TENNESSEE

DEPARTMENT

OF

ENVIRONMENT AND CONSERVATION

DIVISION OF REMEDIATION

OAK RIDGE OFFICE

ENVIRONMENTAL MONITORING REPORT

2015

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List of Common Acronyms and Abbreviations

ALARA	As Low As Reasonably Achievable
ASER	Annual Site Environmental Report (written by DOE)
ASTM	American Society for Testing and Materials
AWQC	Ambient Water Quality Criteria
BCID	Bat Call Identification
BCK	Bear Creek Kilometer (station location)
BFK	Brushy Fork Creek Kilometer (station location)
BJC	Bechtel Jacobs Company (past DOE contractor)
BMAP	Biological Monitoring and Abatement Program
BNFL	British Nuclear Fuels Limited
BOD	Biological Oxygen Demand
BORCE	Black Oak Ridge Conservation Easement
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CBSQGs	Consensus-based Sediment Quality Guidelines
CCK	Clear Creek Kilometer (station location)
CCR	Consumer Confidence Report
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cm	centimeter
CNS	Consolidated Nuclear Security Y-12 Prime Contractor (current)
COC	Contaminants of Concern
COD	Chemical Oxygen Demand
CPM	counts per minute (cpm)
CRBR	Clinch River Breeder Reactor
CRM	Clinch River Mile
CROET	Community Reuse Organization of East Tennessee
CWA	Clean Water Act
CYRTF	Coal Yard Runoff Treatment Facility (at ORNL)
D&D	Decontamination and Decommissioning
DCG	Derived Concentration Guide
DIL	Derived Intervention Levels
DNA	Division of Natural Areas
DO	dissolved oxygen
DOE	Department of Energy
DOE-O	Department of Energy Oversight Office (TDEC)
DoR	Division of Remediation
DWS	Division of Water Supply (TDEC)
E. coli	*Escherichia coli*
EAC	Environmental Assistance Center (TDEC)
ED1, ED2, ED3	Economic Development Parcel 1, Parcel 2, and Parcel 3
EFPCK	East Fork Poplar Creek Kilometer (station location)
EFPC	East Fork Poplar Creek
EMP	Environmental Monitoring Plan

EMR	Environmental Monitoring Report
EMWMF	Environmental Management Waste Management Facility
EPA	Environmental Protection Agency
EPT	*Ephemeroptera*, *Plecoptera*, *Trichoptera* (mayflies, stoneflies, caddisflies)
ESD	Environmental Sciences Division of ORNL
ETTP	East Tennessee Technology Park
FDA	U. S. Food and Drug Administration
FFA	Federal Facilities Agreement
FWS	U. S. Fish and Wildlife Service
FRMAC	Federal Radiation Monitoring and Assessment Center
g	gram
GHK	Gum Hollow Branch Kilometer (station location)
GIS	Geographic Information Systems
GPS	Global Positioning System
GW	Ground Water
GWQC	Ground Water Quality Criteria
HCK	Hinds Creek Kilometer (station location)
HDPE	high-density polyethylene
HFIR	High Flux Isotope Reactor
HRE	Homogeneous Reactor Experiment
IBI	Index of Biotic Integrity
IC	In Compliance
IWQP	Integrated Water Quality Program
K-####	Facility at K-25 (ETTP)
K-25	Oak Ridge Gaseous Diffusion Plant (now called ETTP)
KDOW	Kentucky Department of Water
KFO	Knoxville Field Office
Kg	kilogram
L	liter
LLW	Low Level Waste
MBK	Mill Branch Kilometer (station location)
MCL	Maximum Contaminant Level (for drinking water)
MCLG	Maximum Contaminant Level Goal (for drinking water)
MDC	Minimum Detectable Concentration
MEK	Melton Branch Kilometer (station location)
µg	microgram
m	meter
m^3	cubic meter
mg	milligram
MIK	Mitchell Branch Kilometer (station location)
mv	millivolt
ml	milliliter
MSRE	Molten Salt Reactor Experiment
µmho	micro mho (mho=1/ohm)
MOU	Memorandum of Understanding
µR	microroentgen

mrem	1/1000 of a rem – millirem
N, S, E, W	North, South, East, West
NAAQS	National Ambient Air Quality Standards
NAREL	National Air and Radiation Environmental Laboratory
NAWQA	National Water Quality Assessment Program
NCBI	North Carolina Biotic Index
NEPA	National Environmental Policy Act
NERP	National Environmental Research Park
NESHAPs	National Emissions Standards for HAPs
ng	nanogram
NNSS	Nevada National Security Site (formerly the Nevada Test Site, NTS)
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NPDWR	National Primary Drinking Water Regulations
NRDA	Natural Resource Damage Assessment
NRWTF	Non-Radiological Waste Treatment Facility (at ORNL)
NRWQC	National Water Quality Criteria
NSDWR	National Secondary Drinking Water Regulation Standards
NT	Northern Tributary of Bear Creek in Bear Creek Valley
NTS	Nevada Test Site (now the Nevada National Security Site, NNSS)
NTU	Nephelometric Turbidity Unit
OC	*oligochaetes* and *chironomids*
OMI	Operations Management International (runs utilities at ETTP under CROET)
ORAU	Oak Ridge Associated Universities
OREIS	Oak Ridge Environmental Information System
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
ORP	Oxidation Reduction Potential
ORR	Oak Ridge Reservation
ORRCA	Oak Ridge Reservation Communities Alliance
OSHA	Occupational Safety and Health Association
OSL	Optically Stimulated Luminescent (Dosimeter)
OU	Operable Unit
PAH	Polycyclic Aromatic Hydrocarbons
PCCR	phased construction completion report
PEC	Probable Effect Concentration
PEMS	Project Environmental Measurement System
PER	Potential for Environmental Release
PCB	Polychlorinated Biphenyl
pCi	$1x10^{-12}$ Curie (Picocurie)
PCM	Poplar Creek Mile (station location)
pH	Proportion of Hydrogen Ions (acid vs. base)
PWSID	Potable Water Supply Identification "number"
PWTC	Process Waste Treatment Complex
ppb	parts per billion
ppm	parts per million

ppt	parts per trillion
PPE	Personal Protective Equipment
PRG	Preliminary Remediation Goals
QA	Quality Assurance
QC	Quality Control
R	Roentgen
RBP	Rapid Bioassessment Program
RCRA	Resource Conservation and Recovery Act
REM (rem)	Roentgen Equivalent Man (unit)
RER	Remediation Effectiveness Report
RMD	Resource Management Division
ROD	Record of Decision
RPM	Radiation Portal Monitor
RSE	Remedial Site Evaluation
SARA	Superfund Amendments and Reauthorization Act
SLF	Sanitary Landfill
μS	microSiemens
SMCL	Secondary MCLs (non-regulatory)
SNS	Spallation Neutron Source
SOP	Standard Operating Procedure
SS	Surface Spring
STP	Sewage Treatment Plant or Site Treatment Plan
SQKICK	Semi-Quantitative Kick
SW	Surface Water
SWSA	Solid Waste Storage Area
T&E	Threatened and Endangered Species
TDEC	Tennessee Department of Environment and Conservation
TDH	Tennessee Department of Health
TDS	Total Dissolved Solids
TEC	Threshold Effects Concentration
TIE	Toxicity Identification Evaluation
TLD	Thermoluminescent Dosimeter
TOA	Tennessee Oversight Agreement
TRM	Tennessee River Mile
TRU	Transuranic
TSCA	Toxic Substance Control Act
TTHMs	Total Trihalomethanes
TVA	Tennessee Valley Authority
TWQC	Tennessee Water Quality Criteria
TWRA	Tennessee Wildlife Resources Agency
UCOR	URS/CH2M Oak Ridge LLC (Current EM Prime Contractor)
UEFPC	Upper East Fork Poplar Creek
U.S.	United States
UT Arboretum	University of Tennessee Arboretum
UT-Battelle	University of Tennessee-Battelle (ORNL Prime Contractor)
VHF	very high frequency

VOA	Volatile Organic Analytes
VOC	Volatile Organic Compound
WAC	Waste Acceptance Criteria
WAG	Waste Area Grouping
WCK	White Oak Creek Kilometer (station location)
WM	Waste Management
WMA	Oak Ridge Reservation Wildlife Management Area
WNS	white-nose syndrome
WOC	White Oak Creek
WOL	White Oak Lake
WWSY	White Wing Scrap Yard
X-####	Facility at X-10 (ORNL)
X-10	Oak Ridge National Laboratory
Y-####	Facility at Y-12
Y-12	Y-12 Plant Area

1.0 Introduction

The Tennessee Department of Environment and Conservation (TDEC), Division of Remediation, Oak Ridge Office (TDEC), is providing an annual environmental monitoring report for the calendar year 2015 under terms of the Tennessee Oversight Agreement (TOA) between the state of Tennessee and the United States Department of Energy (DOE), Section A.7.2.1. This monitoring report will focus on radiological emissions and releases, mercury monitoring and releases, monitoring of decommissioning and demolishing (D&D) remedial activities, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) landfills, oversight of impacts to regional groundwater, and general site monitoring on the Oak Ridge Reservation (ORR) and its environs.

The media specific sampling programs are coordinated to apply the full effect of TDEC's resources to the above focus areas. The goal is to ensure that DOE's Oak Ridge operations have no adverse impact to public health, safety, or the environment from past or present activities. If there are adverse effects, those effects are delineated and communicated to DOE, the responsible regulatory state agency, the Tennessee Department of Health (TDH), and affected members of the public when appropriate. Results from monitoring and findings of the quality and effectiveness of DOE's environmental programs are reported in the quarterly and annual status reports. Each spring an annual environmental monitoring report is provided that details the technical results of these studies.

1.1 Primary Focus Areas

TDEC has six primary focus areas that are being covered with this Environmental Monitoring Report (EMR). They include radiological environmental releases, mercury monitoring and releases, monitoring decontamination and decommissioning remedial activities, CERCLA landfills, oversight of impacts to regional groundwater, and general site monitoring. Information from individual project reports will be used to make conclusions and recommendations about present and future monitoring.

1.1.1 Radionuclide Environmental Releases

Radionuclide remediation is an environmental priority in the Oak Ridge area. From the 1940s through 1987, various site operations released radionuclides to air and surface water and generated onsite land disposals of radionuclides. Historical radionuclide releases from the Oak Ridge facilities have been summarized and existing data on the estimated annual liquid release from Oak Ridge operations include tritium (H-3) , cobalt-60 (Co-60), strontium-90 (Sr-90), niobium-95 (Nb-95), zirconium-95 (Zr-95), ruthenium-106 (Ru-106), iodine-131 (I-131), cesium-137 (Cs-137), cerium (Ce-144) and transuranics from Oak Ridge National Laboratory (ORNL); thorium-232 (Th-232) and uranium-238 (U-238) from the Y-12 National Security Complex (Y-12); and technetium-99 (Tc-99), neptunium-237 (Np-237) and U-238 from the former K-25 facility at East Tennessee Technology Park (ETTP).

At ORNL, the activities of fuel reprocessing, isotopes production, waste management, radioisotope applications, reactor developments, and multi-program laboratory operations produced waste streams resulting in environmental releases that contain both radionuclides and hazardous chemicals. In addition, low-level radioactive waste generated by other sites has been disposed of at ORNL.

Y-12 continues to produce components for various nuclear weapons systems and a portion of the effort involves converting uranium-235 (U-235) compounds to metal. The associated waste streams have resulted in environmental releases that contain both radionuclides and hazardous chemicals.

Even though the gaseous diffusion activities at ETTP have concluded, past environmental waste streams and current decommissioning activities have resulted in environmental releases that contain both radionuclides and hazardous chemicals.

TDEC's environmental monitoring plan is designed to aid in determining the level and risk of historic and ongoing releases for public health and the environment. The monitoring focused on potential pathways of air, surface water, groundwater, sediment, soil, and ecological effects.

1.1.2 Mercury Monitoring and Releases

Mercury remediation is the highest cleanup priority in the Oak Ridge area. The largest quantity of mercury released in the environment was from Y-12 operations during the 1950s and early 1960s. East Fork Poplar Creek (EFPC) is contaminated with average aqueous mercury concentrations exceeding those in reference streams by several hundred-fold. Remedial actions over the past 20 years have decreased aqueous mercury concentrations in EFPC by 85% [from >1600 nanograms per liter (ng/L) to <400 ng/L]. The water quality criterion for mercury in recreational waters for organisms only is 51 ng/L [TDEC Rule 0400-40-03-.03 (4)]. Fish fillet concentrations, however, have not responded to this decrease in aqueous mercury and remain above the Environmental Protection Agency (EPA) National Recommended Water Quality Criteria (NRWQC) of 0.3 milligrams per kilogram (mg/kg). To address this release, DOE's mercury remediation technology development scope in the near term includes three main areas:

1. ORNL field and laboratory studies are investigating the use of chemical, physical, and ecological manipulations and management actions in the watershed to decrease mercury concentration and bioaccumulation.
2. DOE is conducting preliminary evaluations to determine the feasibility of placing a field research station along Lower East Fork Poplar Creek. The station will serve as a near-stream research facility for mercury research.
3. URS-CH2M Oak Ridge LLC (UCOR) is investigating waste management practices to gain a better understanding of mercury-contaminated debris disposal techniques, strategies to reduce the quantity of debris that requires treatment, and the extent of contamination in mercury-contaminated areas at Y-12.

DOE has proposed a phased, adaptive management approach to address mercury contamination in surface water. A key component of the plan is the proposed construction of a water treatment facility, the Outfall 200 Mercury Treatment Facility, to reduce the amount of mercury currently in the creek and to prepare for potential releases during future cleanup in the West End Mercury Area at Y-12.

The ongoing and future mercury remediation at Y-12 is a large and complex problem from all perspectives: chemical, geological, ecological, physical, regulatory, and monetary. Efforts are being made daily by multiple contractors, regulators, and DOE officials to define, develop, and implement solutions to the issues.

While the greatest impact with mercury is along EFPC, Bear Creek, White Oak Creek (WOC), and the Clinch River have also been impacted with mercury.

Along Bear Creek

Mean mercury concentrations in rockbass in lower Bear Creek (BCK 3.3) increased in 2013 [0.82 micrograms per gram (µg/g) in fall 2012 and 0.97 µg/g in spring 2013] and are above EPA-recommended Ambient Water Quality Criteria (AWQC) [now the National Recommended Water Quality Criteria (NRWQC)], which is 0.3 µg/g mercury in fish. The October 2012 total mercury result was 6.9 ng/L and the June 2013 result was 18.2 ng/L. Methyl mercury data are available for north tributary 3 (NT-3) from surface water samples collected since winter 2010. The methyl mercury concentrations measured in NT-3 are relatively high as a fraction of the total mercury and in an absolute sense when compared to those measured elsewhere on the ORR.

In White Oak Creek

Mercury concentrations at the Bethel Valley watershed integration point (7500 Bridge) continue to meet the NRWQC of 51 ng/L. Mercury concentrations measured at Fifth Creek and WOC-105 locations upstream of the 7500 Bridge also met the NRWQC limit. In October 2009, a pre-filter and ion exchange water treatment system was installed in the basement of Building 4501. Following pre-treatment, the sump water is routed to the Process Water Treatment Complex (PWTC) for final treatment and discharge to WOC. Mercury concentrations measured at the 7500 Bridge and WOC-105 have experienced dramatic decreases since the sump water reroute.

Average mercury concentrations in fish collected from the stream sections of WOC continue to remain below the EPA recommended fish-based mercury NRWQC of 0.3 µg/g in 2013, likely due to the decreases in aqueous mercury concentrations seen as a result of the work accomplished and noted in the Phased Construction Completion Report for the Bethel Valley Mercury Sumps Groundwater Action Completion at the Oak Ridge National Laboratory in 2008 (DOE/OR/01-2472&D1). Fillet concentrations averaged 0.20 µg/g at WOC kilometer 3.9 (WCK 3.9) and 0.23 µg/g at WCK 2.9 in 2013, and were not significantly different from concentrations observed in 2012 at these sampling locations.

While mercury concentrations in fish collected from upper WOC have been decreasing in recent years, mercury concentrations in fish collected in White Oak Lake (WOL) (WCK 1.5) have been generally increasing possibly due to a better environment for methylation and uptake. Concentrations in bass collected at this site were similar to those seen since 2011, averaging 0.58 µg/g in 2013.

Along the Clinch River

Vertical profiles of mercury have been examined in sediment cores collected in off-site areas. The profiles show a strong correlation with the history of mercury releases from Y-12 and, because the largest releases of mercury from Y-12 coincided with the largest releases of Cs-137 from ORNL, the sediment profiles of mercury and Cs-137 correspond closely. Extrapolation of the mercury concentration data in the sediment cores, indicate that between 50 and 300 metric tons of mercury may have accumulated in off-site areas.

1.1.3 Monitoring Decontamination and Decommissioning Remedial Activities

Old, excess, and contaminated facilities on the ORR are being decommissioned and demolished. In 2016, D&D work will continue with the K-27 building at ETTP. Building K-27 is a four level, rectangular building that contains

approximately 1.1 million square feet (ft^2) of floor space and occupies a footprint of approximately 383,000 ft^2. Building K-27 was constructed and began operations in 1945 as a gaseous diffusion process facility. The building supplied enriched uranium for nuclear weapons production as part of the Manhattan Project. The K-27 building is similar in construction to the K-25 building with its structural challenges and contains 540 stages of gaseous diffusion equipment. K-27 has been shut down since 1964. The process of D&D contaminated facilities may potentially cause a release or threat of release of hazardous substances, radiation, pollutants, or contaminants into the environment. As was seen at ETTP and the K-25 building, radionuclides were released in the environment. Dust from the demolition activities was collected on air monitoring filters and the action of dust suppression has shown an environmental release to the groundwater, stormwater and sewer system of ETTP.

Other concerns are facilities that are deteriorating. Alpha buildings at Y-12 contain radionuclides and mercury. Deterioration of facilities could open pathways for release of contaminants at Y-12. The releases could not only affect workers, but the residences of the Woodland and Scarboro communities.

1.1.4 CERCLA Landfills

The low-level radiological and hazardous wastes generated from Oak Ridge's cleanup projects are disposed of in the Environmental Management Waste Management Facility (EMWMF). The EMWMF is comprised of six disposal areas that have a total capacity of 2.2 million cubic yards. Environmental monitoring is performed to demonstrate compliance with Applicable or Relevant and Appropriate Requirements (ARARs) specified in the Record of Decision (ROD) to include seasonal groundwater fluctuations in the uppermost aquifer beneath the site; and determine impacts to groundwater, surface water, stormwater, contact water, leachate, sediment basin discharge, and ambient air.

Because EMWMF is predicted to reach capacity before all estimated ORR cleanup waste has been generated and dispositioned, DOE has determined the need to evaluate disposal alternatives for CERCLA waste. Plans to construct a new low-level radiological and hazardous wastes disposal facility in Bear Creek have been proposed. Siting a permanent landfill for hazardous waste requires a baseline site topographic survey, wetlands delineation, field surveys to identify and map wetlands and threatened and endangered species, hydrogeological and geotechnical investigations, construction and upgrade of groundwater monitoring wells, and baseline groundwater monitoring.

1.1.5 Oversight of Impacts to Regional Groundwater

As a consequence of past mission activity, groundwater beneath several areas of the ORR has become contaminated. Extensive measures have been implemented attempting to isolate remaining contaminant sources from groundwater, but additional efforts will be required to understand and respond to legacy groundwater challenges.

The projects designed for this focus area will use three criteria for communication of the different studies results:

1. Are contaminants detected?
2. Do they exceed health-based criteria (e.g., NPDWR or NSDWR)?
3. Can the contaminants be attributed to DOE activities?

Collection and interpretation of data in fractured rock and karst settings is complicated by changes in conditions that can occur rapidly in response to precipitation-induced recharge and hydraulic head changes. In order to assess potential public health threats and to protect and restore groundwater resources to beneficial use, a better understanding of the groundwater system is required.

1.1.6 General Site Monitoring

In order to fully assess or detect new releases while collecting enough data to define baseline conditions throughout the ORR, general site monitoring is required. General site monitoring is an ongoing need for radionuclides, air, surface water, sediment, biological monitoring, and groundwater sampling.

1.2 Oak Ridge Reservation Background information

1.2.1 Radiation Monitoring

1.2.1.1 Ambient Gamma Radiation Monitoring of the Oak Ridge Reservation Using Environmental Dosimetry

Gamma radiation is emitted by various radionuclides that have been produced, stored, and disposed of on the ORR. Associated radionuclides are evident in ORR facilities and the surrounding soils, sediment, and water. In order to assess the risk posed by these contaminants, TDEC began monitoring ambient gamma radiation levels on and in the vicinity the ORR in 1995. Environmental dosimeters are used to measure the radiation dose attributable to external radiation at over one hundred locations on and in the vicinity of ORR. Each quarter the dosimeters are collected and processed. The data is used to assess radiation levels at the locations. This program, in conjunction with the Real Time Gamma Radiation monitoring program, is intended to provide:

- conservative estimates of the potential dose/risk to members of the public from exposure to radiation attributable to DOE activities/facilities on the ORR
- baseline values which are used to assess the need/effectiveness of remedial actions
- information necessary to establish trends in radioactive emissions
- information relative to the unplanned release of radioactive contaminants on the ORR

1.2.1.2 Real Time Monitoring of Gamma Radiation on the Oak Ridge Reservation

TDEC has deployed gamma radiation exposure rate monitors equipped with microprocessor controlled data loggers on the ORR since 1996. While the environmental dosimeters used in TDEC's ambient radiation monitoring program provide the cumulative dose over the time period monitored, the results cannot account for the specific time, duration, and magnitude of fluctuations in the dose rates. Consequently, when using dosimeters alone, a series of small releases cannot be distinguished from a single large release. The exposure rate monitors measure and record gamma radiation levels at predetermined intervals (e.g., minutes) over extended periods of time, providing an exposure rate profile that can be correlated with activities and/or changing conditions. The instruments have primarily been used to record exposure rates during remedial and waste management activities to supplement the integrated dose rates provided by TDEC's environmental dosimetry program.

1.2.1.3 Surplus Material Verification

Since 2002, TDEC, in cooperation with DOE and its contractors, conducted random radiological surveys of surplus materials that are destined for sale to the public on the ORR. Standard radiological survey protocols and instrumentation are used for these surveys. In addition to performing the surveys, TDEC reviews the procedures used for release of materials under DOE radiological regulations. The overall goal of the program is to ensure that DOE radiation controls are adequately preventing radiological contamination from reaching the public. Pre-auction surveys are performed for every auction where time and adequate staff are available for the survey.

Also reviewed are any occurrence reports that involve surplus materials. Some materials, such as scrap metal, may be sold to the public under annual sales contracts, whereas other materials are staged at various sites around the ORR awaiting public auction or sale. TDEC, as part of its larger radiological monitoring role on the reservation, conducts these surveys to help ensure that no potentially contaminated materials reach the public.

In the event that radiological activity is detected, TDEC will immediately report to the responsible supervisory personnel of the surplus sales program. TDEC will follow their response to the notification, ensuring that appropriate steps (removal of items from sale, resurveys, etc.) are taken to protect the public. TDEC reviews any occurrence reports, procedural changes, and removal of items from sales inventories.

1.2.1.4 Haul Road Survey

TDEC, with the cooperation of DOE and its contractors, continued to perform weekly surveys of the Haul Road and Haul Road extension to Y-12. For safety reasons, the Haul Road monitoring schedule varied due to adverse weather conditions. The Haul Road was constructed for and is dedicated to trucks transporting CERCLA radioactive and hazardous waste from remedial activities on the ORR to EMWMF in Bear Creek Valley for disposal. To account for wastes that may fall or be blown from the trucks in transit, TDEC performed weekly walk over inspections of the road and associated access roads. Anomalous items noted were surveyed, logged, and their description and location submitted to DOE for disposition.

1.2.1.5 Monitoring of Waste at the Environmental Management Waste Management Facility (EMWMF) Using a Radiation Portal Monitor

The EMWMF was constructed for, and is dedicated to, the disposal of low-level radioactive waste (LLW) and hazardous waste generated by remedial activities on the ORR. Operated under the authority of CERCLA, the facility is required to comply with regulations contained in the ROD authorizing the construction of the facility (DOE, 1999). Only low-level radioactive waste as defined in TDEC 0400-02-11.03(21) with concentrations below limits imposed by waste acceptance criteria (WAC) is approved for disposal in EMWMF. DOE is accountable for compliance with the WAC and has delegated responsibility of WAC attainment decisions to its prime contractor, which it supervises. This includes waste characterization and approval for disposal in EMWMF (DOE, 2001). The state and EPA oversee and audit associated activities, including decisions authorizing waste lots for disposal.

To help ensure compliance with the WAC, TDEC placed a radiation portal monitor (RPM) at the check-in station to scan trucks transporting waste into EMWMF for disposal. As the trucks pass through the portal, gamma radiation levels are measured and transmitted to a secure website monitored by TDEC and available to DOE and its authorized contractors for review. When anomalous measurements are observed, DOE is notified and basic information on the nature and source of the waste passing through the portal at the time of the measurements is obtained from EMWMF personnel. If preliminary information indicates the facility's WAC may have been violated, the information is submitted to TDEC for review and disposition.

1.2.2 Air Monitoring

1.2.2.1 Fugitive Air Monitoring

TDEC performs routine monitoring of fugitive air emissions on the ORR. Monitoring in the program focuses on locations where there is a potential for airborne releases of radioactive contaminants from diffuse (non-point) sources. In 2015, monitored activities included the decommissioning and demolition of uranium enrichment facilities at the East Tennessee Technology Park (ETTP); the Central Campus Removal Action at ORNL; footprint reduction activities at Y-12; and the disposal of radioactive waste at EMWMF in Bear Creek Valley. Data from the program are used to:

- identify and characterize unplanned releases
- evaluate DOE controls to prevent releases to the environment
- verify data reported by DOE and its contractors
- assess the potential impact of DOE activities on the public health and environment

Eight high-volume air samplers are used in the program. Seven of the units are mounted on trailers or elevated platforms positioned near the location and/or activities of interest. The eighth sampler is stationed at Fort Loudoun Dam in Loudon County to collect background information.

1.2.3 Biological Monitoring

1.2.3.1 Threatened and Endangered Species Monitoring

Protection and stewardship of threatened, endangered, and rare species (the overall biodiversity) in their natural habitat is a TDEC priority to enable long-term species survival as invaluable natural resources on the ORR. In support of this mission, TDEC provided monitoring and mapping of the biodiversity of the natural resources (flora and fauna) on the ORR. TDEC lends field biology assistance and support to the Resource Management Division (Natural Areas Program, Bureau of Parks and Conservation) and the Tennessee Wildlife Resources Agency (TWRA) at ORR natural areas and TWRA-managed sites [Black Oak Ridge Conservation Easement (BORCE) and the Three Bends Area]. It is important to note there are 56 TDEC-designated natural areas on the ORR (Baranski 2009) that require monitoring and protection from losses of natural resources. During 2015, TDEC monitored flora and fauna on trails and off-trail areas of the BORCE and other areas of the ORR. Several new populations of TDEC-listed and non-listed flora and fauna were identified.

Objectives

- Monitor, conserve and protect the natural resources on the ORR
- Monitor and map populations of state- and federally-listed threatened and endangered plant and animal species (T&E species) on the BORCE and ORR
- Characterize and document presence of sensitive plant populations (non-listed species) on the BORCE and ORR
- Coordinate T&E species field projects with sister Tennessee agencies such as the TDEC Division of Natural Areas (TDEC DNA) and TWRA
- Report ORR T&E field results to the DOE, TDEC DNA, TWRA, and the US Fish and Wildlife Service (USFWS)
- Monitor, protect, and preserve the biodiversity of the ORR
- Continue field inventory of American Chestnuts (*Castanea dentata*)

The project incorporated TDEC's oversight role of environmental surveillance and monitoring. The TOA supports a comprehensive and integrated monitoring and surveillance program for all media (air, surface water, soil sediment, groundwater, drinking water, food crops, fish and wildlife, and biological systems) and the emissions of any materials (hazardous, toxic, chemical, radiological) on the ORR and environs (TDEC 2011). Additionally, several federal and state laws support this effort:

1) The federal Endangered Species Act of 1973, as amended, provides for the inventory, listing, and protection of species in danger of becoming extinct and/or extirpated, and conservation of the habitats on which such species thrive.
2) The National Environmental Policy Act (NEPA) requires that federally-funded projects avoid or mitigate impacts to listed species.
3) The Tennessee Rare Plant Protection and Conservation Act of 1985 (Tennessee Code Annotated Title 11-26, Sects. 201-214), provides for a biodiversity inventory and establishes the state list of endangered, threatened, and special concern taxa.
4) National Resource Damage Assessments (NRDA) as directed by CERCLA, and as amended by SARA (Superfund Amendments and Reauthorization Act of 1986), relates to damages to natural resources on the ORR.

Currently, there are 21 federally-listed vertebrate and invertebrate species known to occur in Anderson and Roane counties, home of the ORR. Of these species, there are 17 mollusks, three fish, and three mammals. In addition, there are an additional 48 vertebrate and invertebrate species listed by the state of Tennessee for Anderson and Roane counties as either threatened (n= 6), endangered (n= 20), or deemed in need of management (n= 22). Tennessee also lists 12 species as "rare, not state listed." Several raptors are listed as "deemed in need of management" such as the bald eagle, barn owl, and the sharp-shinned hawk. The bald eagle (*Haliaeetus leucocephalus*) was officially removed from the federally threatened list on August 8, 2007. Eagles continue to be protected by the 1940 *Bald and Golden Eagle Protection Act* and the 1918 *Migratory Bird Treaty Act*.

Bald eagles are occasionally sighted on the ORR and a breeding pair was nesting adjacent to Poplar Creek in the vicinity of the ETTP during 2011-2012.

TDEC DNA lists eight statewide mammal species as “deemed in need of management”: Allegheny woodrat, cinereus shrew, long-tailed shrew, meadow jumping mouse, smoky shrew, southeastern shrew, southern bog lemming, and the woodland jumping mouse. Three federally-listed bat species have been documented on the ORR with either mist-net captures and/or ultrasonic acoustic surveys.

1.2.3.2 Acoustic Monitoring of Bats

Acoustic monitoring of Tennessee bat species (Order *Chiroptera*) continued on the ORR during 2015. Of particular interest are the three bat species that are federally listed as threatened or endangered. North American bats have the ability to use ultrasonic echolocation as a navigation tool in obstacle avoidance and location of prey items (Simmons and Conway 2003, Britzke 2003). Ultrasonic detectors are widely used for bat censuses (inventory) and have improved conservation efforts by: (1) providing increased knowledge of bat ecology, (2) providing an inventory of bat species presence, and (3) characterizing bat communities (Vaughn et al. 1997, Barataud 1998, Pauza and Pauziene 1998, Avila-Flores and Fenton 2005, Britzke et al. 2011).

Echolocating bats typically emit an ultrasonic (>20 kilohertz) pulse, and, in turn, analyze the returning echo with specialized ear and brain functions to determine the distance to the object as well as what type of object it is (Fenton 1992). Some researchers support the theory that echolocation calls of most bats are species specific (Fenton and Bell 1981, O’Farrell et al. 1999, O’Farrell and Gannon 1999), whereas others suggest caution using these calls to identify bats (Barclay 1999). Tennessee bat species are nocturnal and exhibit nightly and seasonal activity patterns that vary among species and individuals (Hirshfield et al. 1977, Anthony et al. 1981). Unusual daytime bat activity may suggest infection with white nose disease.

During summer, bats emerge each evening and activity commonly peaks immediately after sunset and can continue for several hours (Kunz 1973, Barclay 1982). Typically, another activity peak occurs before sunrise as bats return to their diurnal roosts after foraging (Kunz 1973). During the night, bats roost at intervals, either at their diurnal roosts or at night-roosts nearer their foraging areas (Adam and Hayes 2000, Johnson et al. 2002, Daniel et al. 2008).

1.2.3.3 White-tailed Deer Monitoring

White-tailed deer harvested during the ORR Wildlife Management Area (WMA) annual hunts are checked for radiological contamination. Deer that are found to be contaminated are retained and not released to the hunter for consumption. For 2015, the focus of this investigation was to equip Melton Valley deer with GPS (global positioning system) radio-collars to track and document their movements and determine home ranges. The investigation is attempting to answer the question: *Are potentially contaminated Melton Valley deer leaving the ORR and wandering into adjacent urban areas surrounding the ORR?* If ORR deer migrate offsite and are harvested, they would not be scanned for radiological contamination (the ORR WMA deer hunt radiological scanning of deer bone and tissue). In that scenario, hunters might consume radiologically contaminated venison.

1.2.3.4 Fungi Monitoring in East Fork Poplar Creek

During 2015, TDEC collected mushroom sporocarps and other fungi in the upper East Fork Poplar Creek floodplain contaminated by legacy mercury (Hg) releases from Y-12. Fungi samples were also collected from several control sites (offsite) such as the University of Tennessee Arboretum, Cedar Hill Greenway, and Haw Ridge Park.

Research has determined that fungi absorb and bioaccumulate mercury due to their filamentous mode of growth, and branching and extra cellular release of enzymes and metabolites (e.g. Stegnar et al. 1973, Byrne et al. 1976, Seeger and Nutzel 1976, Minagava et al. 1980, Kalač et al.1991, 1996, Sesli and Tüzen 1999, Alonso et al. 2000, Svododa et al. 2000, Falandysz et al. 2002, 2003, Cocchi et al. 2006; Ita et al. 2006, Svoboda et al. 2006, Melgar et al. 2009, Elekes et al. 2010). In particular, mercury is found with high abundance in the fruiting bodies of some edible mushroom species (Falandysz and Bielawski 2001).

The goal of the project was to determine if mercury is being bioconcentrated by EFPC fungi at elevated concentrations compared to control samples. During 2015, TDEC collected 147 fungi samples from 16 EFPC and control sampling plots (Table 1.2.3.4). Laboratory analyses revealed total mercury concentrations in collected fungi samples from the EFPC sites ranged from 0-79.0 mg/kg (dry weight); the control fungi samples ranged from 0-6.1 mg/kg (dry weight). Section 3.1.3.4 reports these results.

Table 1.2.3.4 Fungi Sampling Locations

SITE NUMBER	SITE DESCRIPTION
EFPC-01	EFPC floodplain south of NOAA office
EFPC-02	EFPC floodplain south of NOAA office
EFPC-03	EFPC floodplain south of old Kroger store
EFPC-04	EFPC floodplain south of Kmart
EFPC-05	EFPC floodplain south of Kmart
EFPC-06	EFPC floodplain east end of Horizon Center
EFPC-07	EFPC floodplain west end of Horizon Center
CONTROL-01	Small creek floodplain along greenway east of Cedar Hill Park
CONTROL-02	Small creek floodplain along greenway south of Cedar Hill Park
CONTROL-03	Creek floodplain along Rainbow Bike Trail (Haw Ridge Park)
CONTROL-04	Creek floodplain along Red Shore Bike Trail (Haw Ridge Park)
CONTROL-05	Creek floodplain along Low Gap Bike Trail (Haw Ridge Park)
CONTROL-06	Creek floodplain along Saddle Bike Trail (Haw Ridge Park)
CONTROL-07	Small creek floodplain near Backwoods Trail (UT Arboretum)
CONTROL-08	Small creek floodplain near Cross Roads Trail (UT Arboretum)
CONTROL-09	Scarboro Creek floodplain south of Arboretum Office

1.2.3.5 Fish Tissue Monitoring

Fish samples were collected during 2015 in ORR and offsite water bodies by biologists with the Oak Ridge National Laboratory's Environmental Sciences Division (ORNL ESD). Previous ORR fish monitoring programs have focused only on tissue analysis (fish fillets), but few studies have investigated tissue and gut content contaminants in individual species. Fish fillets were sampled and evaluated for mercury and polychlorinated biphenyls (PCBs) content by the ORNL ESD team. In cooperation with ORNL ESD, TDEC obtained the associated gut contents of the filleted fish to conduct taxonomic evaluation and mercury analysis of the gut contents and fish livers. Although 36 fish gut contents were analyzed and liver samples extracted, samples were not submitted to the laboratory for mercury analysis in time to meet the publishing deadline. Therefore, the fish liver mercury results will be presented in the 2016 Fish Tissue EMR.

1.2.3.6 Aquatic Vegetation Monitoring

TDEC conducts monitoring of aquatic vegetation on and near the ORR. In this program, TDEC collects vegetation at locations near or in water with the potential for radiological contamination. If surface water bodies have been impacted by radioactivity, aquatic organisms in the immediate vicinity may uptake radionuclides, bioaccumulating radiological contaminants. The vegetation is analyzed for gross alpha, gross beta, and gamma radionuclides and is compared to the radiological analysis of vegetation taken from a background location. The sampling conducted during 2015 suggests limited areas of elevated radionuclide concentrations (Table 3.1.3.6.1) in the vegetation associated with surface water on the ORR.

1.2.3.7 Benthic Macroinvertebrates

Benthic macroinvertebrates include insects, crustaceans, annelids, mollusks, and other organisms with long aquatic life cycles (multiple stages of larval instars) that inhabit the bottom substrates of aquatic systems, and can be easily collected using aquatic sampling nets of ≤500 µm (Hauer and Resh 1996). Occupying the primary consumer trophic level in aquatic ecosystems, macroinvertebrates serve as a link between producers (e.g., algae) and decomposers (e.g., microorganisms) in a food chain, provide a major food source for fisheries, and maintain a diverse spectrum in species composition (Song 2007). Because they are ubiquitous and sedentary, and sensitive in varying degrees to anthropogenic pollutants and other stressors, macroinvertebrate communities can provide considerable information regarding the biological condition of water bodies (Davis and Simons 1995, Karr and Chu 1998). Aquatic macroinvertebrate assemblages provide a surrogate measure of water chemistry and physical stream conditions (Cummins 1974, Vannote et al. 1980, Rosenberg and Resh 1993, Weigel et al. 2002) to indicate the overall health of the aquatic system (Meyer 1997, Karr 1999).

Introduction of nutrients (organic pollution) and heavy metals into a stream, dilution by tributaries, uptake of contaminants by aquatic organisms, and changes in stream structure/function create a pollution gradient from upstream to downstream, which is superimposed on the natural longitudinal gradient of the stream (Vannote et al. 1980, Clements 1994, Clements and Kiffney 1995, Medley and Clements 1998). Anthropogenic impacts inducing eutrophication (organic pollution) in

aquatic systems are known to have dramatic effects on stream invertebrates (Hynes 1978; Wiederholm 1984; Rosenberg and Resh 1993; Suren 2000). Thus, nutrient enrichment can decrease species richness (Paul and Meyer 2001) by elimination of sensitive taxa, most often represented by the insect orders *Ephemeroptera, Plecoptera* and *Trichoptera* (EPT; mayflies, stoneflies, caddisflies, Lenat 1983). A healthy stream will have a larger number (high EPT) of the different flies where streams impacted by pollution will have a lower EPT due to less flies in the environment. Simultaneously, taxa considered resistant to pollution and adapted to unstable habitats, such as midges (*chironomids*) and worms (*oligochaetes*), are enhanced (Hynes 1978).

In streams where metals concentrations are sufficiently high, benthic macroinvertebrates may be entirely absent or their abundance greatly reduced (Clements 1991). Where metals and organic pollutants do not entirely eliminate the community, however, measures of taxa richness (e.g., total number of species present) or abundance of metals-sensitive taxa provide the most sensitive and reliable measure of community level effects (Barbour et al. 1992, Clements and Kiffney 1995, Kiffney 1996, Carlisle and Clements 1999). Many mayfly species are sensitive to metals contamination (Warnick and Bell 1969), and a reduction in the number of mayfly species present is an effective and reliable measure of metals impacts on benthic macroinvertebrate communities (Ramusino et al. 1981, Specht et al. 1984, Van Hassel and Gaulke 1986, Clements 1991, Clements et al. 1992, Kiffney and Clements 1994). For example, *heptageniids* (mayflies) are highly sensitive to heavy metals and are usually absent in metal-polluted streams (Clements 1994, Clements and Kiffney 1995). Macroinvertebrate biomonitoring is a proven method of assessing and documenting stressors and any community and population changes that may occur within the impacted ecosystem.

Semi-quantitative kick net samples (SQKICK) provide a snapshot of the benthic community population at a particular stream location and the respective taxonomic identifications and taxa counts present at this site are used to calculate the Tennessee Macroinvertebrate Index (TMI, TDEC 2011). Several quantifiable attributes of the biotic assemblage ("metrics") that assess macroinvertebrate assemblage structure, composition, and function comprise these indices (Hilsenhoff 1982, 1987, 1988, Fore et al. 1996, Karr and Chu 1998), and metrics are used to measure and calculate an overall score to represent the ecological condition and integrity of stream health. This multimetric index approach is effective for evaluating anthropogenic disturbance and pollution, for standardizing assessment and for communicating the biotic condition of streams (Barbour et al. 1999), because susceptibility to toxic agents varies with the response of individual genera and species (Resh et al. 1988, 1996).

Historically, four aquatic systems originating on the ORR (East Fork Poplar Creek, Bear Creek, Mitchell Branch, and the White Oak Creek/Melton Branch watershed) have been impacted by DOE-related activities. East Fork Poplar Creek and Bear Creek have received inputs from Y-12, Mitchell Branch from ETTP, and the White Oak Creek/Melton Branch watershed from ORNL. Contaminant releases to surface water and groundwater vary among these industrial sites, but generally include organic pollutants, heavy metals and radionuclides. Benthic macroinvertebrate samples were collected from various locations on these streams for semi-quantitative analysis. Surface water

samples were collected at the sites and analyzed for various constituents in support of the biomonitoring. Parameters analyzed included nutrients, mercury, metals, hardness, residue, and radiological constituents. The objectives of this study were to quantify benthic macroinvertebrate communities and to assess the degree of impact compared to reference conditions.

1.2.4 Drinking Water

TDEC conducted oversight of DOE facilities' safe drinking water programs. The scope of the independent sampling includes oversight of potable water quality on the ORR.

1.2.5 Groundwater

1.2.5.1 Springs

TDEC sampled and analyzed groundwater on the ORR and its environs to gauge the quality of groundwater through the sampling of springs. This project revisited springs that can provide information on the ambient health of the groundwater on the ORR and along geologic strike to the northeast and southwest. Findings will be used to identify and characterize unplanned releases and evaluate DOE monitoring and control measures to manage groundwater releases to the environment.

1.2.5.2 Offsite Residential Monitoring (this includes Background Residential Monitoring)

TDEC collected samples for analysis from 11 residential wells south and southwest of the ORR. TDEC's sampling was conducted in conjunction with DOE's off-site sampling program. Ten of the eleven locations were co-sampled with DOE contractors. These results are compared to EPA drinking water criteria. Where those results exceed the criteria, the well owner is contacted by TDEC and TDH.

1.2.5.3 Background Groundwater Determination for the Oak Ridge Reservation

TDEC will conduct a background monitoring study of offsite groundwater. The first step to determine if the downgradient groundwater has degraded is to determine if the constituent concentrations are greater than background. A representative background study for the ORR has not been performed; therefore, the background groundwater program is being conducted.

1.2.6 Surface Water/Sediment

1.2.6.1 Surface Water Physical Parameters

Two separate tasks are covered with the surface water physical parameter monitoring program. The tasks include 1) discrete ambient surface water physical monitoring and 2) continuous surface water physical monitoring.

1.2.6.1.1 Discrete Ambient Surface Water Physical Monitoring

TDEC collected discrete ambient water quality monitoring data at seven stream sites located in several watersheds. The main ORR watersheds include portions of East Fork Poplar Creek, Bear Creek, and Mitchell Branch. Field data were also collected from Mill Branch, a small reference stream located in the city of Oak Ridge. The EFK 13.8 km monitoring site is located outside the ORR.

Specifically, it is located approximately ten kilometers (km) downstream of Y-12. The project objectives were to create a baseline of water quality monitoring data, physical stream parameters measured on a monthly basis, and to determine possible water quality impairment issues. This monitoring task was directed toward determining long-term water quality trends, assessing attainment of water quality standards, and providing background data for evaluating stream recovery due to toxicity stressors. Table 1.2.6.1.1 and Figure 1.2.6.1.1 show locations that were selected for data collection.

Table 1.2.6.1.1 Discrete Ambient Surface Water Physical Monitoring Locations in Kilometers (Mile Equivalents)

Site	Location
EFK 23.4 (14.5)	East Fork Poplar Creek (near Y-12 east gate)
BCK 12.3 (7.6)	Bear Creek (near Y-12 west gate)
BCK 9.6 (6.0)	Bear Creek (near Walk-in Pits)
BCK 4.5 (2.8)	Bear Creek (Weir at Highway 95)
MIK 0.1 (0.06)	Mitchell Branch (Weir at ETTP)
EFK 13.8 (8.6)	East Fork Poplar Creek (near Big Turtle Park)
MBK 1.6 (1.0)	Mill Branch (Reference)

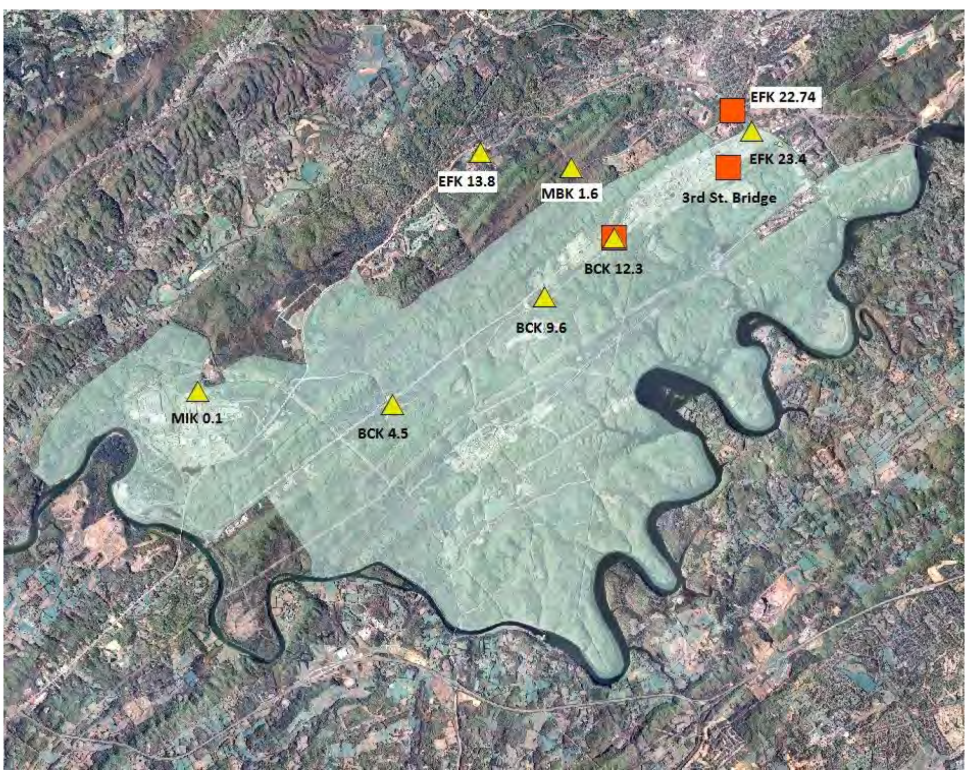


Figure 1.2.6.1.1 Oak Ridge Reservation physical parameter monitoring locations

△ Discrete Monitoring Locations ■ Continuous Monitoring Locations

1.2.6.1.2 Continuous Surface Water Physical Monitoring

The surface water exiting Y-12 has shown a need to be monitored with greater detail. Three continuous monitoring locations were selected around Y-12 (Figure 1.2.6.1.1 and Table 1.2.6.1.2). Two monitoring locations are on EFPC and a third monitoring location is on Bear Creek. The EFPC locations are to monitor the creek after the augmentation water was shut off, and to determine a baseline prior to any mercury abatement work at Outfall 200. The Bear Creek location was installed after reviewing the discrete data from BCK 12.3. This location has shown to be impacted and there is a need to understand its temporal trends with regard to water quality.

Table 1.2.6.1.2 Continuous Surface Water Physical Monitoring Locations in Kilometers (Mile Equivalents)

Site	Location
Third Street Bridge [EFK 24.9 (15.5)]	East Fork Poplar Creek (at the Third Street Bridge)
EFK 22.74 (14.1)	Bear Creek (offsite – water exiting Y-12)
BCK 12.3 (7.6)	Bear Creek (water exiting Y-12)

1.2.6.2 Ambient Surface Water Monitoring

Due to the presence of areas of extensive anthropogenic point and non-point source contamination on the ORR, there exists the potential for this pollution to impact surface water on the ORR as well as offsite aquatic systems. The local karst topography and related structural geology influences the fate and transport of contaminants that may further degrade the groundwater and surface water quality of aquatic systems on or adjacent to the ORR. The biotic integrity of an associated aquatic system/watershed/stream is directly influenced by its surface water quality. In general, the better the surface water quality of a stream, the better its biotic integrity. This project complements the benthic macroinvertebrate monitoring project; assessment of the surface water quality of a stream can more accurately determine the stream's total overall biological health. The evaluation of benthic macroinvertebrate communities is used to determine if a stream is supportive of fish and aquatic life. An integral element of this evaluation is the physical and chemical analysis of the stream's surface water. Relative to the four major ORR watersheds, Bear Creek, East Fork Poplar Creek, Mitchell Branch, and White Oak Creek / Melton Branch, legacy and present DOE operations have released contaminants to their respective surface water with mainly these major chemical families: volatile and semi-volatile organic compounds, nutrients, heavy metals, and radionuclides. These contaminants can have a detrimental effect on the health of benthic macroinvertebrate communities. When contaminant concentrations in surface water are high enough, the total population of benthic communities can be reduced. Negatively impacted benthic communities indicate a polluted, distressed stream/watershed/aquatic system.

1.2.6.3 Rain Event Surface Water Monitoring

TDEC conducted surface water sampling (pH, temperature, conductivity, dissolved oxygen, metals, and radiochemical analysis) following precipitation events at selected sites on the ORR. Monitoring of these parameters is to assess the degree of transport of contaminants, if any, caused by rain events.

