental Monitoring Program | 7-1 |
| 7.1 | Meteorological Monitoring | 7-1 |
| 7.1.1 | Description..... | 7-1 |
| 7.1.2 | Meteorological Impacts on Modeling Results | 7-2 |
| 7.2 | External Gamma Radiation Monitoring..... | 7-3 |
| 7.2.1 | Data Collection and Analysis | 7-3 |
| 7.2.2 | Results..... | 7-3 |
| 7.3 | Ambient Air Monitoring | 7-3 |
| 7.3.1 | ORR Ambient Air Monitoring | 7-3 |
| 7.3.2 | Results..... | 7-5 |

| | | |
|-------------|--|------|
| 7.4 | Surface Water Monitoring | 7-7 |
| 7.4.1 | ORR Surface Water Monitoring | 7-7 |
| 7.4.2 | Results..... | 7-7 |
| 7.5 | Food | 7-8 |
| 7.5.1 | Hay..... | 7-8 |
| 7.5.2 | Vegetables..... | 7-8 |
| 7.5.3 | Milk..... | 7-11 |
| 7.6 | Fish | 7-11 |
| 7.6.1 | Results..... | 7-11 |
| 7.7 | White-Tailed Deer | 7-14 |
| 7.7.1 | Results..... | 7-15 |
| 7.8 | Fowl..... | 7-15 |
| 7.8.1 | Waterfowl Surveys—Canada Geese..... | 7-15 |
| 7.8.2 | Turkey Monitoring..... | 7-15 |
| 8. | Dose | 8-1 |
| 8.1 | Radiation Dose | 8-1 |
| 8.1.1 | Terminology..... | 8-1 |
| 8.1.2 | Methods of Evaluation..... | 8-2 |
| 8.1.3 | Doses to Aquatic and Terrestrial Biota | 8-14 |
| 8.1.4 | Current-Year Summary..... | 8-16 |
| 8.1.5 | Five-Year Trends | 8-16 |
| 8.1.6 | Potential Contributions from Non-DOE Sources..... | 8-16 |
| 8.2 | Chemical Dose..... | 8-16 |
| 8.2.1 | Drinking Water Consumption..... | 8-16 |
| 8.2.2 | Fish Consumption..... | 8-17 |
| 9. | Quality Assurance..... | 9-1 |
| 9.1 | Introduction | 9-1 |
| 9.2 | Field Sampling Quality Assurance | 9-1 |
| 9.3 | Analytical Quality Assurance..... | 9-1 |
| 9.3.1 | Internal Quality Assurance/Quality Control | 9-1 |
| 9.3.2 | External Quality Assurance/ Quality Control | 9-2 |
| 9.3.3 | Y-12 Analytical Chemistry Organization Scores on FY 2006 Performance Evaluation Programs..... | 9-2 |
| 9.3.4 | Quality Assessment Programs for Subcontracted Laboratories..... | 9-3 |
| 9.4 | Data Management, Verification, and Validation | 9-3 |
| Appendix A. | Errata | A-1 |
| Appendix B. | Climate Overview for the Oak Ridge Area | B-1 |
| Appendix C. | Glossary..... | C-1 |
| Appendix D. | Reference Standards and Data for Water..... | D-1 |
| Appendix E. | National Pollutant Discharge Elimination System Noncompliance Summaries for 2006 | E-1 |
| Appendix F. | Permits..... | F-1 |
| Appendix G. | Radiation | G-1 |

| | |
|-----------------------------|-----|
| Appendix H. Chemicals | H-1 |
| References..... | R-1 |