1.2.6.4 Ambient Sediment Monitoring

Sediment is an important part of aquatic ecosystems. Many aquatic organisms depend on sediment for habitat, sustenance, and reproduction. Anthropogenic chemicals and waste materials, such as metals, radionuclides, PCBs, polycyclic aromatic hydrocarbons (PAHs), and agricultural chemicals that are introduced into aquatic systems often accumulate in sediment. Concentrations of contaminants can be much higher in sediment than in the water column. Some sediment contaminants may be directly toxic to benthic organisms or may bioaccumulate in the food chain, creating health risks for wildlife and humans. Sediment analysis is an important aspect of environmental quality and impact assessment for rivers, streams, and lakes.

Contaminants from past DOE activities on the ORR have made their way into several streams that feed into Poplar Creek and the Clinch River. The major pathways of concern are White Oak Creek and East Fork Poplar Creek. The major contaminants of concern from White Oak Creek are strontium-90 (Sr-90) and cesium-137 (Cs-137). East Fork Poplar Creek is contaminated with mercury from past activities at Y-12. In order to characterize and monitor the impact from these streams, TDEC sampled sediment in the Clinch River, Poplar Creek, East Fork Poplar Creek, Bear Creek, and Mitchell Branch. Sediment samples were analyzed for metals and radiological parameters. TDEC sampled sediment at nine sites in May and September 2015 (see Figure 1.2.6.4). Sampling at CRK 37.3 did not yield any fine sediment suitable for analysis. Since there are no federal or state sediment cleanup levels, the metals data were compared to Consensus-based Sediment Quality Guidelines (CBSQGs) (MacDonald et al. 2000). Radiological data were compared to DOE's Preliminary Remediation Goals (PRGs) (DOE 2013). PRGs are upper concentration limits for specific chemicals in environmental media that are intended to protect human health. PRGs are often used at CERCLA sites for risk assessment (Efroymson et al. 1997).

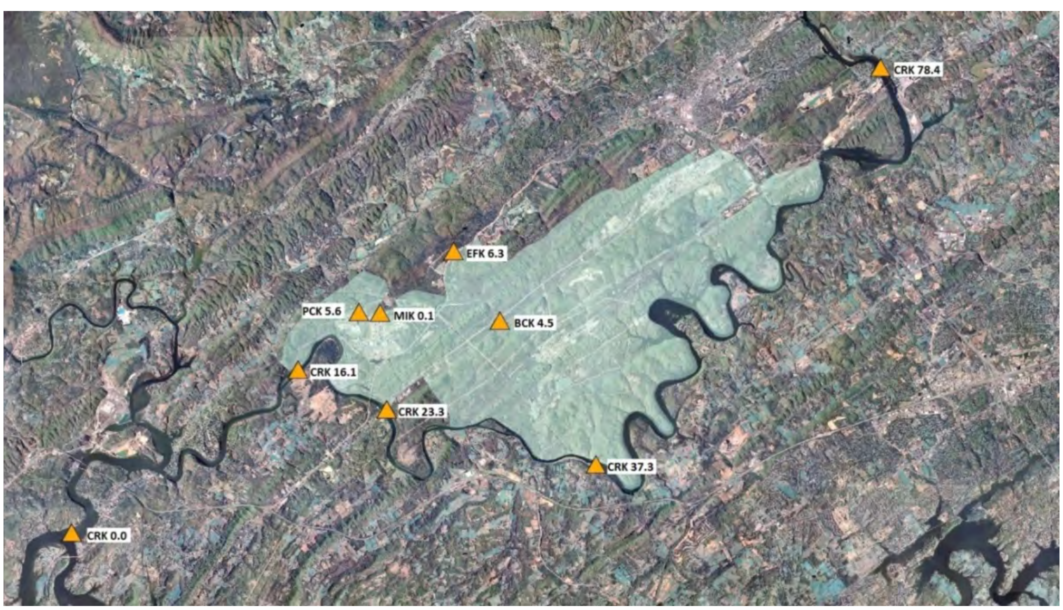


Figure 1.2.6.4 Sediment sampling sites

1.2.6.5 Ambient Trapped Sediment Monitoring

This project focuses on the sediment currently being transported in East Fork Poplar Creek, Bear Creek and North Tributary 5 (NT5) by utilizing passive sediment collectors. The sediment samplers were deployed for approximately six months from March 31, 2015 to October 6, 2015. Sediment samples were analyzed for radiological activity and metals. Many aquatic organisms depend on sediment for habitat, sustenance, and reproduction. Sediment is also a depository for contaminants such as metals, radionuclides, PCBs, PAHs, and agricultural chemicals. Concentrations of contaminants can be much higher than that in the water column. Some sediment contaminants may be directly toxic to benthic organisms or may bioaccumulate in the food web, creating health risks for wildlife and humans. Past sediment sampling activities by TDEC have shown that Poplar Creek and East Fork Poplar Creek have elevated levels of mercury in sediment. This mercury can be attributed to historical discharges from Y-12, and, to a lesser extent, ETTP.

1.2.7 CERCLA Landfill Monitoring of Liquid Effluents, Surface Water, Groundwater

TDEC monitored groundwater elevations, effluents, surface water runoff, and sediment at DOE's EMWMF. This facility was constructed to dispose of waste generated by remedial activities on the ORR and is operated under the authority of CERCLA. The facility is required to comply with permit standards and ARARs in the CERCLA ROD (DOE, 1999) signed by TDEC, EPA and DOE, and with requirements associated with responsibilities delegated to the DOE by the Atomic Energy Act. Figure 1.2.7.1 shows the facility and sampling sites.

Five tasks identified in the environmental monitoring plan approved in December 2014 for the 2015 sampling year:

1. To monitor water parameters leaving EMWMF, continuous water quality parameters will be recorded at two locations: EMWMF-2 (underdrain) and EMWMF-3 (sediment basin v-weir discharge). TDEC will perform basic monitoring of these sites at least twice weekly with the use of a YSI© Professional Plus water quality instrument.
2. To ensure contaminants from the cell are not adversely affecting the surrounding environment, water samples will be collected on a routine basis from select sites. Sediment samples will be collected from the sediment basin as available.
3. To determine the changes in groundwater due to seasonal and precipitation fluxes, data loggers will be placed in seven wells and data downloaded on a monthly basis.
4. To ensure best practices are utilized to limit contaminant migration, site visits will be made at least twice weekly to monitor ongoing activities at EMWMF.
5. To verify compliance that the water table is below the geologic buffer, a review of groundwater level measurements will be conducted annually from data received on wells located on and near EMWMF.

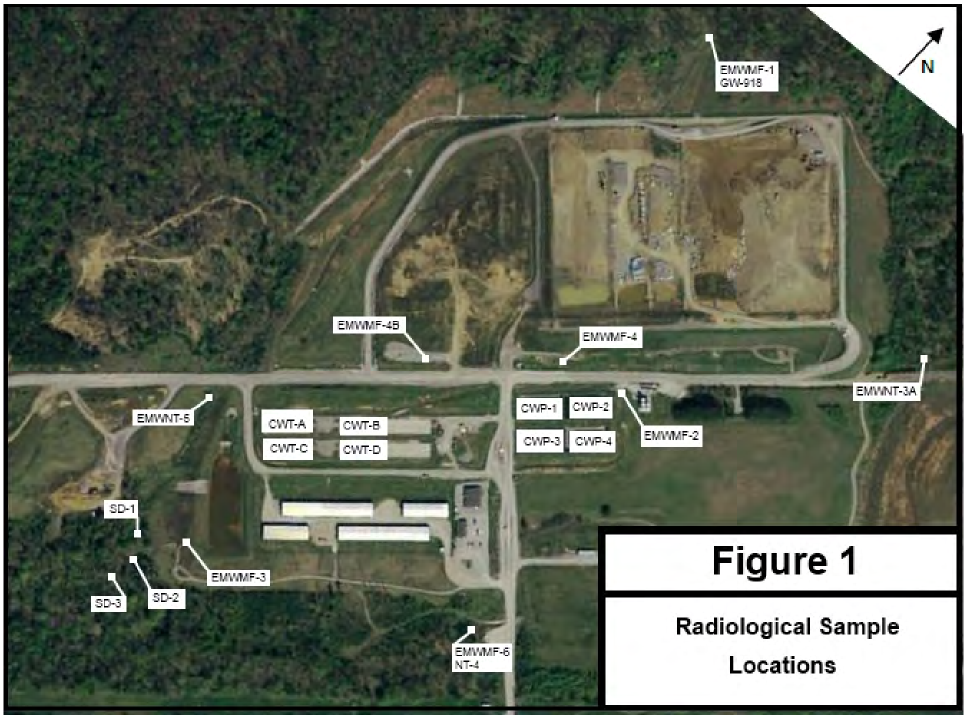


Figure 1.2.7.1 Radiological sample locations
(basemap reproduced Google Maps) (DigitalGlobe, et al., 2011)

Task Introductions

Task 1
The continuous water quality parameters of temperature, pH, conductivity, dissolved oxygen, turbidity, and water level (converted to discharge) were measured with an In-Situ® Troll 9500. Precipitation data was collected from the closest ORR meteorological tower. The continuous water quality data-loggers were visited once per week to aid in determining calibration drift, check on any sedimentation and/or biological problems at the locations, and to make sure the instruments were functioning properly. TDEC performed basic monitoring of these locations for temperature, pH, conductivity, DO, and Oxidation Reduction Potential (ORP) at least twice weekly utilizing a YSI© Professional Plus water quality meter. ORP is a measurement of water's ability to oxidize contaminants. The higher the ORP is, the greater the number of oxidizing agents. Calibration or confidence check of this instrument is performed prior to field use. Locations and rationale are listed in Table 1.2.7.1.

Table 1.2.7.1 Continuous Water Quality Parameter and YSI© Professional Plus Monitoring Locations

TDEC Designation	EMWMF Site Designation	Rationale
EMWMF-2	EMW-VWUNDERDRAIN	Monitor to determine the integrity of the landfill and establish a baseline of water quality parameters for comparison.
EMWMF-3	EMW-VWEIR	Monitor water being discharged to North Tributary 5 from the sediment basin. The sediment basin receives both uncontaminated stormwater runoff and water that has been in contact with the waste stream.

EMWMF - Environmental Management Waste Management Facility
TDEC - Tennessee Department of Environment and Conservation

Task 2

To ensure contaminants from the cell are not adversely affecting the surrounding environment, sediment samples from the sediment basin and water samples from monitoring locations connected with EMWMF were collected to determine if levels leaving the facility are greater than previously established limits or if nearby tributaries have potentially been affected by processes associated with EMWMF.

Task 3

TDEC conducted monitoring of groundwater parameters (level, temperature, and conductivity) at selected wells and piezometers at EMWMF. Monitoring of these parameters is to aid in the initial screening evaluation of the proposed Environmental Management Disposal Facility (EMDF) site.

Task 4

On a bi-weekly basis TDEC visits EMWMF to perform general monitoring of the site. In addition to measuring water parameters, collecting water samples/sediment samples and data logger acquisition, TDEC monitors the water levels in the contact water ponds/ tanks, notes discharges and water condition, observes condition of the sediment basin, and notes daily activity of the cell. Any concerns are brought to the attention of EMWMF personnel. Field notes are recorded and events reported in the monthly report.

Task 5

Due to state and EPA concerns with shallow groundwater at EMWMF, DOE agreed to maintain a 10-foot geologic buffer between the EMWMF liner and the groundwater table [(based on TDEC Rule 0400-11-01-.04(a)] and to emplace a contingency plan to be implemented should groundwater intrude into the buffer. The contingency plan was implemented in 2003, resulting in the construction of the underdrain reestablishing the drainage previously provided by the filled NT-4 channel. Currently, DOE contractors take quarterly water level measurements at thirty-two wells and piezometers at the site to assess the height of the water table. To evaluate EMWMF monitoring, this

data will be reviewed as it becomes available and used to model the potentiometric surface of the water table beneath the facility relative to the bottom of the geologic buffer. Historical data collected by DOE does indicate a potential incursion for groundwater in the geologic buffer.

1.2.8 RadNet

1.2.8.1 Air Monitoring

The RadNet Air monitoring program on the ORR began in August of 1996 and provides radiochemical analysis of air samples taken from five air monitoring stations located near potential sources of radiological air emissions on the ORR. RadNet samples are collected by TDEC and analysis is performed at the EPA National Air and Radiation Environmental Laboratory in Montgomery, Alabama (NAREL). In 2015, as in past years, the data for each of the five RadNet air monitors largely exhibited similar trends and concentrations. The results for 2015 do not indicate a significant impact on the environment or public health from ORR emissions.

In the past, air emissions from DOE activities on the ORR were believed to have been a potential cause of illnesses affecting area residents. While these emissions have substantially decreased over the years, concerns have remained that air pollutants from current activities (e.g., production of radioisotopes and demolition of radioactively contaminated facilities) could pose a threat to public health, the surrounding environment, or both. As a consequence, TDEC has implemented a number of air monitoring programs to assess the impact of ORR air emissions on the surrounding environment and the effectiveness of DOE controls and monitoring systems.

1.2.8.2 Precipitation

The RadNet Precipitation monitoring program on the ORR provides radiochemical analysis of precipitation samples taken from monitoring stations at three locations on the ORR. Samples are collected by TDEC and analysis is performed at NAREL. Analysis for gamma radionuclides is performed on each monthly composite sample. Since there is not a regulatory limit for radioisotopes in precipitation, the results from ORR sampling locations are compared to EPA's drinking water limits and can also be compared to data from other sites nationwide. While the stations located on the ORR stations are in areas near nuclear sources, most of the other stations in the RadNet precipitation program are located near major population centers, with no major sources of radiological contaminants nearby. Regardless, the radiological results seen in the precipitation samples collected at the RadNet sites on the ORR were all below the EPA drinking water limits. The EPA drinking water limits pertain to drinking water, not precipitation, and are only used here as conservative reference values.

TDEC monitors precipitation on the ORR. The RadNet Precipitation monitoring program measures radioactive contaminants that are washed out of the atmosphere and carried to the earth's surface by precipitation. There are no standards that apply directly to contaminants in precipitation; however, the data provide an indication of the presence of radioactive materials that may not be evident in the particulate samples collected by the TDEC air monitors. EPA has provided three monitors to date, which have been co-located at RadNet air stations at each of the ORR sites. One is

located in Melton Valley, in the vicinity of ORNL. Another is located east of ETTP, off Blair Road. The third is co-located with the RadNet air station east of Y-12. Figure 1.2.8.2 depicts the locations of the precipitation samplers.

The first precipitation monitor provided by EPA is located at an existing RadNet air station near ORNL's HFIR (High Flux Isotope Reactor) and the Solid Waste Storage Area 5 (SWSA5) burial grounds in Melton Valley. The station is used to monitor that area of ORNL for gamma radionuclides. The second precipitation monitor is located off Blair Road to monitor contaminants from demolition activities at ETTP. The third station is used to monitor Y-12 and is adjacent to the RadNet air monitor at the east end of Y-12. In addition to monitoring Y-12, the station could potentially provide an indication of any other gamma radioisotopes traveling towards the city of Oak Ridge from ORNL. Analysis for gamma radionuclides is performed on the monthly composite samples for each of the three precipitation monitoring locations.

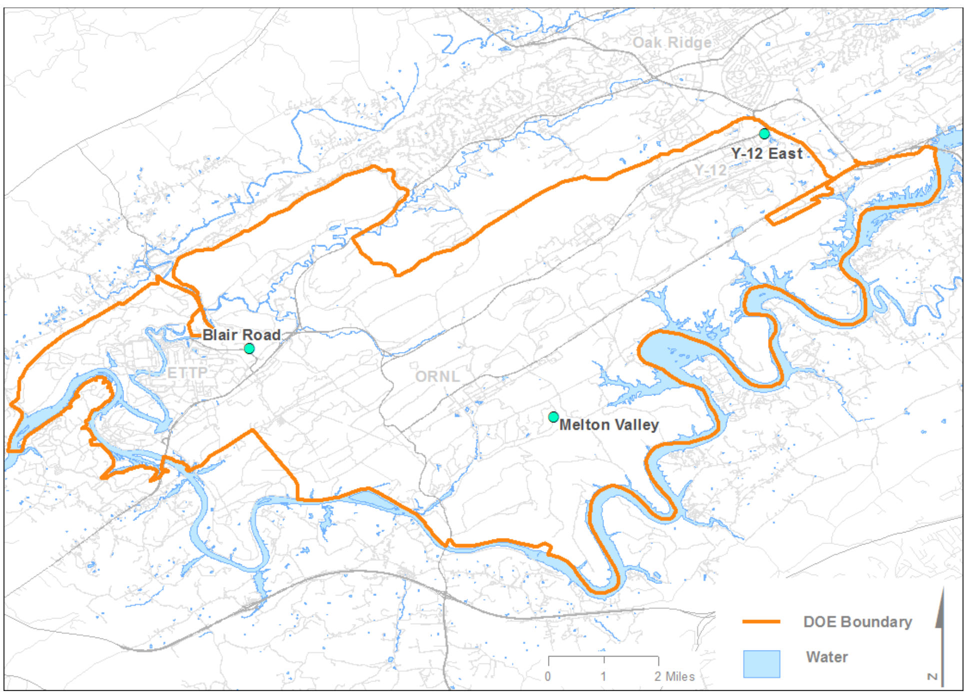


Figure 1.2.8.2 Locations of the RadNet precipitation samplers on the Oak Ridge Reservation

Since there are no regulatory limits for radiological contaminants in precipitation, the results of the gamma analyses are compared to drinking water limits used by EPA as a conservative limit. EPA's Radionuclides Rule for drinking water allows gross alpha levels of up to 15 picocuries per liter (pCi/L), while beta and photon emitters are limited to four millirem (mrem) per year and are radionuclide specific. The monthly composite samples are now solely analyzed for gamma radionuclides, but not all isotopes have EPA drinking water limits. A large portion of the results are less than the minimum detectable concentration for each analysis. Barring nuclear accidents, the results for gamma radionuclides with drinking water limits would be expected to be below these

regulatory limits. Table 1.2.8.2 shows the maximum contaminant levels (MCLs) of beta and photon emitters that EPA uses as drinking water limits for select isotopes.

Table 1.2.8.2 EPA Drinking Water Limits for Select Isotopes (MCLs)

Isotope	EPA limit (pCi/L)
Barium-140 (Ba-140)	90
Beryllium-7 (Be-7)	6,000
Cobalt-60 (Co-60)	100
Cesium-134 (Cs-134)	80
Cesium-137 (Cs-137)	200
Tritium (H-3)	20,000
Iodine-131 (I-131)	3

1.2.8.3 Drinking Water

The RadNet program was developed by EPA to ensure public health and environmental quality as well as to monitor potential pathways for significant population exposures from routine and accidental releases of radioactivity (U.S. EPA, 1988). The RadNet program focuses on nuclear sources and population centers. The RadNet Drinking Water program in the Oak Ridge area provides for radiochemical analysis of finished water at four public water supplies located near and on the ORR. Quarterly samples are collected by TDEC and analysis for radiological contaminants is performed at the NAREL. Analyses include tritium, iodine-131, gross alpha, gross beta, strontium-90, and gamma spectrometry, with further analysis performed when warranted. While results for tritium, gross beta, and strontium-90 have tended to be slightly higher at the ETTP water treatment plant (closed at the end of September 2014), all results generated by the program have remained below regulatory criteria, since its inception in 1996.

Radioactive contaminants released on the ORR can potentially enter local streams and be transported to the Clinch River. While monitoring of the river and local water treatment facilities has indicated that concentrations of radioactive pollutants are below regulatory standards, a concern that area water supplies could be impacted by ORR pollutants remains. The RadNet Drinking Water program provides quarterly radiological sampling of finished water at public water supplies near major population centers and nuclear sources throughout the United States. The RadNet program is designed to:

- monitor pathways for significant population exposure from routine and accidental releases of radioactivity
- provide data indicating additional sampling needs or other actions required to ensure public health and environmental quality
- serve as a reference for data comparisons (U.S. EPA, 1988)

The RadNet program also provides a mechanism to evaluate the impact of DOE activities on area water systems and to supplement DOE monitoring, providing independent third party analysis.

2.0 Methods and Materials

2.1 Oak Ridge Reservation

The TOA supports a comprehensive and integrated monitoring and surveillance program for all media (air, surface water, soil sediments, groundwater, drinking water, food crops, fish and wildlife, and biological systems) and the emissions of any materials (hazardous, toxic, chemical, radiological) on the ORR and environs. There are six area-wide programs and two site-specific programs that monitor the environment on and around the ORR for radiation and chemicals, and other projects can be added or completed as needed. The media being measured are radiation fields, surface and groundwater, sediment, air, and biological flora and fauna. Methods of monitoring vary from real-time measurements to collecting samples for laboratory analysis of chemistries and insect populations.

2.1.1 Radiation Monitoring

2.1.1.1 Ambient Gamma Radiation Monitoring of the Oak Ridge Reservation Using Environmental Dosimeters

The dosimeters used in the program were obtained from Landauer, Inc., of Glenwood, Illinois. Each dosimeter used an aluminum oxide photon detector to measure the dose from gamma radiation (minimum reporting value equals one mrem). At locations where a potential for the release of neutron radiation exists, the dosimeters also contain an allyl diglycol carbonate based neutron detector (minimum reporting value equals 10 mrem). Dosimeters were collected quarterly and sent to Landauer for processing.

To account for exposures received in transit, control dosimeters are provided with each shipment of dosimeters received from the Landauer Company. These dosimeters are stored in a lead container at the TDEC Oak Ridge Office during the monitoring period and returned to Landauer for processing with the associated field deployed dosimeters. Any dose reported for the control dosimeters was subtracted from the results for the field-deployed dosimeters by the vendor prior to being reported.

As the quarterly data are received from the vendor, TDEC reviews the results and compiles a quarterly report, which is distributed to DOE and other interested parties. At the end of the year, the quarterly results are summed for each location and the resultant annual dose is compared to background values and the state's primary dose limit for members of the public (100 mrem/year above background concentrations and medical applications).

2.1.1.2 Real Time Monitoring of Gamma Radiation

The exposure rate monitors deployed in the program are manufactured by Genitron Instruments and are marketed under the trade name GammaTRACER®. Each unit contains two Geiger Mueller tubes, a microprocessor controlled data logger, and lithium batteries sealed in a weather resistant case to protect the internal components. The instruments can be programmed to measure gamma exposure rates from one μrem/hour to one rem/hour at predetermined intervals (one minute to two hours). The results reported are the average of the measurements recorded by the two Geiger

Mueller detectors, but data from either detector can be accessed if needed. Information recorded by the data loggers is downloaded to a computer using an infrared transceiver and associated software.

Monitoring in the program focuses on the measurement of exposure rates under conditions where gamma emissions can be expected to fluctuate substantially over relatively short periods and/or when there is a potential for an unplanned release of gamma emitting radionuclides to the environment. Candidate monitoring locations include remedial activities, waste disposal operations, pre and post operational investigations, and emergency response activities. Results recorded by the monitors are evaluated by comparing the data to background measurements and state radiological standards. In 2015, the exposure rate monitors were used to monitor gamma emissions at the five locations listed below and depicted in Figure 2.1.1.2.1.

- Fort Loudoun Dam (background location)
- Environmental Management Waste Management Facility (EMWMF) in Bear Creek Valley southwest of the Y-12 National Security Complex
- Oak Ridge National Laboratory (ORNL) Central Campus Remediation (Radioisotope Development Lab Removal Action)
- ORNL Molten Salt Reactor Experiment (MSRE)
- Spallation Neutron Source (SNS) exhaust stack

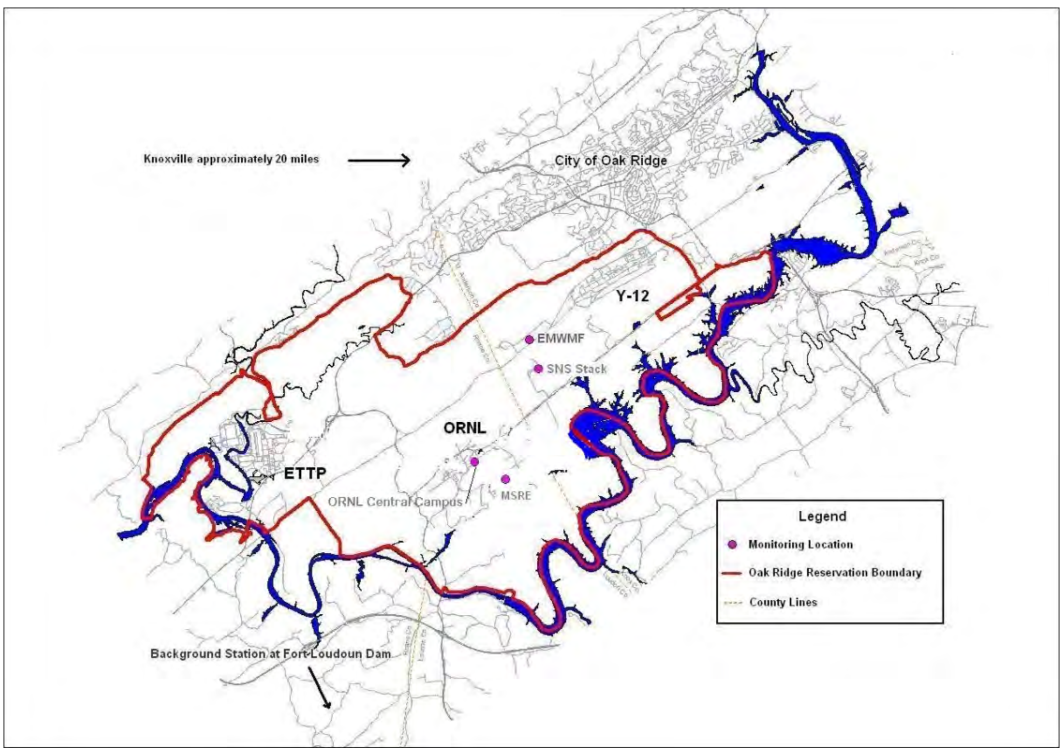


Figure 2.1.1.2.1 Gamma exposure rate monitoring locations in 2015

2.1.2 Air Monitoring

2.1.2.1 Fugitive Radiological Air Emissions Monitoring from EMP

The eight high-volume air samplers used in the program run continuously, except during filter collection, maintenance, or power outages. Seven of the samplers were used to monitor activities on the ORR, the eighth to collect background information. Each sampler used an 8x10 inch glass-fiber filter to collect particulates from air as it was drawn through the unit at a rate of approximately 35 cubic feet per minute. Airflow through each sampler is calibrated quarterly and routine maintenance is performed as described in TDEC Standard Operational Procedure 203, *High Volume Total Suspended Particulate System Maintenance.* Samples were collected weekly. Samples were composited every four weeks and shipped to the state of Tennessee's environmental laboratory in Nashville, Tennessee for analysis. Analyses were based on the radionuclides of concern for the location being monitored, and thus vary for different locations.

When the results were received from the laboratory, the data from the reservation samplers were compared to the background results to assess if releases occurred. An assessment of compliance was made from limits provided in 40CFR61 Appendix E Table 2 (Concentration Levels for Environmental Compliance). The locations of the 2015 monitoring stations are depicted in Figure 2.1.2.1. The analysis for stations ETTP K25 K11, ETTP Portal 4, EMWMF, Y-12 Building B9723, Y-12 Building 9212, and the background station at Ft. Loudoun Dam were isotopic uranium and technetium-99 (Tc-99). ORNL stations B4007 and Corehole 8 were analyzed for isotopic uranium.

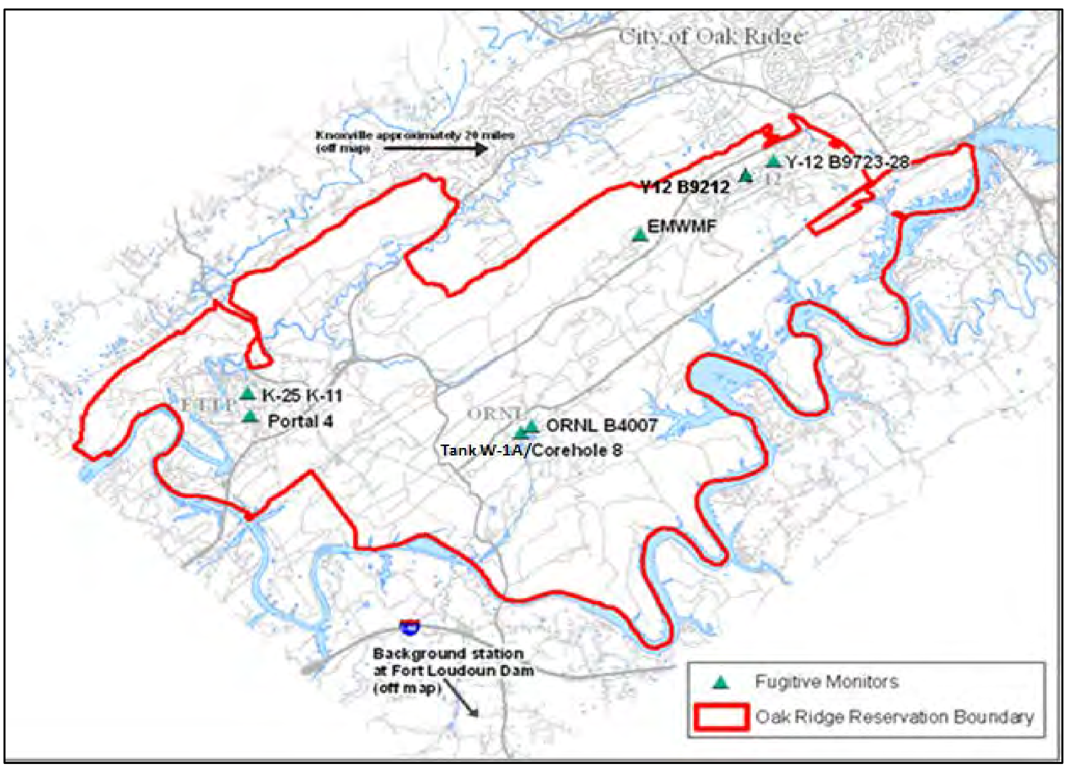


Figure 2.1.2.1 Approximate locations of sites monitored for fugitive air emissions in 2015

Results from the ORR samplers were compared to the results from the background location to determine if releases occurred and to standards provided in the Clean Air Act (CAA) to assess compliance with federal regulations. Title 40 of the Code of Federal Regulations Part 61 (40CFR61), *National Emission Standards for Hazardous Air Pollutants* (NESHAPS), Subpart H (*National Emission Standards for Emissions of Radionuclides other than Radon from Department of Energy Facilities*) limits DOE radiological emissions to quantities that would not cause a member of the public to receive an effective dose equivalent greater than 10 mrem in a year. The effective dose equivalent is the sum of the products of absorbed dose and appropriate factors to account for differences in biological effectiveness due to the quality of radiation and its distribution in the body of reference man. The unit of the effective dose equivalent is the rem. 40CFR61.91(a) Appendix E, Table 2 of the rule provides environmental concentration for individual radionuclides that would be equivalent to the 10 mrem/year dose limit if inhaled continuously over the course of a year. To account for the synergistic effect of multiple radionuclides in the air, the rule calls for a sum of fractions to determine compliance when more than one radionuclide is present. To calculate a sum of fractions, the annual average concentration for each radionuclide was divided by its limit and the results summed. If the sum of the fractions is equal to, or greater than, one (1), then the facility would be considered out of compliance. The compliance point is the nearest off-site residence, school, business, or office. DOE is also required to meet provisions of the law that require all radioactive emissions to be as low as reasonably achievable (ALARA).

The fugitive air monitoring program was designed to identify air releases from non-point sources (remedial activities) to the environment and evaluate DOE control measures and ALARA consideration. Consequently, the monitors were located as near to the activity of interest as feasible.

2.1.3 Biological Monitoring

2.1.3.1 Threatened and Endangered Species Monitoring

Previous vascular plant investigations covered much of the ORR (Mann et al. 1985, Cunningham et al. 1993, Rosensteel and Trettin 1993, King et al. 1994, Awl et al. 1996), but some areas of the Black Oak Ridge Conservation Easement (BORCE) remain unmapped. During the spring and summer of 2015, TDEC conducted limited field botany walk-over excursions on trails and back country sections of the BORCE. Geomorphic habitats such as small drainage ravines, floodplains, wetlands, watersheds, cedar barrens, rock outcroppings, cliffs, and karst features (springs, caves, sinkholes) were surveyed for rare plant taxa. Field locations of rare plants were mapped and located using a Global Positioning System (GPS) hand-held field unit (Garmin®). Using a grid system based on 10-meter centers, the plan was to identify all plant taxa in the forest canopy, subcanopy, shrub, herbaceous, and groundcover layers. Photographs of plants were taken to document sensitive communities and rare species. Field monitoring methods and health and safety procedures generally followed the USFWS standard operating procedures for conducting and reporting botanical inventories for federally listed, proposed, and candidate plants (USFWS 1996); methods and guidance outlined in Awl et al. (1996) and National Park Service field protocols (Fancy et al. 2009, White et al. 2003). TDEC followed the guidelines in the TDEC Health and Safety Plan (TDEC 2013).

Vascular plant and fungi identifications required the use of the following sources and taxonomic keys: Radford et al. 1968, Mickel 1979, Prescott 1980, Lincoff 1981, Cobb 1984, Lellinger 1985, Wofford 1989, Gleason & Cronquist 1991, Chester et al. 1993, Chester et al. 1997, Holmgren et al. 1998, Smith 1998, Barron 1999, Carman 2001, Wofford & Chester 2002, Phillips 2005, and Weakley 2007.

2.1.3.2 Acoustic Monitoring of Bats

Bats were monitored with acoustic detectors such as AnaBat™ (Titley Scientific, Columbia, MO) and SM2BATs (Wildlife Acoustics, Maynard, MA). These detectors record the ultra-high frequencies emitted by bats in flight (echolocation) while they are foraging for insects at night. Survey sites were selected to maximize potential bat usage and foraging of the ORR landscape. For example, bat roost trees such as shagbark hickory, white oaks, and dead standing snags were targeted as high potential bat habitat. Water features such as wetlands, stream riparian zones, and river shorelines were also high priority bat study habitats. Karst features such as caves and rocky bluffs were monitored for bat calls. Field and laboratory safety methods followed TDEC (2013).

Bat data was collected from dusk until dawn at most ORR monitoring sites (2-10 consecutive nights); a few sites were monitored for 2-4 hours after dusk. Data downloads from the detectors were then processed using specialized bat identification software programs that compare the recorded bat calls to a built-in library of bat calls. These programs include Kaleidoscope PRO (Wildlife Acoustics, Maynard, MA), and BCID-East (Bat Call Identification, Inc., Kansas City, MO). The software produces a Microsoft® Excel file with a list of bat species likely recorded during an acoustic monitoring survey.

2.1.3.3 White-tailed Deer Monitoring

White-tailed deer were captured during the winter/spring of 2015 in Melton Valley by “darting,” using a dart projector, chemically immobilizing deer accustomed to the presence of humans in the solid waste storage areas (SWSAs) of Melton Valley at ORNL (controlled access areas). Deer are crepuscular [animals that are primarily active at twilight (dawn and dusk)], thus captures were attempted during morning daylight hours between 0700 and 1100. The deer field team members (ideally four: equipment manager, two handlers, data collector) captured deer by means of immobilization drugs administered by a dart projector. Following capture, deer were fitted with a GPS/VHF collar and ear tags. Field procedures also followed the TDEC Health and Safety Plan (TDEC 2013).

Melton Valley deer were darted by TDEC at a range of 30-60 yards using a disposable dart propelled from a Pneu-Dart Model 389 dart projector (cartridge-powered; Pneu-Dart, Inc., Williamsport, PA). Every attempt was made to deliver the dart to an area of muscle mass at the junction of the neck and shoulder of the deer.

Following dart delivery, deer were quietly observed from a distance during induction time until effects of the drugs became evident (6-10 minutes) and it was determined that the animal was down. The induction time is the interval between initial injection of drugs via dart delivery and immobilization of the animal (Kreeger et al. 1986, Kreeger and Armeno 2007). The field team quietly

approached the area in an evenly spread search pattern where the deer was known to be down or last seen. If the animal was aware of field team's approach (as evidenced by lifting its head or moving its ears or eyes), but was unable to rise off the ground, a dose of Ketamine was administered at 2.5 milligrams per kilogram (mg/kg) [2.5 mg/kg: 1.4 ml of 100 milligram per milliliter (mg/ml) for a 120 lb. deer] intramuscularly (IM) by syringe into the neck muscle to enhance immobilization of the deer (Safe-Capture 2012).

Deer were generally found recumbent within 50-250 yards from the location where the animal was originally darted. Once immobilization was complete, and it was safe to approach the deer, the handler positioned the deer in a sternal recumbent position, ensured the respiratory pathway (airway) was clear and unobstructed, and held the deer's head above the level of the gut rumen. The equipment manager applied a sterile ophthalmic lubricant to the deer's eyes, blindfolded the deer, and recorded age and sex. Next, the equipment manager quickly installed the GPS collar on the deer. Once the collar was applied, the equipment manager and the handler monitored the deer vital signs. Once the heart rate, temperature, and respiration were measured and recorded, then the equipment manager applied the numbered ear tags, and removed the dart from the deer. Reflective Mylar® "space" blankets were sometimes used to help keep the animal warm during recovery from the immobilizing drugs. The data collector took photographs and recorded important details pertinent to the capture (TDEC 2013).

During recovery time, measurements of the deer were taken (length, girth). The deer's vital signs were monitored every 5 to 10 minutes while the deer was immobilized. Deer immobilization (captures) and handling followed the standard operating procedures per the TDEC White-tailed Deer Capture Plan (TDEC 2013), the TDEC Health and Safety Plan (TDEC 2013), and the Safe-Capture Training Manual (Safe-Capture 2012).

2.1.3.4 Fungi Monitoring in East Fork Poplar Creek

The study site included upper and lower reaches of the East Fork Poplar Creek (EFPC) floodplain. Sampling sites were selected based on known concentrations of Hg present in EFPC floodplain soil samples.

TDEC sampled three main EFPC areas during 2015:

- EFPC floodplain behind and south of the K-Mart
- EFPC floodplain behind and south of the National Oceanic and Atmospheric Administration (NOAA) field office
- ETTP Horizon Center (Figures 2.1.3.4.1-2.1.3.4.2)

Control sampling locations included:

- Cedar Hill Greenway
- Haw Ridge Park
- UT Arboretum (Figures 2.1.3.4.3-2.1.3.4.4)

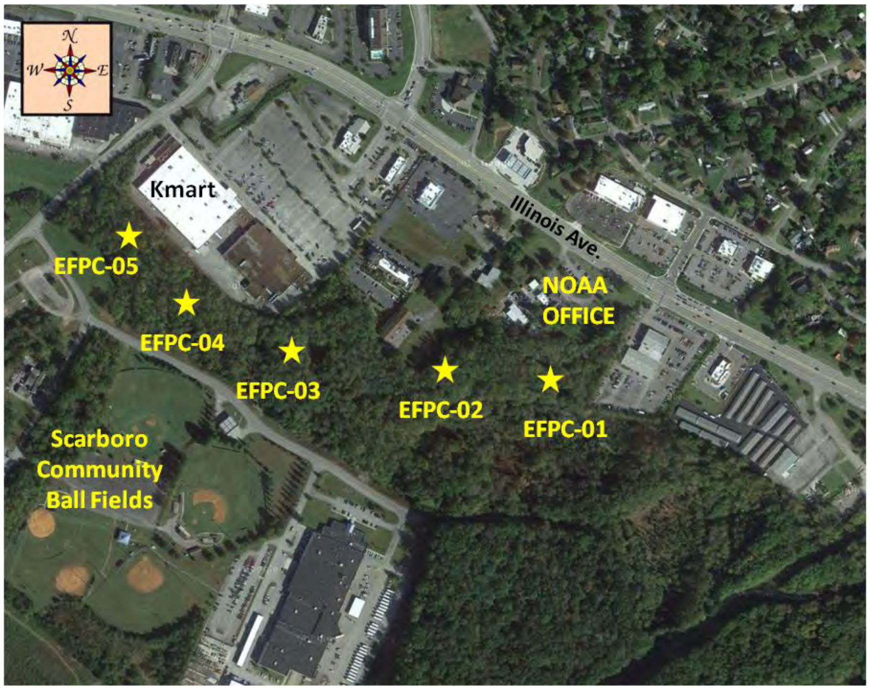


Figure 2.1.3.4.1 Upper East Fork Poplar Creek floodplain fungi sampling plots

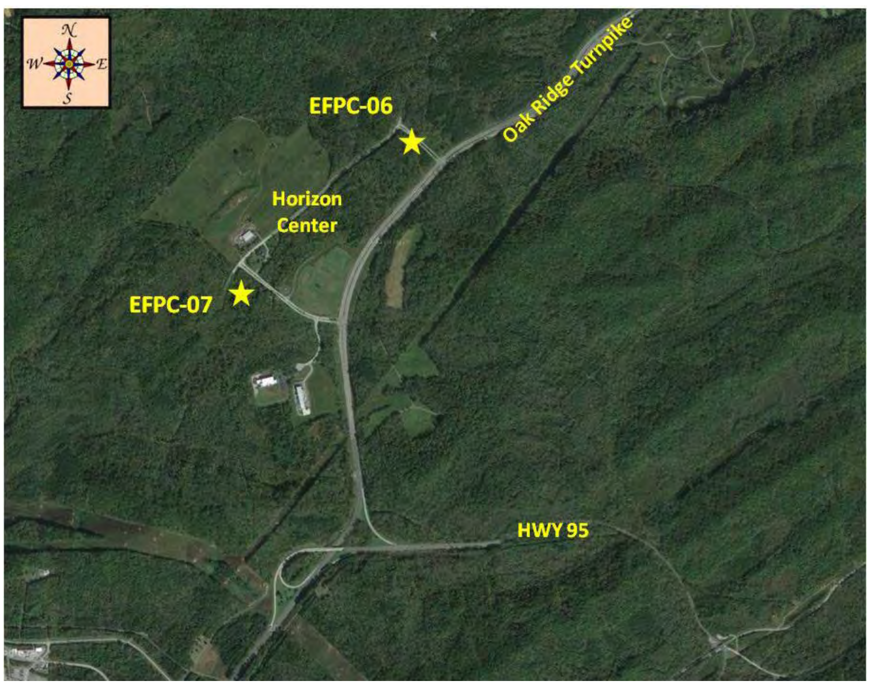


Figure 2.1.3.4.2 Lower East Fork Poplar Creek floodplain fungi sampling plots

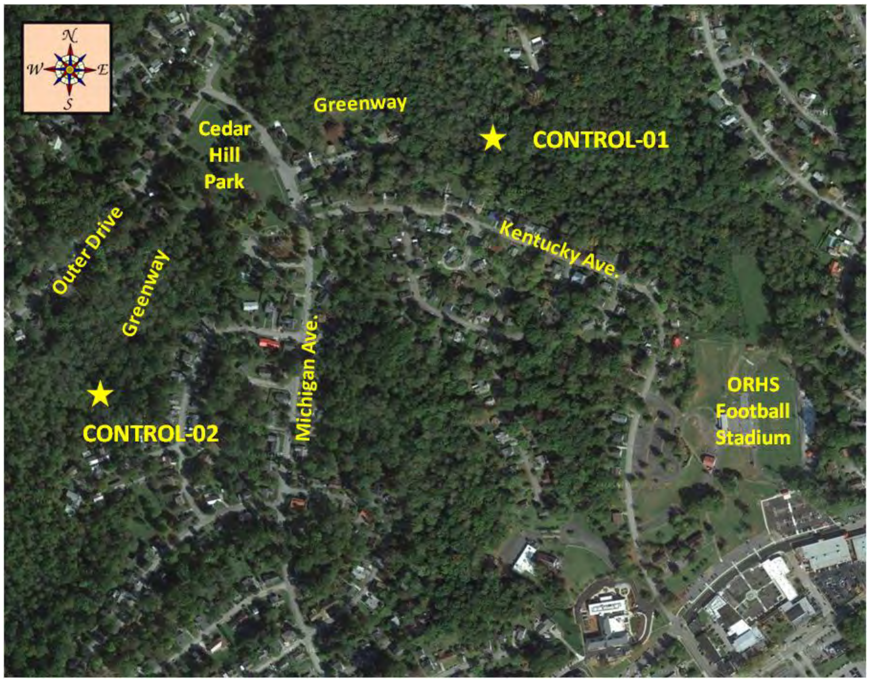


Figure 2.1.3.4.3 Cedar Hill Greenway fungi sampling plots

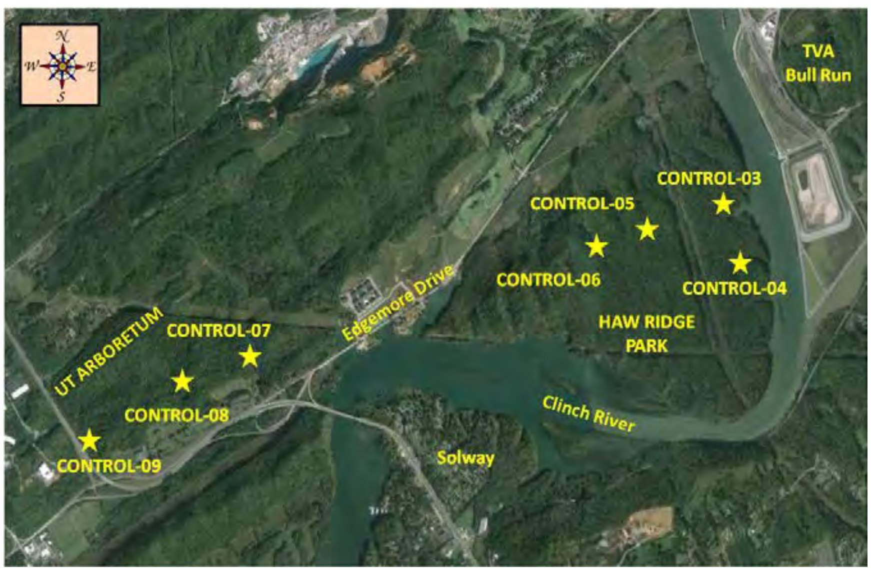


Figure 2.1.4.3.4 Haw Ridge Park and UT Arboretum fungi sampling plots

During the 2015 field season, TDEC conducted sampling trips in May, June, October, and November following significant precipitation events. The plan was to sample mushrooms using two methods: random sampling and sampling of fixed-size plots. In the field, entire fungal sporocarps (fruiting body), including the subsurface root, were collected.

Established fungi sampling protocols suggest that sampling plots be approximately ten square meters and additional subplots may be added if mushrooms are sparse and additional sampling is

necessary to bolster fungal biomass for laboratory analyses (Halling 1996, Rossman et al. 1998, O'Dell 1999). The goal was to collect enough fruiting bodies of each species to provide a 5-10 gram dry weight sample for laboratory analysis (Eckl et al. 1986). Mushrooms were photographed before extraction as an aid to taxonomic identification of each sporocarp. New nitrile gloves were worn while sampling to prevent cross-contamination. Mushrooms were carefully extracted from substrates with plastic, glass, or ceramic instruments in order to avoid any metal contacts and to prevent cross-contamination (Elekes et al. 2010). Samples were stored in either plastic tackle boxes, wax paper, or aluminum foil for transport to the laboratory. Samples were stored overnight at 4 degrees Celsius until further processing (preparing samples for laboratory delivery). Freshly collected fruiting bodies of mushrooms were washed with deionized water to remove extraneous material (plant and substrate debris) and cut with a clean plastic knife into small pieces. Next, the samples were dried at 60 degrees C for 12 hours in a laboratory oven. Dried mushrooms were sealed in polyethylene bags and labeled with chain of custody labels for delivery to the laboratory for mercury analysis. These standard operating procedures were developed and modified from macrofungi survey protocols and guidelines found in the scientific literature (Eckl et al. 1986, Halling 1996, Fine 1998, Rossman et al. 1998, Castellano et al. 1999, 2004, O'Dell 1999, Derr et al. 2003, Falandysz 2002, Falandysz et al. 2003, 2004, Lodge et al. 2004, Halling and Mueller 2005, Van Norman et al. 2008, Elekes et al. 2010, Radulescu et al. 2010, Van Norman and Huff 2012, and Vinichuk 2012). Laboratory safety and sample shipping procedures followed the methods of TDEC (2013), TDH (1999), and TDEC DoR-OR SOP 101.

Fungi samples were identified to as low a taxonomic level as possible using the following literature: Peterson 1977, Miller 1978, Lincoff 1981, Barron 1999, Courtecuisse 1999, Foster and Duke 2000, Phillips 2005, Bessette et al. 2007, Ostry et al. 2010.

2.1.3.5 Fish Tissue Monitoring

Fish samples were collected in ORR and control streams, rivers, and reservoirs by the ORNL ESD team. Fish were captured by electroshocking methods to obtain fish tissue and gut content samples for contaminant analysis (bioaccumulation study). Fish sampling protocols recommend at least six fish per sample for laboratory analysis of metals and PCBs. All collected fish were counted and identified to species, weighed, measured, and age estimated (young-of-the-year, juvenile, adult). Fish guts from each specimen were kept frozen at the ORNL ESD laboratory until transfer to TDEC for gut content analysis. Laboratory safety and sample shipping procedures followed the methods of TDEC (2013), TDH (1999), and TDEC DoR-OR SOP 101.

Although most mercury occurs in the inorganic form, methylmercury (MeHg), an organic form, is the most toxic and readily bioaccumulated form of mercury. Methylmercury normally occurs in the environment at extremely low concentrations; however, it is taken up easily by aquatic organisms and bioaccumulated. Methylmercury has been reported to constitute from 70 percent (%) to 99% of the total-Hg in skeletal muscle in fish (Huckabee et al. 1979; USEPA 1985; Riisgård and Famme 1986; Greib et al. 1990; Saroff 1990, Spry and Wiener 1991, Bloom 1992, Southworth et al. 1995,

Environment Canada 2002). The Food and Drug Administration and EPA agree that 0.3 ppm is the protective level for mercury in locally-consumed freshwater fish.

2.1.3.6 Aquatic Vegetation Monitoring

Twenty vegetation samples were collected in 2015 in areas where there was thought to be a greater potential for radiological contamination. Samples consisted of at least one gallon of vegetation, including minimal other debris, and no roots. Samples were then scanned with a radiological instrument for beta and gamma radiation, double-bagged in re-sealable plastic bags, labeled, and transported back to TDEC. Once enough samples were collected, they were processed and sent to the state of TDH environmental laboratory in Nashville for analysis.

Twenty samples, including a background sample, were collected and analyzed for general radiological contamination. Samples were analyzed for gross alpha, gross beta, and gamma radionuclides. Samples were collected near ORR surface water sites, including springs, creeks, and wetlands to determine if radioactive contaminants had accumulated in the associated vegetation. The species sampled were determined based on what was available at the desired sampling locations. Cattails (*Typha* spp.), watercress (*Nasturtium officinale)*, and willow (*Salix* spp.) were used in previous years as they were good at bioaccumulating radiological contaminants. In locations where radiological contamination seemed possible or even likely, but where cattails, watercress, and willow were not available, mixed floodplain vegetation was collected instead. The mixed floodplain vegetation samples were collected from near the edges of water sources, mainly creeks. A similar method to that used for FRMAC (Federal Radiological Monitoring and Assessment Center) vegetation sampling was used, though an area large enough to fill a gallon bag was sampled (NNSA 2012). Sampling mixed floodplain vegetation allowed for a wider variety of locations of potential interest to be sampled by not being limited by vegetation type. At two of the locations, both a cattail sample and a mixed floodplain vegetation sample were collected to see how the two compared. The locations of the samples collected and analyzed for radiological contaminants in 2015 are shown and listed in Figure 2.1.3.6.

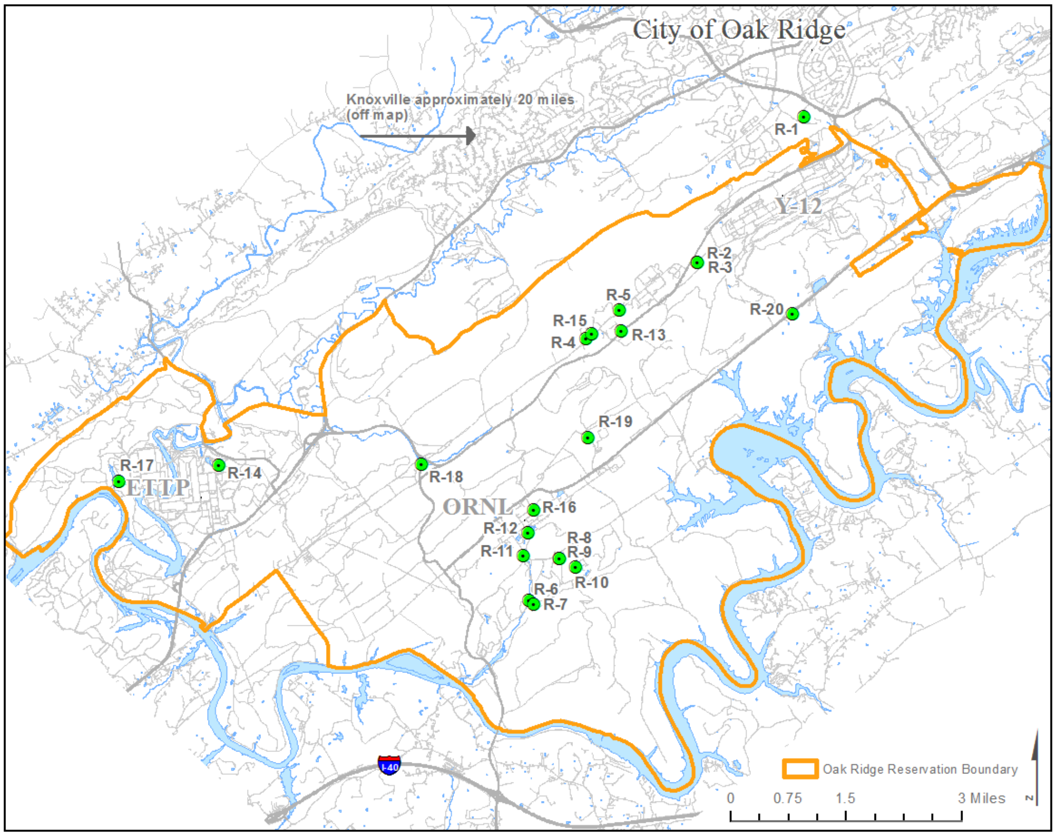


Figure 2.1.3.6 2015 vegetation sampling locations

Table 2.1.3.6 Vegetation Sampling Locations

2015 sites	Location	Vegetation Type
R-1	East Fork Poplar Creek near NOAA/ORCS	mixed
R-2	Y-12 Bear Creek, below S-2, edge of creek	cattail
R-3	Y-12 Bear Creek, below S-2, edge of creek	mixed
R-4	Bear Creek Valley, NT-8 west	mixed
R-5	Bear Creek Valley, NT-6 upstream of haul road	cattail
R-6	ORNL Melton Valley WOC weir	cattail
R-7	ORNL Melton Valley Melton Branch weir	mixed
R-8	ORNL Melton Valley HRE wetland	cattail
R-9	ORNL Melton Valley HRE wetland	mixed
R-10	ORNL Melton Valley HFIR drainage	cattail
R-11	ORNL WOC upstream of Melton Valley Road	mixed
R-12	ORNL WOC upstream of 3rd Street Bridge	mixed
R-13	Y-12 Bear Creek SS-4 Spring	watercress
R-14	ETTP Mitchell Branch	mixed
R-15	Bear Creek Valley NT-8 east	mixed
R-16	ORNL Bethel Valley SWSA2/B4007 area	cattail
R-17	ETTP K901A pond east	cattail, willow

2015 sites	Location	Vegetation Type
R-18	Bear Creek wetland at HWY 95	mixed
R-19	ORNL SNS upper WOC wetland	cattail
R-20	ORNL Spring Creek, near east guard shack, BG	watercress

2.1.3.7 Benthic Macroinvertebrate Monitoring

Benthic macroinvertebrate communities were semi-quantitatively sampled (kick sampling, "SQKICK") between May 7, 2015 and June 9, 2015, using the current US EPA, US Geological Survey, and TDEC, Division of Water Pollution Control standard operating procedures for macroinvertebrates (Barbour et al. 1999, Moulton et al. 2000, TDEC 2006, 2011). Thirteen stream stations were sampled during 2015 on the ORR from the four main watersheds (EFK, BCK, MIK, & WOC). Melton Branch (MEK) is a tributary to WOC. Six other reference streams were also sampled (Table 2.1.3.7, Figures 2.1.3.7.1-2.1.3.7.5).

Table 2.1.3.7.1 Oak Ridge Reservation Benthic Monitoring Sites

Station	Description	Cover	TDEC DWR Designation
EFK 25.1	East Fork Poplar Creek km 25.1	thin canopy	EFPOP015.6AN
EFK 24.4	East Fork Poplar Creek km 24.4	canopy	EFPOP015.2AN
EFK 23.4	East Fork Poplar Creek km 23.4	open	EFPOP014.5AN
EFK 13.8	East Fork Poplar Creek km 13.8	open	EFPOP008.6AN
EFK 6.3	East Fork Poplar Creek km 6.3	canopy	EFPOP003.9RO
HCK 20.6	Hinds Creek km 20.6 Reference	canopy	HINDS012.8AN
CCK 1.45	Clear Creek km 1.45 Reference	thin canopy	ECO67F06
GHK 2.9	Gum Hollow Branch km 2.9 Reference	canopy	GHOLL001.8RO
MIK 1.43	Mitchell Branch km 1.43 Reference	canopy	MITCH000.9RO
MIK 0.71	Mitchell Branch km 0.71	open	MITCH000.4RO
MIK 0.45	Mitchell Branch km 0.45	thin canopy	MITCH000.3RO
BCK 12.3	Bear Creek km 12.3	canopy	BEAR007.6AN
BCK 9.6	Bear Creek km 9.6	canopy	BEAR006.0AN
MBK 1.6	Mill Branch km 1.6 Reference	canopy	FECO67I12
WCK 6.8	White Oak Creek km 6.8 Reference	thin canopy	WHITE004.2RO
WCK 3.9	White Oak Creek km 3.9	thin canopy	WHITE002.4RO
WCK 3.4	White Oak Creek km 3.4	canopy	WHITE002.1RO
WCK 2.3	White Oak Creek km 2.3	canopy	WHITE001.4RO
MEK 0.3	Melton Branch km 0.3	thin canopy	MELTO000.2RO

Figure 2.1.3.7.1 2015 Benthic sites at ORNL (White Oak Creek / Melton Branch)

DigitalGlobe, GeoEye, US Geological Survey, USDA Farm Service Agency (2010) Google Maps [online]

Figure 2.1.3.7.2 2015 Benthic sites at Upper East Fork Poplar Creek

DigitalGlobe, GeoEye, US Geological Survey, USDA Farm Service Agency (2010) Google Maps [online]

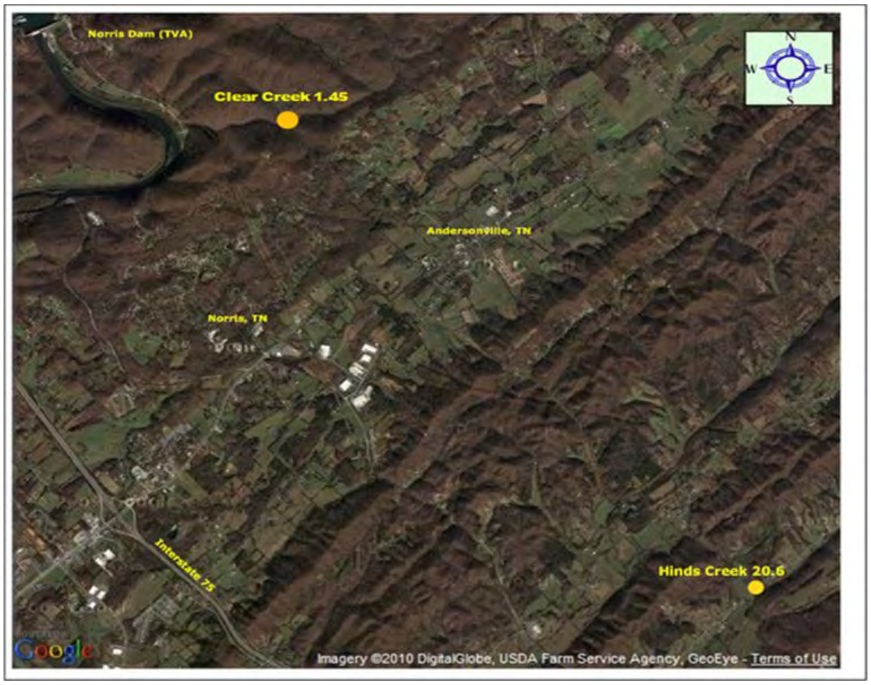


Figure 2.1.3.7.3 2015 Benthic sites at the Hinds Creek & Clear Creek reference streams

DigitalGlobe, GeoEye, US Geological Survey, USDA Farm Service Agency (2010) Google Maps [online]

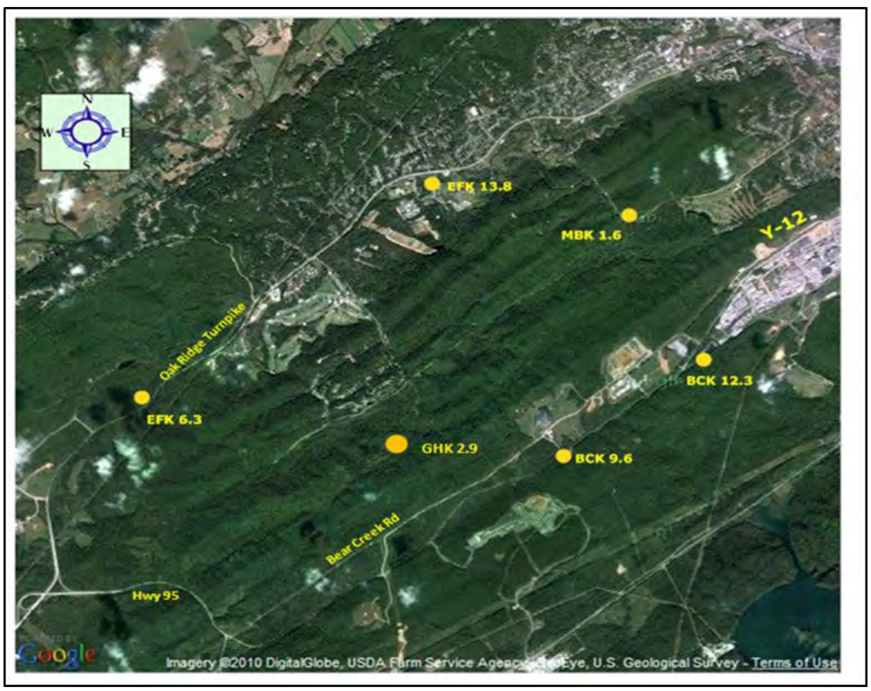


Figure 2.1.3.7.4 2015 Benthic sites at Bear Creek, Mill Branch, Gum Hollow Branch, and Lower East Fork Poplar Creek

DigitalGlobe, GeoEye, US Geological Survey, USDA Farm Service Agency (2010) Google Maps [online]

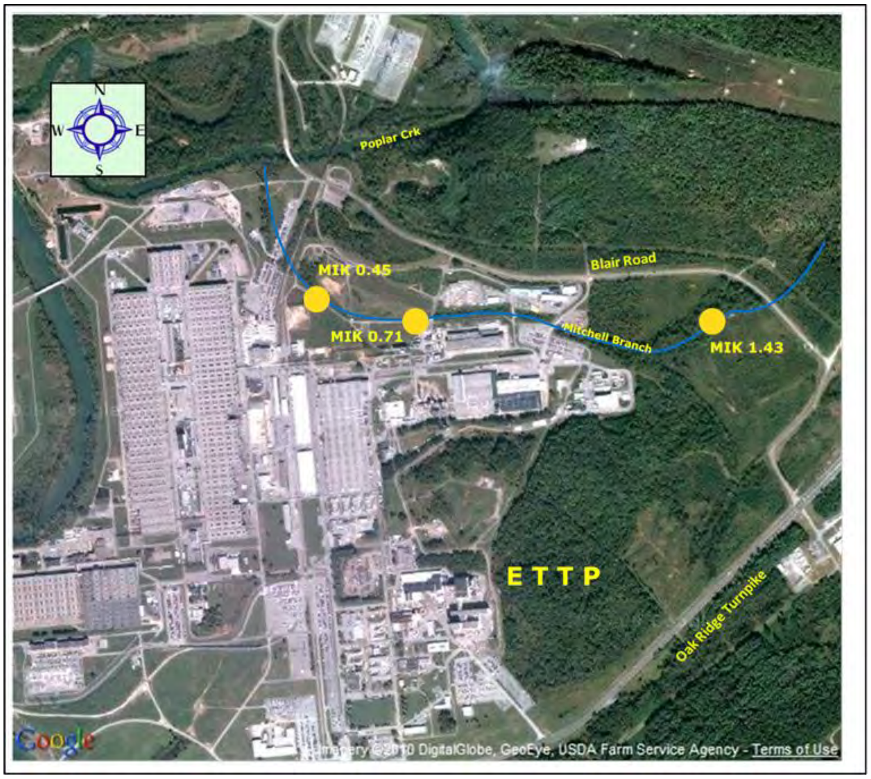


Figure 2.1.3.7.5 2015 Benthic sampling sites at Mitchell Branch
DigitalGlobe, GeoEye, US Geological Survey, USDA Farm Service Agency (2010) Google Maps [online]

Benthic organisms (typically larvae) were collected at each site by combining samples from two similar riffles using a one-square meter kick net (Figures 2.1.3.7.6-2.1.3.7.8). At all sites with the exception of contaminated sites on White Oak Creek (WCK 3.9, WCK 3.4, WCK 2.3) and Melton Branch (MEK 0.3), samples were transferred into labeled sample jars as a composite sample. Benthic macroinvertebrate samples were preserved in 95% ethanol with internal and external site-specific labels. Labeling information included site name, sampling date, and samplers' initials. If more than one sample container was needed at a site, the debris was split evenly with internal and external labels completed for each container. In the case of WCK 3.9, WCK 3.4, WCK 2.3, and MEK 0.3, all samples were laboratory processed in the field to avoid bringing any contaminated sediments back to the TDEC lab.

Surface water samples were collected from each 2015 benthic sampling location. The laboratory results are presented in section 3.1.6.1. Personnel safety while conducting field and laboratory work followed the guidelines of the TDEC Health and Safety Plan (TDEC 2013).

Figure 2.1.3.7.6
Kick sampling

Figure 2.1.3.7.7
Rinsing organisms

Figure 2.31.3.7.8
Picking organisms

Due to the potential for radioactive contamination associated with the lower White Oak Creek / Melton Branch sediments (WCK 3.9, WCK 3.4, WCK 2.3, MEK 0.3), those benthic samples were picked and sorted in the field. Benthic material was separated from the detritus of each of four sub-samples. The picked organisms were then transferred to sealable plastic vials, labeled and preserved in 85% ethanol**.** The remaining benthic samples (BCK, EFK, MIK, and reference stations) were stored and later processed following sub-sampling procedures (picking and sorting) at the TDEC laboratory.

In the laboratory, samples were picked and benthic macroinvertebrates were enumerated and microscopically identified (by TDEC in-house) to the genus and species (where possible) level thus producing raw taxonomic data for each stream station. TDEC Division of Water Pollution Control revision 5 of the macroinvertebrate SOP (TDEC 2011) was used to calculate the metrics and revision 4 (TDEC 2006) was used to aid in interpretation of results. Macroinvertebrate larvae were identified using various taxonomic keys (Edmunds et al. 1976, Simpson and Bode 1980, Brigham et al. 1982, Oliver and Roussel 1983, Stewart and Stark 1988, McAlpine et al. 1981, 1987, Pennak 1989, Wiggins 1996, Needham et al. 2000, Epler 2001, 2006, 2010, Gelhaus 2002, Westfall and May 2006, Merritt et al. 2008, Pfeiffer et al. 2008).

Biological metrics were calculated from the raw data in order to develop an overall site assessment rating. Eight calculated metrics included Taxa Richness, EPT Richness [*Ephemeroptera* (mayflies), *Plecoptera* (stoneflies), *Trichoptera* (caddisflies)], % EPT-*Cheumatopsyche* (% EPT-*Cheum*), % OC (*oligochaetes* and *chironomids*), NCBI (North Carolina Biotic Index), % Clingers, % Nutrient Tolerant organisms and Intolerant Taxa (Table 2, Hilsenhoff 1982, 1987, 1988, KDOW 2009, TDEC 2006, 2011). The EPTs are pollution-sensitive to environmental contamination and the OCs are pollution-tolerant. The biometrics used to generate stream ratings and the expected response of each metric to stress introduced to the system are presented in Table 2.1.3.7.2.

Table 2.1.3.7.2 Description of Metrics and Expected Responses to Stressors.

Category	Metric	Description	Response to Stress
Richness Metrics	Taxa Richness	Measures the overall variety of the macroinvertebrate assemblage	Number decreases
	EPT Richness	Number of taxa in the orders *Ephemeroptera* (mayflies), *Plecoptera* (stoneflies), and *Trichoptera* (caddisflies)	Number decreases
	Intolerant Taxa	Number of taxa in sample that display a tolerance rating of <3.0	Number decreases
Composition Metrics	% EPT-*Cheum*	% of EPT abundance excluding *Cheumatopsyche* taxa	% decreases

Category	Metric	Description	Response to Stress
	% OC	% of *oligochaetes* (worms) and *chironomids* (midges) present in sample	% increases
Tolerance Metrics	NCBI	North Carolina Biotic Index which incorporates richness and abundance with a numerical rating of tolerance	Number increases
	% Total Nutrient Tolerant (%TNUTOL)	% of organisms present in sample that are considered tolerant of nutrients	% increases
Habit Metric	% Clingers	% of macroinvertebrates present in sample w/ fixed retreats or attach themselves to substrates	% decreases

Because some of the streams being monitored on the ORR did not meet the conditions necessary for comparison of results to bioregion biocriteria, an alternative reference stream method cited in the 2011 Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys (TDEC 2011) (with some modifications) was used to evaluate the study's results. The primary condition not met was that certain streams in the study were headwater streams (< 2 sq. mi. of drainage area). The description of the alternative reference stream method is provided in Section 1.I, Protocol K: Pages 3 & 4 of the Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys (TDEC 2011).

In order to generate a table of values for use of comparison of reference stations to potentially impacted stream stations, the eight metrics were first calculated for all of the reference stations (CCK 1.45, GHK 2.9, HCK 20.6, MBK 1.6, MIK 1.43, and WCK 6.8). Based on these average values and using the calculations provided in Section 1.I, Protocol K: Pages 3 & 4 of the Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys (TDEC 2011), ranges of values for ratings of 6, 4, 2, and 0 for each metric were further determined. The results of these calculations are found in Table 2.1.3.7.3.

Table 2.1.3.7.3 Alternative Reference Stream Metrics

Metric	6	4	2	0
Taxa Richness	> 37	24-36	23-Nov	< 11
EPT Richness	>14	9-13	4-8	<4
% EPT- Cheum	>39.81	25.54-39.80	12.27-25.53	<12.27
% OC	<36.22	36.21-57.48	57.47-78.74	>78.74
NCBI	<4.76	4.75-6.51	6.50-8.26	>8.26
% Clingers	>28.71	19.14-28.70	9.57-19.13	<9.57
% TNutol	<37.14	37.13-58.09	58.08-79.04	>79.04

Because some of the streams and stations in the study did not meet the bioregion comparison criteria, some modifications were made to procedures in order to differentiate among the benthic communities in the streams. Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys (TDEC 2011) requires identification of taxa to only the genus level. Taking certain taxa to the species level, where possible, allows for a clearer picture of the health of a site to be developed. Certain genera of mayflies (*Ephemeroptera*) may have more than one species occurring at a sample site. This is particularly true of the genera *Baetis* and *Maccaffertium*. Reference sites may contain as many as five species in these combined genera, whereas an impacted site may only have two of these species, if any. Because of this difference, the numbers generated for EPT Taxa Richness,, and Total Taxa Richness could vary (increase) when using species level identification versus genus level identification. Species level identification could also be important in other genera including the caddisflies *Pycnopsyche* and *Neophylax*. Calculations of all metrics for this study were done using the species level identifications.

2.1.4 Drinking Water

2.1.4.1 Sampling of Oak Ridge Reservation Potable Water Distribution Systems

The oversight of the water distribution systems included random inspections of ORNL and Y-12 to check free residual chlorine levels of the potable water in the distribution systems. Chlorine residual was checked using a Hach Pocket Colorimeter™ following Method 8021 (procedure is equivalent to USEPA method 330.5 for wastewater and Standard Method 4500-Cl G for drinking water) as explained in the equipment manual.

2.1.5 Groundwater

2.1.5.1 Springs

Springs and seeps were sampled according to standard operating procedures enumerated by the EPA, and TDEC (TDEC 2004). Parameters such as pH, temperature, oxidation-reduction potential, and conductivity were collected before sampling and recorded in the field notes. Springs were sampled based on field observation of flow and safety considerations. The sampling period was for a single sampling event for each spring. The need for time series sampling will be determined for future sampling efforts.

Table 2.1.5.1.1 contains locations, analyses, and rationale as described below. Waters influenced by ETTP were analyzed for Tc-99. Waters influenced by ORNL were analyzed for Sr-89/90. If a spring shows a gross alpha activity greater than five picocuries/liter, then a radionuclide isotope-specific analysis for alpha emitters may be performed on the laboratory-archived sample.

Analysis at all sampling locations (Table 2.1.5.1.2) included cation/anion parameters, calcium, magnesium, sodium, potassium, chloride, sulfate, nitrate, bicarbonate (total alkalinity), and carbonate (total hardness) in order to calculate ionic charge balances, and to perform groundwater geochemical “fingerprints”. A list of metals, as seen in Table 2.1.5.1.2, was considered for analysis at all locations. Volatile organic compounds (VOCs) were analyzed from samples collected at all springs.

Radiochemical requests for analysis were varied, as seen in Table 2.1.5.1.2, due to the area where the spring is located and a request by other investigators to collect water for radon and isotopic uranium analyses. The analysis for radon required a special collection technique and special 40 milliliter (mL) vial containers that required an overnight delivery of the sample to the TDH environmental lab in Nashville. One sample location (SD-430) was visited in March 2015 and was sampled for radiological analysis only. The parameters for analysis are gross alpha and gross beta activity and technetium 99.

Samples were collected using approved TDEC and EPA sampling procedures. Field and trip blanks (QA/QC) were utilized to ensure the security/quality of the samples during collection and shipping to the laboratory for analysis. Nanopure or organic free water was used as trip blanks for VOCs. Temperature control bottles were also used in coolers that were shipped to the laboratory to ensure the samples in that cooler did not arrive at the laboratory above six degrees centigrade.

Table 2.1.5.1.1 Sampling Locations

LOCATION No.	ANALYTES	LOCATION	SAMPLING RATIONALE	Date SAMPLED
2015SPGEMP-01	M, I, V, R1	Grassy Creek Spring/Mossy Rock Spring	Spring that drains Bear Creek Valley and the Firing Range	Not Sampled
2015SPGEMP-02	M, I, V, R4	Turnpike Spring	Regional offsite spring EMDF baseline	7/8/2015
2015SPGEMP-03	M, I, V, R1	CCC-Spring	Regional Base flow spring in the Copper Ridge Formation	6/10/2015
2015SPGEMP-04	M, I, V, R1	Poplar Spring	Base flow spring offsite in Bethel Valley	6/10/2015
2015SPGEMP-05	M, I, V, R6	Jacks Spring	Drains Walker Branch And Chestnut Ridge not sampled since 1998	5/20/2015
2015SPGEMP-06	M, I, V, R2	N.W. Tributary Spring	Spring drains parts of WAG 3	5/27/2015
2015SPGEMP-07	M, I, V, R6	Gaston Spring	Base flow spring that drains Chestnut Ridge/Landfills	5/20/2015
2015SPGEMP-08	M, I, V, R6	Green Barn Spring	Base flow spring that drains Chestnut Ridge/Landfills	5/20/2015
2015SPGEMP-09	M, I, V, R1	Edwards Spring	Offsite regional base flow spring	7/8/2015
2015SPGEMP-10	M, I, V, R2	Blue Spring (CEC Spring)	Regional base flow spring	Not Sampled
2015SPGEMP-11	M, I, V, R6	Horizon	Spring drains East Ridge area	7/8/2015
2015SPGEMP-12	M, I, V, R7	JES Sludge Seep	Below EMWMF, Oil Landfarm and Bone Yard Burn Yard	Dry
2015SPGEMP-13	M, I, V, R2	Kevin's Spring	Base flow spring for UEFPC and north slope of Chestnut Ridge	6/3/2015
2015SPGEMP-14	M, I, V, R2	Outfall 2 Spring	Drains northeast end of Y-12	6/3/2015
2015SPGEMP-15	M, I, V, R3	Sugar Grove Spring	Offsite regional base flow spring	Not Sampled
2015SPGEMP-16	M, I, V, R3	JAJONES Spring	Last sampled in 2005 check on remediation	9/2/2015
2015SPGEMP-17	M, I, V, R2	Rifle Range Spring/0956 Spring	Spring drains Chestnut Ridge towards ORNL	5/27/2015
2015SPGEMP-18	M, I, V, R2	Crooked Tree Spring	Spring drains WAG 6	5/27/2015

LOCATION No.	ANALYTES	LOCATION	SAMPLING RATIONALE	Date SAMPLED
2015SPGEMP-19	M, I, V, R3	Dead Horse Spring	Regional OFFSITE Spring	Not Located
2015SPGEMP-20	M, I, V, R1	Love Spring	Regional offsite spring downgrade from ETTP	6/10/2015
2015SPGEMP-21	M, I, V, R3	Syncline Spring	Drains large portion of ETTP	Dry
2015SPGEMP-22	M, I, V, R6	MVMR	Base flow spring that drains Chestnut Ridge/Landfills	5/20/2015
2015SPGEMP-23	M, I, V, R6	RCB Spring	Regional spring downgrade from Y-12	Inundated
2015SPGEMP-24	M, I, V, R3	TOMSSEEP	Off of Mitchell Branch Contains VOCs	9/2/2015
2015SPGEMP-25	M, I, V, R2	Eddies Spring	Copper Ridge Spring	Dry
2015SPGEMP-26	M, I, V, R2	Sycamore Spring/Raccoon Creek Tributary	Spring drains parts of WAG 3	Not Sampled
2015SPGEMP-27	M, I, V, R3	Regina Loves Bobby Spring	Spring offsite near ETTP	7/8/2015
2015SPGEMP-28	M, I, V, R7	SS-5 Spring	Spring drains most of western Y-12/SNS/EMWMF	6/22/2015
2015SPGEMP-29	M, I, V, R7	SS-7 Spring	Spring drains most of western Y-12/EMWMF	6/22/2015
2015SPGEMP-30	M, I, V, R1	Gallaher Spring	Regional offsite spring in Bear Creek Valley	Not Sampled
2015SPGEMP-31	M, I, V, R7	SS-4 Spring	Spring drains most of western Y-12/Bear Creek	6/22/2015
2015SPGEMP-32	M, I, V, R3	21002 Spring	Basin contains K-1070A	9/2/2015
2015SPGEMP-33	M, I, V, R1	Gum Branch 1 Spring	Not Sampled Before baseline spring for EMDF	Not Sampled
2015SPGEMP-34	M, I, V, R1	Gum Branch 2 Spring	Not Sampled Before baseline spring for EMDF	Not Sampled
2015SPGEMP-35	M, I, V, R1	Pinhook Spring	Not Sampled Before baseline spring for EMDF	Not Sampled
2015SPGEMP-36	M, I, V, R3	Rarity Spring	Regional spring downgrade from ETTP	Inundated
2015SPGEMP-37	M, I, V, R5	USGS 10-895 Spring	Drains ETTP North Rail Yard, K-1070A	7/8/2015
2015SPGEMP-38	M, I, V, R2	Bootlegger Spring	Base flow spring that drains Chestnut Ridge/Security Pits	6/3/2015
2015SPGEMP-39	M, I, V, R1	Cattail Spring/Cattail Spring East	Spring drains east end of Y-12 volatile plume	6/3/2015
2015SPGEMP-40	M, I, V, R1	Mtn. Dew/Overhang Spring	Base flow spring offsite in Bethel Valley	6/10/2015
SD-430	R8	SD-430 Spring	ETTP, flow from K-25 Building	3/26/2015

M	Metals from Table 2									
V	Volatile Organic Compounds									
I	Inorganics from Table 2									
R1	Gamma Radionuclides	Gross Alpha	Gross Beta	Sr-89/90	Tc-99	Tritium				
R2	Gamma Radionuclides	Gross Alpha	Gross Beta	Sr-89/90		Tritium				
R3	Gamma Radionuclides	Gross Alpha	Gross Beta		Tc-99	Tritium				
R4	Gamma Radionuclides	Gross Alpha	Gross Beta	Sr-89/90	Tc-99					
R5	Gamma Radionuclides	Gross Alpha	Gross Beta	Sr-89/90						
R6	Gamma Radionuclides	Gross Alpha	Gross Beta			Tritium				
R7	Gamma Radionuclides	Gross Alpha	Gross Beta	Sr-89/90	Tc-99	Tritium	Radon-222	U-233/U-234	U-235	U-238
R8		Gross Alpha	Gross Beta		Tc-99					

Table 2.1.5.1.2 Analytes for Collected Samples

METALS		
Aluminum	Iron	Potassium
Arsenic	Lead	Selenium
Barium	Lithium	Sodium
Cadmium	Magnesium	Strontium
Calcium	Manganese	Uranium
Chromium	Mercury	
Chromium, Hexavalent Sample not analyzed	Nickel	
INORGANICS		
Alkalinity as $CaCO_3$ (total alkalinity)	Nitrate by IC	Nitrate and Nitrite
Boron	pH	
Chloride by IC	Residue, Dissolved	
Conductivity	Sulfate	
Hardness as $CaCO_3$ (total hardness)		
RADIOLOLOGIC		
Gross Alpha/Beta by LSC*	Strontium 89/90	Technetium-99
Gamma Radionuclides	Tritium	Radon-222 (SS-4, SS-5, SS-7 springs)
Uranium-233/234 (SS-4, SS-5, SS-7 springs)	Uranium-235 (SS-4, SS-5, SS-7 springs)	Uranium-238 (SS-4, SS-5, SS-7 springs)
VOLATILE ORGANIC COMPOUNDS		
SDWA** 524.2		

* Liquid Scintillation Counting

** Safe Drinking Water Act

Spring samples were collected using one of two methods. The method used for the majority of this project was the peristaltic pump method. This consists of placing a length of high-density polyethylene (HDPE) tubing into the spring issuance or pool. Placing the tubing below the surface of the water resulted in samples collected from water more representative of the true concentrations. Radiochemical samples were collected first, then inorganic samples. Organic samples were collected last using the tubing but not using the pump to fill the tubing. A syringe is attached to the pump end of the tubing after being detached from the pump. The length of the tubing was determined to hold at least 60 milliliters (ml) of water. After using the syringe to pull water into the tubing, the water was transferred from the tubing into clean vials for VOC analysis. This was repeated until the set of vials were filled.

The second method of collection was dipping the bottles into the water being careful not to lose preservatives. This method was used for the 5/20/2015 sampling event and for individual samples at 2015SPGEMP-14 (Outfall 2 spring) and at 2015SPGEMP-02 (Turnpike spring). The flow at the latter springs was large enough that a representative sample was collected by dipping the bottle.

Standard Operating Procedures followed:

- EPA SESDPROC-203-R3 Pump Operation, September 12, 2013
- Division of Water Pollution Control QS-SOP for Chemical & Bacteriological Sampling of Surface Water Revision 4 Effective Date, August 1, 2011
- EPA SESDPROC-301-R3 Groundwater Sampling, March 67, 2013
- TDEC SOP 101, Shipping Samples to the State Lab in Nashville, March 2, 2015

2.1.5.2 Offsite Residential Well Monitoring

Offsite Residential Well Monitoring
The off-site groundwater assessment by TDEC in 2015 consisted of the collection and analysis of samples from the areas southwest and south of the ORR (see Figure 2.1.5.2.2). The water samples were analyzed for radiochemicals, inorganics, and VOCs. Analysis of the samples was conducted either by the TDH environmental laboratory, or, for uranium and transuranic isotopes, by a contract laboratory. All samples were collected and handled according to relevant TDEC standard operating procedures with no deviations being reported.

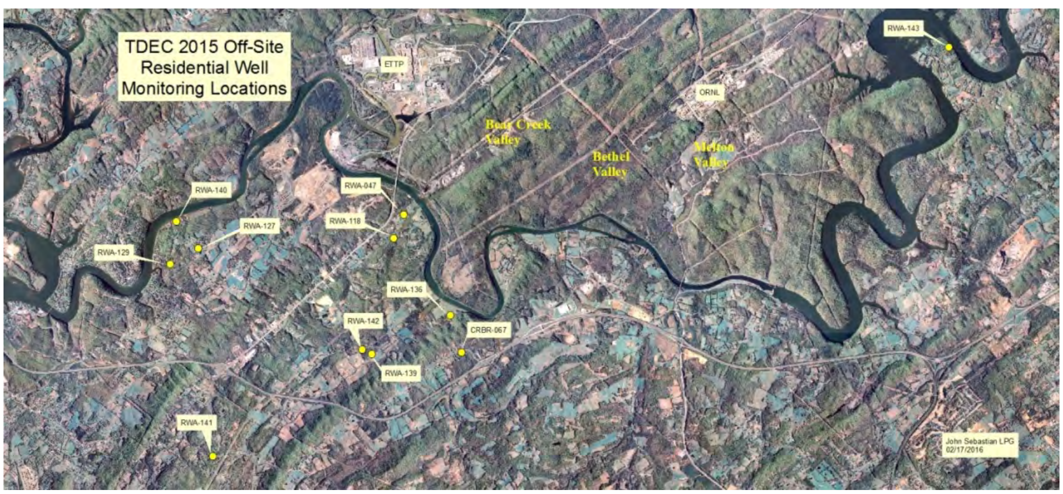


Figure 2.1.5.2.2 2015 study area sampling locations

Background Residential Monitoring
This project was unfinished in 2015. The initial task of the first phase included a search of all residential wells to the northeast of the ORR. In addition, the task sought consent from landowners for the state to sample and acquire well completion information to determine what formation(s) the water may be coming from. A door-to-door survey was started with just a few wells identified.

The background sampling program needs to be completed in two phases with multiple tasks. The first phase is to do a thorough search of the area northeast of the ORR and collect initial groundwater samples. Figure 2.1.5.2.3 shows potential targets from the state of Tennessee well database for Anderson County. The second step of the first phase is to sample a target population of the wells to determine the hydrogeologic characteristics and provide initial sample results from a list of potential contaminants of concerns. The goal is to sample enough potential targets to identify the

four hydrogeologic water quality zones discussed in the conceptual model section. The second step may be a multiyear process, with an estimate of approximately 20 samples.

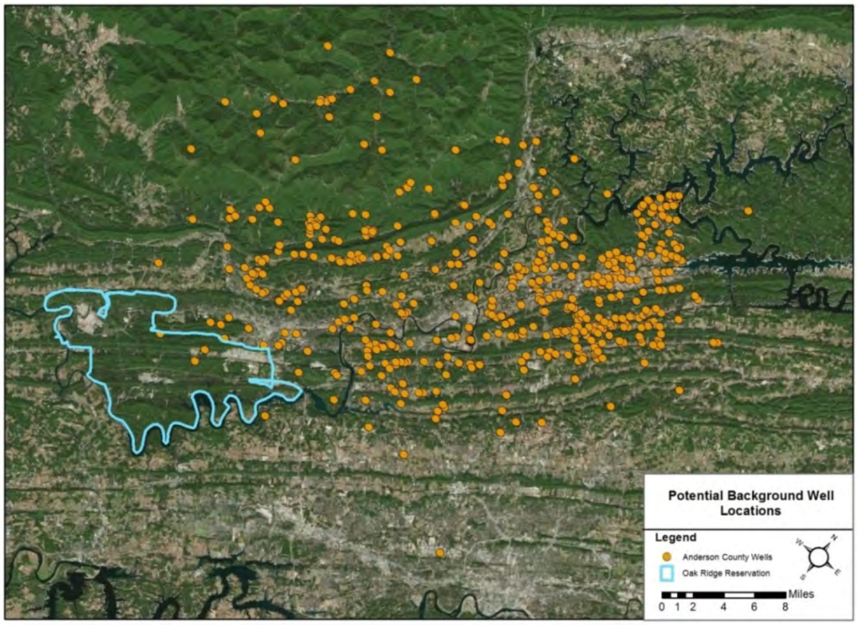


Figure 2.1.5.2.3 Potential background well survey locations

2.1.6 Surface Water / Sediment

2.1.6.1 Ambient Sediment Monitoring Program

Sediment samples were taken during May and September 2015 using the methods described in the TDEC Sediment Monitoring SOP. At least three grab samples were taken at each site; the grab samples were combined and containerized for transport. The TDH environmental laboratory processed the samples according to EPA approved methods. Samples were analyzed for arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, mercury, and nickel. In addition, samples were analyzed for gross alpha, gross beta, and gamma radionuclides. Table 2.1.6.1 lists the sampling locations and the rationale for the monitoring.

Table 2.1.6.1 Ambient Sediment Sampling Sites

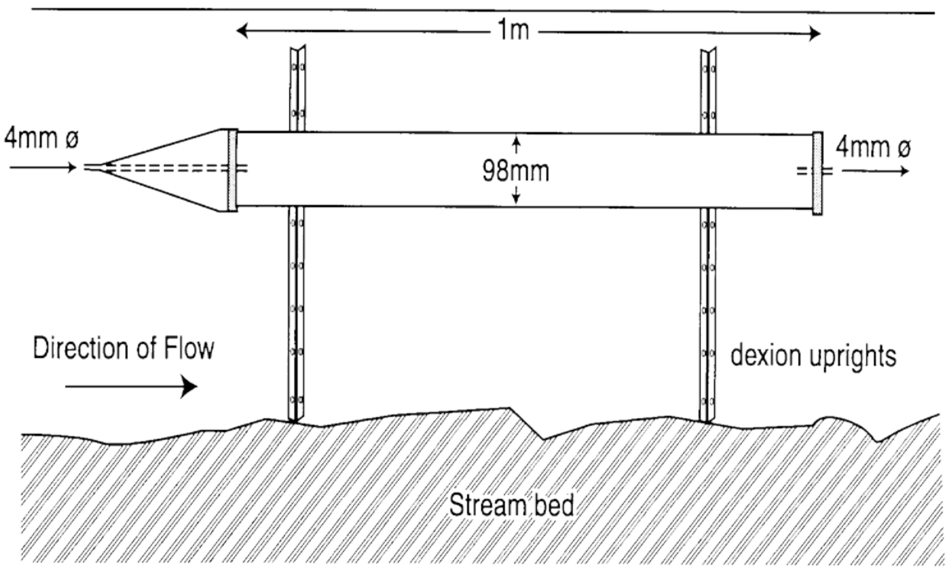
Monitoring Location	ID	Alternate ID	Monitoring Rationale
Clinch River Mile 48.7	CLINC048.7AN	CRK78.4	Reference site upstream of DOE facilities
Clinch River Mile 23.2	CLINC023.2RO	CRK37.3	Sediment depositional area upstream of White Oak Creek outfall
Clinch River Mile 14.5	CLINC014.5RO	CRK23.3	Sediment depositional area downstream of White Oak Creek outfall
Clinch River Mile 10.0	CLINC010.0RO	CRK16.1	Sediment depositional area downstream of White Oak Creek and

Monitoring Location	ID	Alternate ID	Monitoring Rationale
			Poplar Creek outfalls
Clinch River Mile 0.0	CLINC000.0RO	CRK0.0	Sediment depositional area downstream of all DOE inputs
Poplar Creek Mile 3.5	POPLA003.5RO	PCK5.6	Sediment depositional area downstream of Mitchell Branch and East Fork Poplar Creek outfalls
East Fork Poplar Creek Mile 3.9	EFPOP003.9RO	EFK6.3	Sediment depositional area downstream of Y-12 influence
Bear Creek Mile 2.8	BEAR002.8RO	BCK4.5	Sediment depositional area downstream of Y-12 influence
Mitchell Branch Mile 0.1	MITCH000.1RO	MIK0.1	Sediment depositional area downstream of ETTP influence

2.1.6.2 Ambient Trapped Sediment Monitoring

Sediment traps were deployed at the following approximate stream locations: East Fork Poplar Creek km (EFK) 6.3, 13.8, 23.4, Bear Creek km (BCK) 4.5, 7.6 and at NT5 (Figure 2.1.6.2.1). The sediment traps were modeled after a design described by Phillips *et al.* (2000) (Figure 2.1.6.2.2). Figure 2.1.6.2.3 shows one of the sediment traps; the body is constructed of four-inch (4") polyvinyl chloride (PVC) pipe with 4" fittings. The other fitments of the trap are common items available in most hardware stores. The sediment traps were fastened to the streambed with metal stakes and traps were oriented horizontally in an orientation parallel to the flow of the current (Figure 2.1.6.2.4). Safety caps constructed of PVC pipe were attached to tops of the metal stakes. Once deployed, the sediment traps were visited weekly for maintenance. Debris was removed from the sediment trap and the inlet and outlet tubes were cleared of algae and biofilm with a brush. All traps were deployed for approximately six months, from March 31 to October 6, 2015. Other methods used were TDEC 1996 and USEPA Sediment Sampling 2010.

Figure 2.1.6.2.1 Ambient sediment sampling site locations



Phillips *et al.* (2000)

Figure 2.1.6.2.2 Sediment trap design

Figure 2.1.6.2.3 Photo of sediment trap

Figure 2.1.6.2.4 Sediment trap deployed

2.1.6.3 Ambient Surface Water Monitoring

In May of 2015, TDEC conducted surface water sampling at the following impacted ORR watersheds: BCK, EFK, MIK, RCK, and WCK. In September, the Clinch River was sampled. Samples were analyzed by the TDH environmental laboratory for nutrients, metals, and radiological analyses. Conductivity, pH, dissolved oxygen, and temperature were measured with YSI© Professional Plus multi-parameter water quality instruments. The surface water monitoring program followed the 2011 TDEC WPC Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water. In addition, all work associated with this program was conducted in compliance with the TDEC Health and Safety Plan*.* The analyses from some of these stations will be used by the benthic macroinvertebrate monitoring project. Assessment of the surface water quality of a stream can more accurately determine the stream's total overall biological health.

Samples were taken for the following parameters:

- Inorganics: ammonia, nitrate & nitrite (NO^3 & NO^2), total dissolved solids, total suspended solids, total hardness, Kjeldahl nitrogen, total phosphorus
- Metals: arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, and zinc
- Radionuclides: gamma radionuclides, gross alpha, and gross beta

2.1.6.4 Surface Water Physical Parameters Monitoring

Discrete Ambient Surface Water Physical Monitoring

The measured parameters were temperature, pH, conductivity, and dissolved oxygen. Both YSI© 556 MPS and YSI© Professional Plus multi-parameter water quality instruments were used to collect the data. The instruments were calibrated prior to operation in the field. During each stream

examination, the data was recorded in a field notebook including time, date, and weather conditions. Unusual occurrences relating to stream conditions were noted.

If field readings such as pH and conductivity were beyond benchmark ranges, then the following actions were taken: 1) wait 24 hours, re-calibrate the instrument, and collect new physical parameter readings; 2) if readings were still deviant, investigate possible causes (defective equipment, storm surge/rain events, releases that may have affected pH, etc.); 3) following the investigation, report findings to appropriate program(s) within the office to determine if further action is needed. Field and monitoring methods, and health and safety procedures were followed per the TDH Standard Operating Procedures (TDH 1999), and the TDEC Health and Safety Plan (TDEC 2013).

Continuous Surface Water Physical Monitoring

Continuous water quality parameters were taken at three locations at Y-12. Water quality parameters were collected utilizing an In-Situ® Troll 9500 multiparameter water quality monitoring probe. A YSI-556/YSI© Professional Plus was used periodically to check the performance of the In-Situ® Troll 9500, and to aid in adjusting for sensor drift corrections. The continuous data are plotted and presented in Section 3.1.6.2 with total daily precipitation data collected from the nearest meteorological tower.

2.1.6.5 Rain Event Surface Water Monitoring

TDEC selected eight locations that were sampled after qualifying rain events. Figure 2.1.6.5.1 shows the rain event surface water monitoring locations. Mill Branch (MBK 1.6) serves as the reference location and is located off the ORR. Sites were selected based on the areas feeding the sites and the COCs in the surrounding area. The rationale behind the selected sites is provided in Table 2.16.5.

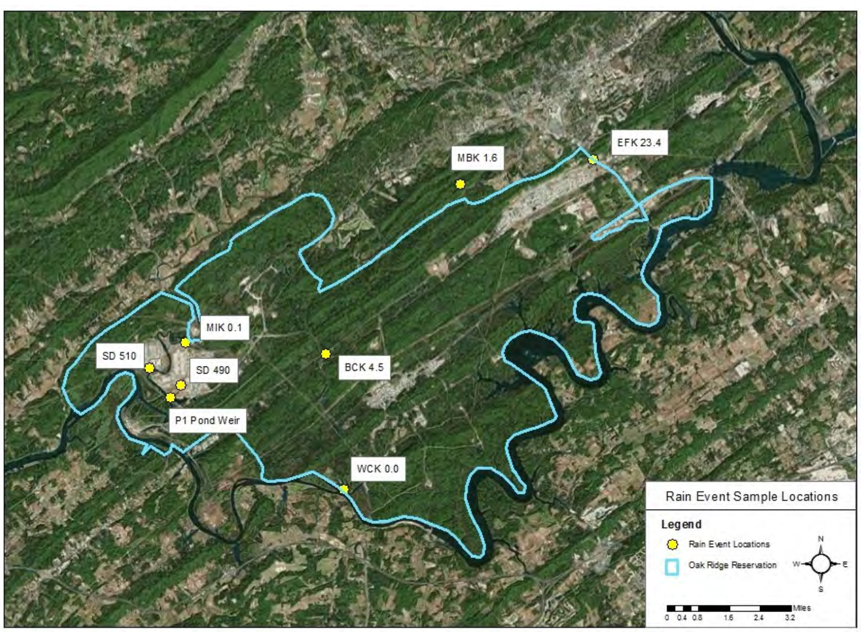


Figure 2.1.6.5.1 Rain event surface water monitoring locations

Table 2.1.6.5 Sample Locations and Rationale

Location	Rationale
EFK23.4	Monitor of Mercury in East Fork Popular Creek
WCK0.0	Legacy contamination in White Oak Creek
BCK4.5	Runoff from Y-12, Coverage of EMWMF
MBK1.6	Background location
SD490	Discharge point for Tc99 area of concern
P1 Pond Weir	ETTP Drain Point location
MIK0.1	Monitoring of ETTP & Hexavalent Chrome Removal System
SD510	Monitoring of D&D activities in area

Rain event samples were collected following rain events on January 15, 2015, April 15, 2015, July 15, 2015, and November 19, 2015. A YSI© Professional Plus water quality meter was calibrated according to the manufacturer's instructions prior to sampling. Following the sampling event the instrument was challenged using the field instrument drift check guidance provided in the TDEC Water Pollution Control Quality System SOP for Chemical and Bacteriological Sampling of Surface Water, August 2011. All samples collected were grab samples taken according to the TDEC SOP. Surface water samples collected were analyzed by the TDH environmental lab for the following parameters:

Metals: arsenic, cadmium, chromium, copper, lead, manganese, zinc, mercury, and iron. Hexavalent chromium was collected at MIK0.1, SD490, SD510, and the P1 Pond Weir. Uranium was sampled at WCK0.0, P1 Pond Weir, MBK1.6, and SD510 during the 1st quarter of 2015. Uranium was sampled at P1 Pond Weir, MBK1.6, SD510, and SD490 during the 2nd, 3rd, and 4th quarters of 2015.