Figures

| Figure | | Page |
|---------------|--|-------------|
| 1.1 | Location of the city of Oak Ridge..... | 1-2 |
| 1.2 | The Oak Ridge Reservation | 1-3 |
| 1.3 | Population by county in the 10-county region surrounding the Oak Ridge Reservation.... | 1-3 |
| 1.4 | Locations and populations of towns nearest to the Oak Ridge Reservation | 1-3 |
| 1.5 | Vertical relationships of flow zones of the ORR: estimated thicknesses, water flux, and water types..... | 1-6 |
| 1.6 | The Y-12 National Security Complex..... | 1-6 |
| 1.7 | The East Tennessee Technology Park..... | 1-8 |
| 1.8 | The Oak Ridge National Laboratory | 1-9 |
| 1.9 | The Oak Ridge National Environmental Research Park covers about 8,094 hectares (about 20,000 acres) on the reservation..... | 1-10 |
| 2.1 | Five-year summary of NPDES noncompliances | 2-20 |
| 2.2 | The relationship between environmental management systems and the Integrated Safety Management System..... | 2-32 |
| 4.1 | Locations of airborne radionuclide point sources at the ETTP | 4-2 |
| 4.2 | Total curies of uranium discharged from the ETTP to the atmosphere, 2002–2006..... | 4-4 |
| 4.3 | Total kilograms of uranium discharged from the ETTP to the atmosphere, 2002–2006..... | 4-5 |
| 4.4 | ETTP National Pollutant Discharge Elimination System major representative storm water outfalls..... | 4-7 |
| 4.5 | Five-year trend of uranium releases to surface waters from the K-1407-J Central Neutralization Facility | 4-8 |
| 4.6 | Percentage of DOE derived concentration guides for uranium isotopes from the K-1407-J Central Neutralization Facility | 4-8 |
| 4.7 | Total taxonomic richness (a) and richness of pollution-sensitive taxa (b) in Mitchell Branch | 4-14 |

Oak Ridge Reservation

| | | |
|------|---|------|
| 4.8 | Density of pollution-intolerant stoneflies and (a) pollution-tolerant mayflies (b) in Mitchell Branch | 4-15 |
| 4.9 | Locations of ambient air monitoring stations at the ETPP..... | 4-16 |
| 4.10 | Ambient air monitoring 5-year trend results for lead at the ETPP..... | 4-18 |
| 4.11 | Ambient air monitoring 5-year trend results for uranium at the ETPP | 4-19 |
| 4.12 | Monitoring locations for surface water at the ETPP | 4-21 |
| 4.13 | Percentage of DOE derived concentration guides for ETPP surface water monitoring locations | 4-22 |
| 5.1 | Locations of major stacks (radiological emission points) at ORNL..... | 5-2 |
| 5.2 | Total discharges of ³ H from ORNL to the atmosphere, 2002–2006 | 5-8 |
| 5.3 | Total discharges of ¹³¹ I from ORNL to the atmosphere, 2002–2006 | 5-8 |
| 5.4 | Total discharges of ⁴¹ Ar and ¹³⁸ Cs from ORNL to the atmosphere, 2002–2006..... | 5-8 |
| 5.5 | Locations of ambient air monitoring stations at ORNL | 5-10 |
| 5.6 | ORNL surface water, National Pollutant Discharge Elimination System, and reference sampling locations | 5-12 |
| 5.7 | Radionuclides at ORNL sampling sites having average concentrations greater than 4% of the relevant derived concentration guides in 2006 | 5-16 |
| 5.8 | Cobalt-60 discharges at White Oak Dam, 2002–2006 | 5-17 |
| 5.9 | Cesium-137 discharges at White Oak Dam, 2002–2006..... | 5-17 |
| 5.10 | Gross alpha discharges at White Oak Dam, 2002–2006 | 5-17 |
| 5.11 | Gross beta discharges at White Oak Dam, 2002–2006 | 5-17 |
| 5.12 | Total radioactive strontium discharges at White Oak Dam, 2002–2006..... | 5-17 |
| 5.13 | Tritium discharges at White Oak Dam, 2002–2006..... | 5-17 |
| 5.14 | Total aqueous mercury concentrations at sites in White Oak Creek downstream from ORNL, 1998–2006..... | 5-22 |
| 5.15 | Mean mercury concentrations (µg/g, ± SE) in fish fillets collected from the WOC watershed, 1998–2006 | 5-23 |
| 5.16 | Mean total PCB concentrations (µg/g, ± SE) in largemouth bass and sunfish fillets collected from the WOC watershed, 1998–2006..... | 5-25 |