Radionuclides: Gamma Radionuclides samples were collected for analysis from all sites during the first three quarters of 2015. Gamma was only collected at WCK0.0 during the fourth quarter. Gross alpha and gross beta was collected from all sites. Strontium 90 was collected for analysis at WCK0.0. Tritium sampled at SD490 and the P1 Pond Weir. Tc-99 was sampled at SD510, SD490, and the P1 Pond Weir.

PCBs: Polychlorinated Biphenyls (PCBs) were sampled for at SD510.

Data Collection Problems:
Due to a failure of the sampling equipment, (a hand pump lost its seal and allowed contamination of the sample bottle) no hexavalent chromium sample was obtained during the July 15, 2015 sampling event at the P1 Pond Weir.

2.2 Site Specific Monitoring

2.2.1 Haul Road

TDEC personnel, performing weekly inspections, log in at the ETTP transportation hub. Site personnel were advised that TDEC would be walking the road to perform the survey. The DOE contractor responsible for the road briefs TDEC on any known conditions that could present a safety

hazard. The contractor also provides a two-way radio to maintain communication should unforeseen conditions arise that could present a safety hazard while on the road. Where excessive traffic presented a safety concern, the survey was postponed to a later date. Alternate entrances were used to access the road with DOE approval, but the basic requirements remained in effect.

No less than two people performed the surveys, each walking in a serpentine pattern along opposite sides of the road. A Ludlum Model 2221 Scaler Ratemeter with Model 44-10 2"X2" sodium iodide (NaI) gamma scintillator probe held approximately six inches above the ground surface was used to scan for radioactive contaminants.

Anomalous items found during the survey were marked with contractor's ribbon at the side of the road and a description of the item and its location logged and reported to DOE and its contractors for disposition. Due to the association with CERCLA activities and potential contamination, each anomalous item was surveyed for radiological contamination, the findings were included in the above report, and the item was flagged with yellow contractor's ribbon. The radiological contamination was documented in disintegrations per minute per 100 cm^2 ($dpm/100cm^2$) and compared to the limits set forth in U.S. Atomic Energy Commission Regulatory Guide 1.86. Instrumentation and procedures used in the radiological assessments were recorded. Table 2.2.1 provides the current inventory of equipment available to TDEC for such assessments.

When TDEC returns to the road for the next weekly inspection, they perform a follow-up inspection of the flagged anomalous items found in previous weeks. If the anomalous items were removed, the flagging will be pulled. If any anomalous items remain, they were included in subsequent reports, until removed by DOE personnel, or advised the item(s) have been determined to be free of radioactive and hazardous constituents.

Table 2.2.1 TDEC Oak Ridge Office Portable Radiation Detection Equipment

Radiological Detection Instruments	Radiological Detection Probes	Radioactivity Measured
Ludlum Model 2221 Scaler Ratemeter	Ludlum Model 44-10 2x2 inch NaI Gamma Scintillator	Gamma (cpm)
Ludlum Model 3 Survey Meter	Ludlum Model 44-9 Pancake G-M Detector	Alpha, Beta, Gamma (cpm)
Ludlum Model 3 Survey Meter	Ludlum Model 43-65 50 cm2 Alpha Scintillator	Alpha (cpm)
Bicron Micro-Rem	Internal 1x1inch NaI Gamma Scintillator	Tissue Dose Equivalent, Gamma (μrem/hr)
Ludlum Model 2224 Scaler/Ratemeter	Ludlum Model 43-93 Alpha/Beta Scintillator	Alpha, Beta
Ludlum Model 48-2748	Gas proportional detector with 821 cm^2 active.	Alpha, Beta
Identifinder-NGH	Isotopic Identifier and Ratemeter	Gamma Spectroscopy and Dose Rate Meter

cpm – counts per minute
μrem/hr – microrem per hour

2.2.2 CERCLA Landfill (EMWMF)

2.2.2.1 Monitoring Liquid Effluents, Surface Water, Groundwater

This project was divided into five tasks and the individual task methods and materials are listed here:

Task 1

Continuous water quality parameters were taken at two locations at EMWMF. Water quality parameters were collected utilizing an In-Situ® Troll 9500 multi-parameter water quality monitoring probe. A YSI-556/YSI© Professional Plus was used periodically to check the performance of the In-Situ® Troll 9500, and to aid in adjusting for sensor drift corrections. The continuous data are plotted with total daily precipitation data collected from the nearest meteorological tower. Continuous monitoring of physical parameters at EMWMF-2 was from January 1 through December 31, 2015. Another In-Situ® Troll 9500 was deployed at EMWMF-3 to monitor the sediment basin discharge from March 17 to December 31, 2015. Graphs of EMWMF-2 and EMWMF-3 are presented in Figures 2.2.2.1.1 and 2.2.2.1.2, respectively.

Task 2

Water samples were collected on a routine basis or as opportunity arises / conditions merit the monitoring of water discharges. Table 2.2.2.1.1 and Figure 2.2.2.1.1 illustrate locations of interest at EMWMF, analytes and rationale for sampling. To assess compliance with the DOE limit placed on radionuclides released from the contact water ponds and tanks (100 mrem/yr), samples were collected from the discharge of contact water as it was pumped to the drainage ditch at the contact water ponds (EMW-CWP). At the estimated time of the peak flow of the released contact water, samples were taken of the discharge from the v-weir at the basin (EMW-VWEIR). This is done to assess compliance with the TDEC limit for the outfall of the sedimentation basin. Analyses focused on those radionuclides that have historically contributed the most to the annual dose limits for each location. To evaluate the performance of the liner and associated EMWMF monitoring, samples were collected from the underdrain (EMW-VWUNDERDRAIN). To capture contaminants that could be migrating from the cells laterally in shallow groundwater, the NT-3 and NT-5 tributaries were sampled down gradient of the waste cells under base flow and high flow conditions, at locations currently monitored under the EMWMF surface water program (EMWNT-03a & EMWNT-05). GW-918 was co-sampled with DOE as a background well.

Task 3

TDEC instrumented eight monitoring wells or piezometers with HOBO® U20 water level and U24 conductivity continuous data loggers to determine how water levels, temperature, and conductivity behave with changes in precipitation. The locations of the wells and piezometers monitored are provided in Figure 2.2.2.1.1. The wells selected were based on a general cross section from Pine Ridge to Bear Creek Valley in order to gain a better understanding of the dynamics that precipitation, groundwater flow, and geology have on the proposed EMDF landfill below the southern slope of Pine Ridge (Figure 2.2.2.1.2). The rationale for selecting specific wells for

monitoring is provided in Table 2.2.2.1.1. Table 2.2.2.1.2 provides well and well construction information during the initial deployment of the data loggers.

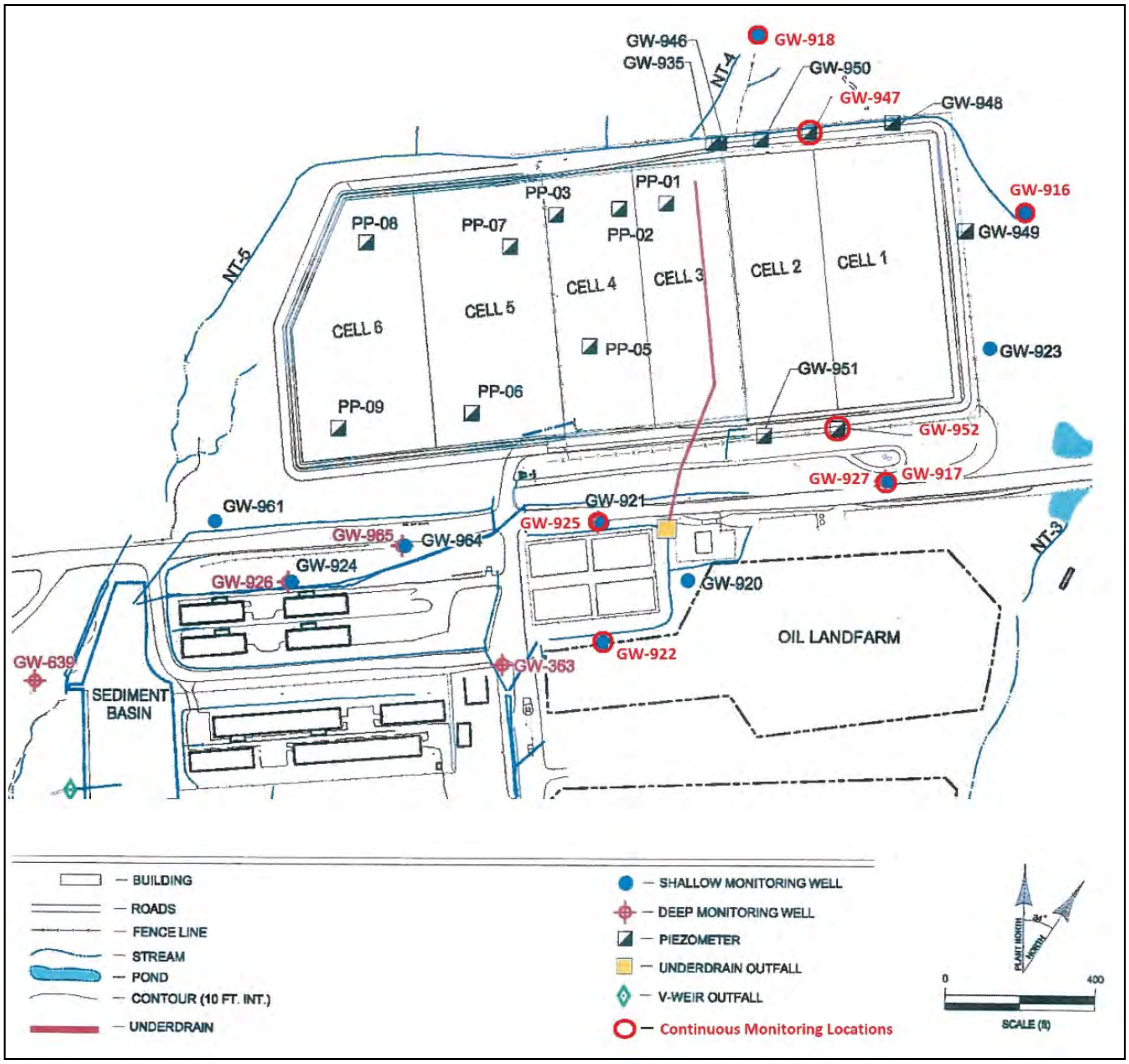


Figure 2.2.2.1.1 Continuous monitoring locations

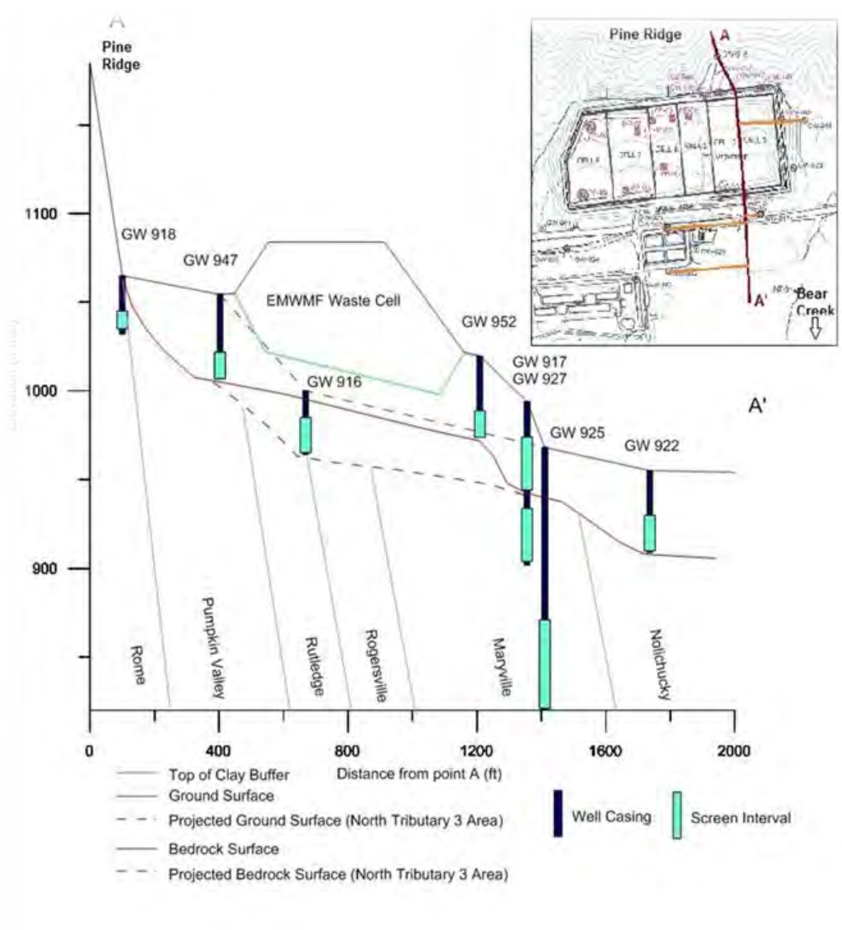


Figure 2.2.2.1.2 Cross section from Pine Ridge toward Bear Creek at EMWMF (A to A')

Table 2.2.2.1.1 Continuous Groundwater Monitoring Locations

Well/ Piezometer	Rationale
GW-918	Will help understand hydrogeologic conditions along Pine Ridge
GW-947	The fluctuating seasonal groundwater levels have been near, at, or above the ground surface
GW-952	Seasonal fluctuation in groundwater levels have been observed
GW-916	Is close to a seep and an existing wetland near EMDF, near NT-3
GW-917	Overburden well, paired with GW-927. The well pair shows an upward gradient.
GW-927	Bedrock well, paired with GW-917. The well pair shows an upward gradient.
GW-925	This well is hydraulically connected to NT-4 (water levels decreased when underdrain was installed) - see how NT-4 responds to rain events and other variations
GW-922	Little groundwater fluctuations have been previously observed, near NT-4 - see how lower NT-4 responds to seasonally and to rain events

Table 2.2.2.1.2 Well Construction and Data Logger Set-up Information

Well ID	Continuous Monitoring Start Date	Depth to Groundwater on Start Date (ft TOC)	Top of Casing Elevation (ft msl)	Land Surface Elevation (ft msl)	Top of Screen Elevation (ft msl)	Total Well Depth (ft msl)	Equipment in Well	Depth to Obstruction or Total Depth (ft TOC)	Approximate Length of Wire Used to Secure Pressure Transducer
GW-918	9/16/2014	5.6	1067.96	1065	1045.00	1032.00	Well Wizard	24.75	22.10
GW-947	9/16/2014	16.72	1056.5	1054.4	1021.80	1006.72		47.70	38.00
GW-952	9/16/2014	5.72	1002.85	1000	985.00	964.00	Well Wizard	22.00	24.00
GW-916	9/16/2014	40.42	1022.3	1019.7	988.70	974.70		47.83	47.00
GW-917	9/16/2014	21.03	997.1	994	974.00	943.00	Well Wizard	34.00	35.00
GW-927	9/16/2014	18.97	997.19	994	934.00	902.00	Well Wizard	73.65	70.00
GW-925	4/15/2015	3.11	971.14	968	871.00	820.00	Well Wizard	122.40	110.00
GW-922	9/16/2014	5.1	956.91	955	930.00	909.00	Well Wizard	31.80	30.00

TOC - Top of Casing
ft - feet
msl - mean sea level

The data loggers were deployed, downloaded, and set up per their instrument manuals. Each data logger was set up to record data on five-minute increments. Each water level data logger records absolute pressure (atmospheric pressure and water head), which is later converted to water level readings by software using initial deployment water elevation and a barometric pressure reference. To compensate for barometric pressure changes, one HOBO® water level logger was deployed as a barometric reference above the water column in one of the wells. Water levels were manually recorded with a water level indicator from each well before the data loggers were pulled for download, before redeployment, and immediately after deployment. To ensure accuracy, the ending water elevations from each download were used to determine if there were errors associated with water level measurements and to check for potential problems that may be caused by the downhole sampling equipment and the movement caused by weekly water level measurements by site personnel. Table 2.2.2.1.3 provides the time interval and water elevation error for each download period.

Table 2.2.2.1.3 Water Level Error for Each Download Period

Download Period			Water Level Error							
		Well ID:	GW-918	GW-947	GW-916	GW-952	GW-917	GW-927	GW-925	GW-922
	Start Date	End Date	feet							
1	9/16/2014	10/16/2014	0.17	0.108	0.073	-0.014	-0.085	0.05	NI	0.203
2	10/16/2014	11/19/2014	Mal	-0.039	0.039	0.113	0.224	0.096	NI	0.017
3	11/19/2014	12/17/2014	0.04	-0.066	0.029	0.026	0.048	-0.11	NI	-0.023
4	12/17/2014	1/14/2015	0.21	0.035	-0.235	-0.011	-0.044	0	NI	-0.084
5	1/14/2015	3/9/2015	-0.07	0.125	-0.14	0.01	-0.2	0.127	NI	0.014
6	3/9/2015	4/15/2015	0.128	0.073	0.116	0.007	0.031	-0.057	NI	-0.162
7	4/15/2015	5/13/2015	-0.095	-0.037	-0.068	-0.092	0.005	0.242	-0.092	NI
8	5/13/2015	6/24/2015	-0.134	0.017	-0.108	-0.021	-0.028	0.054	0.049	NI
9	6/24/2015	7/22/2015	0.146	0.015	0.083	0.01	-0.045	0.056	0.21	NI
10	7/22/2015	8/24/2015	-0.083	0.019	-0.067	-0.054	0.055	0.055	-0.052	NI

Download Period		Well ID:	Water Level Error							
			GW-918	GW-947	GW-916	GW-952	GW-917	GW-927	GW-925	GW-922
	Start Date	End Date	feet							
11	8/24/2015	10/5/2015	0.014	0.031	0.08	0.009	Mal	0.028	0.197	NI
12	10/5/2015	11/16/2015	0.195	0.008	-0.002	0.002	Mal	0.71	0.116	NI
13	11/16/2015	12/16/2015	0.199	-0.004	-0.095	-0.055	Mal	0.069	-0.042	NI

Mal - malfunction
NI - not installed

To ensure the conductivity values were accurate, at the beginning and ending of each download period, the conductivity HOBO® data logger was placed in a conductivity standard in the field and was allowed to sit in the solution for enough time to record several readings. Table 2.2.2.1.4 provides the HOBO® response to the conductivity standard for each download period. The conductivity parameters were simultaneously recorded with a YSI© Professional Plus water quality meter and are provided in the trip reports provided in Appendix D.

Table 2.2.2.1.4 Conductivity Check for Each Download Period

Download Period		Well ID:	Specific Conductivity							
			GW-918	GW-947	GW-916	GW-952	GW-917	GW-927	GW-925	GW-922
	Start Date	End Date	□S/cm							
1	9/16/2014	10/16/2014	1426.8	1462.5	Mal	1453.6	1432.6	1453.3	NI	1448.9
2	10/16/2014	11/19/2014	Mal	1514	1446.3	1498.2	1480.4	1476.8	NI	1488.3
3	11/19/2014	12/17/2014	NI	1486	1429.7	1471.1	1457.6	1456.4	NI	1464.1
4	12/17/2014	1/14/2015	NI	1489.1	1435.5	1482.8	1462.6	1460.5	NI	1468.2
5	1/14/2015	3/9/2015	NI	1455.7	1430	1458.1	1448.6	1452.6	NI	1432.3
6	3/9/2015	4/15/2015	NI	1441.7	1419.1	1426.2	1423	1434.3	NI	1425.2
7	4/15/2015	5/13/2015	NI	1444	1422	1433.7	1419.1	1431.6	1424.9	NI
8	5/13/2015	6/24/2015	NI	1424.7	1413.6	1411.1	1395	1413.4	1407.5	NI
9	6/24/2015	7/22/2015	NI	1419.9	1405.9	1409.1	Mal	1416.3	1397.8	NI
10	7/22/2015	8/24/2015	NI	1437.1	1429.6	1433.9	Mal	1436.9	1427	NI
11	8/24/2015	10/5/2015	NI	1430.6	1412.1	1420.6	1417.4	1426.5	Mal	NI
12	10/5/2015	11/16/2015	NI	1450.9	1429	1446.5	1431.4	1431.4	NI	NI
13	11/16/2015	12/16/2015	NI	1439.1	Mal	1430.5	1421.3	1419.7	NI	NI

Mal - malfunction
NI - not installed
□S/cm- microsiemens per centimeter

Task 4

On a bi-weekly basis, TDEC visits EMWMF to perform general monitoring of the site. In addition to measuring water parameters, collecting water samples/sediment samples and data logger acquisition, TDEC monitors the water levels in the contact water ponds / tanks, note discharges and water condition, observe condition of the sediment basin and note daily activity of the cell. Any concerns are brought to the attention of EMWMF personnel. Field notes are recorded and events reported in the monthly report. Water samples were collected from the sediment basin outfall and analyzed for chrome.

TDEC continues to monitor and note concerns to EMWMF personnel to help improve surface water conditions at EMWMF.

Task 5
TDEC has conducted reviews of the last two PCCRs for EMWMF. Findings indicate DOE has determined from modeled groundwater level data the potential exists for incursion of groundwater into the geologic buffer. There is no need for the state to duplicate this effort, other than to review the PCCR to ensure it is correct.

Data Collection Problems Task 1
There are two data gaps at EMWMF-2. The data gaps occurred due to equipment servicing and from safeguarding the equipment during nearby construction activities. The data gap from May 7-14 was due to equipment cleaning and calibration. The data gap from October 8-November 24 was due to concrete placement along a slope nearby and equipment servicing.

At EMWMF-3, the unit was placed in service on March 17 after the threat of stagnant freezing water, which might damage the probes, was eliminated. The two data gaps that occurred were for equipment maintenance, cleaning, and calibration from May 5-7 and October 20-22.

Data Collection Problems Task 3
At GW-917, the conductivity data logger would not transfer data to the shuttle or computer; therefore, no readings were collected from June 24 to August 24, until the sensor was replaced. In addition, the water level sensor data malfunctioned during the October 2015 download; water level monitoring was terminated on August 24, 2015.

At GW-918, the security cable failed shortly after reinstallation of the data loggers following the October 2014 download. The HOBO® data loggers wedged the pump in the well requiring several attempts to remove the data loggers from the well. It was reported that the data loggers and pump would catch at the PVC joints in the well. EMWMF personnel strongly advised us not to install another data logger in the well. The state still needed additional water level data at GW-918 to help determine the hydrogeologic conditions along Pine Ridge; however, it was concluded that the conductivity data logger could not be properly repositioned in the well. A decision was made not to reinstall the conductivity sensor at GW-918 and conductivity monitoring at the well was terminated as of October 16, 2014. The water level data logger was secured with multiple crimps and stops and placed approximately 10 feet below the top of the casing on November 19, 2014.

At GW-925, the conductivity sensor malfunctioned and failed to download in October 2015; conductivity monitoring was terminated on August 24, 2015.

In addition to those problems, the water elevation and temperature data was reviewed for shifts and data anomalies. All shifts and anomalies were corrected and are listed in each trip report in Appendix D. The shifts and most of the anomalies were due to the data loggers being repositioned in the well during weekly water level measurements and during data downloads.

2.2.2.2 Monitoring of Waste Using a Portal Monitor
A Canberra© RadSentry Model S585 portal monitor is used at EMWMF. The system is comprised of two large area gamma-ray scintillators, an occupancy sensor, a control box, a computer, and

associated software. The gamma-ray scintillators and instrumentation are contained in radiation sensor panels (RSPs) mounted on stands located on each side of the road at the check-in station for trucks hauling waste into the disposal area (Figure 2.2.2.2.1). Measurements (one per 200 milliseconds) are initiated by the occupancy sensor when a truck enters the portal. Results are transmitted from the RSPs to the control box, where they are stored, analyzed, and uploaded to a secure website, along with associated information date, time, and background measurements. Data on the website is monitored by TDEC and available for review by DOE and their authorized contractors. If radiation levels exceed a predetermined level, the RPM sends an alert notification to TDEC email. When an alert notification is received or anomalies are noted in review of the data, DOE and EMWMF personnel are contacted and the source of the waste passing through the portal monitor at the time of the measurements is determined. If available information suggests the waste acceptance criteria (WAC) may have been violated, the information is submitted to TDEC for review and disposition.

Figure 2.2.2.2.1 TDEC portal monitor at EMWMF

2.2.3 Surplus Material Verification

TDEC performs biased surveys of items using standard radiological monitoring meters and techniques: sodium iodide for gamma radiations, zinc sulfide scintillator (alpha)/plastic scintillator (beta) dual detection, or equivalent meters. The alpha/beta scintillator dual detection meters have been found to be the most likely to find increased activity (most increased activity found is either alpha or beta radiation). Inspections are scheduled just prior to sales after the material has been staged. Items range from furniture and equipment (shop, laboratory, and computer) to vehicles and construction materials. Particular attention is paid to items originating from shops and laboratories. Where radiological release tags are attached, radiation clearance information is compared to procedural requirements. If any contamination is detected during the on-site survey, the surplus materials manager is notified immediately.

2.3 RadNet

2.3.1 RadNet Air Monitoring on the Oak Ridge Reservation

The locations of the five RadNet air samplers are provided in Figure 2.3.1.1 and EPA's analytical parameters and frequencies are listed in Table 2.3.1. The RadNet air samplers run continuously, collecting suspended particulates on synthetic fiber filters (10 centimeters in diameter) as air is drawn through the units by a pump at approximately 35 cubic feet per minute. TDEC collects the filters from each sampler twice weekly. Following EPA protocol (U.S. EPA 1988, U.S. EPA 2006), the filters are then shipped to EPA's National Air and Radiation Environmental Laboratory (NAREL) in Montgomery, Alabama, for analysis.

NAREL performs gross beta analysis on each sample collected. If the gross beta result for a sample exceeds one picocurie per cubic meter (pCi/m^3), gamma spectrometry is performed on the sample. A composite of the air filters collected from each monitoring station during the year is analyzed for uranium and plutonium isotopes annually.

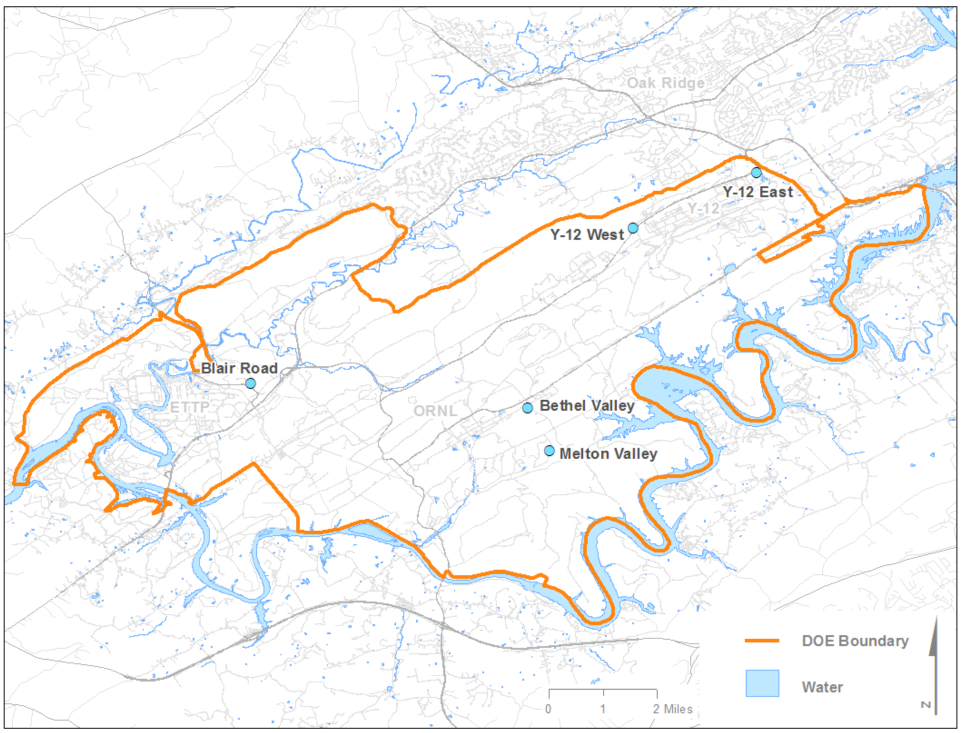


Figure 2.3.1.1 Locations of air stations monitored by TDEC on the Oak Ridge Reservation in association with EPA's RadNet air monitoring program

The results of NAREL's analyses of the nationwide RadNet air data are available at NAREL's website in the Envirofacts RadNet searchable database, via either a simple or a customized search (websites listed in references).

Table 2.3.1 EPA Analysis of Air Samples Taken in Association with EPA's RadNet Program

ANALYSIS	FREQUENCY
Gross Beta	Each sample, twice weekly
Gamma Scan	As needed on samples showing greater than 1 pCi/m^3 of gross beta
Plutonium-238, Plutonium-239, Plutonium-240, Uranium-234, Uranium-235, Uranium-238	Annually on a composite of the filters from each station (switching to every four years on an annual composite from each station starting in 2014)

Gross beta from the RadNet air monitoring program is now compared to background data from the RadNet air monitor in Knoxville, Tennessee, and to the Clean Air Act (CAA) environmental limit for strontium-90, as it is a pure beta emitter with a conservative limit. Previously, the RadNet ORR data was compared to the TDEC fugitive air monitoring program background location, but the program no longer runs analysis for gross beta at the background location.

2.3.2 RadNet Precipitation Monitoring on the Oak Ridge Reservation

The precipitation samplers provided by EPA's RadNet program are used to collect samples for the RadNet precipitation program. Each sampler drains precipitation that falls on a 0.5 square meter fiberglass collector into a five-gallon plastic collection bucket. A sample is collected from the bucket (in a four-liter Cubitainer®) and sent to EPA when a minimum of two liters of precipitation has accumulated in the Cubitainer®, or potentially less than that if it is the final sample of the month. The sample is processed as specified by EPA (US EPA 1988, US EPA 2013) and is shipped to NAREL in Montgomery, Alabama, for analysis. The NAREL laboratory composites the samples collected during the month for each station and analyzes each composite by gamma spectrometry.

The results of NAREL's analyses are available at NAREL's website in the Envirofacts RadNet searchable database, via either a simple or a customized search (websites listed in references). The data are used to identify anomalies in radiological contaminant levels, to assess the significance of precipitation in contaminant pathways, to evaluate associated control measures, to appraise conditions on the ORR compared to other locations in the RadNet program, and to determine levels of local contamination in the case of a nuclear disaster anywhere in the world.

2.3.3 RadNet Drinking Water on the Oak Ridge Reservation

In the Oak Ridge RadNet Drinking Water Program, EPA provides radiochemical analysis of finished drinking water samples taken quarterly by TDEC at four public water supplies located on and in the vicinity of the ORR. The samples are collected using procedures and supplies prescribed by EPA protocol (U.S. EPA, 1988; U.S. EPA, 2013). The samples are analyzed at NAREL. The analytical frequencies and parameters are provided in Table 2.3.3.

The four locations sampled in the Oak Ridge area (listed from upstream to downstream) on the Clinch and then Tennessee River are the Anderson County Water Authority Water Treatment Plant, the Y-12 Water Treatment Plant (run by the city of Oak Ridge), the West Knox Utility District Water

Treatment Facility, and the Kingston Water Treatment Plant. Figure 2.3.3.1 depicts the locations of the raw water intakes associated with these facilities.

The results of NAREL's analyses are available, along with nationwide data, at NAREL's website in the Envirofacts RadNet searchable database, via either a simple or a customized search (websites listed in references).

Table 2.3.3 RadNet Drinking Water Analyses

ANALYSIS	FREQUENCY
Tritium	Quarterly
Iodine-131	Annually on one individual sample/sampling site
Gross Alpha, Gross Beta, Strontium-90, Gamma Scan	Annually on composite samples
Radium-226, Uranium-234, Uranium-235, Uranium-238, Plutonium-238, Plutonium-239, Plutonium-240	Annually on samples with gross alpha >2 pCi/L
Radium-228	Annually on samples with Radium-226 between 3-5 pCi/L

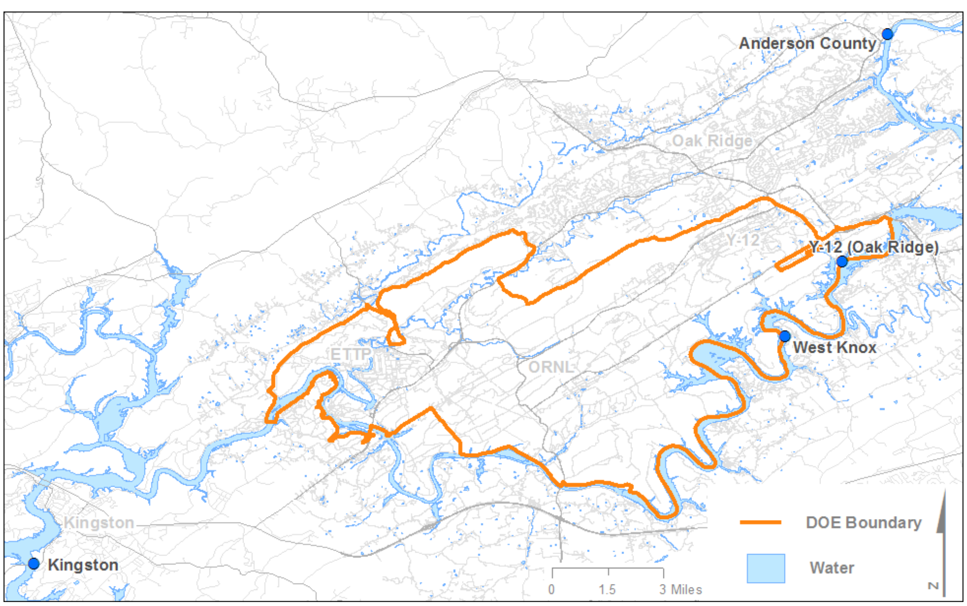


Figure 2.3.3.1 RadNet drinking water facility intakes

3.0 Results and Discussions

3.1 Oak Ridge Reservation

3.1.1 Radiation Monitoring

3.1.1.1 Ambient Gamma Radiation Monitoring of the Oak Ridge Reservation Using Environmental Dosimetry

The Atomic Energy Act exempts DOE from outside regulation of radiological materials at its facilities, but requires DOE to manage these materials in a manner protective of the public health and the environment. Since access to the reservation has in the past been predominately restricted to DOE employees or their contractors, locations within the fenced areas of the reservation have traditionally been viewed as inaccessible to the general public. With the reindustrialization and revitalization of portions of the reservation, there has been an influx of workers employed by businesses not directly associated with DOE operations and, in some cases, property deeded to private entities within the reservation boundaries. Under state regulations, a member of the public is considered to be any individual, unless employed to perform duties that involve exposures to radiation. The state regulations go on to limit the dose to members of the public to 100 mrem/year (above background and medical applications) and the release of radiation to unrestricted areas to a dose of two mrem in any one-hour period. In this context, a restricted area is defined as an area with access limited for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials.

The dose of radiation an individual receives at any given location is dependent on the intensity and the duration of the exposure. For example, an individual standing at a site where the dose rate is one mrem/hour would receive a dose of two mrem if he or she stayed at the same spot for two hours. If that person were exposed to the same level of radiation for eight hours a day for the approximately 220 working days in a year (1,760 hours), the individual would receive a dose of 1,760 mrem in that year. It is important to note that the doses reported in the program are based on the exposure an individual would receive if he or she remained at the monitoring station twenty-four hours a day for one year (8,760 hours). Since this is unlikely, the doses reported should be viewed as conservative estimates of the maximum dose an individual could receive at each location.

Tables accompanying the discussion of each area (offsite, ETTP, ORNL, SNS, Y-12 and EMWMF) provide the dosimetry results for 2015, along with the total dose in 2014 for comparison. None of the neutron dosimeters recorded a dose during the 2015 calendar year. The results have been organized according to location and are summarized below. Figures 3.1.1.1.1 to 3.1.1.1.11 are also provided to help the reader more easily visualize comparative data for 2014 and 2015 dosimeters. Table 3.1.1.1.12 contains explanatory notes for Tables 3.1.1.1.1 through 3.1.1.1.11.

Since all data are viewed based on a year-long estimate of exposure, extrapolations were made to the data to estimate a full year's data for those situations where data was incomplete due to missing dosimeters, deployment periods less than one-year, and instances where certain quarters of data

were eliminated because of extreme differences from the expected norm for a station. Monitoring results that varied extremely from the norm were usually found to possess elevated dosage levels for the control (theoretically unexposed) dosimeters. The fourth quarter data for 2015 were considered to be anomalous (extremely high control dosimeter readings) and had to be adjusted accordingly by multiplying available data by the appropriate factor to extrapolate values for a full year. In instances where the result for a given dosimeter was returned as “M” (<1 mrem), the value for that quarter was assumed to be zero.

Stations off the Oak Ridge Reservation

In 2015, the results for offsite locations ranged from three to 65 mrem/year. The highest results reported for offsite locations were for station A-23 (65 mrem), and station A-14 (51 mrem). Station A-14 is located adjacent to the Emory Valley Greenway approximately one hundred feet from the Emory Valley pump station and Station A-23 is on the fence surrounding the pump station. The slightly elevated results (compared to other offsite locations) may be an artifact of the use of sediments from the East Fork Poplar Creek flood plain downstream of Y-12 as fill during the construction of portions of the Oak Ridge sewer system (1982, MMES). In all instances (Figure 3.1.1.1.1) results for 2015 were slightly lower than for 2014. Table 3.1.1.1.1 provides the identity of the stations and Figure 3.1.1.1.1 depicts the results for dosimeter data for the period 2014 and 2015

Table 3.1.1.1.1 Offsite Dosimeter Stations

Dosimeter Designation (Dosimeter number)	**Location** *Optically Stimulated Luminescent Dosimeter (OSLs) and neutron dosimeters are reported quarterly.*	**Type of Radiation**	**Dose Reported for 2015 in mrem** *M = Below Minimum Reportable Quantity*				**2015 Total Dose ****	**2014 Total Dose ****
			1st Quarter	2nd Quarter	3rd Quarter	4th Quarter		
A-11 (9)	Norris Dam Air Monitoring Station (Background)	Gamma	3	Absent	4	10	14	22
A-12 (86)	Loudoun Dam Air Monitoring Station (Background)	Gamma	3	4	4	36	15	16
A-13 (86a)	Loudoun Dam Air Monitoring Station (Background)	Gamma	2	3	4	65	12	16
A-13 (86a)	Loudoun Dam Air Monitoring Station (Background)	Neutron	M	M	M	M	0	0
A-14 (66)	Emory Valley Greenway	Gamma	10	14	14	69	51	52
A-15 (80)	Elza Gate	Gamma	3	2	2	14	9	10
A-16 (65)	California Avenue	Gamma	2	2	2	51	8	12
A-17 (64)	Cedar Hill Greenway	Gamma	3	3	4	85	13	18
A-18 (63)	Key Springs Road	Gamma	M	2	M	69	3	10
A-19 (62)	East Pawley	Gamma	4	4	5	25	17	20
A-21 (67)	West Vanderbilt	Gamma	5	7	5	35	23	28
A-22 (70)	Scarboro Perimeter Air Monitoring Station	Gamma	6	6	6	62	24	28
A-23 (91)	Emory Valley Pump House	Gamma	16	16	17	4	65	74

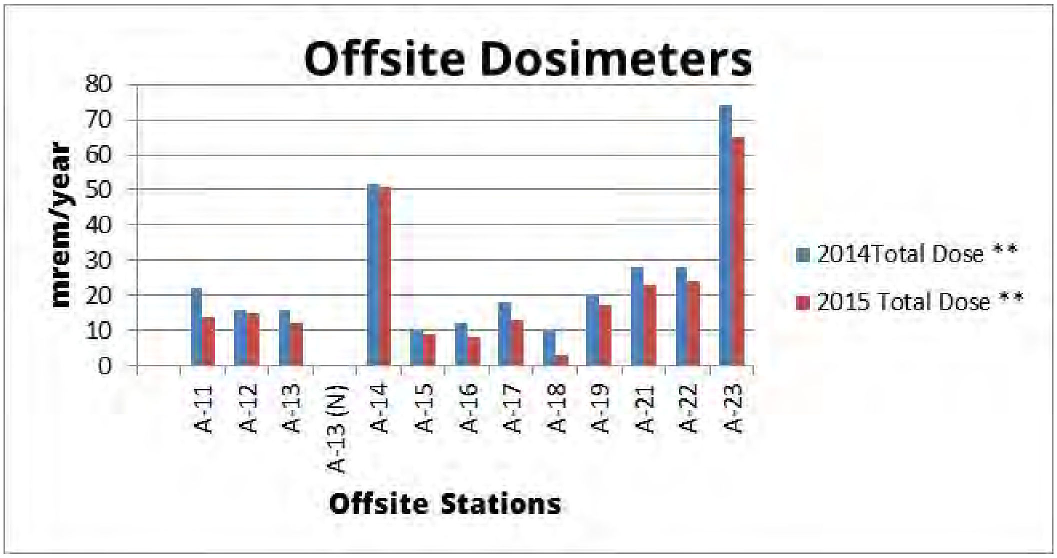


Figure 3.1.1.1.1 Offsite dosimeter stations

East Tennessee Technology Park

The K-25 Gaseous Diffusion Plant, now known as the ETTP, was constructed during World War II to produce enriched uranium for use in the first atomic weapons and later to fuel commercial and government-owned reactors. Other activities at the site included uranium enrichment by liquid thermal diffusion; development and testing of the gas centrifuge method of uranium enrichment; laser isotope separation research and development; and the incineration of 35 million pounds of hazardous and radioactive waste at the Toxic Substance Control Act (TSCA) Incinerator (1991-2012). The original gaseous diffusion facilities were put in stand-by mode in 1967 and the plant permanently closed in 1987. The focus subsequently turned to remediation of the site and its reindustrialization, with a long-term goal of transitioning ETTP into an industrial park. Under the reindustrialization program, portions of ETTP may be leased or sold to private entities for use or development. During 2015, the results for dosimeters stationed at ETTP ranged from one to 83 mrem/year. The highest results were at stations C-42 (83 mrem/year), C-52 (52 mrem/year), C-51 (51 mrem/year), C-53 (36 mrem/year), and C-44 (28 mrem/year). Station C-42 (highest reading) is located just off the ETTP reservation on Bear Creek Road across from an active waste handling business. Other results were similar to background values. The ETTP dosimeters showed lower values in 2015 than in 2014.

Although the readings may seem high, an individual would have to remain at the given station for 24-hours a day for the entire year to receive the measured dose.

Table 3.1.1.1.2 provides the identity of the stations and Figure 3.1.1.1.2 depicts the results for dosimeter data for 2014 and 2015.

Table 3.1.1.1.2 ETTP Dosimeter Stations

Dosimeter Designation (Dosimeter number)	Location *Optically Stimulated Luminescent Dosimeter (OSLs) and neutron dosimeters are reported quarterly*	Type of Radiation	Dose Reported for 2015 in mrem *M = Below Minimum Reportable Quantity*				2015 Total Dose **	2014Total Dose **
			1st Quarter	2nd Quarter	3rd Quarter	4th Quarter		
C-10 (43)	K-1401 Building (West Side)	Gamma	5	5	7	42	23	28
C-12 (48)	K-1420 Building	Gamma	M	1	M	32	1	5
C-17 (44)	K-25 Building	Gamma	M	1	3	19	5	14
C-18 (160)	K-27 Building (Southwest) Corner)	Gamma	2	2	M	M	5	11
C-19 (159)	K-27 Building (South Side)	Gamma	1	3	M	M	5	11
C-20 (158)	K-27 Building (Southeast) Corner)	Gamma	1	2	M	M	4	11
C-21 (155)	K-27 Building (Northwest) Corner)	Gamma	5	5	5	M	20	29
C-22 (156)	K-27 Building (North Side)	Gamma	3	3	3	M	12	18
C-23 (157)	K-27 Building (Northeast) Corner)	Gamma	1	2	M	M	4	8
C-24 (16)	K-901 Pond	Gamma	M	2	3	M	7	19
C-25 (15)	K-1070-A Burial Ground	Gamma	2	4	3	M	12	22
C-27 (79)	ED1 On Pole	Gamma	4	7	5	28	21	22
C-28 (58)	K-25 Portal 5	Gamma	2	4	4	15	13	15
C-29 (177)	TSCA West Gate	Gamma	M	M	M	M	0	14
C-30 (178)	TSCA North Gate	Gamma	1	2	M	M	4	16
C-40 (72)	ETTP Visitors Overlook	Gamma	9	M	10	73	25	30
C-41 (45)	K-770 Scrap Yard	Gamma	M	M	M	26	0	6
C-42 (47)	Bear Creek Road ~ 2800 Feet From Clinch River	Gamma	20	21	21	53	83	89
C-43 (11)	Grassy Creek Embayment On The Clinch River	Gamma	Absent	Absent	4	18	16	16
C-44 (21)	White Wing Scrap Yard	Gamma	6	6	9	24	28	40
C-50 (179)	Uranium Storage Yard (East)	Gamma	3	6	5	M	19	20
C-51 (180)	Uranium Storage Yard (South)	Gamma	12	12	14	M	51	63
C-52 (181)	Uranium Storage Yard (South)	Gamma	13	13	13	47	52	61
C-53 (182)	Uranium Storage Yard (West)	Gamma	9	9	9	33	36	53

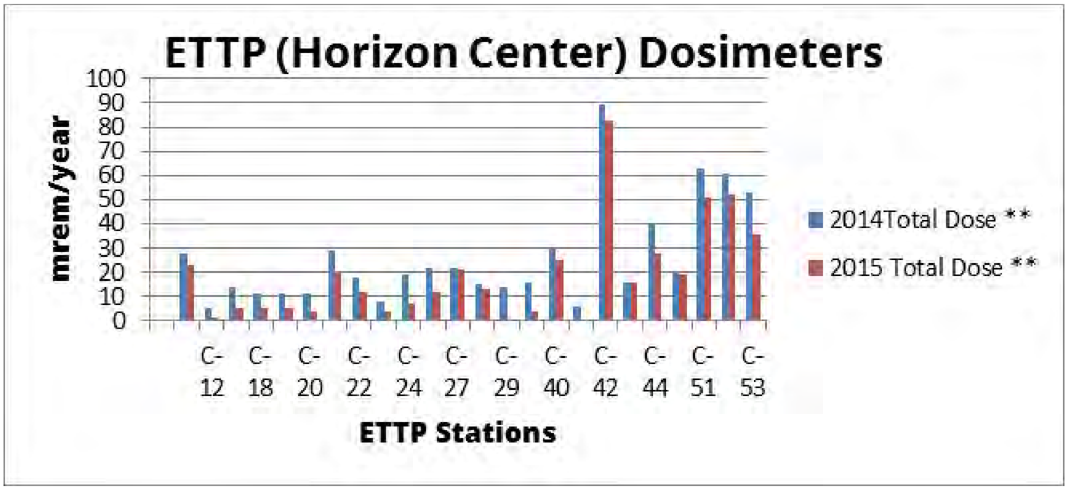


Figure 3.1.1.1.2 ETTP (Horizon Center) dosimeter stations

The Y-12 National Security Complex

Similar to K-25, Y-12 was constructed during World War II to produce enriched uranium by the electromagnetic separation process. In ensuing years, the facility was expanded and used to produce fuel for naval reactors, conduct lithium/mercury enrichment operations, manufacture components for nuclear weapons, dismantle nuclear weapons, and store enriched uranium. In addition to this, a number of Y-12 buildings were utilized by ORNL personnel for various pursuits including animal studies, research on the Molten Salt Reactor Experiment (MSRE), production of radioactive isotopes, and the Aircraft Nuclear Propulsion Program. Due to the nature of its mission, Y-12 is the least accessible to members of the public of the three Oak Ridge facilities. There are three locations within the Y-12 complex currently being monitored. These are the Uranium Oxide Storage Vaults, the Walk-In Pits, and the East Perimeter air monitoring station. The results for the Y-12 locations ranged from 13 to 17 mrem/year. These low levels are expected because the majority of the material handled at Y-12 emits primarily alpha and beta (not gamma) radiation. Results for 2015 were slightly lower than those for 2014.

Table 3.1.1.1.3 provides the identity of the stations and Figure 3.1.1.1.3 depicts the results for dosimeter data for the period 2014-2015.

Table 3.1.1.1.3 Y-12 Dosimeter Stations

Dosimeter Designation (Dosimeter number)	**Location** *Optically Stimulated Luminescent Dosimeter (OSLs) and neutron dosimeters are reported quarterly.*	**Type of Radiation**	**Dose Reported for 2015 in mrem** *M = Below Minimum Reportable Quantity*				**2015 Total Dose ****	**2014 Total Dose ****
			1st Quarter	2nd Quarter	3rd Quarter	4th Quarter		
B-10 (71)	Y-12 East Perimeter Air Monitoring Station	Gamma	4	**4**	**5**	80	17	18
B-11 (39)	Y-12 at back side of Walk In Pits	Gamma	3	**5**	**3**	26	15	22
B-12 (38)	Y-12 Uranium Oxide Storage Vaults	Gamma	2	**3**	**5**	M	13	18

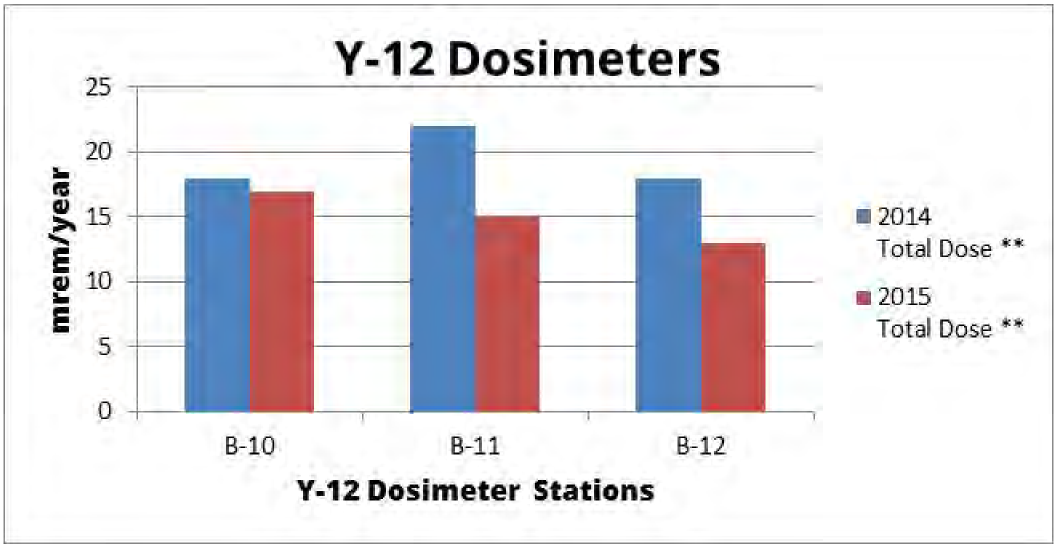


Figure 3.1.1.1.3 Y-12 dosimeter stations

Environmental Management Waste Management Facility

Located immediately to the west of the Y-12 complex (in Bear Creek Valley), EMWMF was constructed in 2002 to dispose of radioactive and hazardous waste generated by remedial activities from all three plants on the ORR. The facility is operated under the authority of CERCLA and waste approved for disposal is limited by waste acceptance criteria agreed upon by DOE, EPA, and the state. Monitoring stations have been established at the boundary of the waste disposal cells and at secondary waste management systems (contact water ponds). For this report, the dosimeters surrounding the EMWMF waste cell and those surrounding the contact water ponds are discussed separately.

During 2015, the results for the contact water pond dosimeters ranged from 12 to 39 mrem/year. Dosimeters surrounding the EMWMF waste cell ranged from 13 to 45 mrem/year. The results for the contact water ponds tended to be slightly higher in 2015 than in 2014. This is also true for the majority of the stations for the EMWMF waste cell.

Table 3.1.1.1.4 provides the identity of the stations and Figure 3.1.1.1.4 depicts the results for dosimeter data for the contact water ponds for the period 2014 and 2015. Table 3.1.1.1.5 provides the identity of the stations and Figure 3.1.1.1.5 depicts the results for dosimeter data for the EMWMF waste cell for the period 2014 and 2015.

Table 3.1.1.1.4 EMWMF Contact Water Pond Dosimeters

Dosimeter Designation (Dosimeter number)	**Location** *Optically Stimulated Luminescent Dosimeter (OSLs) and neutron dosimeters are reported quarterly.*	Type of Radiation	**Dose Reported for 2015 in mrem** *M = Below Minimum Reportable Quantity*				2015 Total Dose **	2014 Total Dose **
			1st Quarter	2nd Quarter	3rd Quarter	4th Quarter		
B-24 (92)	Contact Water Ponds Fence at Gate	Gamma	2	4	3	M	12	16
B-25 (105)	Contact Water Ponds Fence (Northwest Side)	Gamma	7	10	10	M	36	42
B-26 (106)	Contact Water Ponds Fence (Northeast Side)	Gamma	6	10	8	M	32	42
B-29 (109)	Contact Water Ponds Fence (Southeast Side)	Gamma	9	10	10	M	39	44
B-30 (110)	Contact Water Ponds Fence (Southwest Side)	Gamma	10	9	8	M	36	42
B-32 (112)	Contact Water Tanks Fence (Northeast Side)	Gamma	4	6	4	M	19	24
B-33 (113)	Contact Water Tanks Fence (Northwest Side)	Gamma	4	5	4	74	17	24
B-36 (116)	Contact Water Tanks Fence (Southwest Side)	Gamma	7	8	8	17	31	38
B-37 (117)	Contact Water Tanks Fence (Southeast Side)	Gamma	6	7	6	20	25	38

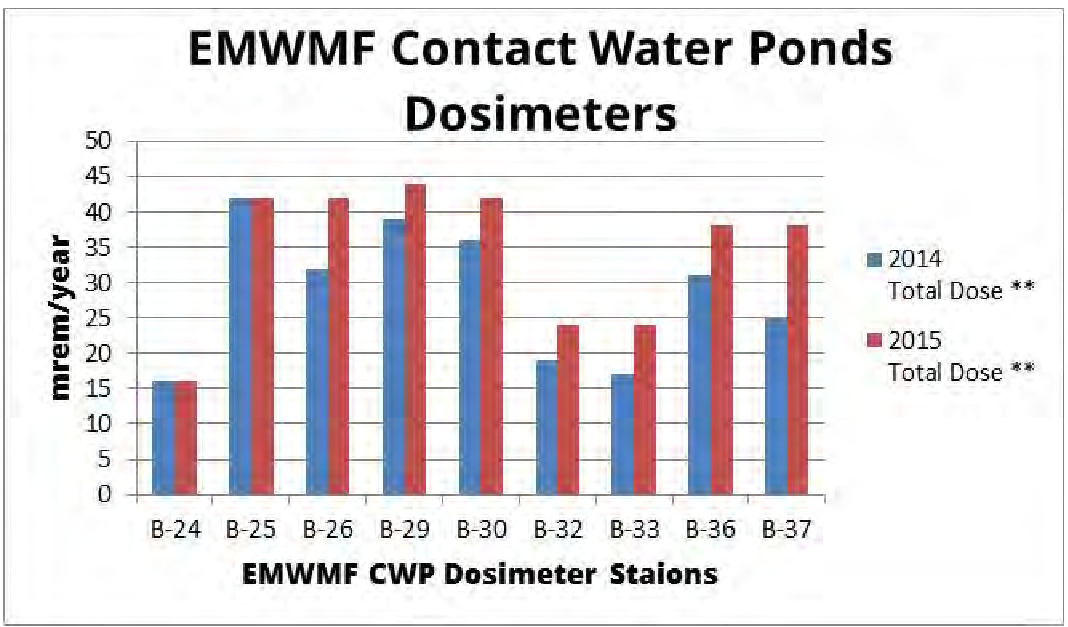


Figure 3.1.1.1.4 EMWMF contact water ponds dosimeters

Table 3.1.1.1.5 EMWMF Waste Cell Dosimeters

Dosimeter Designation (Dosimeter number)	Location *Optically Stimulated Luminescent Dosimeter (OSLs) and neutron dosimeters are reported quarterly.*	Type of Radiation	Dose Reported for 2015 in mrem *M = Below Minimum Reportable Quantity*				2015 Total Dose **	2014 Total Dose **
			1st Quarter	2nd Quarter	3rd Quarter	4th Quarter		
B-23 (90)	Waste Cell Perimeter Fence at Gate	Gamma	**4**	**3**	**3**	25	13	14
B-38 (118)	Waste Cell Perimeter Fence (Southeast Corner)	Gamma	**8**	**10**	**8**	16	35	42
B-39 (119)	Waste Cell Perimeter Fence (South Side)	Gamma	**9**	**10**	**6**	9	33	40
B-40 (120)	Waste Cell Perimeter Fence (South Side)	Gamma	**8**	**10**	**8**	3	35	36
B-41 (121)	Waste Cell Perimeter Fence (South Side)	Gamma	**7**	**6**	**7**	M	27	40
B-42 (122)	Waste Cell Perimeter Fence (South Side)	Gamma	**9**	**11**	**9**	M	39	42
B-43 (123)	Waste Cell Perimeter Fence (South Side)	Gamma	**10**	**11**	**9**	76	40	50
B-44 (124)	Waste Cell Perimeter Fence (South Side)	Gamma	**9**	**11**	**11**	43	41	50
B-45 (125)	Waste Cell Perimeter Fence (South Side)	Gamma	**10**	**10**	**9**	34	39	48
B-46 (126)	Waste Cell Perimeter Fence (South Side)	Gamma	**9**	**11**	**8**	50	37	42
B-47 (127)	Waste Cell Perimeter Fence (South Side)	Gamma	**9**	**11**	**10**	20	40	48
B-48 (128)	Waste Cell Perimeter Fence (South Side)	Gamma	**5**	**6**	**5**	35	21	28
B-49 (129)	Waste Cell Perimeter Fence (SW Corner)	Gamma	**10**	**11**	**11**	21	43	48
B-50 (130)	Waste Cell Perimeter Fence (West Side)	Gamma	**10**	**11**	**11**	10	43	44
B-51 (131)	Waste Cell Perimeter Fence (West Side)	Gamma	**9**	**10**	**9**	7	37	42
B-52 (132)	Waste Cell Perimeter Fence (West Side)	Gamma	**9**	**11**	**9**	1	39	44
B-53 (133)	Waste Cell Perimeter Fence (West Side)	Gamma	**9**	**10**	**9**	94	37	42
B-54 (134)	Waste Cell Perimeter Fence (West Side)	Gamma	**9**	**11**	**9**	65	39	44
B-55 (135)	Waste Cell Perimeter Fence (West Side)	Gamma	**10**	**10**	**11**	44	41	48
B-56 (136)	Waste Cell Perimeter Fence (NW Corner)	Gamma	**10**	**10**	**9**	35	39	50
B-57 (137)	Waste Cell Perimeter Fence (North Side)	Gamma	**8**	**10**	**9**	32	36	42
B-58 (138)	Waste Cell Perimeter Fence (North Side)	Gamma	**10**	**11**	**12**	11	44	46
B-59 (139)	Waste Cell Perimeter Fence (North Side)	Gamma	**8**	**9**	**10**	12	36	40
B-60 (140)	Waste Cell Perimeter Fence (North Side)	Gamma	**11**	**10**	**11**	19	43	50
B-61 (141)	Waste Cell Perimeter Fence (North Side)	Gamma	**10**	**12**	**10**	5	43	50
B-62 (142)	Waste Cell Perimeter Fence (North Side)	Gamma	**7**	**9**	**8**	M	32	36
B-63 (143)	Waste Cell Perimeter Fence (North Side)	Gamma	**8**	**11**	**8**	M	36	44
B-64 (144)	Waste Cell Perimeter Fence (North Side)	Gamma	**8**	**11**	**7**	3	35	42
B-65 (145)	Waste Cell Perimeter Fence (North Side)	Gamma	**10**	**12**	**12**	10	45	44
B-66 (146)	Waste Cell Perimeter Fence (North Side)	Gamma	**9**	**11**	**7**	M	36	44
B-67 (147)	Waste Cell Perimeter Fence (NE Corner)	Gamma	**10**	**8**	**10**	M	37	42
B-68 (148)	Waste Cell Perimeter Fence (East Side)	Gamma	**5**	**7**	**4**	M	21	30
B-69 (149)	Waste Cell Perimeter Fence (East Side)	Gamma	**8**	**10**	**8**	M	35	38
B-70 (150)	Waste Cell Perimeter Fence (East Side)	Gamma	**9**	**10**	**7**	M	35	42
B-71 (151)	Waste Cell Perimeter Fence (East Side)	Gamma	**8**	**10**	**8**	M	35	36
B-72 (152)	Waste Cell Perimeter Fence (East Side)	Gamma	**6**	**10**	**9**	M	33	32
B-73 (153)	Waste Cell Perimeter Fence (East Side)	Gamma	**7**	**8**	**7**	M	29	42
B-74 (154)	Waste Cell Perimeter Fence (East Side)	Gamma	**8**	**11**	**6**	M	33	42

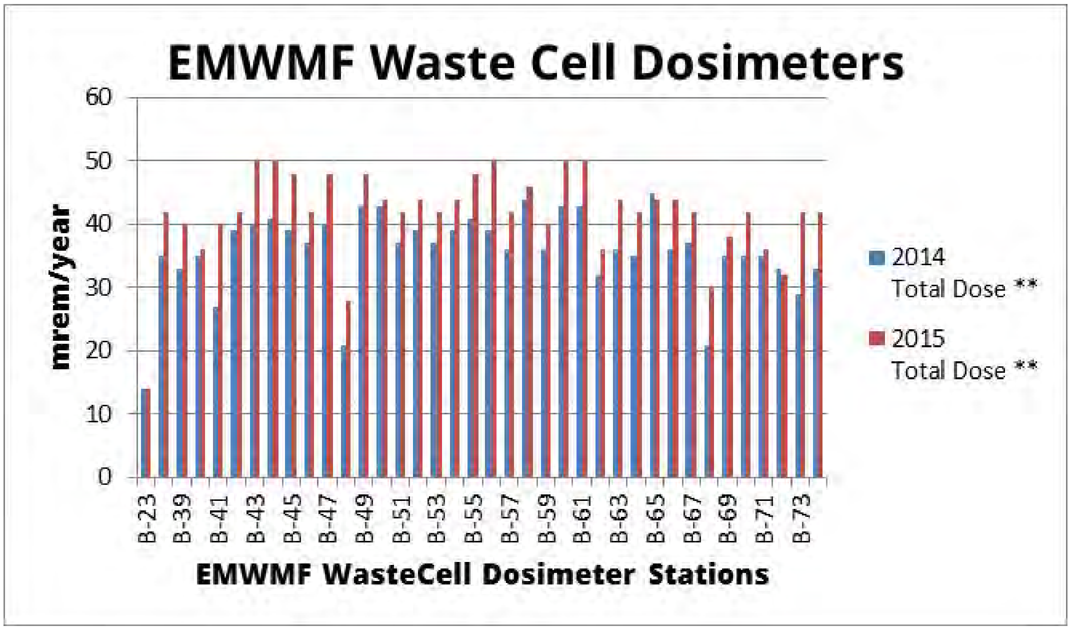


Figure 3.1.1.1.5 EMWMF waste cell dosimeters

Oak Ridge National Laboratory (ORNL)

Like the K-25 and Y-12 facilities, ORNL was also established during the World War II Manhattan Era. Its war time mission focused on reactor research and the production of plutonium and other radionuclides that were chemically extracted from uranium irradiated in ORNL's Graphite Reactor and later other ORNL and Hanford reactors. Over the years, thirteen reactors were constructed and operated at the ORNL site, including the currently active High Flux Isotope Reactor (HFIR). Since its inception, ORNL has evolved into DOE's largest multi-program national science and energy laboratory hosting thousands of visitors a year. In addition, land adjacent to ORNL's main campus has been deeded to organizations outside of DOE; buildings have been constructed using private funds; and facilities are now occupied by non-DOE contractors (ORAU, 2003). Many of the facilities constructed during World War II and the cold war era that remain are contaminated and have fallen into disrepair, complicating remediation. Access to the site is controlled for security, but admittance is allowed with the appropriate visitor's pass and associated training. Within the access controlled areas, certain locations have been designated as radiation areas and access restricted for safety, including legacy burial grounds and associated facilities.

Due to the nature of some of the radioactive contaminants at ORNL (high energy gamma emitters), the highest dose rates in the dosimetry program are typically associated with stations at ORNL. The dose rates measured at ORNL in 2015 ranged from one to 12,401 mrem for the year. The dose rates reported here reflect the dose that could be received if a person remained at the monitoring station for 365 days a year, 24 hours a day. Consequently, the results are conservative estimates of the potential dose at the monitoring locations, which are used to identify locations that merit further evaluation. The actual dose any individual would receive is dependent on the time spent at the location, which in all cases would be a fraction of that assumed for the dose estimates. A complete listing of all stations related to ORNL is included in Table 3.1.1.1.6.

Table 3.1.1.1.6 Complete List of ORNL Related Dosimeters

Dosimeter Designation (Dosimeter number)	Location *Optically Stimulated Luminescent Dosimeter (OSLs) and neutron dosimeters are reported quarterly.*	Type of Radiation	Dose Reported for 2015 in mrem *M = Below Minimum Reportable Quantity*				2015 Total Dose **	2014 Total Dose **
			1st Quarter	2nd Quarter	3rd Quarter	4th Quarter		
D-10 (20)	Freels Bend Entrance	Gamma	2	4	5	9	15	12
D-12 (69)	Graphite Reactor	Gamma	9	6	7	75	29	44
D-13 (167)	South Side Of Central Avenue	Gamma	15	15	17	47	63	82
D-14 (166)	North Side Of Central Avenue Building 3038	Gamma	56	51	58	66	220	80
D-16 (30)	X-3513 Impoundment	Gamma	7	6	absent	14	26	30
D-17 (28)	White Oak Dam at Highway 95	Gamma	M	2	3	M	7	14
D-18 (34)	SWSA 6 On Fence at Highway 95	Gamma	4	5	5	1	19	20
D-19 (75)	Hot spot on Haw Ridge	Gamma	35	34	42	84	148	174
D-20 (25)	Molten Salt Reactor Experiment	Gamma	45	19	21	39	113	578
D-21 (27)	White Oak Creek Weir at Lagoon Rd	Gamma	31	30	34	22	127	156
D-22 (24)	Building X-7819	Gamma	7	7	8	20	29	30
D-23 (35)	Confluence of White Oak Creek and Melton Branch	Gamma	111	108	114	110	444	456
D-24 (56)	Old Hydrofracture Pond	Gamma	12	11	14	57	49	60
D-26 (23)	SWSA 5 (South 7828)	Gamma	M	4	3	16	9	10
D-27 (46)	Homogeneous Reactor Experiment Site	Gamma	2	3	2	41	9	14
D-28 (22)	High Flux Isotope Reactor	Gamma	8	7	8	20	31	34
D-30 (55)	SWSA 5 TRU Waste Trench	Gamma	40	27	27	42	125	144
D-31 (87)	SWSA 5 Near Storage Tank Area	Gamma	23	21	24	90	91	114
D-31 (87)	SWSA 5 Near Storage Tank Area	Neutron	M	M	M	M	0	0
D-32 (168)	New Hydrofracture Facility	Gamma	103	99	101	72	404	410
D-33 (169)	Melton Valley Haul Road Near Creek	Gamma	139	162	149	80	600	630
D-34 (170)	Cask Storage Containment Area	Gamma	1363	1,192	1,332	1,315	5183	5,364
D-35 (171)	Building 3038 N	Gamma	116	105	85	55	408	376
D-36 (172)	Building 3607 Material Storage Area	Gamma	3130	3,045	3,126	3,174	12401	13,002
D-37 (173)	TH4 Tank	Gamma	155	134	157	151	595	522
D-38 (174)	Hot Storage Garden (3597)	Gamma	1107	1,118	1,112	1,085	4449	4,346
D-39 (175)	Building 3618	Gamma	75	71	76	80	296	312
D-40 (84)	Tower Shielding Facility at Gate (West)	Gamma	4	5	4	M	17	18
D-41 (85)	Tower Shielding Facility (North Side)	Gamma	2	5	4	M	15	18
D-42 (176)	Neutralization Plant	Gamma	2940	1,122	438	878	6000	7,520

Dosimeter Designation (Dosimeter number)	**Location** *Optically Stimulated Luminescent Dosimeter (OSLs) and neutron dosimeters are reported quarterly.*	Type of Radiation	Dose Reported for 2015 in mrem *M = Below Minimum Reportable Quantity*				2015 Total Dose **	2014 Total Dose **
			1st Quarter	2nd Quarter	3rd Quarter	4th Quarter		
D-50 (68)	White Oak Creek at Coffer Dam	Gamma	M	1	M	75	1	4
D-51 (26)	Cesium Fields	Gamma	6	5	7	7	24	28
D-52 (31)	Cesium Forest Boundary	Gamma	14	15	17	9	61	66
D-53 (31a)	Cesium Forest Boundary (Duplicate)	Gamma	13	13	14	12	53	64
D-54 (32)	Cesium Forest On Tree	Gamma	2662	3,201	2,516	3,121	11172	10,160
D-55 (33)	Cesium Forest Satellite Plot	Gamma	80	97	80	86	343	340
D-60 (183)	ORNL Melton Valley Trench 7	Gamma	11	11	14	39	48	50
D-62 (185)	ORAU Pumphouse Road	Gamma	8	5	5	38	24	44
D-62 (185)	ORAU Pumphouse Road	Neutron	M	M	M	M	0	0

For this report, ORNL dosimeters are considered to fall in the following groups:

- ORNL Main Campus [dosimeters on the main campus of ORNL as well as all other dosimeters not in Melton Valley, at the Spallation Neutron Source (SNS), or South of Melton Valley]
- ORNL Melton Valley (dosimeters in the waste areas of Melton Valley)
- ORNL south of Melton Valley (dosimeters at Tower Shielding and Cesium Forest)
- ORNL SNS

In 2015, eighteen monitoring stations at ORNL had results exceeding 100 mrem over the year. Seven of these sites are located on the main campus of ORNL but are away from the most heavily traveled areas of the facility except for station D-14 (Table 3.1.1.1.7; Figure 3.1.1.1.7). Eight of these sites are located in the considerably less traveled ORNL Melton Valley Area (Table 3.1.1.1.8; Figure 3.1.1.1.8). Two of these sites are sites are in the Cesium Forest located south of the Melton Valley (Table 3.1.1.1.9; Figure 3.1.1.1.9). One of these sites is at the SNS (Table 3.1.1.1.11; Figure 3.1.1.1.11).

Table 3.1.1.1.7 ORNL Campus Dosimeters >100 mrem/year

Dosimeter Designation (Dosimeter number)	Location *Optically Stimulated Luminescent Dosimeter (OSLs) and neutron dosimeters are reported quarterly.*	Type of Radiation	Dose Reported for 2015 in mrem *M = Below Minimum Reportable Quantity*				2015 Total Dose **	2014Total Dose **
			1st Quarter	2nd Quarter	3rd Quarter	4th Quarter		
D-14 (166)	North Side Of Central Avenue	Gamma	56	51	58	66	220	80
D-35 (171)	Building 3038 N	Gamma	116	105	85	55	408	376
D-36 (172)	Building 3607 Material Storage Area	Gamma	3130	3,045	3,126	3,174	12401	13,002
D-37 (173)	TH4 Tank	Gamma	155	134	157	151	595	522
D-38 (174)	Hot Storage Garden (3597)	Gamma	1107	1,118	1,112	1,085	4449	4,346
D-39 (175)	Building 3618	Gamma	75	71	76	80	296	312
D-42 (176)	Neutralization Plant	Gamma	2940	1,122	438	878	6000	7,520

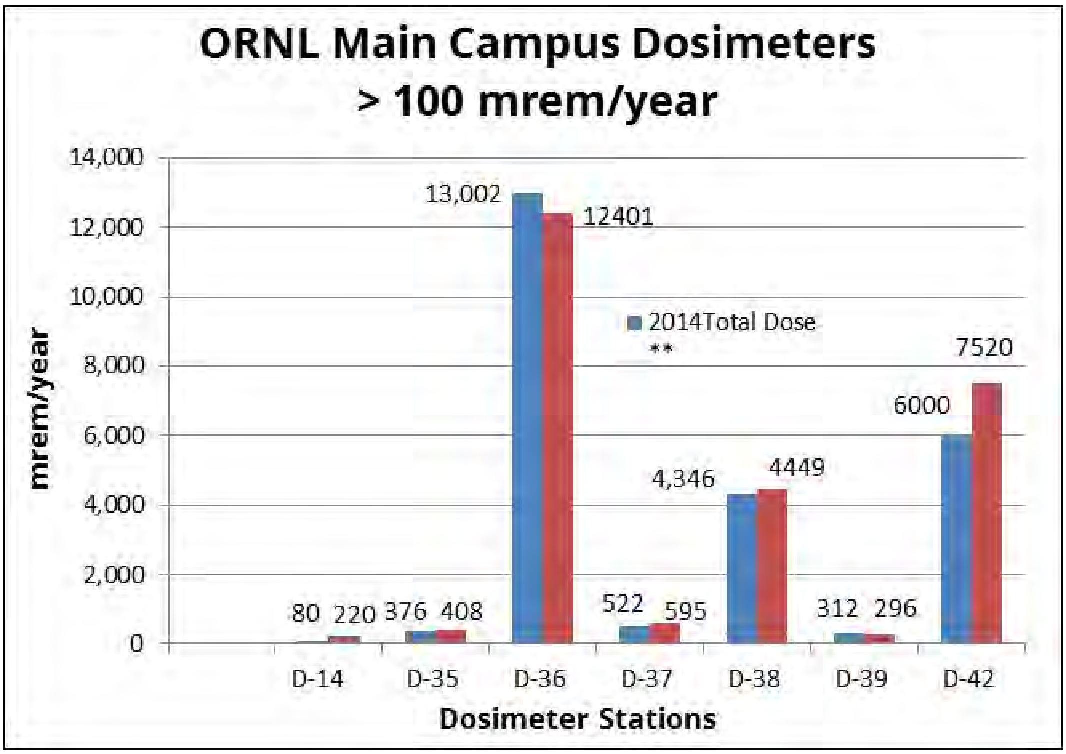


Figure 3.1.1.1.6 ORNL main campus dosimeters >100 mrem/year

Table 3.1.1.1.8 ORNL Melton Valley Dosimeters >100 mrem/year

Dosimeter Designation (Dosimeter number)	Location *Optically Stimulated Luminescent Dosimeter (OSLs) and neutron dosimeters are reported quarterly*	Type of Radiation	Dose Reported for 2015 in mrem *M = Below Minimum Reportable Quantity*				2015 Total Dose **	2014 Total Dose **
			1st Quarter	2nd Quarter	3rd Quarter	4th Quarter		
D-19 (75)	Hot spot on Haw Ridge	Gamma	35	34	42	84	148	174
D-20 (25)	Molten Salt Reactor Experiment	Gamma	45	19	21	39	113	578
D-21 (27)	White Oak Creek Weir at Lagoon Rd	Gamma	31	30	34	22	127	156
D-23 (35)	Confluence of White Oak Creek and Melton Branch	Gamma	111	108	114	110	444	456
D-30 (55)	SWSA 5 TRU Waste Trench	Gamma	40	27	27	42	125	144
D-32 (168)	New Hydrofracture Facility	Gamma	103	99	101	72	404	410
D-33 (169)	Melton Valley Haul Road Near Creek	Gamma	139	162	149	80	600	630
D-34 (170)	Cask Storage Containment Area	Gamma	1363	1,192	1,332	1,315	5183	5,364

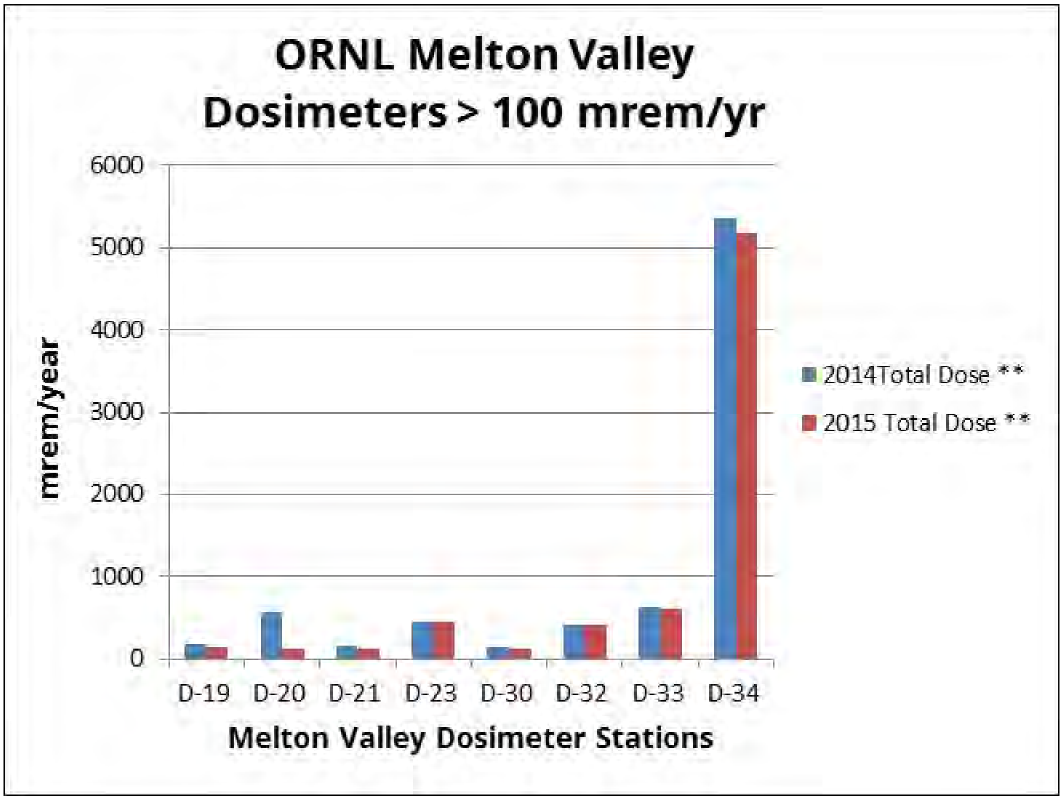


Figure 3.1.1.1.7 ORNL Melton Valley dosimeters >100 mrem/year

Table 3.1.1.1.9 ORNL Dosimeters >100 mrem/year south of Melton Valley

Dosimeter Designation (Dosimeter number)	Location *Optically Stimulated Luminescent Dosimeter (OSLs) and neutron dosimeters are reported quarterly.*	Type of Radiation	Dose Reported for 2015 in mrem *M = Below Minimum Reportable Quantity*				2015 Total Dose **	2014 Total Dose **
			1st Quarter	2nd Quarter	3rd Quarter	4th Quarter		
D-54 (32)	Cesium Forest On Tree	Gamma	2662	3,201	2,516	3,121	11172	10,160
D-55 (33)	Cesium Forest Satellite Plot	Gamma	80	97	80	86	343	340

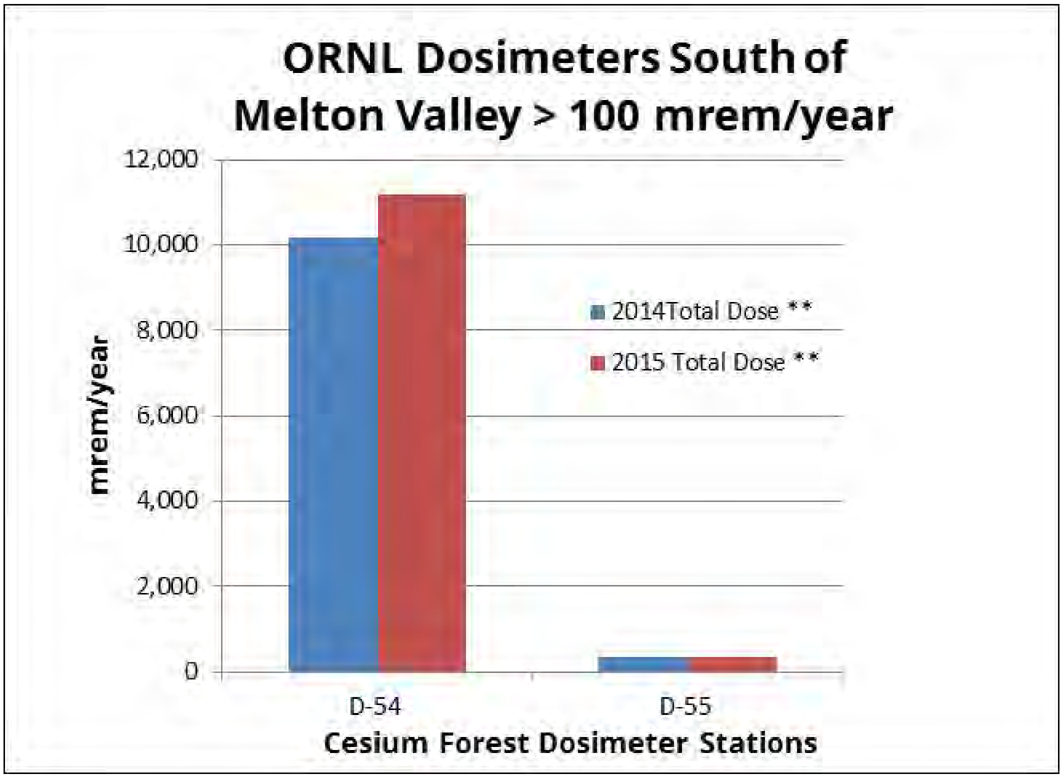


Figure 3.1.1.1.8 ORNL dosimeters south of Melton Valley >100 mrem/year

As in 2014, the highest dose reported in the program for 2015 (12,401 mrem) was at station D-36 (station 172 in 2013 report), which is located on the main ORNL campus at the Building 3607 Materials Storage Area. In the 2013 report, Station D-54 (station 32 in 2013 report), a dosimeter located at the base of a tree in the Cesium Forest, had the highest annual reading. In 1962, a group of trees at this location were injected with a total of 360 millicuries of cesium-137, as part of a study on the isotope's behavior in a forest ecosystem (Witkamp, 1964). The Cesium Forest is located in a remote gated area of the reservation posted as a radiation area. The dosimeter, which is placed on or near the trunk of the tree, is exchanged remotely with the assistance of ORNL personnel. The variability in the results, that can be noted in the quarterly and 2015 results in Table 3.1.1.1.9, is primarily due to the inexact nature of the remote apparatus in placing the dosimeter near the tree. The higher readings for 2015 compared to 2014 may be due in part to a more secure placement of the dosimeters at the base of the tree.

There was one station greater than 100 mrem/year in 2015, which was below 100 mrem/year in 2014. This was station D-14, north side of Central Avenue (station 166 in the 2013 report). Readings at D-14 were 220 mrem/year in 2015 and only 80 mrem/year in 2014. Only two quarters of valid dosimeter data were available in 2014, while three quarters of data were available for 2015. Extrapolation of the data to a full year may have led to somewhat lower estimates in 2014. The increase for 2015 may also reflect research activities ongoing in the area.

Overall, the dose rates at the ORNL locations decreased in 2015 when compared to 2014 results. Most of these locations are associated with legacy facilities that are either undergoing or scheduled for remediation. As the clean-up continues the dose rates measured are expected to be further reduced. Exceptions may be found where activities continue.

Dosimeter data for all stations at ORNL (except stations at SNS which are treated separately) with lower than 100 mrem/year in 2015 are presented in Tables 3.1.1.1.10 and Figure 3.1.1.1.10. One of these stations (D-31; SWSA 5 near Storage Tank Area) was above 100 mrem/year in 2014, but was below 100 mrem/year for 2015 (Figure 3.1.1.1.10).

Table 3.1.1.1.10 ORNL Stations (except SNS) with Annual Readings <100 mrem/year

Dosimeter Designation (Dosimeter number)	**Location** *Optically Stimulated Luminescent Dosimeter (OSLs) and neutron dosimeters are reported quarterly.*	**Type of Radiation**	**Dose Reported for 2015 in mrem** *M = Below Minimum Reportable Quantity*				**2015 Total Dose ****	**2014 Total Dose ****
			1st Quarter	2nd Quarter	3rd Quarter	4th Quarter		
D-10 (20)	Freels Bend Entrance	Gamma	2	4	5	9	15	12
D-12 (69)	Graphite Reactor	Gamma	9	6	7	75	29	44
D-13 (167)	South Side Of Central Ave.	Gamma	15	15	17	47	63	82
D-16 (30)	X-3513 Impoundment	Gamma	7	6	absent	14	26	30
D-17 (28)	White Oak Dam at Highway 95	Gamma	M	2	3	M	7	14
D-18 (34)	SWSA 6 On Fence at Highway 95	Gamma	4	5	5	1	19	20
D-22 (24)	Building X-7819	Gamma	7	7	8	20	29	30
D-24 (56)	Old Hydrofracture Pond	Gamma	12	11	14	57	49	60
D-26 (23)	SWSA 5 (South 7828)	Gamma	M	4	3	16	9	10
D-27 (46)	Homogeneous Reactor Experiment Site	Gamma	2	3	2	41	9	14
D-28 (22)	High Flux Isotope Reactor	Gamma	8	7	8	20	31	34
D-31 (87)	SWSA 5 Near Storage Tank Area	Gamma	23	21	24	90	91	114
D-40 (84)	Tower Shielding Facility at Gate (West)	Gamma	4	5	4	M	17	18
D-41 (85)	Tower Shielding Facility (North Side)	Gamma	2	5	4	M	15	18
D-50 (68)	White Oak Creek at Coffer Dam	Gamma	M	1	M	75	1	4
D-51 (26)	Cesium Fields	Gamma	6	5	7	7	24	28
D-52 (31)	Cesium Forest Boundary	Gamma	14	15	17	9	61	66
D-53 (31a)	Cesium Forest Boundary (Duplicate)	Gamma	13	13	14	12	53	64
D-60 (183)	ORNL Melton Valley Trench 7	Gamma	11	11	14	39	48	50

Dosimeter Designation (Dosimeter number)	**Location** *Optically Stimulated Luminescent Dosimeter (OSLs) and neutron dosimeters are reported quarterly.*	Type of Radiation	Dose Reported for 2015 in mrem *M = Below Minimum Reportable Quantity*				2015 Total Dose **	2014 Total Dose **
			1st Quarter	2nd Quarter	3rd Quarter	4th Quarter		
D-62 (185)	ORAU Pumphouse Road	Gamma	8	5	5	38	24	44
D-62 (185)	ORAU Pumphouse Road	Neutron	M	M	M	M	0	0

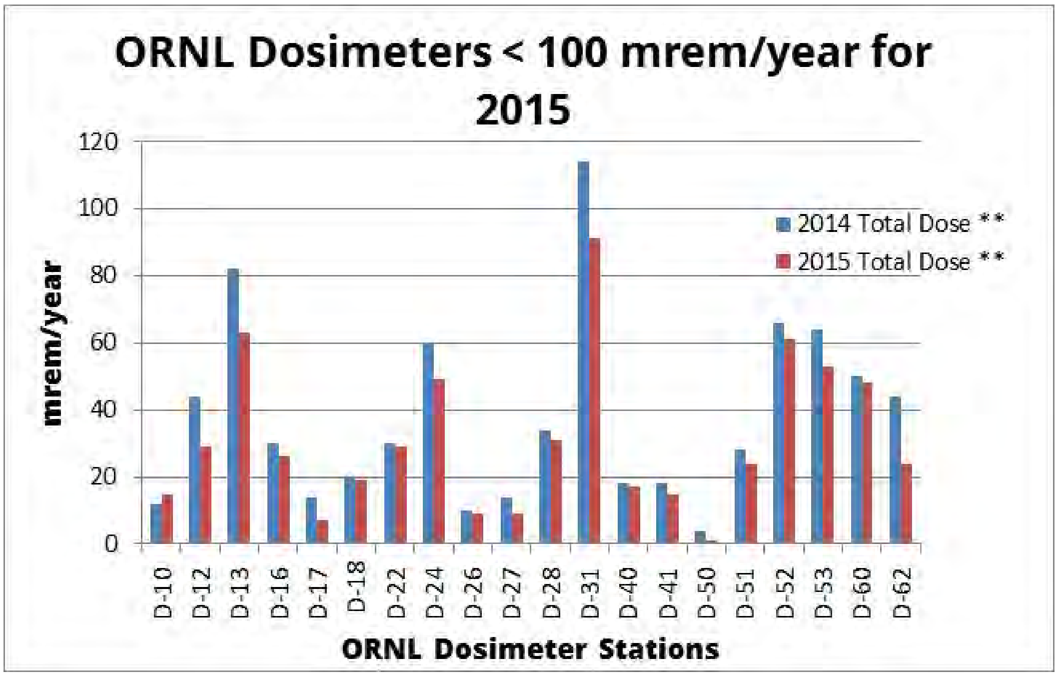


Figure 3.1.1.1.9 ORNL (except SNS) dosimeters with annual readings <100 mrem/year

While all locations exceeding 100 mrem warrant continued monitoring, special attention should be given to the materials storage area at Building 3607, south of the irradiated fuels building (Building 3525), which had an annual dose of 12,401 mrem in 2015 (13,002 mrem in 2014). Vehicles often park next to the monitoring station, which is located at the radiation boundary of the storage area.

Spallation Neutron Source (SNS)

The SNS is a one-of-a-kind research facility that produces the most intense pulsed neutron beams in the world. The facility was designed and built in partnership with six DOE national laboratories, including Lawrence Berkeley in California, Los Alamos in New Mexico, Argonne in Illinois, Brookhaven in New York, Thomas Jefferson in Virginia, and ORNL in Tennessee. The process begins with a source that produces negatively charged hydrogen ions, consisting of one proton and two electrons. The hydrogen ions are injected into a linear particle accelerator (linac) where they are accelerated to high energies and passed through a magnetic foil that strips off the electrons, converting the ions into protons. The protons pass into an accumulator ring, which releases them in high-energy pulses directed toward a liquid mercury target. When the protons strike the nucleus of the mercury atoms in the target, neutrons are "spalled" or thrown off, along with other spallation

products. The neutrons released by the spallation process are guided through beam lines to areas containing specialized instruments for conducting experiments. During the process, high-energy protons interact with nuclei of the accelerator components and materials in the air inside the facility, converting the struck nucleus to that of a different isotope, which is often radioactive. Air evacuated from the facility is held to allow short-lived radioisotopes to decay, filtered to remove particulates, and released to the atmosphere through the central exhaust stack.

TDEC has placed dosimeters outside the linac, accumulator ring, target building, central exhaust stack, and other locations of interest. During 2015, the results ranged from eight to 543 mrem/year. The only result to exceed 100 mrem in 2015 was for a dosimeter located on the central exhaust stack (543 mrem/year). This was higher than the reading obtained in 2014 (464 mrem/year). During 2015, the beamline was run at higher power levels than previously.

Table 3.1.1.1.11. SNS Dosimeters

Dosimeter Designation (Dosimeter number)	Location *Optically Stimulated Luminescent Dosimeter (OSLs) and neutron dosimeters are reported quarterly.*	Type of Radiation	Dose Reported for 2015 in mrem *M = Below Minimum Reportable Quantity*				2015 Total Dose **	2014 Total Dose **
			1st Quarter	2nd Quarter	3rd Quarter	4th Quarter		
D-70 (53)	Central Exhaust Facility	Gamma***	118	142	147	280	543	464
D-70 (53)	Central Exhaust Facility	Neutron	M	M	M	M	0	
D-71 (93)	Ring Building Perimeter Fence	Gamma	5	5	5	75	20	32
D-71 (93)	Ring Building Perimeter Fence	Neutron	M	M	M	M	0	
D-72 (17)	Beam Dump Bldg. # 8520	Gamma	5	6	6	49	23	28
D-72 (17)	Beam Dump Bldg. # 8520	Neutron	M	M	M	M	0	
D-73(73)	SNS Water Tower (Overlook) North	Gamma	6	8	9	46	31	34
D-74 (101)	LINAC Beam Tunnel Berm West (#1)	Gamma	5	5	9	69	25	28
D-74 (101)	LINAC Beam Tunnel Berm West (#1)	Neutron	M	M	M	M	0	
D-75 (102)	LINAC Beam Tunnel Berm (#2)	Gamma	7	8	11	70	35	36
D-75 (102)	LINAC Beam Tunnel Berm (#2)	Neutron	M	M	M	M	0	
D-76 (103)	LINAC Beam Tunnel Berm (#3)	Gamma	6	5	9	56	27	26
D-76 (103)	LINAC Beam Tunnel Berm (#3)	Neutron	M	M	M	M	0	
D-77 (100)	LINAC Beam Tunnel Berm (#4)	Gamma	7	8	14	58	39	36
D-77 (100)	LINAC Beam Tunnel Berm (#4)	Neutron	M	M	M	M	0	
D-78 (99)	LINAC Beam Tunnel Berm (#5)	Gamma	6	6	7	73	25	28
D-78 (99)	LINAC Beam Tunnel Berm (#5)	Neutron	M	M	M	M	0	
D-79 (98)	LINAC Beam Tunnel Berm (#6)	Gamma	8	9	14	78	41	40
D-79 (98)	LINAC Beam Tunnel Berm (#6)	Neutron	M	M	M	M	0	
D-80 (97)	LINAC Beam Tunnel Berm East (#7)	Gamma	6	6	8	56	27	28
D-80 (97)	LINAC Beam Tunnel Berm East (#7)	Neutron	M	M	M	280	0	
D-81 (74)	SNS Cooling Tower South	Gamma	3	3	5	M	15	14
D-82 (52)	Target Bldg West	Gamma	6	8	4	17	24	40
D-82 (52)	Target Bldg West	Neutron	M	M	M	37	0	
D-83 (51)	Target Bldg South	Gamma	M	M	2	M	3	12
D-83 (51)	Target Bldg South	Neutron	M	M	M	25	0	

Dosimeter Designation (Dosimeter number)	Location *Optically Stimulated Luminescent Dosimeter (OSLs) and neutron dosimeters are reported quarterly.*	Type of Radiation	Dose Reported for 2015 in mrem *M = Below Minimum Reportable Quantity*				2015 Total Dose **	2014 Total Dose **
			1st Quarter	2nd Quarter	3rd Quarter	4th Quarter		
D-84 (12)	Target Bldg East	Gamma	4	4	3	M	15	20
D-84 (12)	Target Bldg East	Neutron	M	M	M	33	0	
D-85 (104)	SNS Administrative Building	Gamma	M	3	3	M	8	10
D-85 (104)	SNS Administrative Building	Neutron	M	M	M	71	0	464

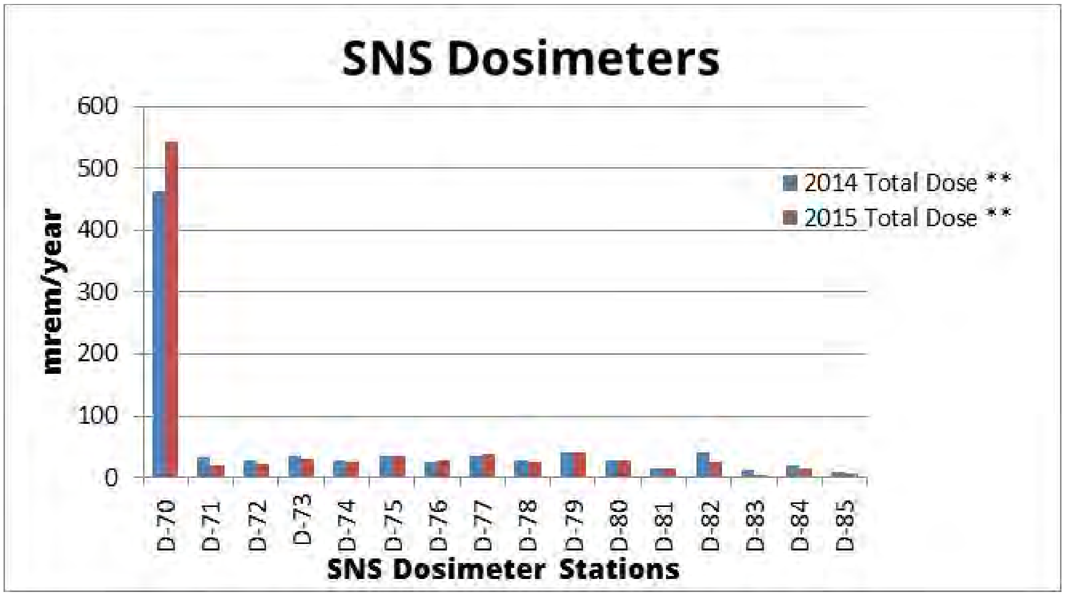


Figure 3.1.1.1.10 SNS dosimeters

Table 3.1.1.1.12 Descriptive Notes for Tables 1-11

Notes: Two types of dosimeters are used in the program, optically stimulated luminescent dosimeters (OSLs) and neutron dosimeters. The OSLs measure the dose from gamma radiation, which is considered sufficient for most of the monitoring stations. The neutron dosimeters, which have been placed at selected locations, measure the dose from neutrons in addition to the gamma radiation. At the locations where the neutron dosimeters have been deployed, the total dose is the sum of the doses reported for neutrons and the dose reported for gamma radiation.
The primary dose limit for members of the public specified in both DOE Orders and 10 CFR Part 20 (Standards for Protection Against Radiation) is 100 mrem total effective dose equivalent in a year, exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The Nuclear Regulatory Commission limit for a decommissioned facility is 25 mrem/yr.
NEW = Data for the period does not exist for this station because it is new.
M = Below minimum reportable quantity (one mrem for gamma, 10 mrem for thermal neutrons)
NA = Not analyzed or not deployed at location.
Absent = The dosimeter was not found at the time of collection.
Damaged = The dosimeter was physically damaged and the results were not consistent with historical values.

** A control dosimeter is provided with each batch of dosimeters received from the vender. The control dosimeters are used to identify the portion of the dose reported due to radiation exposures received in storage and transit. The dose reported for the control dosimeter is subtracted from the dose reported for each field deployed dosimeter.
Values in Red: Values for the 4th Quarter Dosimeters have been highlighted in red because of questions as to the accuracy of the data. Control dosimeters for this quarter were excessively high indicating that the package of dosimeters may have been x-rayed during shipping.

3.1.1.2 Real Time Monitoring of Gamma Radiation

The amount of radiation an individual can be exposed to is restricted by state and federal regulations. The primary dose limit for members of the public specified by these regulations is a total effective dose equivalent of 100 mrem in a year. Since there are no agreed upon levels where exposures to radiation constitute zero risk, radiological facilities are also required to maintain exposures as low as reasonably achievable (ALARA). Table 3.1.1.2 provides some of the more commonly encountered dose limits.

Table 3.1.1.2: Commonly Encountered Dose Limits for Exposures to Radiation

Dose Limit	Application
5,000 mrem/year	Maximum annual dose for radiation workers
100 mrem/year	Maximum dose to a member of the general public
25 mrem/year	Limit required by state regulations for free release of facilities that have been decommissioned
2 mrem in any one hour period	The state limit for the maximum dose in an unrestricted area in any one hour period

The unit used to express the limits (rem) refers to the dose of radiation an individual receives (the amount of radiation absorbed by the individual). For alpha and neutron radiation, the measured quantity of exposure, roentgen (R), is multiplied by a quality factor to derive the dose. For gamma radiation, the roentgen and the rem are generally considered equivalent. The more familiar unit, rem, is used in this report to avoid confusion. The monitors used in this program only account for the doses attributable to external exposures from gamma radiation. Any dose contribution from alpha, beta, or neutron radiation would be in addition to the measurements reported.