| | | |
|------|--|------|
| 5.17 | Taxonomic richness (top) and richness of the pollution-intolerant taxa (bottom) of the benthic macroinvertebrate community in First Creek, April sampling periods, 1987–2006 | 5-26 |
| 5.18 | Taxonomic richness (top) and richness of the pollution-intolerant taxa (bottom) of the benthic macroinvertebrate community in Fifth Creek, April sampling periods, 1987–2006 | 5-27 |
| 5.19 | Taxonomic richness (top) and richness of the pollution-intolerant taxa (bottom) of the benthic macroinvertebrate communities in White Oak Creek, April sampling periods, 1987–2006. | 5-28 |
| 5.20 | Density (fish/m ²) estimates for fish in spring and fall samples from upper White Oak Creek and from a reference site on Mill Branch (MBK 16), 1985–2006 | 5-30 |
| 5.21 | Density (fish/m ²) estimates for fish in spring and fall samples from First Creek, 1985–2006 | 5-30 |
| 5.22 | Density (fish/m ²) estimates for fish in spring and fall samples from Fifth Creek; 1985–2006 | 5-31 |
| 5.23 | Density (fish/m ²) estimates for fish in spring and fall samples from Melton Branch, 1985–2006..... | 5-31 |
| 5.24 | ORNL surface water sampling locations..... | 5-32 |
| 5.25 | ORNL sediment sampling locations..... | 5-34 |
| 5.26 | UT-Battelle exit pathway groundwater monitoring locations at ORNL, 2006 | 5-36 |
| 5.27 | Groundwater monitoring locations at HFIR, 2006..... | 5-38 |
| 5.28 | Groundwater monitoring locations at SNS, 2006..... | 5-39 |
| 6.1 | Total curies of uranium discharged from the Y-12 Complex to the atmosphere, 2002–2006 | 6-2 |
| 6.2 | Total kilograms of uranium discharged from the Y-12 Complex to the atmosphere, 2002–2006 | 6-2 |
| 6.3 | Locations of ambient air monitoring stations at the Y-12 Complex | 6-5 |
| 6.4 | Temporal trends in mercury vapor concentration for the boundary mercury monitoring stations at the Y-12 National Security Complex, July 1986 to January 2007 (Graphs A and B) and January 1993 to January 2007 for AAS8 (Graph C)..... | 6-7 |
| 6.5 | Surface water and sanitary sewer radiological sampling locations at the Y-12 Complex | 6-11 |
| 6.6 | Five-year trend of Y-12 Complex release of uranium to surface water | 6-12 |

Oak Ridge Reservation

| | | |
|------|--|------|
| 6.7 | Major Y-12 Complex National Pollutant Discharge Elimination System (NPDES) outfalls..... | 6-13 |
| 6.8 | Locations of biological monitoring sites on East Fork Poplar Creek in relation to the Oak Ridge Y-12 National Security Complex | 6-24 |
| 6.9 | Locations of biological monitoring reference sites in relation to the Oak Ridge Y-12 National Security Complex | 6-25 |
| 6.10 | Semiannual average mercury concentration in muscle fillets of fish and water in East Fork Poplar Creek at Station 17 through spring 2006..... | 6-26 |
| 6.11 | Mean concentrations of PCBs in redbreast sunfish and rock bass muscle fillets in East Fork Poplar Creek at Station 17 through spring 2006..... | 6-26 |
| 6.12 | Total taxonomic richness (mean number of taxa/sample) and total taxonomic richness of the Ephemeroptera, Plecoptera, and Trichoptera (EPT) (mean number of EPT taxa/sample) of the benthic macroinvertebrate communities in East Fork Poplar Creek and two reference sites, one on Brushy Fork and one on Hinds Creek (BFK 7.6 and HCK 20.6) | 6-27 |
| 6.13 | Comparison of mean sensitive species richness (number of species) collected each year from 1985 through 2006 from four sites in East Fork Poplar Creek and a reference site (Brushy Fork) | 6-28 |
| 6.14 | Locations of Y-12 Complex surface water surveillance sampling stations..... | 6-29 |
| 6.15 | Surface Water Hydrological Information Support System (SWHISS) monitoring locations..... | 6-31 |
| 6.16 | Known or potential contaminant sources for which groundwater monitoring was performed on the Y-12 Complex during CY 2006 | 6-33 |
| 6.17 | Hydrogeologic regimes at the Y-12 Complex..... | 6-35 |
| 6.18 | Locations of ORR perimeter/exit pathway well, spring, and surface water monitoring stations in the Environmental Monitoring Plan for the Oak Ridge Reservation..... | 6-38 |
| 6.19 | Nitrate (as nitrogen) observed in groundwater at the Y-12 Complex, 2006 | 6-41 |
| 6.20 | Summed volatile organic compounds observed in groundwater at the Y-12 Complex, 2006 | 6-42 |
| 6.21 | Gross alpha radioactivity observed in groundwater at the Y-12 Complex, 2006..... | 6-44 |
| 6.22 | Gross beta radioactivity observed in groundwater at the Y-12 Complex, 2006..... | 6-45 |
| 6.23 | Construction on the Jack Case Center | 6-55 |