Fort Loudoun Dam Background Station

On average, individuals in the United States receive a dose of approximately 300 mrem in a year from naturally occurring radiation. Most of this dose is from internal exposures received as a result of breathing radon and associated daughter radionuclides. Background exposure rates fluctuate over time due to various phenomena that alter the quantity of radionuclides in the environment and/or the intensity of radiation being emitted by these radionuclides. For example, the gamma exposure rate above soils saturated with water after a rain are expected to be lower than the rate over dry soils because the moisture shields radiation released by terrestrial radionuclides. To better

assess exposure rates measured on the reservation and the influence that natural conditions have on these rates, TDEC maintains one gamma monitor at Fort Loudoun Dam in Loudon County to collect background information. The background results are provided on Figures 3.1.1.2.1 through 3.1.1.2.4. During the 2015 calendar year, exposure rates averaged 8.6 μrem/hour and ranged from seven to 14 μrem/hour, which is equivalent to a dose of approximately 76 mrem/year.

The Environmental Management Waste Management Facility

The EMWMF was constructed in Bear Creek Valley (near Y-12) to dispose of wastes generated by CERCLA activities on the ORR. The EMWMF relies on a waste profile provided by the generator to characterize waste disposed of in the facility. This profile is based on an average of the contaminants in a waste lot. Since the size of waste lots can vary from a single package to many truckloads of waste, the averages reported are not necessarily representative of each load of waste transported to the facility. Some loads may have highly contaminated wastes, while other loads may contain little contamination. Historically, the exposure rate monitors were used to identify waste potentially exceeding waste acceptance criteria (WAC) as it was transported into the disposal cells, and which was subject to audit. In 2011, TDEC replaced the unit with a radiation portal monitor (RPM). One of the exposure rate monitors was returned to the site and placed alongside the RPM to assess the performance of each and confirm associated results. Measurements taken averaged 6.8 μrem/hour and ranged from five to 11 μrem/hour, which was similar to the background measurements collected during the period (Figure 3.1.1.2.1).

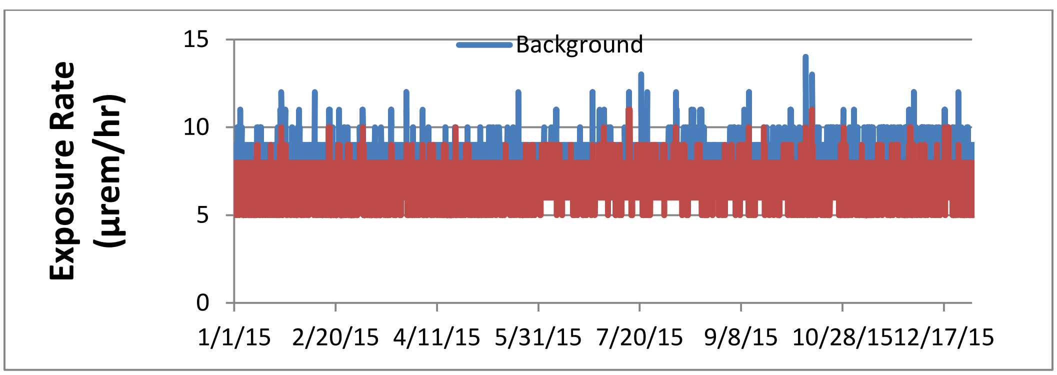


Figure 3.1.1.2.1 2015 Results of gamma exposure rate monitoring at the weigh-in station for EMWMF and at the background station

The state dose limit in an unrestricted area is two mrem (2,000 μrem) in any one-hour period. The state dose limit for members of the public is 100 mrem (100,000 μrem) in a year.

ORNL Central Campus Remediation / Building 3026 Radioisotope Development Lab

Monitoring of the ORNL Central Campus remediation began September 1, 2011, and continued through 2015. Concerns include potential releases during the demolition of high risk facilities centrally located on ORNL's main campus in close proximity to pedestrian and vehicular traffic, privately funded facilities, and active ORNL facilities. Many of these facilities were constructed during the Manhattan Era to produce radioisotopes in support of the development of the first nuclear weapons and later for medical research and commercial applications. Among these facilities is the Radioisotope Development Laboratory, a wooden structure comprised of the 3026-C and 3026-D facilities, which are being addressed as a CERCLA time critical removal action.

The 3026 facilities were constructed in the 1940s to house operations for the separation of barium-140 from uranium fuel slugs irradiated in ORNL's Graphite Reactor and later Hanford reactors. Over the years, the facilities were modified for various uses, including the separation of radioisotopes from liquid wastes generated by the processing of irradiated fuel elements for uranium and plutonium in the 3019 Radiochemical Chemical Development Lab. In the 1960s, 3026-C was equipped to enrich krypton-85 by thermal diffusion and in the 1970s a tritium lab was added to package, store, and test radio-luminescent lights. 3026-D was modified in the 1960s to support processing of fuel from the Sodium Reactor Experiment and examine irradiated metallurgical reactor components. Both facilities were shut down in the late 1980s. In the interim, the wood frame structures experienced significant physical deterioration, to the point of failure. As a consequence of the hazards presented by radioactive contamination present in the facilities, the condition of the structures, and their location, a time critical removal action was initiated in 2009 to include demolition of the 3026 wooden frame structure and stabilization of the hot cells contained in each of the two facilities. The 3026 wooden superstructure was demolished in 2010 and demolition of the 3026-C hot cells was completed in 2012. The 3026-D hot cell demolition was completed in 2013, although higher than expected radiation levels hindered the project. Due to the nature of historical operations in the facilities, potential contaminants include a long list of radionuclides including cesium-137, strontium-90, carbon-14, nickel-59 and 63, iron-55 and 59, krypton-85, promethium-147, silver-110m, tritium, technetium-99, zinc-65, americium-241, and neptunium-239, along with isotopes of europium (153, 154, and 155), plutonium (239, 240, and 241), and uranium (233, 234, 235, 236, and 238).

One of TDEC's exposure rate monitors was placed at the 3026 demolition site on January 11, 2012 (prior to the demolition of the 3026-C hot cell) and has remained at the site through 2015. In 2012, the levels of gamma radiation measured ranged from 12 to 88 μrem/hour and averaged of 24.7 μrem/hour. As the removal action turned to the more contaminated 3026-D hot cells in 2013, the exposure rates increased substantially, then declined near the end of the year as the waste was removed for disposal (Figure 3.1.1.2.2). During 2015, gamma radiation measured at the site ranged from 12 to 24 μrem/hour and averaged 16.8 μrem/hour.

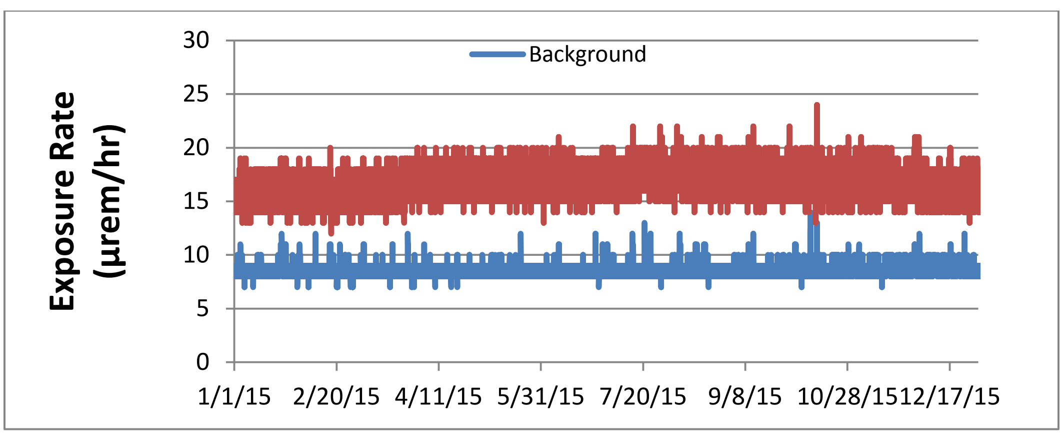


Figure 3.1.1.2.2 2015 Results of gamma exposure rate monitoring at the ORNL central campus removal action and at the background station

The state dose limit in an unrestricted area is two mrem (2,000 µrem) in any one-hour period. The state dose limit for members of the public is 100 mrem (100,000 µrem) in a year.

The Molten Salt Reactor Experiment

The concept of a molten salt reactor was first explored at ORNL in association with a 1950s campaign to design a nuclear powered airplane. After interest in an atomic airplane subsided, the MSRE was constructed to evaluate the feasibility of applying the technology to commercial power applications. The concept called for circulating uranium fluoride (the fuel) dissolved in a molten salt mixture through the reactor vessel. The MSRE achieved criticality (a chain reaction resulting in a release of radiation) in 1965 and was used for research until 1969.

When the reactor was put into shutdown mode, the molten fuel salts and flush salts were transferred to drain tanks and allowed to solidify. In 1994, an investigation of the MSRE revealed elevated levels of uranium hexafluoride and fluorine gases throughout the off-gas piping connected to the drain tanks. Among other problems, uranium had migrated through the system to the auxiliary charcoal bed, creating criticality concerns. Actions were subsequently taken to stabilize the facility and a CERCLA Record of Decision (ROD) was issued in July 1998 requiring the removal, treatment, and safe disposition of the fuel and the flushing of salts from the drain tanks.

From November 1, 2012 through the end of 2015, TDEC has recorded gamma exposure rates with a gamma monitor that was placed near the gate where trucks containing radioactive materials (fuel removed from the drain tanks) exit the MSRE. The location is also near a radiation area that is used to store equipment used in the remediation. During the 2015 monitoring period, the average exposure rate measured ranged from 37 to 54 µrem/hour and averaged 47.3 µrem/hour (Figure 3.1.1.2.3). The major source of the radiation measured appears to be a salt probe stored in the radiation area adjacent to the monitoring station.

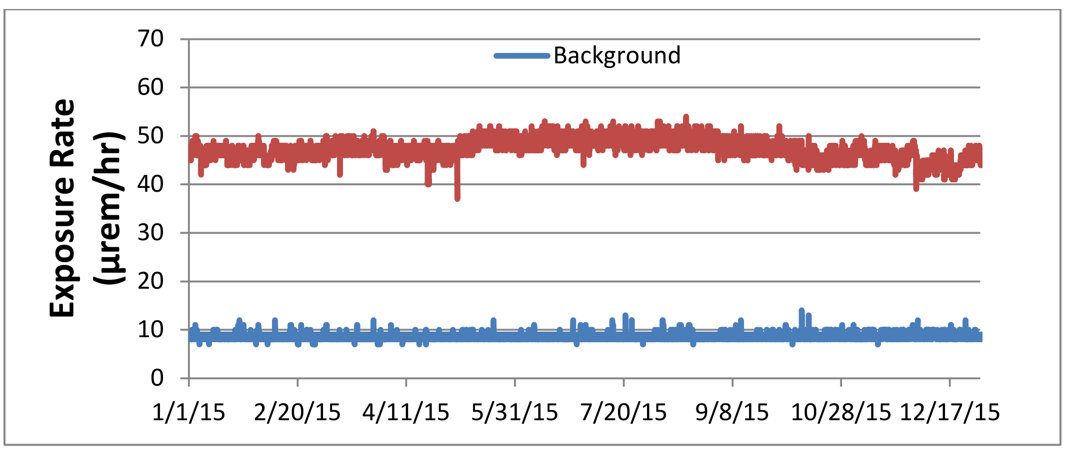


Figure 3.1.1.2.3 2015 Results of gamma exposure rate monitoring at the ORNL MSRE and at the background station

The state dose limit in an unrestricted area is two mrem (2,000 µrem) in any one-hour period. The state dose limit for members of the public is 100 mrem (100,000 µrem) in a year.

Spallation Neutron Source

To assess the gamma component of air releases from the SNS, one of TDEC's exposure rate monitors has been located on the central exhaust stack used to vent air from process areas inside the linac and target building. The exposure rates vary with the operational status of the accelerator. During periods when the accelerator is not on line, the rate is similar to background measurements, with much higher levels recorded during operational periods. The exposure rates measured in 2015 ranged from five to 616 μrem/hour and averaged 234.3 μrem/hour (Figure 3.1.1.2.4).

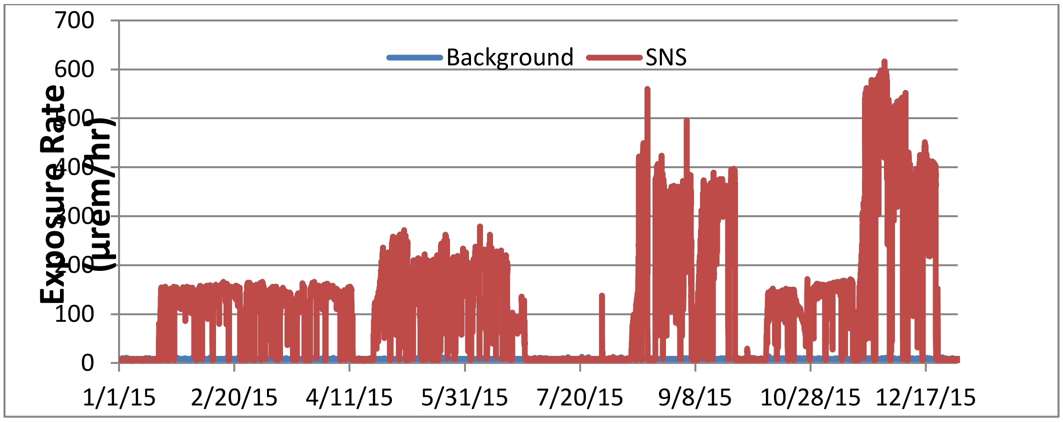


Figure 3.1.1.2.4 2015 Results of gamma exposure rate monitoring at the SNS stack and at the background station

The state dose limit in an unrestricted area is two mrem (2,000 μrem) in any one-hour period. The state dose limit for members of the public is 100 mrem (100,000 μrem) in a year.

3.1.1.3 Surplus Material Verification

A total of six inspections were conducted during 2015, all at ORNL. No sales were held at Y-12 or at ETTP. No items with elevated levels of alpha and beta radiological contamination requiring further evaluation were discovered during the surveys. On occasion, items containing NORM (naturally occurring radioactive material) are included among the auction items. These include old cathode ray tube televisions, electronic insulators, ceramic sinks and other items made from ceramics. When found, these items are noted and that information is provided to auction personnel.

When items of concern are found, they are reevaluated by ORNL/Y-12 to ensure they meet the appropriate Y-12 or ORNL release criteria for release of items to the public. The elevated levels of activity are often determined to be due to an accumulation of radon.

3.1.2 Air Monitoring

3.1.2.1 Fugitive Air Monitoring

East Tennessee Technology Park (ETTP)

The K-25 Gaseous Diffusion Plant, now known as the East Tennessee Technology Park, began operations in World War II as part of the Manhattan Project. Its original mission was to produce uranium enriched in the uranium-235 isotope (U-235) for use in the first atomic weapons and later to fuel commercial and government-owned reactors. The plant was permanently shut down in 1987. As a consequence of operational practices and accidental releases, many of the facilities scheduled for decontamination and decommissioning (D&D) at ETTP are contaminated to some degree.

Uranium isotopes are the primary contaminants, but Tc-99 and other fission and activation products are also present, due to the processing of recycled uranium obtained from spent nuclear fuel originating from reactors. Two samplers were used at ETTP. One operated the entire year at location K-25/K11. The other sampler was at Portal 4 from January 1, 2015 until November 4, 2015, and was then moved to location K-27 and operated from November 4, 2015 through the end of the year. Samples are collected weekly from the two units and composited every four weeks for radiochemical analysis. Current analysis includes uranium, U-234, U-235, U-238, and Tc-99. Tables 3.1.2.1.1, 3.1.2.1.2, and 3.1.2.1.3 provide a summary of the results for K-25/K-11, Portal 4, and K-27 respectively.

Table 3.1.2.1.1 ETTP K-25/K-11 Air Monitoring Average Result for 2015 (pCi/m^3)

ETTP K-25/K11	U-234	U-235	U-238	Tc-99	Sum of Fractions
12 Month Average for 2015	3.36E-05	2.61E-05	3.19E-05	1.58E-04	
Average Background (Ft. Loudoun Dam)	3.47E-05	3.32E-06	3.62E-05	1.08E-04	
Net Activity (Avg. Minus Background)	-1.20E-06	2.28E-05	-4.30E-06	4.95E-05	
40CFR Part 61 Limit Appendix E (Table 2)	7.70E-03	7.10E-03	8.30E-03	1.40E-01	
Fraction of Limit Net/Limit	-1.50E-04	3.21E-03	-5.20E-04	3.53E-04	0.0029

Table 3.1.2.1.2 ETTP Portal 4 Air Monitoring Average Result for 2015 (pCi/m^3)

ETTP Portal 4	U-234	U-235	U-238	Tc-99	Sum of Fractions
10 Month Average for 2015	3.65E-05	2.78E-06	3.55E-05	2.33E-04	
Average Background (Ft. Loudoun Dam)	3.47E-05	3.32E-06	3.62E-05	1.08E-04	
Net Activity (Avg. Minus Background)	-1.74E-06	-5.30E-07	-6.60E-07	1.25E-05	
40CFR Part 61 Limit Appendix E (Table 2)	7.70E-03	7.10E-03	8.30E-03	1.40E-01	
Fraction of Limit Net/Limit	0.0002	-0.0001	-0.0001	0.0009	0.0010

Table 3.1.2.1.3 ETTP K-27 Air Monitoring Average Result for 2015 (pCi/m^3)

ETTP K-27	U-234	U-235	U-238	Tc-99	Sum of Fractions
12 Month Average for 2015	4.58E-05	3.58E-06	4.12E-05	1.24E-04	
Average Background (Ft. Loudoun Dam)	3.47E-05	3.32E-06	3.62E-05	1.08E-04	
Net Activity (Avg. Minus Background)	1.11E-05	2.64E-07	4.96E-06	1.52E-05	
40CFR Part 61 Limit Appendix E (Table 2)	7.70E-03	7.10E-03	8.30E-03	1.40E-01	
Fraction of Limit Net/Limit	1.44E-03	3.71E-05	5.97E-04	1.09E-04	0.0022

Y-12 National Security Complex

The Y-12 Plant, now known as the Y-12 National Security Complex, was also constructed during World War II to enrich uranium, in this case by the electromagnetic separation process. In ensuing years, the facility was expanded, and used to produce fuel for naval reactors, conduct

lithium/mercury enrichment operations, manufacture components for nuclear weapons, dismantle nuclear weapons, and store highly enriched uranium. The Y-12 B9723 air monitor was located centrally at Y-12 near Building 9723 in July 2010 to monitor the D&D of contaminated facilities associated with the Y-12 Integrated Facilities Disposition Project. A second air monitor was stationed east of Building 9212 in September 2012 to monitor footprint reduction activities. Building 9212 was constructed in 1945 and is currently used to process highly enriched uranium. The aging facility is expected to be replaced by the proposed Uranium Processing Facility in the future. Samples were collected weekly from the two Y-12 samplers and composited every four weeks for radiochemical analysis. Current analysis includes U-234, U-235, U-238 and Tc-99. Tables 3.1.2.1.4 and 3.1.2.1.5 provide a summary of the results for Building 9212 and 9723-28 area fugitive air monitors, respectively.

Table 3.1.2.1.4 Y-12 Building 9212 Air Monitoring Average Result for 2015 (pCi/m^3)

Building 9212	U-234	U-235	U-238	Tc-99	Sum of Fractions
12 Month Average for 2015	2.06E-04	1.26E-05	4.35E-05	8.31E-05	
Average Background (Ft. Loudoun Dam)	3.47E-05	3.32E-06	3.62E-05	1.08E-04	
Net Activity (Avg. Minus Background)	1.72E-04	9.28E-06	7.34E-06	-2.50E-05	
40CFR Part 61 Limit Appendix E (Table 2)	7.70E-03	7.10E-03	8.30E-03	1.40E-01	
Fraction of Limit Net/Limit	2.23E-02	1.31E-03	8.84E-04	-1.80E-04	0.0243

Table 3.1.2.1.5 Y-12 Building 9723-28 Air Monitoring Average Result for 2015 (pCi/m^3)

Building 9723-28	U-234	U-235	U-238	Tc-99	Sum of Fractions
12 Month Average for 2015	5.71E-05	4.98E-06	4.71E-05	1.05E-04	
Average Background (Ft. Loudoun Dam)	3.47E-05	3.32E-06	3.62E-05	1.08E-04	
Net Activity (Avg. Minus Background)	2.23E-05	1.67E-06	1.09E-05	-3.10E-06	
40CFR Part 61 Limit Appendix E (Table 2)	7.70E-03	7.10E-03	8.30E-03	1.40E-01	
Fraction of Limit Net/Limit	2.90E-03	2.35E-04	1.32E-03	-2.20E-05	0.0044

Oak Ridge National Laboratory

Construction of the Oak Ridge National Laboratory began in 1943. While the initial mission of K-25 and Y-12 was the production of enriched uranium, the ORNL site focused on reactor research, and the production of plutonium, and other activation and fission products, which were chemically extracted from uranium irradiated in ORNL's Graphite Reactor and later other ORNL and Hanford reactors. During early operations, leaks and spills were common in the facilities, and associated radioactive materials were released from operations as gaseous, liquid, and solid effluents, with little or no treatment (ORAU, 2003). As a consequence, many of the facilities are contaminated with a long list of fission and activation products. Many of these facilities are considered the highest risk facilities at ORNL, due to their physical deterioration, the presence of loose contamination, and their proximity to privately funded facilities, active ORNL facilities, and pedestrian and vehicular traffic. Over recent years, a concerted effort has been made to D&D these facilities, and to remediate associate sites. Two of the fugitive air monitors are currently positioned to monitor the remedial

efforts: one to the southwest of the W1A/Core Hole 8 removal action completed in 2012, and the other at Building B4007, which is northeast of the D&D of the 3026 Radioisotope Development Laboratory, and in the vicinity of other facilities undergoing or scheduled for remediation.

The 3026 Radioisotope Development Laboratory consisted of two facilities (3026-C and 3026-D) that shared a common wall, and were constructed in the early 1940s to house operations for the separation of barium-140 from uranium fuel slugs irradiated in the Graphite Reactor and Hanford reactors. Over the years, the facilities were modified for various uses, including the separation of radioisotopes from liquid wastes generated by processing of irradiated uranium fuel elements for plutonium. 3026-D was modified in the 1960s to support processing of fuel from the Molten Salt Reactor Experiment, and examine irradiated metallurgical reactor components. Both facilities were shut down in the late 1980s. In the interim, the wood frame structures deteriorated to the point of failure.

As a consequence of the hazards presented by radioactive contamination present in the 3026 C and D facilities, a time-critical removal action was initiated in 2009 to include demolition of the 3026 wooden frame structure and stabilization of the hot cells contained in each of the two 3026 facilities. The 3026 wooden superstructure was demolished in 2010 and demolition of the 3026-C hot cells was completed in 2012. Although hindered by high radiation levels, the 3026-D hot cell demolition was completed in 2013. Due to the nature of historic operations in the facilities, potential contaminants include a long list of radionuclides: cesium-137, strontium-90, sarbon-14, nickel-59 and 63, iron-55 and 59, krypton-85, promethium-147, silver-110m, tritium, Tc-99, zinc-65, americium-241, and neptunium-239, along with isotopes of europium (153, 154, and 155), plutonium (239, 240, and 241), and uranium (233, 234, 235, 236, and 238). Samples were collected weekly from the two ORNL samplers and composited every four weeks for radiochemical analysis. Current analysis includes U-234, U-235, U-238, and gamma spectrometry. The gamma spectrometry analysis is not shown, as only naturally occurring daughter products of radon were detected. Tables 3.1.2.1.6 and 3.1.2.1.7 provide a summary of the isotopic uranium results for B4007 and Corehole 8 area fugitive air monitors, respectively.

Table 3.1.2.1.6 ORNL B4007 Air Monitoring Average Result for 2015 (pCi/m^3)

ORNL B4007	U-234	U-235	U-238		Sum of Fractions
12 Month Average for 2015	3.49E-05	2.41E-06	3.44E-05		
Average Background (Ft. Loudoun Dam)	3.47E-05	3.32E-06	3.62E-05		
Net Activity (Avg. Minus Background)	1.46E-07	-9.10E-07	-1.80E-06		
40CFR Part 61 Limit Appendix E (Table 2)	7.70E-03	7.10E-03	8.30E-03		
Fraction of Limit Net/Limit	1.90E-05	-1.30E-04	-2.10E-04		-0.0003

Table 3.1.2.1.7 ORNL Corehole 8 Air Monitoring Average Result for 2015 (pCi/m^3)

ORNL Corehole 8	U-234	U-235	U-238		Sum of Fractions

ORNL Corehole 8	U-234	U-235	U-238		Sum of Fractions
12 Month Average for 2015	3.09E-05	2.64E-06	3.21E-05		
Average Background (Ft. Loudoun Dam)	3.47E-05	3.32E-06	3.62E-05		
Net Activity (Avg. Minus Background)	-3.80E-06	-6.80E-07	-4.10E-06		
40CFR Part 61 Limit Appendix E (Table 2)	7.70E-03	7.10E-03	8.30E-03		
Fraction of Limit Net/Limit	-5.00E-04	9.60E-05	-5.00E-04		-0.0011

The Environmental Management Waste Management Facility

The EMWMF was constructed in Bear Creek Valley near the Y-12 National Security Complex to dispose of low level radioactive waste and hazardous waste generated by remedial activities on the reservation. During disposal, and prior to being covered, wastes disposed of in the facility are subject to dispersion by winds that typically travel northeast through the valley in the daytime and southwest at night. To monitor the air emissions at EMWMF, one of the fugitive air samplers was placed at the southeast corner of the facility in December of 2004. Since many different radionuclides are contained in waste disposed of in EMWMF, gross alpha, gross beta, and gamma spectrometry are used to screen samples and isotopic analysis performed as warranted. Samples were collected weekly and composited every four weeks for radiochemical analysis. Current analysis includes U-234, U-235, U-238 and Tc-99. Table 3.1.2.1.8 provides a summary of the results for the EMWMF area fugitive air monitor.

Table 3.1.2.1.8 EMWMF Air Monitoring Average Result for 2015 (pCi/m^3)

EMWMF	U-234	U-235	U-238	Tc-99	Sum of Fractions
12 Month Average for 2015	4.91E-05	4.71E-06	4.81E-05	1.59E-04	
Average Background (Ft. Loudoun Dam)	3.47E-05	3.32E-06	3.62E-05	1.08E-04	
Net Activity (Avg. Minus Background)	1.43E-05	8.55E-06	1.19E-05	5.10E-05	
40CFR Part 61 Limit Appendix E (Table 2)	7.70E-03	7.10E-03	8.30E-03	1.40E-01	
Fraction of Limit Net/Limit	1.86E-03	1.20E-04	1.44E-03	3.64E-04	0.0038

3.1.3 Biological Monitoring

3.1.3.1 Threatened and Endangered Species Monitoring

During 2015, TDEC re-surveyed and characterized sections of the Black Oak Ridge Conservation Easement (BORCE) to document the rich diversity of species observed on woodland trails and off-trail areas. For the protection of natural resources, specific locations of protected plant species are not listed in this report; however, TDEC presents fauna and flora species identified and documented during 2015 in Appendix A. Results include plant species, their respective scientific names, and, if applicable, their state and federal status. The majority of plants and animals that were documented during 2015 are non-T&E species, but collectively represent the biodiversity of natural resources present on the ORR.

Accordingly, the results consist of two main parts: ORR fauna (3.1.3.1.1), and ORR flora (3.1.3.1.2).

3.1.3.1.1 ORR Fauna

The goal is to identify biodiversity, from microscopic fauna to large mammals, that characterizes the ORR ecosystem, including elements of the National Environmental Research Park (NERP). The following represents 2015 records for four biological groups:

- Mammals (Phylum = Chordata, Superclass: Tetrapoda, Clade = Mammaliaformes Class = Mammalia)
- Snakes (Phylum = Chordata, Superclass = Tetrapoda, Class = Reptilia, Order = Squamata, Clade = Ophidia, Subgroup: Serpentes)
- Turtles (Phylum = Chordata, Class = Reptilia, Order = Testudines)
- Dragonflies (Phylum = Arthropoda, Class = Insecta, Order = Odonata, Suborder = Anisoptera)

The ORR provides habitat for game animals such as white-tailed deer (*Odocoileus virginianus*) and wild turkey. Top predators such as the bobcat (*Lynx rufus*) have been observed on the ORR.

Mammals that are nocturnal insect-predators on the ORR include a diverse bat community. Species that have been documented with both acoustic and mist-net surveys include the federally-endangered gray bat and Indiana bat and the federally-threatened northern Long-eared bat.

Three snake species were observed during TDEC field surveys on the BORCE during 2015 (Figures 3.1.3.1.1 through 3.1.3.1.3). These animals included the venomous copperhead, and non-venomous black racer and red-bellied snake. All are important for the ORR web of life, especially for control of rats and mice, and maintaining ecological balance

Figure 3.1.3.1.1 Copperhead (venomous)

Figure 3.1.3.1.3 Red-bellied snake (non-venomous)

Figure 3.1.3.1.2 Black racer (non-venomous)

The Eastern box turtle (*Terrapene carolina carolina*; Fig. 3.1.3.1.4) is a subspecies within a group of hinge-shelled turtles, normally called box turtles, native to the eastern part of the United States. The eating habits of eastern box turtles vary greatly due to individual taste, temperature, lighting, and their surrounding environment. Unlike warm-blooded animals, their metabolism does not drive their appetite. Instead, they can lessen their activity level, retreat into their shells and halt their food intake until better conditions arise. In the wild, eastern box turtles are opportunistic omnivores and will feed on a variety of animal and vegetable matter (earthworms, snails, slugs, grubs, beetles, caterpillars, grasses, fallen fruit, berries, mushrooms, flowers, duck weed, and carrion). Box turtles are also known to have consumed poisonous fungi making their flesh inedible. Snapping turtles are also seen on the ORR (Figure 3.1.3.1.5).

Figure 3.1.3.1.4 Eastern box turtle

Figure 3.1.3.1.5 Snapping Turtle

Dragonflies are predators, both during the aquatic larval stage, when they are known as nymphs, and as flying adults. Up to several years of the insect's life are spent as a nymph living in freshwater; the adults may be on the wing for just a few days or weeks (Figure 3.1.3.1.6). Dragonflies are environmental indicators of stream water quality.

Figure 3.1.3.1.6 Dragonfly

3.1.3.1.2. ORR Flora

The goal is to identify biodiversity of flora that characterizes the ORR ecosystem, including elements of the NERP. Table 3.1.3.1.1 presents 2015 records of cryptogams (non-seed, spore-producing plants) and phanerogams (flowering seed plants) found on the ORR.

Table 3.1.3.1.1 List of Flora Found on the ORR

1. CRYPTOGAMS (Non-seed, spore-producing plants): FERNS	
hay-scented fern	rock fern
maidenhair fern	broad beech fern
ground cedar	shining club moss
lady fern	sensitive fern
climbing fern	cinnamon fern
2. CRYPTOGAMS (Non-seed, spore-producing plants): FUNGI	
stalked scarlet cup	devils urn
amanita sp. mushroom	coral fungi (clavariaceae)
morel mushroom	bracket (shelf) fungi
chocolate slime mold	varnish bracket fungi
green elfcup	bearded-tooth fungi
3. PHANEROGAMS—FLOWERING SEED PLANTS (ANGIOSPERMS / SPERMATOPHYTES):	
blue star	white crownbeard
pinxter flower	butterfly weed
cardinal flower	chickory
ginseng (special concern)	sedum
dwarf larkspur	blue cohosh
phlox	chickweed
hearts-a-bustin'	white baneberry/dolls-eyes
early meadow rue	wind flower
spring beauty	trout lily
pinesap (saprophyte)	Indian pink
passion flower	bee balm
goldenseal	large-flowered trillium
pink trillium	red trillium
spotted mandarin	wood betony
skullcap	hepatica (liverwort)
toothwort	red sessile trillium
dwarf-crested iris	squaw corn
lemon trillium	pink lady slipper

3.1.3.2 Acoustic Monitoring of Bats

Acoustic bat surveys were conducted at eight major ORR areas and adjacent areas during 2015: (1) Haw Ridge Park, (2) Bethel Valley (ORNL), (3) ETTP west ponds, (4) Upper East Fork Poplar Creek floodplain (UEFPC), (5) White Wing Scrapyard Area (WWSY), (6) ETTP proposed airport site, (7) Parcel ED-5 (Horizon Center), and (8) Freels Bend Wildlife Management Area. For 209 nights during 2015 (multiple detectors deployed/night), approximately 226,000 files of bat acoustic data were recorded at 48 field stations (Table 3.1.3.2.1) and were processed with specialized, automated bat identification software (Kaleidoscope PRO) yielding 12,567 bat identifications. An additional 2,249 bat calls were detected but not identified to species due to poor call quality, inclement weather

conditions, or field clutter. Fourteen species were detected on the ORR including: Townsend's big-eared bat, big brown bat, eastern red bat, hoary bat, silver-haired bat, southeastern bat, eastern small-footed bat, little brown bat, northern long-eared bat (federally-listed threatened), Indiana bat (federally-listed endangered), evening bat, tri-colored bat (eastern pipistrelle), and the Mexican free-tailed bat (Table 3.1.3.2.2, Figure 3.1.3.2.1). Of these species, the hoary bat (18%), silver-haired bat (16%), eastern red bat (11%), and big brown bat (11%) were the dominant combined species detected at all sites. Federally-listed species detected included the gray bat (7%), Indiana bat (1%), and northern Long-eared bat (>1%).

TDEC documented all three federally-listed bat species with acoustic surveys on the ETTP proposed airport site in bat roost trees such as white oaks and dead snags. The information was shared with the TWRA, DOE, and the USFWS.

TDEC also documented all three federally-listed bat species with acoustic surveys on the Parcel ED-5 (Horizon Center), in bat roost trees such as white oaks, shagbark hickory, and dead snags. The information was shared with the TWRA, DOE, the City of Oak Ridge, and the USFWS.

Table 3.1.3.2.1 2015 ORR Acoustic Monitoring Sites

Site	Site description	Detector type
ORR-01	Haw Ridge Park/embayment area/Red Shore Trail	Anabat Express
ORR-02	Haw Ridge Park/embayment area/Red Shore Trail	Anabat Express
ORR-03	Haw Ridge Park/pond/Red Shore Trail	Anabat Express
ORR-04	Haw Ridge Park/embayment area/East Shore Trail	Anabat Express
ORR-05	Spallation Neutron Source (SNS) sedimentation pond	Anabat SD-2
ORR-06	TWRA deer checking station	Anabat SD-2
ORR-07	East Tennessee Technology Park (ETTP) ponds near Clinch River (ORNL-sponsored public outreach program: amphibians/bats)	Anabat SD-2
ORR-08	East Tennessee Technology Park (ETTP) open field (ORNL-sponsored public outreach program: amphibians/bats)	Anabat SD-2
ORR-09	East Fork Poplar Creek (EFPC 22.0 km)/riparian zone near Old Ben Franklin Motors	Anabat Express
ORR-10	East Fork Poplar Creek (EFPC 21.0 km)/edge of riparian zone adjacent to open field	Anabat Express
ORR-11	City of Oak Ridge Water Treatment Plant/ DOE Patrol Road	Anabat SD-2
ORR-12	Gum Hollow access road / limestone outcropping with small cave	Anabat SD-2
ORR-13	Hembree Marsh/White Wing Scrap Yard area	Anabat Express
ORR-14	ETTP proposed airport site/forested ridge north of Oak Ridge Turnpike	Anabat SD-2
ORR-15	ETTP proposed airport site/small pond near Oak Ridge Turnpike	Anabat Express
ORR-16	ETTP proposed airport site/RSI Brightfield adjacent to Oak Ridge Turnpike	Anabat SD-2
ORR-17	ETTP proposed airport site/open field near office building	Anabat Express
ORR-18	ETTP proposed airport site/forested ridge north of Oak Ridge Turnpike	Anabat Roost Logger
ORR-19	ETTP proposed airport site/wetlands north of Oak Ridge Turnpike (forested ridge)	SM3BAT
ORR-20	ETTP proposed airport site/forested ridge north of Oak Ridge Turnpike	SM2BAT
ORR-21	ETTP proposed airport site/forested ridge and abandoned water-storage(?) tank north of Oak Ridge Turnpike	Anabat Express

Site	Site description	Detector type
ORR-22	ETTP proposed airport site/wetlands north of Oak Ridge Turnpike (forested ridge)	Anabat SD-2
ORR-23	ETTP proposed airport site/pine plantation north of Oak Ridge Turnpike	Anabat Express
ORR-24	ETTP proposed airport site/wetlands north of Oak Ridge Turnpike (forested ridge)	SM2BAT
ORR-25	ETTP proposed airport site/groundwater monitoring well access trail near Blair Road	Anabat Express
ORR-26	ETTP proposed airport site/pipeline ROW near George Jones Church (off Blair Road)	SM3BAT
ORR-27	Horizon Center/EFPC 6.3 km sampling station/riparian zone on limestone bluff	Anabat SD-2
ORR-28	ED-5 parcel/wetlands in forest near East Fork Poplar Creek	Anabat Express
ORR-29	ED-5 parcel/East Fork Poplar Creek shoreline embankment	Anabat Express
ORR-30	ED-5 parcel/gas pipeline right-of-way (ROW)	SM3BAT
ORR-31	ED-5 parcel/gas pipeline right-of-way (ROW)	SM2BAT
ORR-32	Horizon Center/open field near Horizon Center office building	Anabat SD-2
ORR-33	Horizon Center/open area at gated dead end road	Anabat SD-2
ORR-34	ED-5 parcel/interior forested area along old access trail	Anabat Express
ORR-35	ED-5 parcel/interior forested area	SM2BAT
ORR-36	Horizon Center/open area at gated dead end road	Anabat SD-2
ORR-37	ED-5 parcel/EFPC access road	Anabat SD-2
ORR-38	ED-5 parcel/EFPC access road	SM2BAT
ORR-39	ED-5 parcel/EFPC access road	Anabat SD-2
ORR-40	ED-5 parcel/EFPC access road near limestone karst feature	SM3BAT
ORR-41	ED-5 parcel/EFPC access road	Anabat SD-2
ORR-42	ED-5 parcel/EFPC access road	SM3BAT
ORR-43	ED-5 parcel/interior forested ridge area	Anabat Express
ORR-44	ED-5 parcel/interior forested ridge area	Anabat SD-2
ORR-45	ED-5 parcel/large wet land area near EFPC access road	Anabat Express
ORR-46	Freels Bend Wildlife Management Area/Rainy Knob karst feature	Anabat SD-2
ORR-47	Freels Bend Wildlife Management Area/limestone bluff	Anabat Express
ORR-48	Freels Bend Wildlife Management Area/limestone karst feature	Anabat Express

Table 3.1.3.2.2 Summary of ORR Bat Species Detected During 2015 Acoustic Surveys

BAT SPECIES	BAT CALLS
COTO	67
EPFU	1653
LABO	1652
LACI	2589
LANO	2364
MYAU	18
MYGR	1010
MYLE	20
MYLU	498
MYSE	49
MYSO	74
NYHU	1024
PESU	1230
TABR	319
UNKN	2249

Table 3.1.3.2.3 Bat Species Codes

BAT SPECIES CODES
COTO = *Corynorhinus townsendii* (Townsend's big-eared bat)
EPFU = *Eptesicus fuscus* (big brown bat)
LABO = *Lasiurus borealis* (eastern red bat)
LACI = *Lasiurus cinereus* (hoary bat)
LANO = *Lasionycteris noctivagans* (silver-haired bat)
MYAU = *Myotis austroriparius* (southeastern bat)
MYGR = *Myotis grisescens* (gray bat, endangered)
MYLE = *Myotis leibii* (eastern small-footed bat)
MYLU = *Myotis lucifugus* (little brown bat)
MYSE = *Myotis septentrionalis* (northern long-eared bat, threatened)
MYSO = *Myotis sodalis* (Indiana bat, endangered)
NYHU = *Nycticeius humeralis* (evening bat)
PESU = *Perimyotis subflavus* (tri-colored bat; eastern pipistrelle)
TABR = *Tadarida brasiliensis* (Mexican free-tailed bat)
UNKN = unknown (bat detected but not identified)

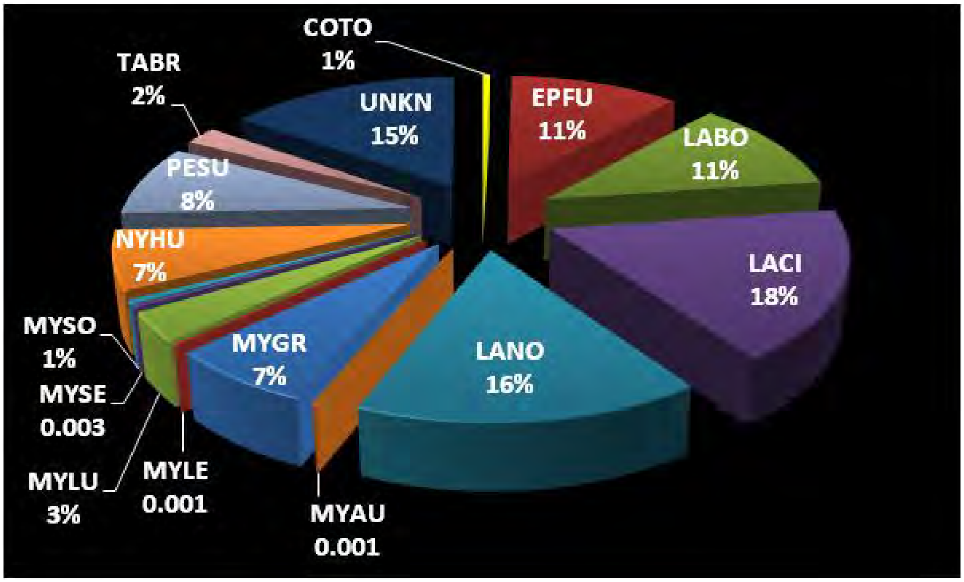


Figure 3.1.3.2.1 Distribution of combined 2015 ORR bat calls

Below are a map and figure with locations of the stations and the representation of the bat species identified. This was completed for all 48 stations and can be found in Appendix A.

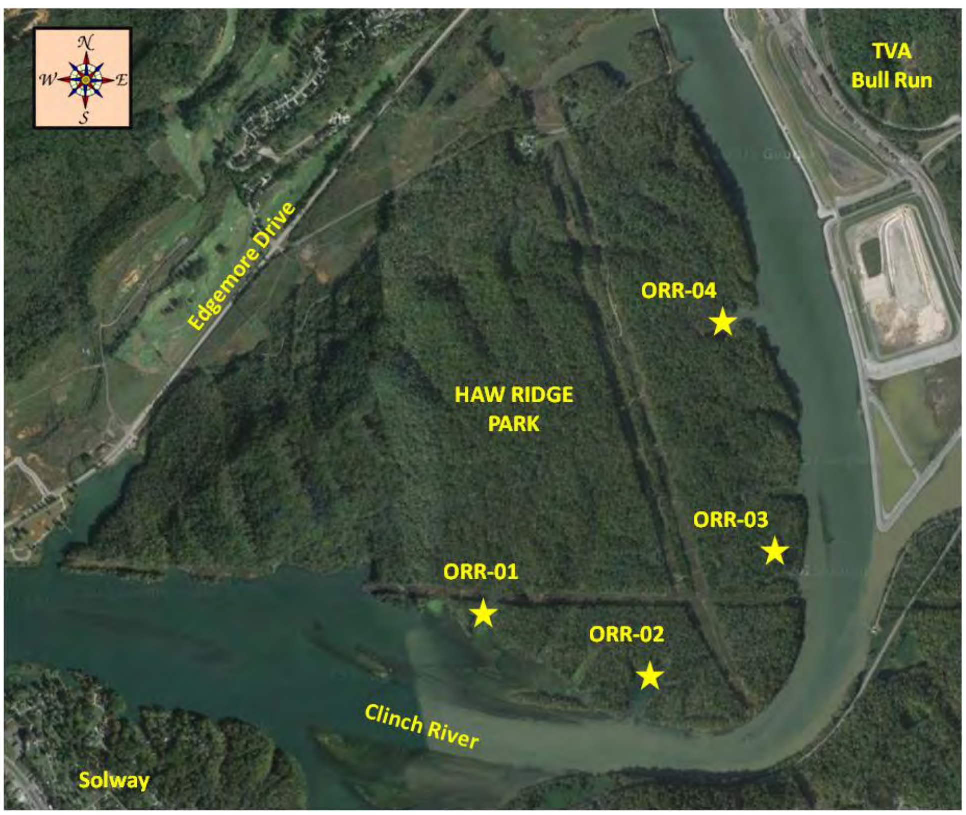


Figure 3.1.3.2.2 Haw Ridge Park acoustic survey map

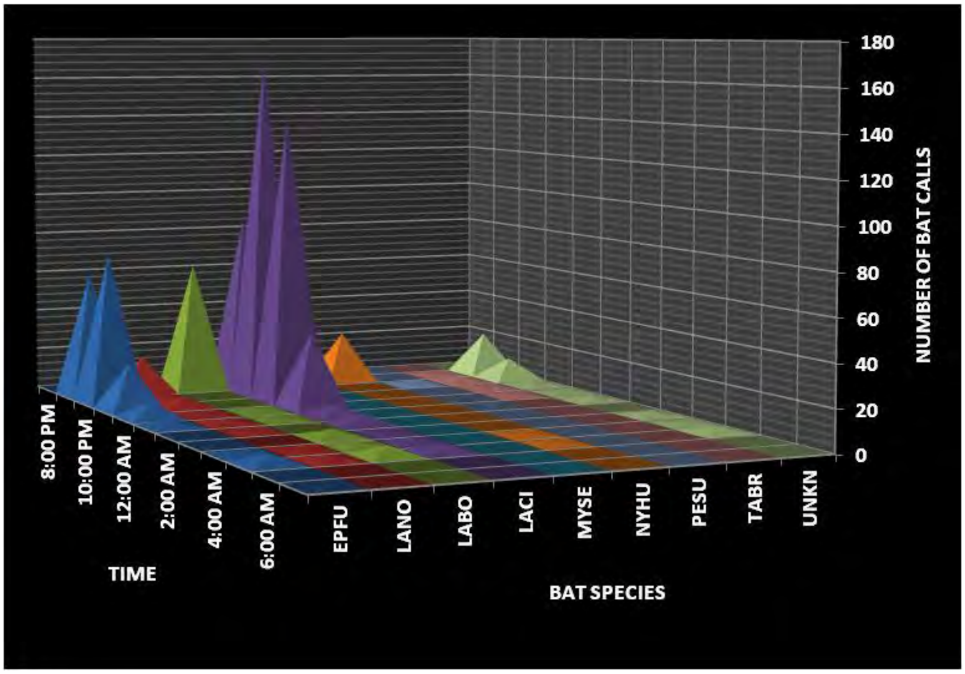


Figure 3.1.3.2.3 ORR-01-Haw Ridge Park / Red Shore Trail embayment area

Figure 3.1.3.2.3 Bat species codes: EPFU = *Eptesicus fuscus* (big brown bat), LABO = *Lasiurus borealis* (eastern red bat), LACI = *Lasiurus cinereus* (hoary bat), LANO = *Lasionycteris noctivagans* (silver-haired bat), MYSE = *Myotis septentrionalis* (northern long-eared bat, threatened), NYHU = *Nycticeius humeralis* (evening bat) , PESU = *Perimyotis subflavus* (tri-colored bat; eastern pipistrelle), TABR = *Tadarida brasiliensis* (Mexican free-tailed bat), UNKN = unknown (bat detected but not identified).

3.1.3.3 White-tailed Deer Monitoring

Deer captured and collared during 2015 are shown in Table 3.1.3.3.1. Six deer in the legacy burial areas of the ORNL SWSAs in Melton Valley were fitted with GPS collars. In addition, two collars from deer previously collared in 2014 were recovered. Two deer (Wilson, Samuel) were killed by hunters in November 2015 during the TWRA managed hunt on the ORR. All deer on the managed hunts are tested for strontium-90 and cesium-137 before they are released to the hunter. Samuel was found to be above the release criteria for strontium-90 and was confiscated from the hunter. The data downloads from each collar are represented in Figures 3.1.3.3.1-3.1.3.3.8 to show their respective core areas and excursions from the core area. Using ArcGIS to plot our deer GPS data points, TDEC found that the eight deer for this year's report remained on the ORR, with the exception of Teresa's migration to Jones Island in November 2015. All collars retrieved were found on the ORR, often near where the deer was originally captured.