| | | |
|-----|---|------|
| 7.1 | The ORR meteorological monitoring network..... | 7-2 |
| 7.2 | External gamma radiation monitoring locations on the ORR | 7-4 |
| 7.3 | Locations of ORR perimeter air monitoring stations | 7-5 |
| 7.4 | Locations of ORR surface water surveillance sampling stations | 7-9 |
| 7.5 | Hay sampling locations on the ORR, indicated by numbered areas | 7-10 |
| 7.6 | Milk sampling locations in the vicinity of the ORR..... | 7-13 |
| 7.7 | Fish sampling locations for the ORR | 7-14 |
| B.1 | Wind rose for ORNL Meteorological Tower C for data taken at 10 m above ground level, 2006 | B-4 |
| B.2 | Wind rose for ORNL Meteorological Tower C for data taken at 30 m above ground level, 2006 | B-5 |
| B.3 | Wind rose for ORNL Meteorological Tower C for data taken at 100 m above ground level, 2006 | B-6 |
| G.1 | The hydrogen atom and its isotopes | G-3 |
| G.2 | Examples of radiation pathways..... | G-6 |

Tables

| Table | | Page |
|--------------|--|-------------|
| 2.1 | Closed RCRA units for ORR, CY 2006..... | 2-2 |
| 2.2 | RCRA operating permits, 2006..... | 2-3 |
| 2.3 | Summary of 2006 annual update of ORR solid waste management units..... | 2-5 |
| 2.4 | ORR underground storage tank (UST) status, 2006..... | 2-6 |
| 2.5 | RCRA corrective action processes and CERCLA response actions..... | 2-8 |
| 2.6 | RCRA postclosure status for former treatment, storage, and disposal units on the ORR..... | 2-9 |
| 2.7 | National Environmental Policy Act (NEPA) activities during 2006..... | 2-10 |
| 2.8 | Animal species of concern reported from the Oak Ridge Reservation..... | 2-15 |
| 2.9 | Vascular plant species listed by state or federal agencies, 2006..... | 2-17 |
| 2.10 | Descriptions of the main parts of The Emergency Planning and Community Right-to-Know Act (EPCRA)..... | 2-29 |
| 2.11 | EPCRA Section 313 toxic chemical release and off-site transfer summary for the ORR, 2006..... | 2-30 |
| 2.12 | ORR pollution prevention project implementation results summary, 2006..... | 2-35 |
| 2.13 | ORR affirmative procurement and waste reduction progress summary, 2006..... | 2-36 |
| 2.14 | Summary of environmental audits and assessments, 2006..... | 2-41 |
| 2.15 | Summary of permits as of December 2006..... | 2-42 |
| 4.1 | ETTP radionuclide air emission totals, 2006 (Ci)..... | 4-4 |
| 4.2 | Allowable emissions of criteria pollutants from the ETTP, 2002–2006..... | 4-5 |
| 4.3 | Actual emissions of criteria pollutants from permitted ETTP sources, 2006..... | 4-6 |
| 4.4 | Actual vs allowable air emissions from the Toxic Substances Control Act Incinerator at the ETTP, 2006..... | 4-7 |
| 4.5 | Radionuclides released to off-site surface waters from the ETTP, 2006..... | 4-8 |

Oak Ridge Reservation

| | | |
|------|--|------|
| 4.6 | National Pollutant Discharge Elimination System compliance at the ETTP, 2006 | 4-9 |
| 4.7 | EWQP storm water monitoring—radiological monitoring results that exceeded screening criteria, 2006 | 4-10 |
| 4.8 | EWQP storm water monitoring—nonradiological monitoring results that exceeded screening criteria, 2006 | 4-10 |
| 4.9 | NPDES permit renewal sampling, 2006—Maximum exceedances of radiological screening criteria for storm water outfalls, (pCi/L)..... | 4-11 |
| 4.10 | Radionuclides released to off-site surface waters from the ETTP storm water system, 2006..... | 4-11 |
| 4.11 | Maximum exceedances of nonradiological screening criteria for each storm water outfall, 2006 (µg/L)..... | 4-12 |
| 4.12 | Mitchell Branch and associated storm water outfall toxicity test results, April 2006..... | 4-12 |
| 4.13 | PCB concentrations in biota at the ETTP, 2006..... | 4-13 |
| 4.14 | Summary of types and frequencies of samples collected at ETTP perimeter ambient air monitoring stations, 2006..... | 4-17 |
| 4.15 | Lead concentrations in ambient air at the ETTP, 2006 | 4-18 |
| 4.16 | Hazardous air pollutant concentrations in ambient air at the ETTP, 2006..... | 4-19 |
| 4.17 | Total uranium in ambient air by inductively coupled plasma mass spectrometry analysis at the ETTP, 2006..... | 4-19 |
| 4.18 | Radionuclides in ambient air by radiochemistry at the ETTP, 2006..... | 4-20 |
| 5.1 | Radiological airborne emissions from all sources at ORNL, 2006 (Ci)..... | 5-4 |
| 5.2 | Actual vs allowable air emissions from ORNL steam production, 2006 | 5-9 |
| 5.3 | Radionuclide concentrations measured at ORNL perimeter air monitoring stations, 2006 (pCi/mL)..... | 5-11 |
| 5.4 | National Pollutant Discharge Elimination System (NPDES) compliance at ORNL, 2006..... | 5-13 |
| 5.5 | ORNL National Pollutant Discharge Elimination System Radiological Monitoring Plan..... | 5-15 |
| 5.6 | Toxicity test results of ORNL wastewaters, 2006..... | 5-21 |
| 5.7 | Total mercury and PCB (Aroclor 1254 + 1260) concentrations in fish (mean ± SE; range in parentheses) from sites in White Oak Creek and a reference stream, Hinds Creek, April 2006 | 5-23 |