Table 3.1.3.3.1 2015 Deer Capture Data

Deer	Date captured	Est. Age	Est. Weight (lbs.)	GPS collar	VHF frequency	Successful Pulse	Collar Release
Samuel	1/26/2015	0.8	80	1-yr	151.415	60 bpm	11/14/2015*
Teresa	1/27/2015	2.5	120	1-yr	151.25	50 bpm	1/20/2016
Ursula	1/28/2015	1	80	1-yr	151.205	50 bpm	1/20/2016
Veronica	2/3/2015	2.5	120	1-yr	151.295	50 bpm	1/20/2016
Wilson	2/5/2015	1	110	1-yr	151.205	60 bpm	11/15/2015*
Xandra	3/24/2015	1	100	1-yr	151.415	50 bpm	1/20/2016
Quey	2/13/2014	2	110	2-yr	151.295	60 bpm	3/1/2016
Renee	3/4/2014	2	120	2-yr	151.25	60 bpm	11/8/2015**

bpm - beats per minute
Est. - estimated
GPS - global positioning system
lbs. - pounds
VHF - very high frequency
yr – year
*Deer killed during annual hunt in fall 2015 (collars retrieved)
**Renee died from unknown causes

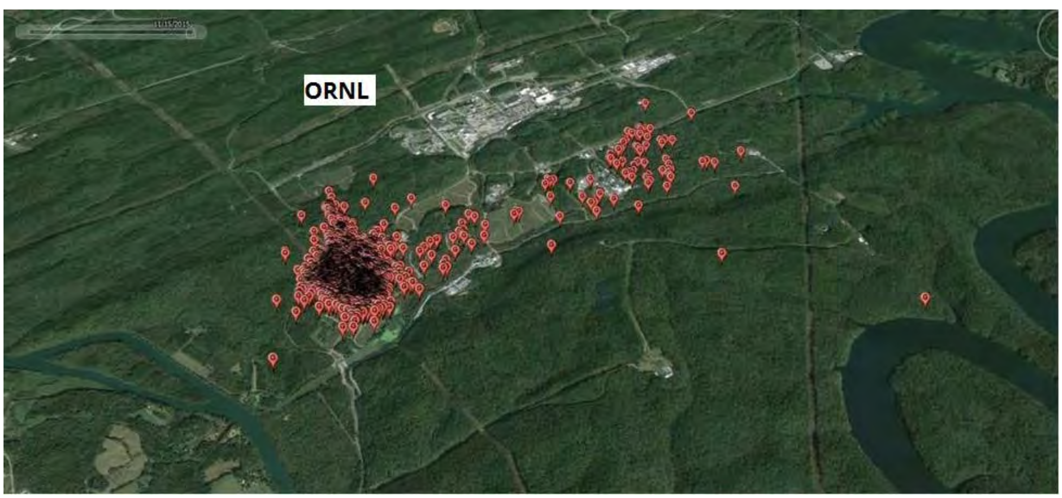


Figure 3.1.3.3.1 Samuel's movements 2015

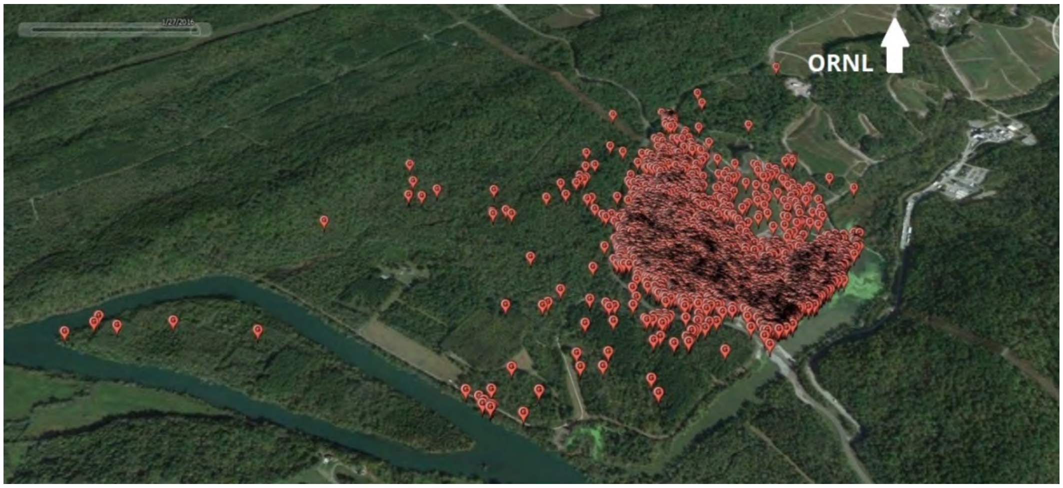


Figure 3.1.3.3.2 Teresa's movements 2015

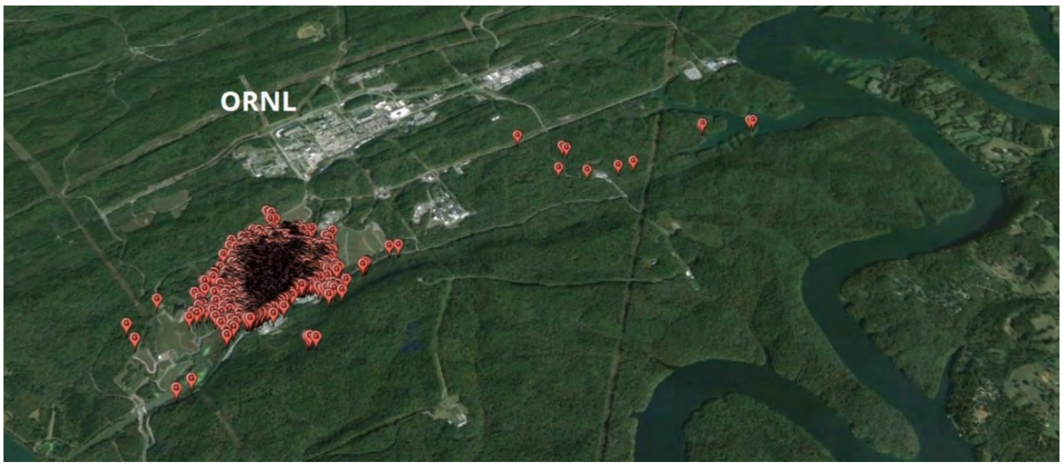


Figure 3.1.3.3.3 Ursula's movements 2015

Figure 3.1.3.3.4 Veronica's movements 2015

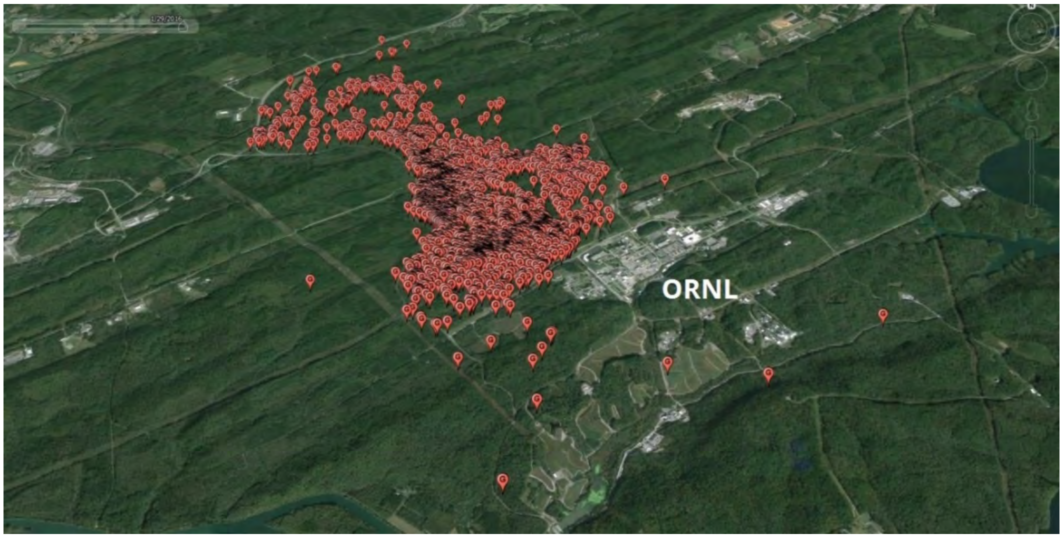


Figure 3.1.3.3.5 Wilson's movements 2015

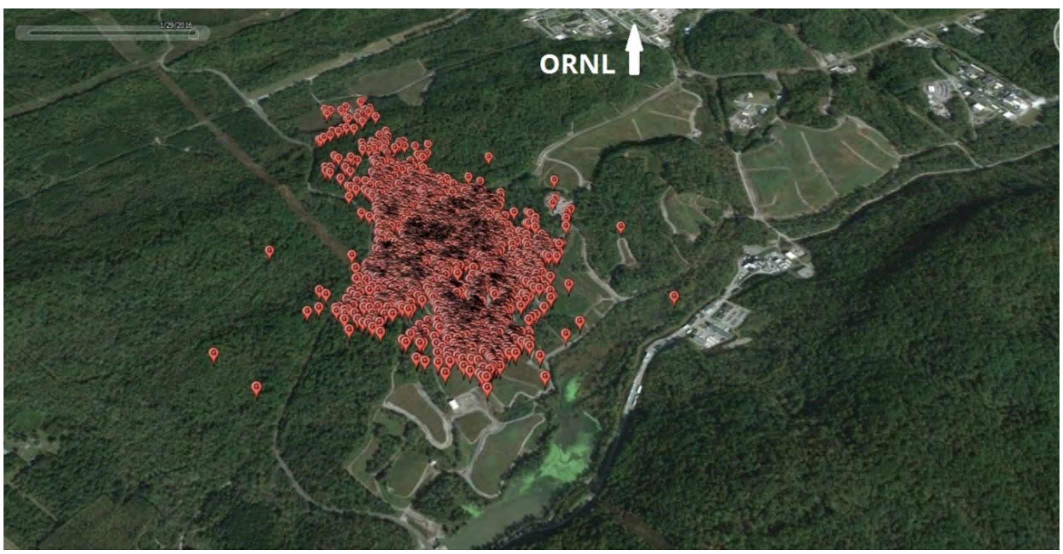


Figure 3.1.3.3.6 Xandra's movements 2015

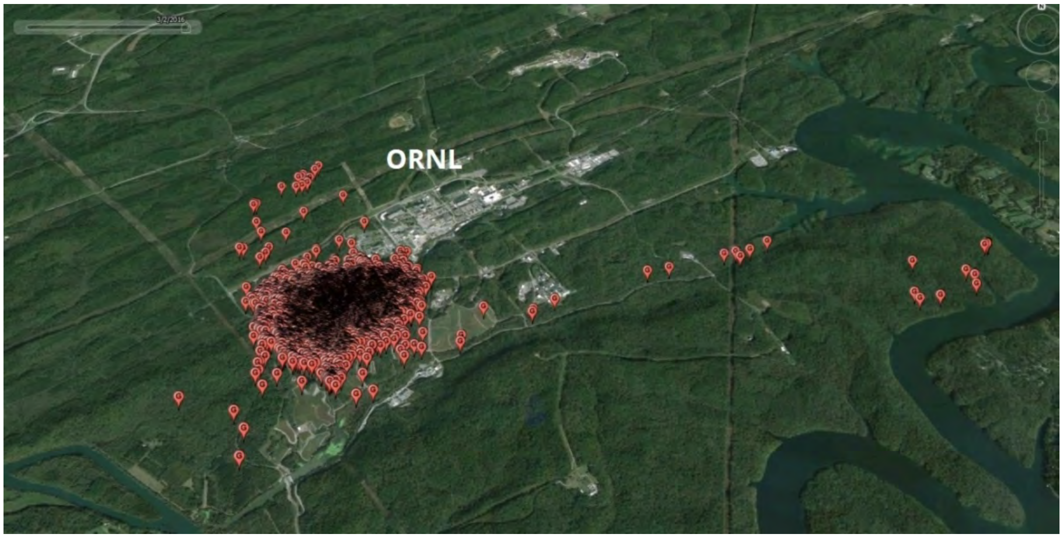


Figure 3.1.3.3.7 Quey's movements 2014-2015

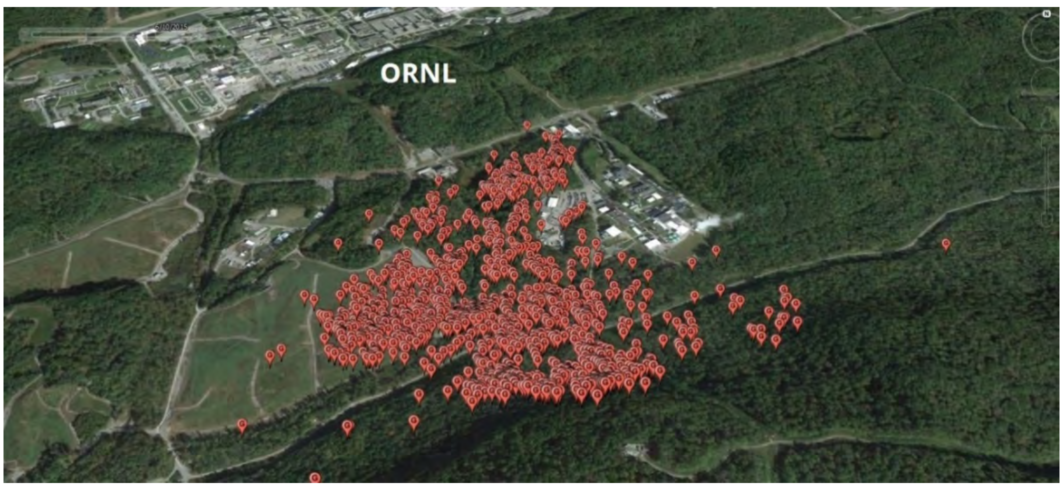


Figure 3.1.3.3.8 Renee's movements 2014-2015

3.1.3.4 Fungi Monitoring in East Fork Poplar Creek

TDEC collected 147 mushroom/fungi samples during 2015: 51 samples from EFPC plots and 96 control samples. Figure 3.1.3.4.1 presents the laboratory analytical results for all 147 samples (mg/kg). Fungi samples from all EFPC sites ranged from 0-79.0 mg/kg (dry weight) whereas the control fungi samples ranged from 0-6.1 mg/kg (dry weight). The mean mercury for all 51 EFPC samples was 6.11 mg/kg and the mean Mercury for all 96 control samples was 0.60 mg/kg, therefore the EFPC Mercury result is an order of magnitude greater than the control Mercury (Figure 3.1.3.4.2). TDEC calculated the mean Mercury content of combined edible fungi species to combined non-edible fungi species and found edible species was 3.30 Mercury (mg/kg) and non-edible species was 2.72 Mercury (mg/kg; Figure 3.1.3.4.3). Edible fungi sampled include chanterelles. Non-edible fungi sampled include *Amanita* sp. (Destroying Angel).

Mean Mercury results for each of the seven EFPC sampling plots ranged from 0.78-13.41mg/kg (Figures 3.1.3.4.4-3.1.3.4.10). Mean Mercury results for each of the nine control sampling plots ranged from 0.05-1.63 mg/kg (Figures 3.1.3.4.11-3.1.3.4.19).

The upper EFPC sampling plots (EFPC-01 through EFPC-05) exhibited an order of magnitude greater than Mercury body burden (8.22 mg/kg vs. 0.83 mg/kg) compared to the downstream EFPC sampling plots (EFPC-06 and EFPC-07).

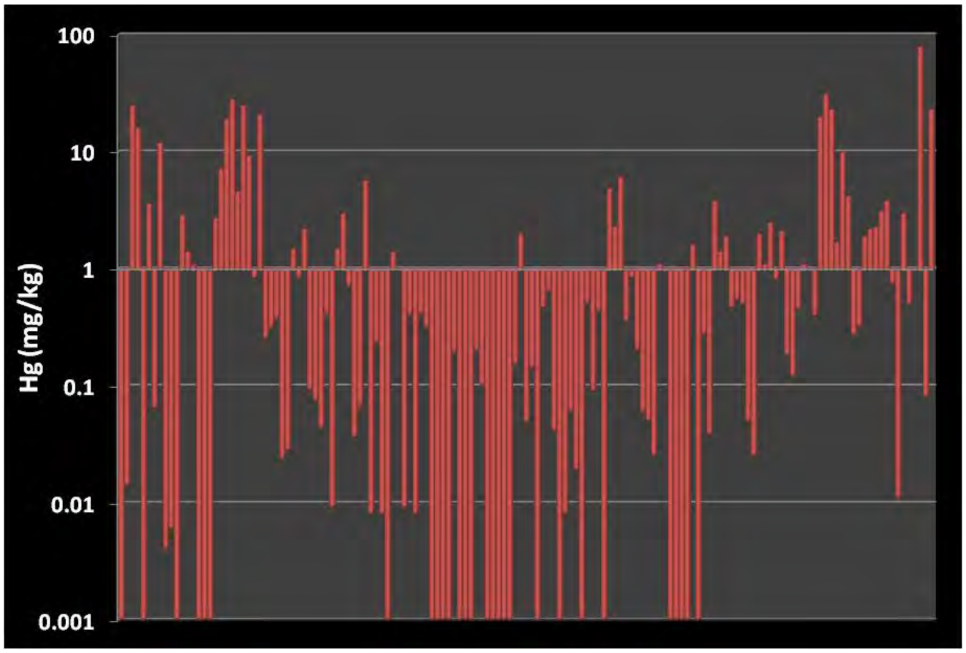


Figure 3.1.3.4.1 All Hg data plotted (mg/kg; *n*=147)

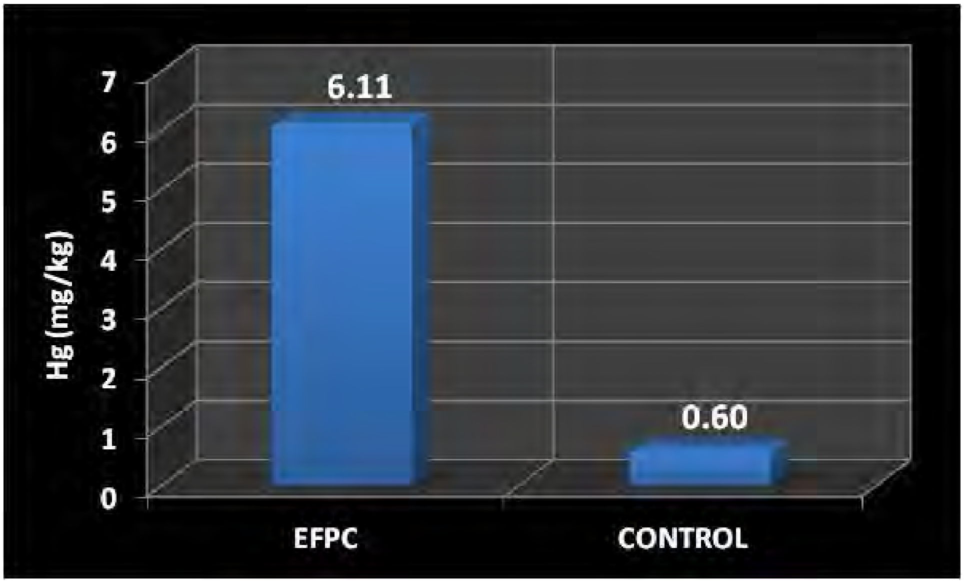


Figure 3.1.3.4.2 Combined EFPC Hg data compared to control Hg (mg/kg)

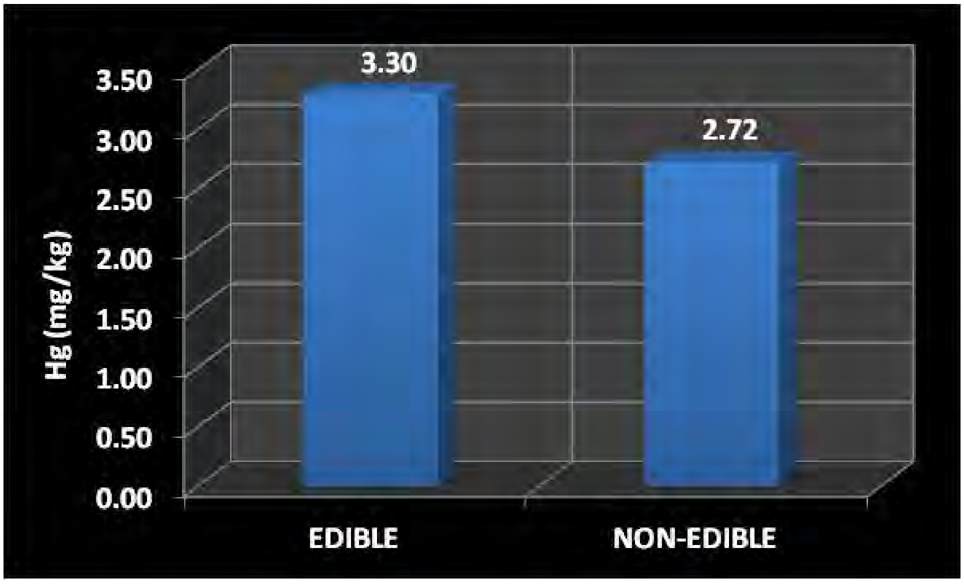


Figure 3.1.3.4.3 Combined EFPC Hg data compared to control Hg (mg/kg)

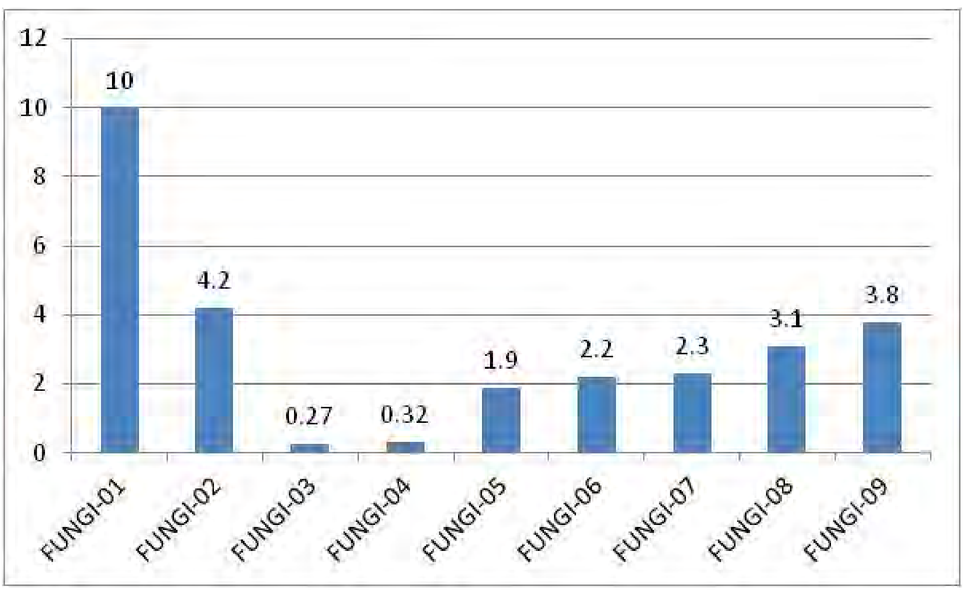


Figure 3.1.3.4.4 EFPC-01 sampling plot (*n*=9 subsamples; Hg= 3.12 mg/kg)

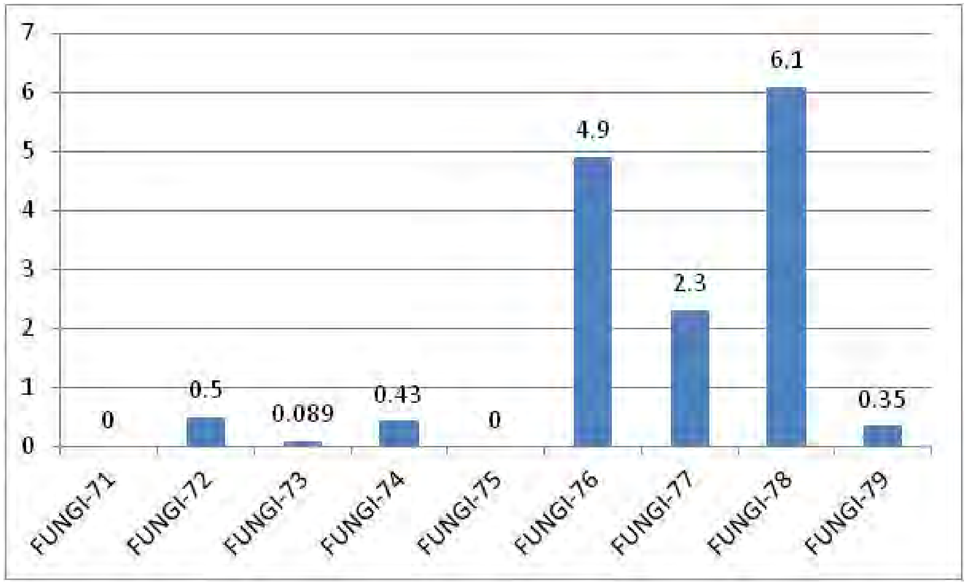


Figure 3.1.3.4.11 Control-01 sampling plot (*n*=9 subsamples; Hg= 1.63 mg/kg)

The remaining figures of the sampling plots and controls are found in Appendix B.

3.1.3.5 Fish Tissue Monitoring

Approximately thirty-six fish gut samples were collected during 2014 and 2015 from ORR and control streams, rivers, and reservoirs by the ORNL ESD fisheries team. Frozen gut content samples were provided by ORNL ESD personnel to TDEC biologists for gut processing and analysis. Fish gut samples were processed and gut contents identified to the lowest taxonomic level possible (Table 3.1.3.5). Examples of striped bass and large-mouth bass gut contents are shown in Figures 3.1.3.5.1 (threadfin shad prey items) and 3.1.3.5.2 (crayfish prey items) respectively. Fish prey items were identified using Etnier and Starnes (1993).

Table 3.1.3.5 Fish Gut sample Locations and Contents Summary

Site	ORNL ID#	SPECIES	CONTENTS WT (g)	TOTAL GUT WT (g)	LIVER WT (g)	STOMACH CONTENT IDENTIFIED (TAXA)	COMMENTS
Nor. Res.	23810	STBASS	12.782	n/a	46.399	Unrecognizable contents	>90% digested
Nor. Res.	23811	STBASS	21.418	n/a	63.904	7 Threadfin Shad (*Dorosoma petenense*)	Recently ingested prey (at time of capture)
Nor. Res.	23812	STBASS	23.771	n/a	91.586	Unrecognizable contents	>90% digested
Nor. Res.	23813	STBASS	0	n/a	59.69	no contents	Empty stomach
Nor. Res.	23814	STBASS	34.301	n/a	94.796	Unrecognizable contents	>90% digested
Nor. Res.	23815	STBASS	45.942	n/a	115.376	Unrecognizable contents	>90% digested
TRM 531	23714	LMBASS	0	n/a	2.743	no contents	Empty stomach
TRM 531	23715	LMBASS	0	n/a	5.433	no contents	Empty stomach
TRM	23716	LMBASS	0	n/a	10.864	no contents	Empty stomach

Site	ORNL ID#	SPECIES	CONTENTS WT (g)	TOTAL GUT WT (g)	LIVER WT (g)	STOMACH CONTENT IDENTIFIED (TAXA)	COMMENTS
531							
TRM 531	23717	LMBASS	6.724	n/a	16.194	Unrecognizable contents	>90% digested
TRM 531	23718	LMBASS	0	n/a	20.208	no contents	Empty stomach
TRM 531	23719	LMBASS	18.412	n/a	27.716	Unrecognizable contents	>90% digested
PCK 1.6	23644	LMBASS	3.272	31.337	5.415	Unrecognizable contents	>90% digested
PCK 1.6	23645	LMBASS	1.985	36.527	8.794	1 threadfin shad (*Dorosoma petenense*)	Recently ingested prey (at time of capture)
PCK 1.6	23646	LMBASS	0	38.634	9.135	no contents	Empty stomach
PCK 1.6	23647	LMBASS	2.072	47.985	11.446	Unrecognizable contents	>90% digested
PCK 1.6	23648	LMBASS	5.279	70.073	12.227	Unrecognizable contents	>90% digested
PCK 1.6	23649	LMBASS	5.03	109.783	20.292	1 shad (*Dorosoma* sp.)	30-50% digested
CRM 11	23683	LMBASS	0	26.723	2.227	no contents	Empty stomach
CRM 11	23684	LMBASS	0	29.246	3.832	no contents	Empty stomach
CRM 11	23685	LMBASS	12.805	81.018	10.619	3 crayfish (*Cambarus* sp.) + 3 juvenile fish	~50-75% digested making IDs difficult
CRM 11	23686	LMBASS	0	54.819	7.18	no contents	Empty stomach
CRM 11	23687	LMBASS	25.67	115.92	33.173	2 crayfish (*Cambarus* sp.)	Recently ingested prey (at time of capture)
CRM 11	23688	LMBASS	0	105.277	14.718	no contents	Empty stomach
CRM 20	23697	LMBASS	0	23.76	3.894	no contents	Empty stomach
CRM 20	23698	LMBASS	0.925	46.155	7.188	Unrecognizable contents	>90% digested
CRM 20	23699	LMBASS	0	40.26	6.739	no contents	Empty stomach
CRM 20	23700	LMBASS	0	71.571	14.041	no contents	Empty stomach
CRM 20	23701	LMBASS	0	78.061	23.948	no contents	Empty stomach
CRM 20	23702	LMBASS	0	120.806	12.016	no contents	Empty stomach
CRM 24	23658	LMBASS	3.548	36.409	3.919	2 unrecognizable fish carcasses (shad?)	>75% digested
CRM 24	23659	LMBASS	6.349	62.801	8.251	3 fish (*Dorsoma* sp.?) + crayfish parts	>50% digested
CRM 24	23660	LMBASS	0	82.606	11.158	no contents	Empty stomach
CRM 24	23661	LMBASS	0	74.021	7.978	no contents	Empty stomach
CRM 24	23662	LMBASS	3.548	69.396	13.184	Unrecognizable contents	>90% digested
CRM 24	23663	LMBASS	0	170.125	29.521	no contents	Empty stomach

Nor. Res. - Norris Reservoir
PCK - Poplar Creek
STBASS - striped Bass

TRM - Tennessee River Mile
CRM - Clinch River Mile
LMBASS - largemouth Bass

WT - weight
g - grams
n/a - not available

Figure 3.1.3.5.1 Fish gut contents from striped bass (threadfin shad prey items)

Figure 3.1.3.5.2 Fish gut contents from large-mouth bass (crayfish prey items)

3.1.3.6 Aquatic Vegetation Monitoring

The EPA does not currently regulate radionuclide levels in vegetation. The Food and Drug Administration (FDA) has established guidelines called Derived Intervention Levels (DILs) to describe radionuclide concentrations at which the introduction to protective measures should be considered

(FDA 1998, FDA 2005). These values are meant to be protective in the event a nuclear incident occurs and food is radioactively contaminated. They are specific to certain radionuclides and are not directly comparable to gross alpha, gross beta, and gamma activity, which were the analyses run on the vegetation samples for this project. A potentially more useful comparison is to the levels of alpha, beta, and gamma seen at a background location or other samples with low levels of radionuclides. Generally, this is done by determining that results more than twice background levels are considered elevated, at least at environmental levels.

TDEC gathered twenty vegetation samples for radiological analysis during May 2015. One sample was taken as a background (R-20) and two locations with cattails available had a mixed vegetation sample collected for comparison. Table 3.1.3.6.1 provides the results of the radiochemical analysis of the twenty vegetation samples collected in 2015. Samples were collected at each of the three larger sites or areas on the ORR: ORNL, Y-12, and ETTP.

The data have been arranged based on the levels of gross beta, with the most elevated gross beta results at the top of the table. The yellow and blue bars shown in Table 3.1.3.6.1 for gross alpha and gross beta, respectively, are to visually highlight which values are higher and which are lower; the longer the bar, the higher the result. The values representing two times those seen at the background location are shown at the bottom of the table for further comparison, but since they are not actual results, they are not compared using the blue and yellow bars. Values greater than twice background have a light yellow background to make them easier to identify in the tables below. Data shown in bold and black type are results with values greater than the sample specific detection limit for that analysis. Results shown in gray were less than the sample specific detection limit for that analysis. The data suggest limited areas of elevated radionuclide concentrations in the aquatic vegetation on the ORR. The highest levels of gross alpha and gross beta activity for 2015 were from samples collected at R-8 and R-10.

The R-8 sample was collected at the edge of the wetland area behind the old Homogeneous Reactor Experiment site (HRE) in ORNL's Melton Valley and had elevated gross alpha (2.0 pCi/g) and gross beta (69.1 pCi/g) levels. Samples have been collected at the HRE area since 2012, though not all have been the exact same location or media. The HRE area has yielded the highest gross beta result each year since it has been sampled. In Table 3.1.3.6.2, the highest gross alpha and gross beta values for this site are listed for 2012 through 2015. Gross alpha levels were similar for all years. The highest levels of gross beta seen at the 2014 and 2015 sampling locations were much lower than levels seen at the first locations sampled in 2012 and 2013 closer to the creek that runs through the wetland.

The R-9 sample (Figure 2.1.3.6) was collected in approximately the same area as the R-8 sample, but consisted of mixed floodplain vegetation and not cattails, while the R-8 sample was solely cattails. The R-9 sample also had elevated gross beta levels (12.4 pCi/g) and gross alpha levels less than twice what was seen at the background location (0.31 pCi/g). Contamination has long been an issue at the HRE site. The R-10 sample also had elevated gross alpha (0.70 pCi/g) and gross beta levels (29.8 pCi/g).

The R-10 sample was collected from a roadside wetland with cattails downhill from the HFIR experiment buildings. It was sampled this year as it had shown elevated gross beta levels in 2014, though slightly less than five times the gross beta levels were seen at the same location in 2015 (Table 3.1.3.6.3). Due to the increase in the gross beta values seen at the HFIR sampling location, strontium 90 (Sr-90) analysis was run on the same sample, as it was likely to be a major contributor to the elevated gross beta result.

Table 3.1.3.6.1 Results for Radiochemical Analysis of 2015 Vegetation Samples (pCi/g wet weight)

vegetation			gross	gross	gamma				
type	stn	location	alpha	beta	Cs-137	K-40	Pb-214	Bi-214	Be-7
cattail	R-8	ORNL Melton Valley HRE wetland *	2.00	69.1		5.23			
cattail	R-10	ORNL Melton Valley HFIR drainage	0.70	29.8		3.75		0.153	
mixed	R-11	ORNL WOC upstream of Melton Valley ROAD	0.06	22.2	23.3	3.69			
cattail	R-6	ORNL Melton Valley WOC weir	0.37	13.5	1.76	2.70	0.137	0.227	
mixed	R-9	ORNL Melton Valley HRE wetland *	0.31	12.4		5.30			
mixed	R-12	ORNL WOC upstream of 3rd Street Bridge	0.16	12.3	9.9	5.62			
mixed	R-7	ORNL Melton Valley Melton Branch weir	0.43	8.2		5.46	0.175	0.146	
mixed	R-15	Bear Creek Valley NT-8 east	0.52	5.0		0.81			
mixed	R-14	ETTP Mitchell Branch	0.22	4.1		4.79	0.115		1.19
mixed	R-3	Y-12 Bear Creek, below S-2, edge of creek *	0.31	3.9			0.210		
mixed	R-18	Bear Creek wetland at HWY 95	0.20	3.6		12.90			1.40
cattail	R-2	Y-12 Bear Creek, below S-2, edge of creek *	0.17	3.5					
mixed	R-4	Bear Creek Valley, NT-8 west	0.23	3.4		4.50			0.47
mixed	R-1	East Fork Poplar Creek near NOAA/ORCS	0.23	3.2					
cattail,willow	R-17	ETTP K901A pond east	0.20	3.2			0.482	0.640	
watercress	R-13	Y-12 Bear Creek Valley SS-4 Spring	0.23	2.9		3.12	0.113	0.127	0.45
cattail	R-16	ORNL Bethel Valley SWSA2/B4007area	0.15	2.9					
cattail	R-5	Bear Creek Valley, NT-6 upstream of haul road	0.17	2.8		4.66	0.420	0.430	
watercress	R-20	ORNL Spring Creek, near east guard shack, BG	0.22	2.7		3.52	0.097	0.120	
cattail	R-19	ORNL SNS upper WOC wetland	0.15	2.5		10.40	0.119	0.093	
		* two types of samples taken at same location 2X BG:	0.44	5.4		7.04	0.194	0.240	

Table 3.1.3.6.2 Highest Gross Beta Analyses at HRE Wetland 2012-2015 (pCi/g)

Station	Year	Gross Alpha	Gross Beta	Units
HRE Wetland	2012	2.5	189	pCi/g
HRE Wetland	2013	3.2	213	pCi/g
HRE Wetland	2014	3.0	53.9	pCi/g
HRE Wetland	2015	2.0	69.1	pCi/g

HRE – Homogeneous Reactor Experiment

Table 3.1.3.6.3 HFIR Sampling Results 2014-2015 (pCi/g wet weight)

Station	Year	Gross Alpha	Gross Beta	Sr-90	Units
HFIR	2014	0.4	6.3	-	pCi/g wet weight
HFIR	2015	0.7	29.8	10.3	pCi/g wet weight

HFIR - High Flux Isotope Reactor

The other sites with gross beta levels greater than two times background were stations R-11, R-6, R-12, and R-7 (Table 3.1.3.6.1). Three of these locations are located at ORNL along White Oak Creek and the fourth is on Melton Branch in Melton Valley. White Oak Creek and Melton Branch are known to have radiological contamination. R-11 and R-12 were new sampling locations along White Oak Creek that were able to be sampled due to the addition of the mixed floodplain vegetation as a sampling medium for radiological contamination in vegetation, as was R-7 on Melton Branch. The three samples with cesium 137 (Cs-137) were all samples from White Oak Creek (R-11, R-6, R-12).

The site other than HRE R-8 (Table 3.1.3.6.1) with a gross alpha result more than twice background was from R-15 along North Tributary 8 (NT-8) east in Bear Creek Valley (0.52 pCi/g) and is located downstream of burial grounds. In 2014, NT-8 west had elevated gross alpha (3.9 pCi/g) and gross beta (8.9 pCi/g) levels. In 2015, the same location gross alpha and gross beta levels were less than twice background levels, though mixed vegetation, not jewelweed, was sampled.

In 2015, two sample locations had one sample of cattails collected and the other of mixed floodplain or wetland vegetation. At each location, these samples were collected adjacent to each other in time and location. For the samples from HRE (R-8 and R-9), the cattail sample had much higher gross alpha and gross beta levels than the mixed vegetation sample.

3.1.3.7 Benthic Macroinvertebrate Monitoring

Semi-quantitative Assessments (SQKICK Sample Results)

East Fork Poplar Creek

Benthic laboratory results, i.e., metric values, metric scores, overall Tennessee Macroinvertebrate Index (TMI) scores (alternative reference stream method), and biological condition ratings are presented in Table 3.1.3.7.1 for the East Fork Poplar Creek (EFK) watershed. For monitoring purposes, the watershed is herein considered the upper EFK (UEFK) with three sampling stations within Y-12, (EFK 25.1, EFK 24.4, EFK 23.4) and lower EFK (LEFK) with two sampling stations (EFK 13.8, EFK 6.3) (Figures 2.1.3.7.2 and 2.1.3.7.4). The stream numbers represent distances in kilometers that decrease from headwaters (EFK 25.1) towards the mouth downstream (EFK 0.0). The reference streams for the EFK watershed include Hinds Creek (HCK 20.6) and Clear Creek (CCK 1.45). Generally, stream biotic integrity in EFK appeared to be slightly better in the LEFK than in UEFK.

The East Fork Poplar Creek is one of the streams on the ORR where impacts occur from the headwaters of the stream to a considerable distance downstream in the watershed. The headwaters of the stream originate from tributaries that flow through stormwater conduits in the main industrialized portion of Y-12. Downstream, the stream flows through urbanized and suburbanized sections of Oak Ridge before flowing through less developed areas prior to its confluence with Poplar Creek. Near its origin, East Fork receives inputs of contaminants such as mercury, uranium, volatile organic compounds (VOCs) and other metals and organics. Once leaving the Y-12 boundary, East Fork receives further contaminant loading from urban and suburban runoff as well as sewage treatment plant discharge. Only near its mouth does East Fork flow through relatively undisturbed terrain. During 2015, no flow augmentation from the Clinch River was provided in East Fork. Flows in

the creek were reduced from years prior to 2014 due to lack of this augmentation. Metrics from 2014 and 2015 benthic sampling are compared to see if there are any changes that can possibly be related to the halting of flow augmentation in 2014.

Table 3.1.3.7.1 Metric Values, Scores, and Biological Condition Ratings for East Fork Poplar Creek

2015 RESULTS	EAST FORK POPLAR CREEK									
Stream Station	EFK 25.1		EFK 24.4		EFK 23.4		EFK 13.8		EFK 6.3	
METRIC	VALUE	SCORE	VALUE	SCORE	VALUE	SCORE	VALUE	SCORE	VALUE	SCORE
Taxa Richness	25	2	28	4	38	4	41	4	55	6
EPT Richness	3	2	5	2	6	2	10	4	14	4
% EPT-Cheum	0.49	0	1.16	0	1.97	0	19.87	2	6.18	0
% OC	72.78	2	26.68	6	69.68	2	33.55	6	50.35	4
NCBI	5.27	4	5.13	6	5.30	4	5.02	6	4.29	6
% Clingers	78.65	6	76.50	6	27.55	4	71.74	6	64.36	6
% TNUTOL	77.18	2	74.42	2	70.85	2	46.58	4	52.30	4
Intolerant Taxa	0		2		2		4		5	
TMI INDEX SCORE		18	2	26		18		32		30
RATING		C		B		C		A		B

TMI = Tennessee Macroinvertebrate Index

A = Supporting / Non-Impaired (TMI Scores ≥32)

B = Partially Supporting / Slightly Impaired (TMI Scores 21-31)

C = Partially Supporting / Moderately Impaired (TMI Scores 10-20)

D = Non Supporting / Severely Impaired (TMI Scores <10)

In order to determine the condition of the sampling stations in East Fork, the following series of nine graphs comparing Total Score, Taxa Richness, EPT Richness, %EPT-Cheum, %OC, NCBI , %Clingers, %TNUTOL, and Intolerant Taxa for the years 2014 and 2015 are provided (Figures 3.1.3.7.1 – 3.1.3.7.9). Table 2.1.3.7.2 defines these nine metrics. Values for the impacted stations in East Fork are given in Table 3.1.3.7.1 and values for reference stations are provided in Table 3.1.3.7.2. Their discussion follows the figures below.

Table 3.1.3.7.2 Metric Values, Scores, and Biological Condition Ratings for Reference Stations

2015 RESULTS	BENTHIC MACROINVERTEBRATE REFERENCE STATIONS													
Stream station	CCK 1.45		CCK 1.45 DUP		HCK 20.6		MIK 1.43		GHK 2.9		MBK 1.6		WCK6.8 DUP	
METRIC	VAL	SCR	VAL	SCR	VAL	SCR	VAL	SCR	VAL	SCR	VAL	SCR	VAL	SCR
Taxa Richness	50	6	58	6	56	6	63	6	57	6	62	6	54	6
EPT Richness	26	6	26	6	19	6	14	4	19	6	23	6	21	6
% EPT-Cheum	55.11	6	39.38	6	36.69	6	25.32	4	34.40	6	55.17	6	56.88	6
% OC	14.10	6	9.52	6	9.61	6	34.38	6	52.55	4	11.02	6	16.92	6
NCBI	3.06	6	3.37	6	5.00	6	4.22	6	3.34	6	3.01	6	2.84	6
% Clingers	28.45	4	37.66	6	75.67	6	39.67	6	12.86	2	52.18	6	44.06	6
%TNUTOL	9.43	6	20.76	6	51.64	4	41.94	6	21.63	6	11.44	6	8.14	6
Intolerant Taxa	17	0	19	0	18	0	16	0	19	0	17	0	16	0
TMI INDEX SCORE		40		42		40		38		36		42		42
RATING		A		A		A		A		A		A		A

TMI = Tennessee Macroinvertebrate Index
VAL = Value
SCR = Score
A = Supporting / Non Impaired (TMI Scores ≥32)
B = Partially Supporting / Slightly Impaired (TMI Scores 21-31)
C = Partially Supporting / Moderately Impaired (TMI Scores 10-20)
D = Non Supporting / Severely Impaired (TMI Scores <10)

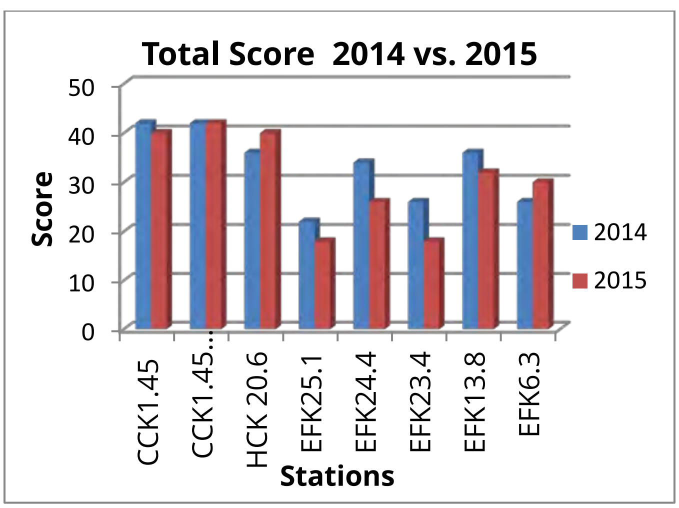


Figure 3.1.3.7.1 Total Score East Fork 2014 vs. 2015

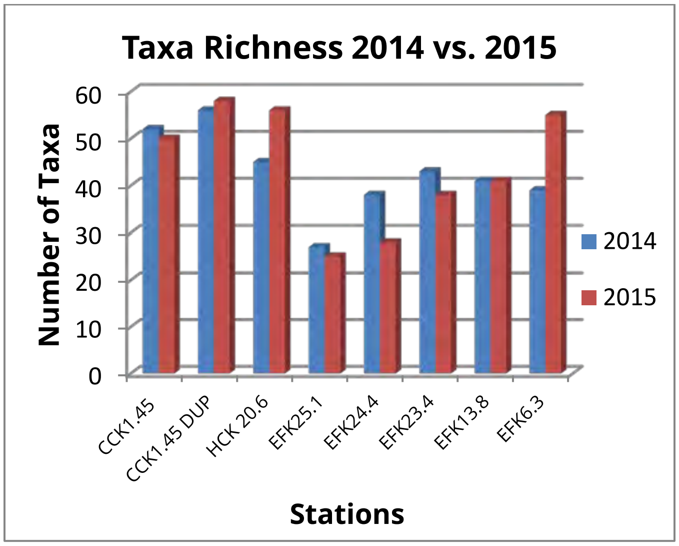


Figure 3.1.3.7.2 Taxa Richness East Fork

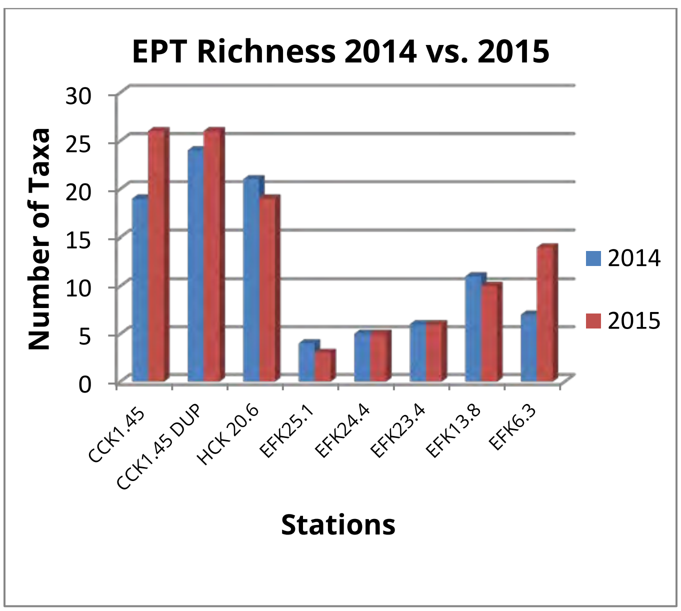


Figure 3.1.7.3.3 EPT Richness East Fork

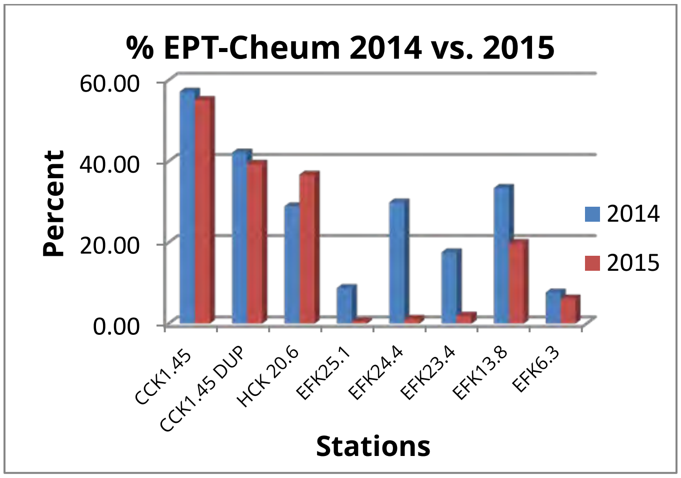


Figure 3.1.3.7.4 % EPT-Cheum East Fork

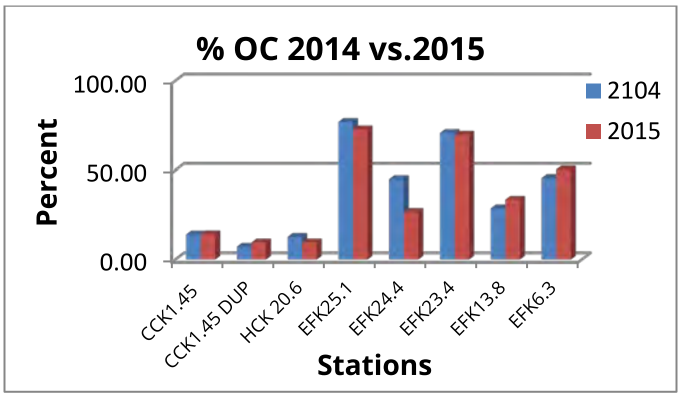


Figure 3.1.3.7.5 % OC East Fork

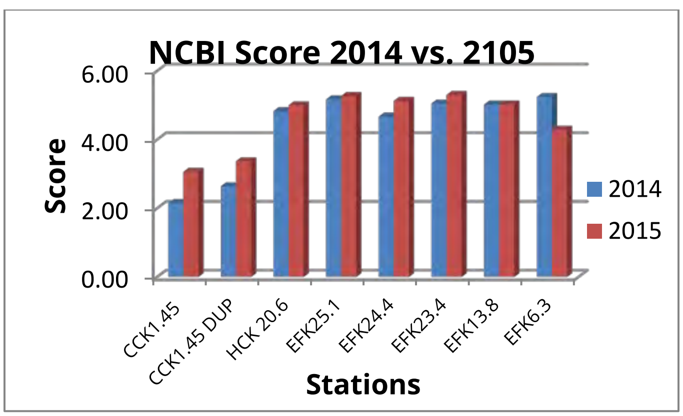


Figure 3.1.3.7.6 NCBI East Fork

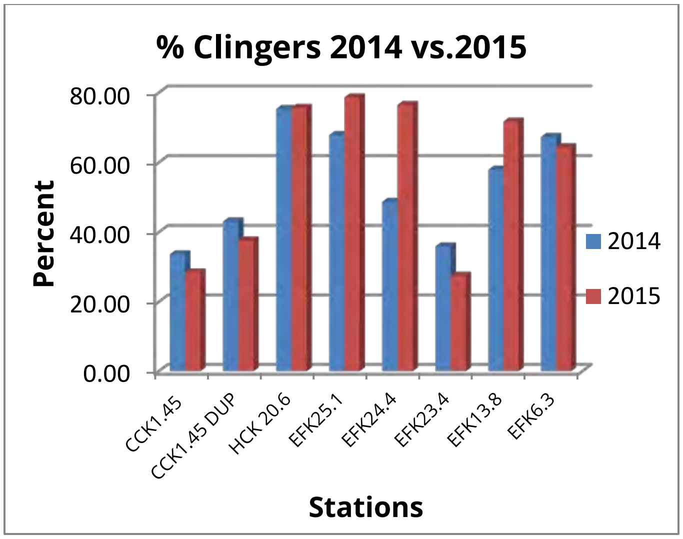


Figure 3.1.3.7.7 % Clingers East Fork

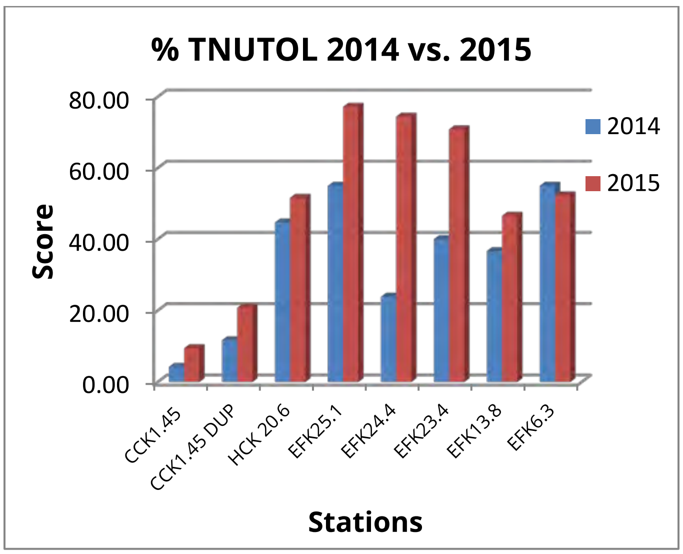


Figure 3.1.3.7.8 % TNUTOL East Fork

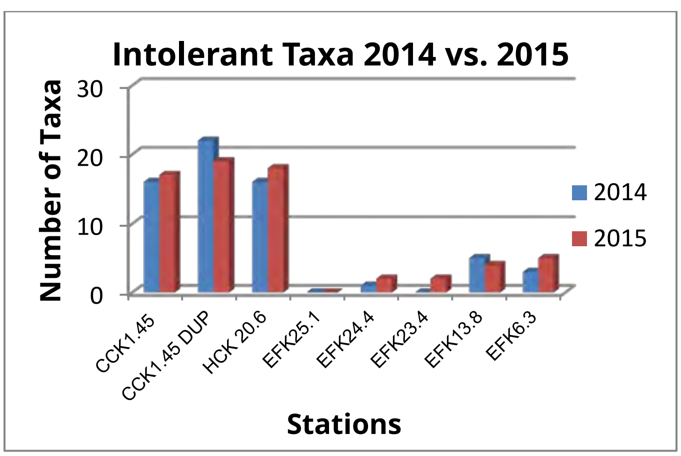


Figure 3.1.3.7.9 Intolerant Taxa East Fork

Figure 3.1.3.7.1 compares the TMI Total Score results for the two reference sites (CCK 1.45 and HCK 20.6) with the five sampling stations in East Fork Poplar Creek for both 2014 and 2015. The scores for the two reference stations (including a duplicate sample taken on Clear Creek) exceed those for all stations of East Fork with EFK 13.8 and EFK 24.4 approaching the controls in 2014 but not in 2015. The metric Taxa Richness (Figure 3.3.3.7.2) shows that the reference stations (CCK and HCK) displayed a higher number of Total Taxa than any of the East Fork stations with the exception of EFK 6.3 in 2015. A trend may be seen for the 2015 data with the number of taxa increasing incrementally in a downstream direction. EPT Richness (Figure 3.1.3.7.3) shows a distinct difference between the reference stations and the East Fork stations with the best East Fork station (EFK 13.8) possessing approximately five fewer EPT taxa than the lowest number for the reference stations (HCK 20.6) in 2015. The same trend as with Total Taxa Richness may be seen here with the number of EPT taxa increasing in a downstream direction.