| | | |
|------|--|------|
| 5.8 | Benthic macroinvertebrate results for lower Melton Branch (MEK 0.6) in 2006..... | 5-29 |
| 5.9 | ORNL surface water sampling locations, frequencies, and parameters, 2006 | 5-33 |
| 5.10 | Mean concentrations for radiological parameters detected at SNS (all flow conditions) – April 2004 through March 2006 | 5-44 |
| 5.11 | Mean radionuclide concentrations in groundwater sampled from background wells at ORNL..... | 5-44 |
| 5.12 | Radiological constituents detected in groundwater at SNS— operational monitoring, April through December 2006 | 5-45 |
| 5.13 | National Pollutant Discharge Elimination System (NPDES) compliance at SNS, 2006..... | 5-46 |
| 6.1 | Actual vs allowable air emissions from the Oak Ridge Y-12 Steam Plant, 2006 | 6-3 |
| 6.2 | Summary results for the Oak Ridge Y-12 Complex’s mercury in ambient air monitoring program, 2006..... | 6-6 |
| 6.3 | Summary results for HF measured as fluorides (7-day average) in the Scarboro Community, 2006 | 6-8 |
| 6.4 | Radiological parameters monitored at the Y-12 Complex in 2006..... | 6-9 |
| 6.5 | Summary of Y-12 Complex radiological monitoring plan sample requirements..... | 6-12 |
| 6.6 | Release of uranium from the Y-12 Complex to the off-site environment as a liquid effluent, 2002–2006 | 6-12 |
| 6.7 | NPDES compliance monitoring requirements and record for the Y-12 Complex, January through April 2006..... | 6-15 |
| 6.8 | NPDES compliance monitoring requirements and record for the Y-12 Complex, May through December 2006..... | 6-17 |
| 6.9 | Y-12 Complex Discharge Point SS6, Sanitary Sewer Station 6 January through December 2006..... | 6-20 |
| 6.10 | Summary of storm water data above cut-off concentration at the Y-12 Complex (mg/L)..... | 6-20 |
| 6.11 | Y-12 Complex Biomonitoring Program summary information for wastewater treatment systems and storm sewer effluents for 2006..... | 6-22 |
| 6.12 | Y-12 Complex Biomonitoring Program summary information for outfall 201 for 2006 | 6-22 |
| 6.13 | Y-12 Complex Biomonitoring Program summary information for outfalls 200, 135, and 125 for 2006 | 6-23 |

Oak Ridge Reservation

| | | |
|------|---|------|
| 6.14 | Surface water surveillance measurements exceeding Tennessee water quality criteria at the Y-12 Complex, 2006 | 6-32 |
| 6.15 | Results of Y-12 Complex sediment monitoring | 6-32 |
| 6.16 | Summary of CY 2006 groundwater monitoring at the Y-12 Complex | 6-37 |
| 6.17 | History of waste management units and underground storage tanks included in CY 2006 groundwater monitoring activities, Upper East Fork Poplar Creek Hydrogeologic Regime..... | 6-39 |
| 6.18 | History of waste management units included in CY 2006 groundwater monitoring activities, Bear Creek Hydrogeologic Regime | 6-48 |
| 6.19 | Nitrate and uranium concentrations in Bear Creek | 6-49 |
| 6.20 | History of waste management units included in CY 2006 groundwater monitoring activities, Chestnut Ridge Hydrogeologic Regime..... | 6-52 |
| 7.1 | ORR meteorological towers | 7-1 |
| 7.2 | External gamma averages for the ORR, 2006 | 7-4 |
| 7.3 | Average radionuclide concentrations at ORR perimeter air monitoring stations, 2006 (pCi/mL)..... | 7-6 |
| 7.4 | Uranium concentrations in ambient air on the ORR | 7-8 |
| 7.5 | ORR surface water sampling locations, frequencies, and parameters, 2006..... | 7-9 |
| 7.6 | Concentrations of radionuclides detected in hay, 2006 (pCi/kg) | 7-10 |
| 7.7 | Concentrations of radionuclides detected in vegetables, 2006 (pCi/kg) | 7-12 |
| 7.8. | Concentration of radionuclides detected in raw milk, 2006..... | 7-13 |
| 8.1 | Emission point parameters and receptor locations used in the dose calculations..... | 8-3 |
| 8.2 | Summary of ORR meteorological towers, sampling heights, and sources..... | 8-4 |
| 8.3 | Calculated radiation doses to maximally exposed off-site individuals from airborne releases during 2006..... | 8-5 |
| 8.4 | Calculated collective effective dose equivalents from airborne releases during 2006..... | 8-5 |
| 8.5 | Hypothetical effective dose equivalents from living at ORR and ETTP ambient-air monitoring stations during 2006 | 8-6 |
| 8.6 | Summary of annual maximum individual (mrem) and collective (person-rem) effective dose equivalents (EDEs) from waterborne radionuclides | 8-7 |

| | | |
|------|--|------|
| 8.7 | Summary of maximum potential radiation dose equivalents to an adult during 2006 and locations of the maximum exposures | 8-17 |
| 8.8 | Trends in total effective dose equivalent (mrem) for selected pathways | 8-18 |
| 8.9 | Chemical hazard quotients and estimated risks for drinking water, 2006..... | 8-18 |
| 8.10 | Chemical hazard quotients and estimated risks for carcinogens in fish, 2006..... | 8-19 |
| B.1 | Climate normals (1976–2005) and extremes (1948–2006) for Oak Ridge, Tennessee (Town Site) with 2006 comparisons..... | B-8 |
| B.2 | Hourly freeze data for Oak Ridge, Tennessee, 1985–2006..... | B-10 |
| B.3 | Hourly mixing height statistics for the Oak Ridge Reservation during 2006 (eastern standard time) | B-11 |
| B.4 | Stability distribution by hour of the day measured at ORNL Tower C, 2006 (local time) | B-12 |
| D.1 | Reference standards for radionuclides in water..... | D-3 |
| D.2 | Reference standards for chemicals and metals in water | D-4 |
| F.1 | Y-12 Complex environmental permits, 2006 | F-3 |
| F.2 | Oak Ridge National Laboratory air permits, 2006 | F-5 |
| F.3 | East Tennessee Technology Park environmental permits, 2006..... | F-6 |
| F.4 | Periods of excess emissions and out-of-service conditions for Y-12 Steam Plant east and west opacity monitors, 2006 | F-7 |
| G.1 | Radionuclide half-lives..... | G-4 |
| G.2 | Comparison and description of various dose levels | G-8 |
| G.3 | Summary of annual maximum individual effective dose equivalents from waterborne radionuclides (mrem) | G-13 |
| H.1 | Chemical reference doses and slope factors used in drinking water and fish intake analysis | H-5 |

Acronyms and Abbreviations

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

Oak Ridge Reservation

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

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

Oak Ridge Reservation

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

Units of Measure and Conversion Factors

Units of measure and their abbreviations

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

Quantitative prefixes

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

Unit conversions

| Unit | Conversion | Equivalent | Unit | Conversion | Equivalent |
|----------------------|---------------------------|---------------------|---------------------|--------------------------|---------------------|
| Length | | | | | |
| in. | × 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 | × 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 | × 1000 | 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 ASER technical coordinators and project team wish to thank those who participated in the publication of the *Annual Site Environmental Report*. Although we cannot name everyone involved in the environmental monitoring program, we would like to also thank and acknowledge those conducting sampling and analytical support.

ENVIRONMENTAL MANAGEMENT

Betsy Brucken
Kevin Crow
Leslie Cusick
Steve Douglas
Glen Galen
Stephen Goodpasture
Mona Johnson
Charles Justice
Steve Kucera
David Mabry
H. B. McElhoe
Susan Michaud
Jeff Murphy
Tony Poole
Roxianne Sherles
Lisa Shipe
Steven Wood

ORNL

Kevin Birdwell
Terry Bonine
Rac Cox (ORAU)
Nancy Dailey
Karla Gaither
Neil Giffen
Wes Goddard
Mark Greeley
Scott Gregory
James Hall
Frank Kornegay
Regis Loffman
Susan Michaud
Lori Muhs
Eric Mulkey
Frank O'Donnell
Wayne Parker
Pat Parr
Mark Peterson
Kyle Rutherford
Pat Scofield
Kathy Settles
David Skipper
John Smith
Linda Smith
Steve Trotter
Martin Tull
Charlie Valentine
Joe Wolfe

Y-12 COMPLEX

Gary Beck
Rebekah Bell
Don Bohrman
Mark Burriss
Terry Cothron
L. L. Cunningham
Jennifer Dixon
Stan Duke
Jim Eaton
Jan Gilbert
Kim Hanzelka
Russ Harden
Gail Harp
Clarence Hill
Robert Johnson
Steve Jones
Ivy Lalonde
Cathy McCoy
Bobby Oliver
Larry Petrowski
Beth Schultz
Gary Seeber
Mark Shedden
Brad Skaggs
Johnny Skinner
Lenny Vaughn
Larissa Welch
Mick Wiest