The % EPT-*Cheumatopsyche* (Cheum) (Figure 3.1.3.7.4) shows a dramatic decrease in the upper stations of East Fork (EFK 25.1, EFK 24.4, and EFK23.4) during 2015 compared to 2014. The % OC (percent Oligochaeta and Chironomidae) metric (Figure 3.1.3.7.5) shows a distinction between the reference stations and all stations in East Fork. All East Fork sites display a higher proportion of oligochaetes and midges, often a sign of degraded conditions. Data for 2014 and 2015 are similar. The metrics for NCBI (Figure 3.1.3.7.6), % Clingers (Figure 3.1.3.7.7), and %TNUTOL (Figure 3.1.3.7.8) do not distinguish between the reference streams and impacted sites. The reference station HCK 20.6 displays NCBI (Figure 3.1.3.7.6) value that is indistinguishable from those of the East Fork stations. The metric for % Clingers (Figure 3.1.3.7.7) also does not distinguish between the reference stations and stations in East Fork.

The % TNUTOL metric (Figure 3.1.3.7.8) does not distinguish between reference and impacted stations with the values for the majority of the East Fork stations for 2014, but shows a greater difference in the 2015 data. A trend may be seen in the 2015 East Fork data with % TNUTOL trending downward in a downstream direction. Overall, HCK 20.6 appears more similar to East Fork than to Clear Creek in % TNUTOL. The comparison of the number of Intolerant Taxa between reference and impacted streams (Figure 3.1.3.7.9) shows a difference between reference and impacted stations with impacted stations displaying few sensitive taxa. The 2015 data shows a gradual increase in the number of sensitive taxa in a downstream direction.

Two metrics for the 2015 data show potential effects of the loss of augmentation flow in East Fork Poplar Creek during 2014. Both % TNUTOL and % EPT-Cheum suggest the loss of flow augmentation has led to increased enrichment levels in the stream. Since cleaner water from the Clinch River no longer dilutes the nutrient content of East Fork, it is intuitive that nutrient concentrations in East Fork would increase. This increase in nutrient load could be impacting dissolved oxygen levels, particularly at low flow, accounting for more tolerant taxa to outcompete less tolerant taxa (as suggested by the % EPT-Cheum metric).

Although East Fork Poplar Creek has shown improvement over the time since the 1980s when sampling initially began, improvements have leveled off somewhat in the past few years. There is some indication that due to lower flows (related to halting of flow augmentation) East Fork (particularly upstream East Fork) may be adjusting toward a less healthy condition.

Mitchell Branch

The TMI Total Scores (Figure 3.1.3.7.10) decrease downstream in Mitchell Branch suggesting deteriorating water quality conditions at MIK 0.71 and MIK 0.45 compared to the upstream reference (MIK 1.43). Mitchell Branch is a small headwater tributary to Poplar Creek at the ETTP. The highest upstream station, which serves as the reference station (MIK 1.43), does not meet the criteria for rating, according to the bioregion concept, due to the size of the watershed above it (<two square miles). Because of the small upstream watershed and variable flow conditions depending on annual rainfall, MIK 1.43 does not always provide a clear picture of the impacted condition of the downstream stations (MIK 0.71 and MIK 0.45). Historically, MIK 1.43 has been relatively unimpacted by the presence of ETTP. The lower stations (MIK 0.71 and MIK 0.45) have, however, been impacted not only from former industrial activities at ETTP and waste areas; they have also been channelized with much of the channel being replaced with unnatural substrate.

In order to determine the condition of the sampling stations in Mitchell Branch, the following series of nine graphs comparing Total Score, Taxa Richness, EPT Richness, % EPT-Cheum, % OC, NCBI , % Clingers, % TNUTOL, and Intolerant Taxa have been provided (Figures 3.1.3.7.10 – 3.1.3.7.18). Metric data for all stations, including the reference station (MIK 1.43), are found in Table 3.1.3.7.3. The discussion of the data follows the table and figures below.

Table 3.1.3.7.3 Metric Values, Scores, and Biological Condition Ratings for Mitchell Branch

2015 RESULTS	MITCHELL BRANCH					
Stream Station	MIK 1.43		MIK 0.71		MIK 0.45	
METRIC	VALUE	SCORE	VALUE	SCORE	VALUE	SCORE
Taxa Richness	63	6	54	6	62	6
EPT Richness	14	4	8	2	10	4
% EPT-Cheum	25.32	4	11.38	2	9.55	0
% OC	34.38	6	56.88	4	45.58	4
NCBI	4.22	6	5.37	4	5.46	4
% Clingers	39.67	6	52.91	6	56.23	6
% TNUTOL	41.94	6	28.84	6	49.93	4
Intolerant Taxa	16	0	8	0	9	0
TMI INDEX SCORE		38		30		28
RATING		A		B		B

TMI = Tennessee Macroinvertebrate Index
A = Supporting / Non-Impaired (TMI Scores ≥32)
B = Partially Supporting / Slightly Impaired (TMI Scores 21-31)
C = Partially Supporting / Moderately Impaired (TMI Scores 10-20)
D = Non Supporting / Severely Impaired (TMI Scores <10)

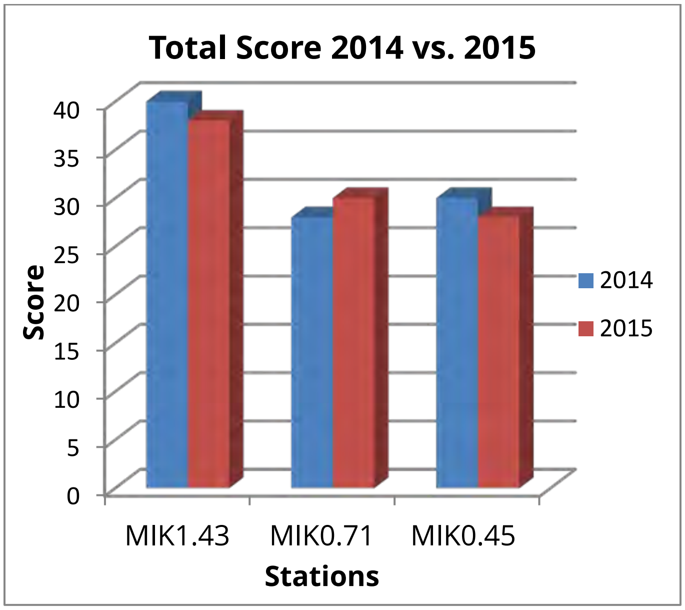


Figure 3.1.3.7.10 Total Score Mitchell Branch

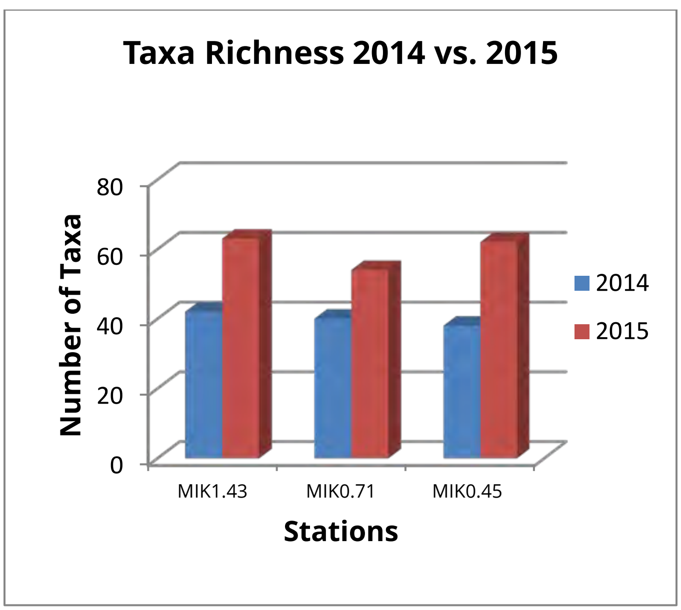


Figure 3.1.3.7.11 Taxa Richness Mitchell Branch

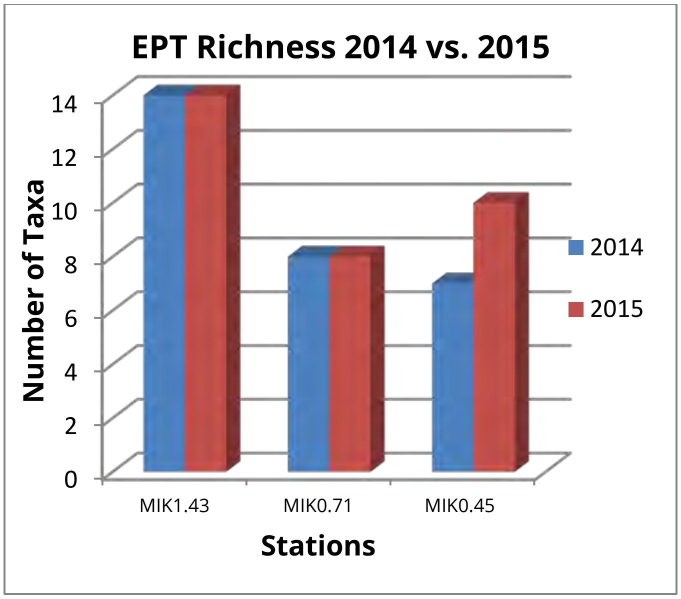


Figure 3.1.3.7.12 EPT Richness Mitchell Branch

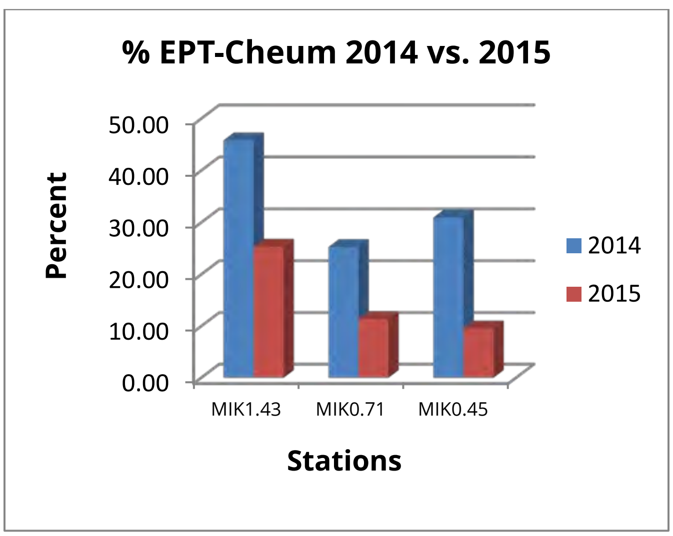


Figure 3.1.3.7.13 % EPT-Cheum Mitchell Branch

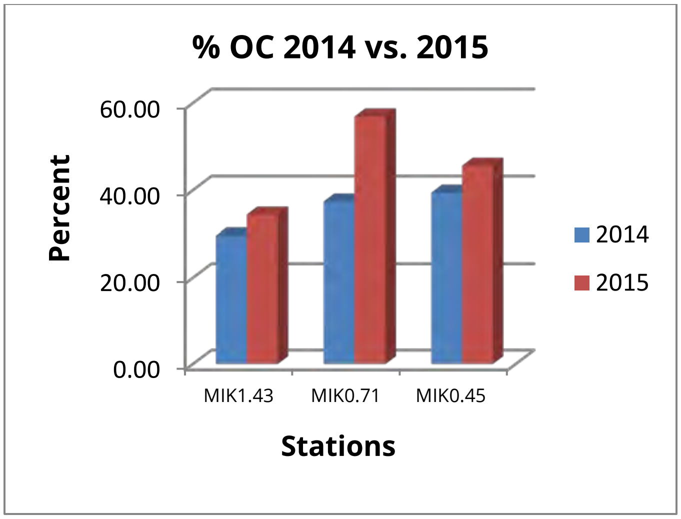


Figure 3.1.3.7.14 % OC Mitchell Branch

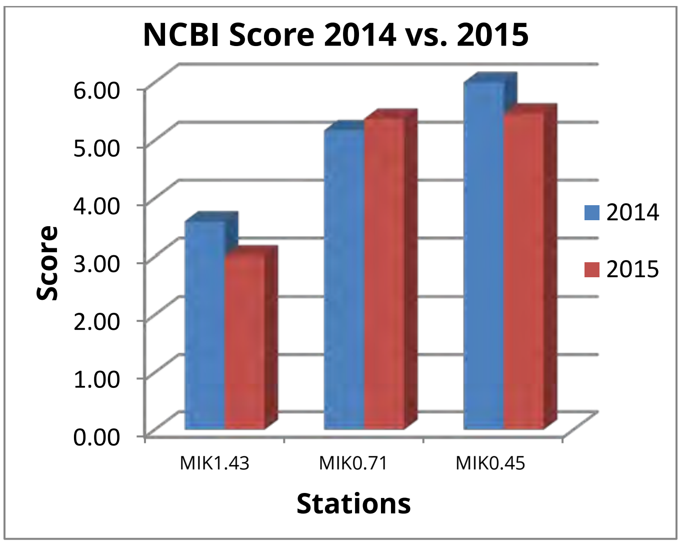


Figure 3.1.3.7.15 NCBI Mitchell Branch

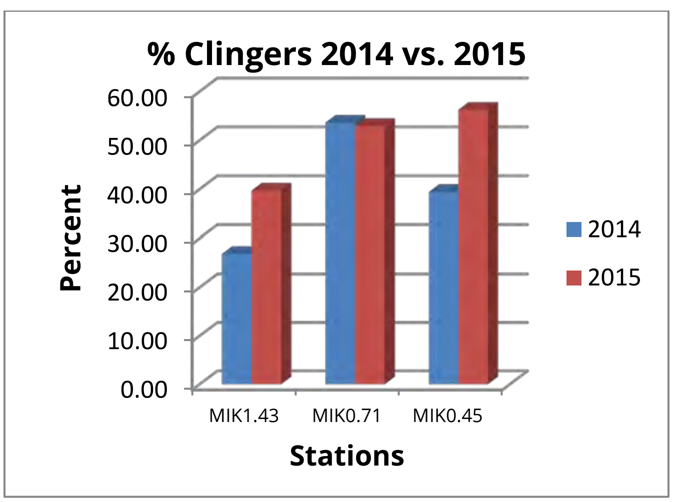


Figure 3.1.3.7.16 % Clingers Mitchell Branch

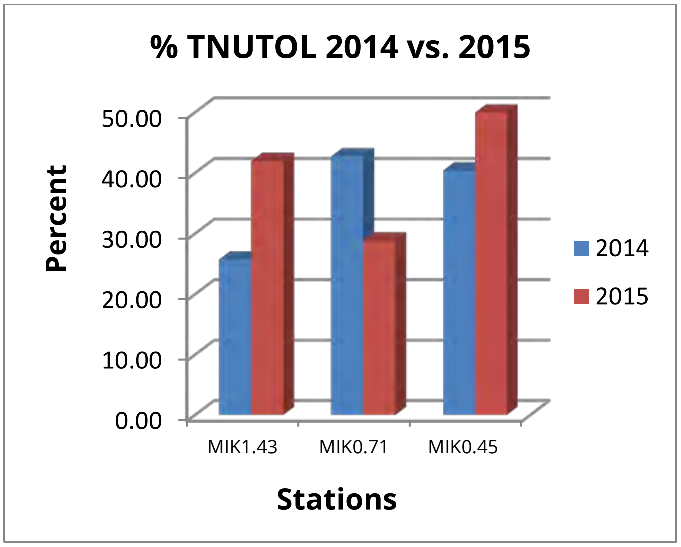


Figure 3.1.3.7.17 % TNUTOL Mitchell Branch

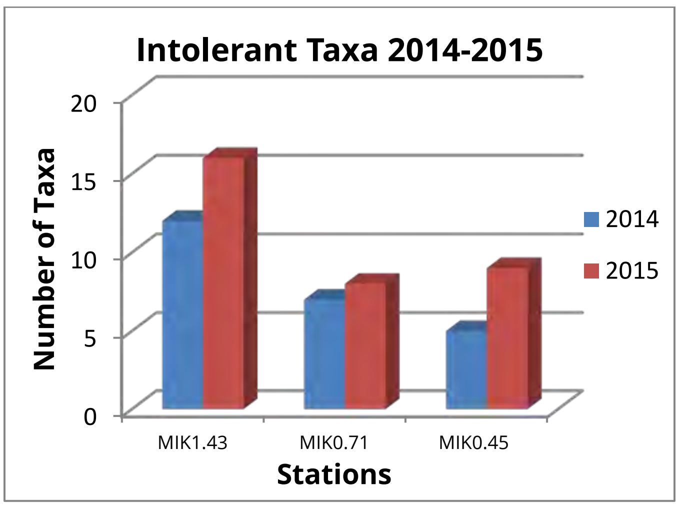


Figure 3.1.3.7.18 Intolerant Taxa Mitchell Branch

The Total Score for the Mitchell Branch stations (Figure 3.1.3.7.10) shows the overall better condition of MIK 1.43 compared to the lower two Mitchell Branch stations (MIK 0.71 and MIK 0.45). Taxa Richness (Figure 3.1.3.7.11) provides a less clear picture with all three stations being comparable in the total number of taxa present. EPT Richness (Figure 3.1.3.7.12) shows a clear superiority for MIK 1.43 with a larger number of these sensitive taxa occurring at that station. Both % EPT-Cheum (Figure 3.1.3.7.13) and % OC (Figure 3.1.3.7.14) are indicative of somewhat more stressful conditions at MIK 0.71 and MIK 0.45. This stress is shown in the more tolerant EPT community at these stations as well as the higher proportion of chironomid midges and oligochaetes (worms). In line with the less stressful conditions at MIK 1.43, this site shows a lower (better) score for the NCBI (biotic integrity) metric (Figure 3.1.3.7.15). Both % Clingers (Figure 3.1.3.7.16) and TNUTOL (Figure 3.1.3.7.17) are similar for all stations during 2014 and 2015. Generally, the greater the proportion of Clingers present, the better the health of the community; a higher proportion of nutrient tolerant organisms at a site is indicative of a less healthy community. The number of Intolerant Taxa (Figure

3.1.7.3.18) at MIK 1.43 is nearly twice that found at either of the lower MIK stations. This further highlights the better condition of this headwater reference site.

The lower stations of Mitchell Branch appear to be maintaining, if not slightly improving in condition. Over time the substrate (stream bottom) is becoming more natural at the lower stations (MIK 0.71 and MIK 0.45) of Mitchell Branch allowing a more diverse community to inhabit those stations. Further improvements in substrate as well as water quality improvements due to remedial activities should allow Mitchell Branch to continue to slowly improve. Perhaps more significant than these improvements is the protection from degradation of the upstream portions of Mitchell Branch which currently continue to provide communities of healthy organisms which may eventually establish themselves in the lower reaches of the stream.

Bear Creek

Tennessee Macroinvertebrate Index (TMI; Alternative Reference Stream Method) Total Scores increase considerably from BCK 12.3 (with a score of 24) downstream to BCK 9.6 (with a score of 34). Bear Creek is a small to moderate-sized stream whose headwaters begin partly in the west end of the industrialized complex at Y-12. Historically, Bear Creek has received pollution from industrial activities, as well as waste disposal activities at Y-12. Former waste sites such as the S3 ponds (at its headwaters) continue to negatively influence the water quality of the stream. Heading downstream from its source, Bear Creek continues to be impacted by inputs from various former and current waste sites. Bear Creek is also a stream where shallow groundwater and surface waters mingle freely throughout its length to its confluence with East Fork Poplar Creek. Because Bear Creek is impacted from its headwaters, two small tributaries to East Fork Polar Creek are utilized as its references (Mill Branch, MBK 1.6; and Gum Hollow Branch, GHK 2.9).

In order to determine the condition of the sampling stations in Bear Creek, the following series of nine graphs comparing Total Score, Taxa Richness, EPT Richness, % EPT-Cheum, % OC, NCBI , % Clingers, % TNUTOL, and Intolerant Taxa have been provided (Figures 3.1.3.7.19 – 3.1.3.7.27). Metric data for both Bear Creek stations may be found in Table 3.1.3.7.4. Table 3.1.3.7.4 also contains metric data for the two reference stations (GHK 2.9 and MBK 1.6). The discussion of the data follows the table and figures below.

Table 3.1.3.7.4 Metric Values, Scores, and Biological Condition Ratings for Bear Creek

2015 RESULTS	**BEAR CREEK**							
Stream station	**GHK 2.9**		**MBK 1.6**		**BCK 12.3**		**BCK 9.6**	
METRIC	VALUE	SCORE	VALUE	SCORE	VALUE	SCORE	VALUE	SCORE
Taxa Richness	57	6	62	6	45	6	65	6
EPT Richness	19	6	23	6	10	4	18	6
% EPT-Cheum	34.40	6	55.17	6	4.77	0	11.34	2
% OC	52.55	4	11.02	6	28.85	6	19.76	6
NCBI	3.34	6	3.01	6	6.51	4	5.19	4

2015 RESULTS	BEAR CREEK							
% Clingers	12.86	2	52.18	6	12.09	2	48.42	6
%TNUTOL	21.63	6	11.44	6	65.33	2	46.49	4
Intolerant Taxa	19		17		8		21	
TMI INDEX SCORE		36		42		24		34
RATING		A		A		B		A

TMI = Tennessee Macroinvertebrate Index
A = Supporting / Non-Impaired (TMI Scores ≥32)
B = Partially Supporting / Slightly Impaired (TMI Scores 21-31)
C = Partially Supporting / Moderately Impaired (TMI Scores 10-20)
D = Non Supporting / Severely Impaired (TMI Scores <10)

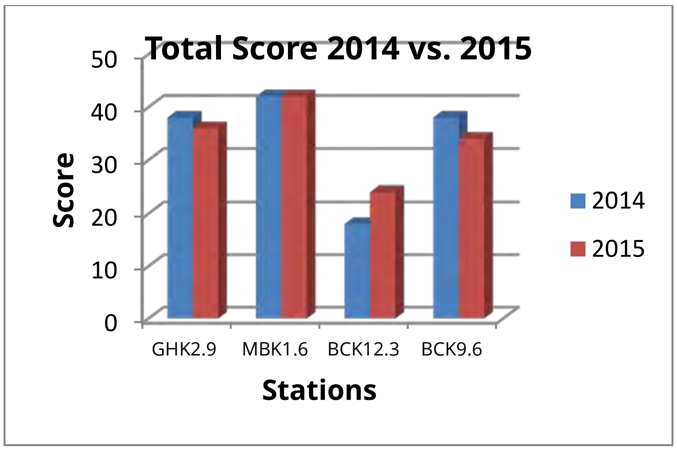


Figure 3.1.3.7.19 Total Score Bear Creek

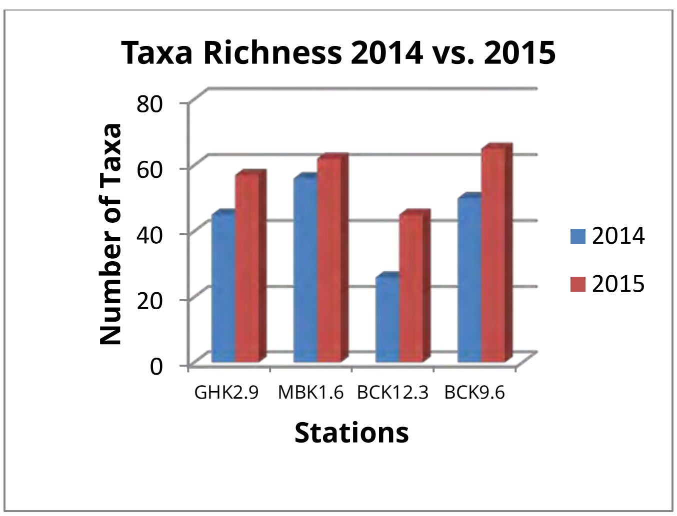


Figure 3.1.3.7.20 Taxa Richness Bear Creek

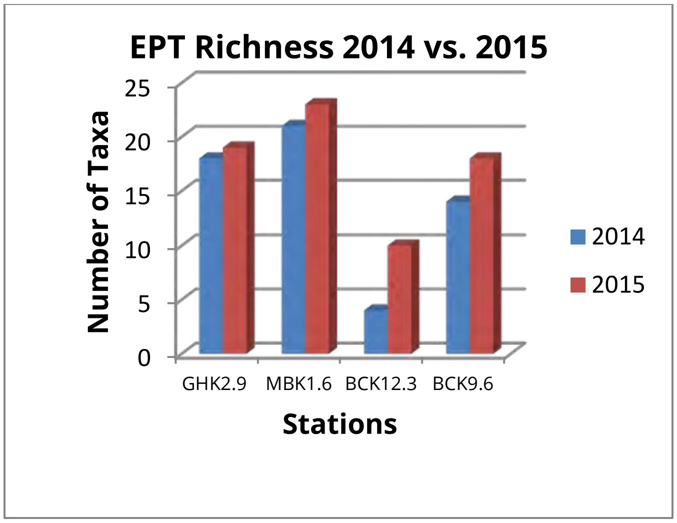


Figure 3.1.3.7.21 EPT Richness Bear Creek

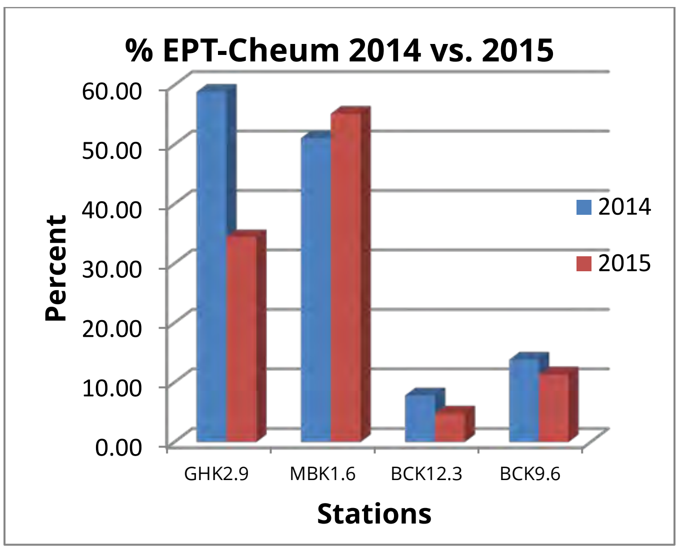


Figure 3.1.3.7.22 % EPT-Cheum Bear Creek

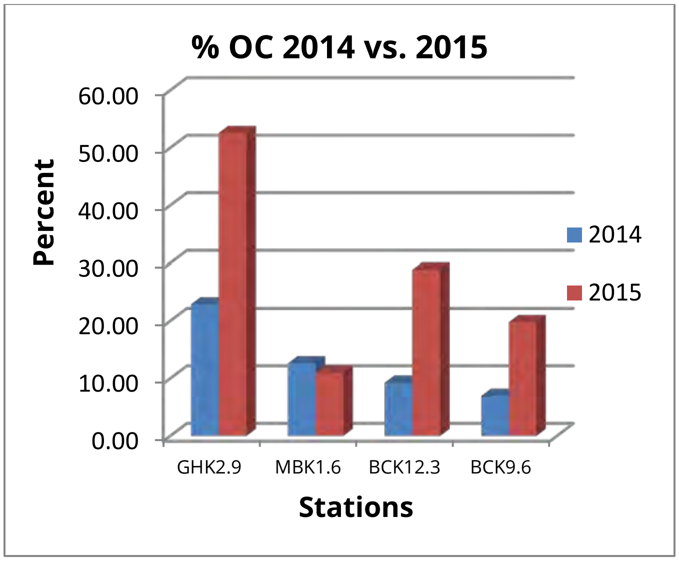


Figure 3.1.3.7.23 % OC Bear Creek

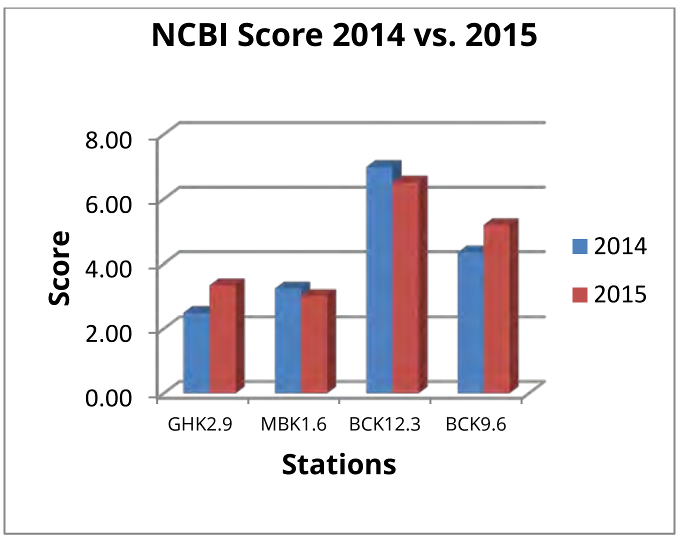


Figure 3.1.3.7.24 NCBI Bear Creek

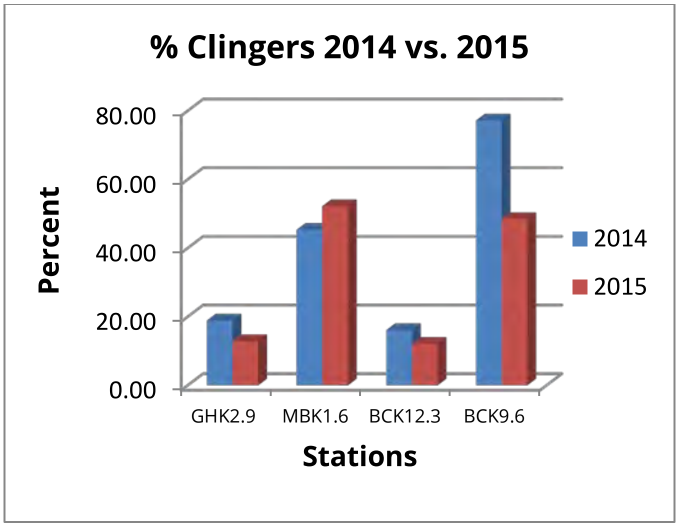


Figure 3.1.3.7.25 % Clingers Bear Creek

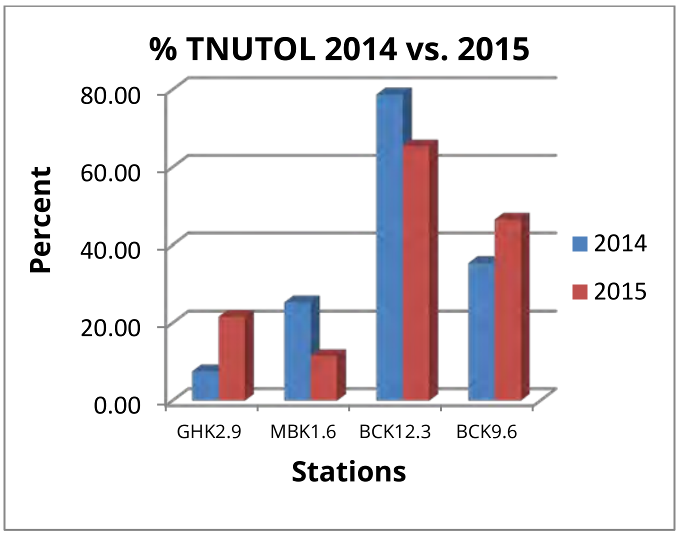


Figure 3.1.3.7.26 % TNUTOL Bear Creek

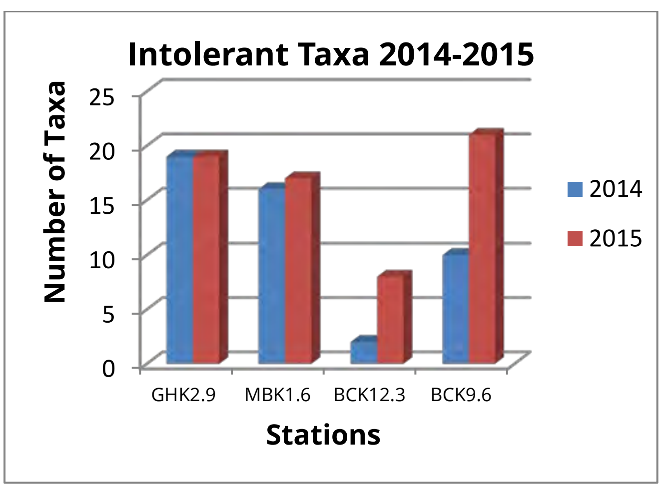


Figure 3.1.3.7.27 Intolerant Taxa Bear Creek

Bear Creek 12.3 displays a reduced benthic macroinvertebrate community, although BCK 12.3 was at one time the station in this study with the lowest TMI score. Its score increased (Figure 3.1.3.7.19) in 2015 ranking it above two stations in upper East Fork (EFK 25.1 and EFK 23.4). BCK 12.3 also continues to score low on the majority of the metrics compared to other healthier stream stations (Figures 3.1.3.7.20-3.1.3.7.22; 3.1.3.7.24-3.1.3.7.27). Conditions have improved as shown in the 2015 sampling. This improvement is evident in a number of metrics including Total Score (Figure 3.1.3.7.25), Taxa Richness (Figure 3.1.3.7.20), EPT Richness (Figure 3.1.3.7.21), NCBI Score (Figure 3.1.3.7.24,), and Intolerant Taxa (Figure 3.1.3.7.27).

At station BCK 12.3, a number of the Intolerant Taxa are successfully reproducing at the site. This is illustrated by the large number (42 were found in the subsample) of the "young of year" (first instar) caddisfly *Psilotreta* sp. The successful reproduction of this sensitive caddisfly is indicative of fairly constant, good water quality conditions at the site throughout the year. Several Intolerant Taxa (Figure 3.1.3.7.27) continue to hold on at this station. A total of eight Intolerant taxa were found at BCK 12.3 during the 2015 sampling compared to only two such taxa in 2014. Bear Creek 12.3 continues to receive inputs from industry and former and current waste sites. BCK 12.3 lacks adequate substrate for colonization by aquatic organisms. The watershed upstream of BCK 12.3 is limited in size, thus affecting the amount of flow at the station, particularly in the summer. BCK 12.3 suffers from a paucity of aquatic macroinvertebrate refuges in its vicinity from which recolonization of the station can occur. Little is currently known of the condition of Bear Creek proper between BCK 12.3 and BCK 9.6; however, a number of the tributaries in that reach of stream have likely been impacted from former and current waste activities. Further study would be required to determine if refugia of aquatic macroinvertebrates exist in the vicinity of BCK 12.3.

BCK 9.6 continues to show improvement as noted in 2012 through 2014. This station compares well with the two reference stations (GHK 2.9; MBK 1.6) in a number of the metrics. With a TMI score of 34 (38 in 2014) (Figure 3.1.3.7.19; Table 3.1.3.7.4), BCK 9.6 lags only slightly behind GHK 2.9) (Figure 3.1.3.7.19; Table 3.1.3.7.4). BCK 9.6 compares favorably with the reference stations in Taxa Richness (Figure 3.1.3.7.20), EPT Richness (Figure 3.1.3.7.21), and Intolerant Taxa (Figure 3.1.3.7.27). BCK 9.6 has a higher North Carolina Biotic Index (NCBI) score than either GHK 2.9 or MBK 1.6 (Figure 3.1.3.7.24). BCK 9.6 shows a considerably higher value for the percent of nutrient tolerant organisms (% NUTOL: Figure 3.1.3.7.26). The EPT-Cheum metric (Figure 3.1.3.7.22) shows that BCK 9.6 continues to suffer some pollutional stress with the majority of the EPT at the site consisting of the more tolerant caddisfly *Cheumatopsyche* sp.

GHK2.9 and MBK 1.6 are two of the higher scoring reference stations being used in this study. With TMI scores of 42 (Table 3.1.3.7.4; Figure 3.1.3.7.35), MBK 1.6 scores a maximum ranking on all of the metrics calculated. GHK 2.9 lags only slightly behind with a score of 36. Of note are the scores for Taxa Richness (Figure 3.1.3.7.20), EPT Richness (Figure 3.1.3.7.21), % EPT-Cheum (Figure 3.1.3.7.22), NCBI (Figure 3.1.3.7.24), % NUTOL (Figure 3.1.3.7.26) and numbers of Intolerant Taxa (Figure 3.1.3.7.27). In all, these streams appear to have high diversity and little organic loading.

White Oak Creek and Melton Branch

The TMI Total Scores (Figure 3.1.3.7.28) for the White Oak Creek watershed are highest for the upstream reference site (WCK 6.8 DUP) and for the site on Melton Branch, a tributary to White Oak Creek in Melton Valley (MEK 0.3). Scores for stations in lower White Oak Creek (WCK 3.9, WCK 3.4, WCK 2.3) are lower, indicating some degree of impairment.

White Oak Creek is the main drainage for the majority of ORNL's disturbed areas. As such, it flows from its headwaters near the Spallation Neutron Source and through the main plant area in Bethel Valley, then passing into Melton Valley, flowing through the Solid Waste Storage Areas and entering White Oak Lake before exiting the reservation through White Oak Embayment and flowing into the Clinch River. The reference station (WCK 6.8) is in the headwaters fed by several springs just below SNS. Station WCK 3.9 is located in the main plant area in Bethel Valley, with both WCK 3.4 and WCK 2.3 located in the SWSAs in Melton Valley. Melton Branch drains the eastern portion of Melton Valley with the sampling station MEK 0.3 being located near the High Flux Isotope Reactor facility. Before the development of SNS, WCK 6.8 was relatively unimpacted. The construction of SNS resulted in some sediment inputs into White Oak Creek, but the negative impacts caused by that sedimentation have since dissipated. WCK 3.9 is located on the south side of the ORNL complex and downstream of Fifth Creek, which receives inputs from a large part of the main campus of ORNL. This station at one time was impacted heavily by discharges, spills, and former waste sites. WCK 3.4 is located on the north side of the SWSAs soon after White Oak Creek passes over into Melton Valley. WCK 3.4 receives inputs from the main portion of White Oak Creek as well as inputs from First Creek. WCK 2.3 is on the south side of the SWSAs and receives added impact from the SWSAs. MEK 0.3, located near HFIR, historically received impacts from HFIR and other facilities in the area. Parts of Melton Branch have also been channelized.

Traditionally, all samples were collected in the field, preserved in ethanol, and returned to the TDEC laboratory for processing; however, processing samples in the TDEC lab left TDEC with radioactive sediments to dispose of. In 2015, the decision was made to process White Oak Creek contaminated sites (WCK 3.9, WCK 3.4, WCK 2.3, and MEK 0.3) in the field to avoid having to return sediments to the laboratory. During 2015, all contaminated sites were processed in the field removing all organisms and returning the sediments to the site of their origin. The complete sorts done in the field were later subsampled in the TDEC laboratory in order to make White Oak Creek data comparable to other sites in the study.

In order to determine the condition of the sampling stations in White Oak Creek and Melton Branch, the following series of nine graphs comparing Total Score, Taxa Richness, EPT Richness, % EPT-Cheum, % OC, NCBI , % Clingers, % TNUTOL, and Intolerant Taxa have been provided (Figures 3.1.3.7.28-3.1.3.7.36). Metric data for all White Oak Creek stations and Melton Branch may be found in Table 3.1.3.7.5. The discussion of the data follows the table and figures below.

Table 3.1.3.7.5 Metric Values, Scores, and Biological Condition Ratings for White Oak Creek and Melton Branch

2015 RESULTS	White Oak Creek and Melton Branch									
Stream station	WCK 6.8 DUP		WCK 3.9		WCK 3.4		WCK 2.3		MEK 0.3	
METRIC	VALUE	SCORE	VALUE	SCORE	VALUE	SCORE	VALUE	SCORE	VALUE	SCORE
Taxa Richness	54	6	28	4	36	4	22	2	42	6
EPT Richness	21	6	3	2	5	2	5	2	17	6
% EPT-Cheum	56.88	6	0.34	0	10.38	0	10.29	0	12.68	2
% OC	16.92	6	30.30	6	23.88	6	15.81	6	31.84	6
NCBI	2.84	6	5.35	4	4.19	6	5.62	4	4.90	6
% Clingers	44.06	6	69.36	6	71.28	6	79.41	6	57.46	6
% TNUTOL	8.14	6	52.19	4	29.07	6	59.56	4	36.99	6
Intolerant Taxa	16		5		4		3		5	
TMI INDEX SCORE		42		26		30		24		38
RATING		A		B		B		B		A

TMI = Tennessee Macroinvertebrate Index
A = Supporting / Non Impaired (TMI Scores ≥32)
B = Partially Supporting / Slightly Impaired (TMI Scores 21-31)
C = Partially Supporting / Moderately Impaired (TMI Scores 10-20)
D = Non Supporting / Severely Impaired (TMI Scores <10)

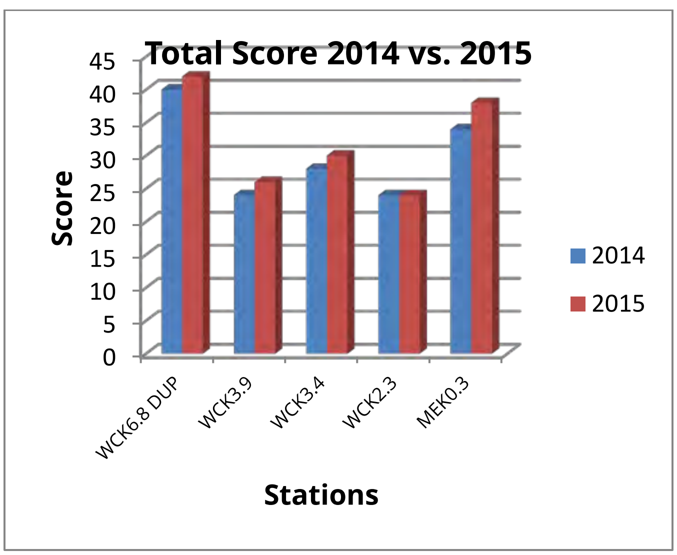


Figure 3.1.3.7.28. Total Score White Oak Creek and Melton Branch

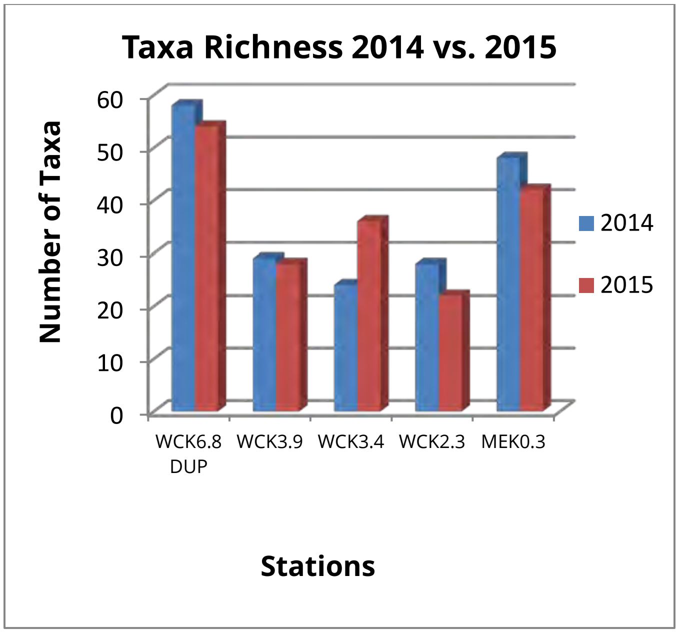


Figure 3.1.3.7.29 Taxa Richness White Oak Creek and Melton Branch

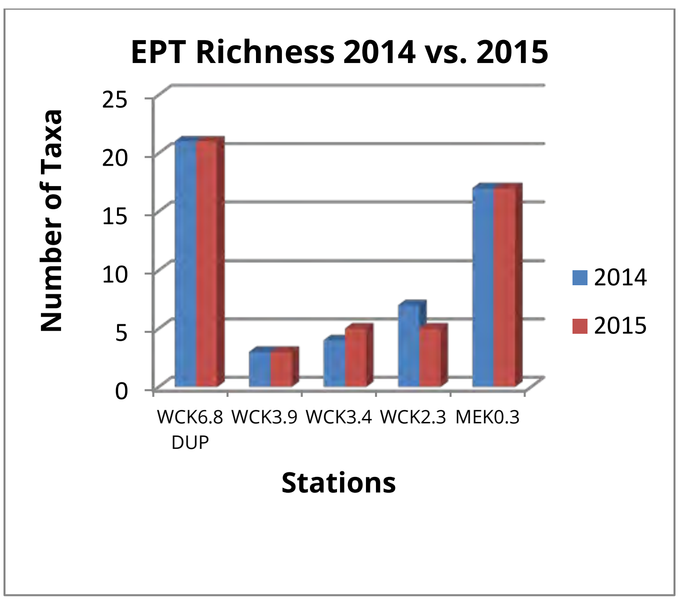


Figure 3.1.3.7.30 EPT Richness White Oak Creek and Melton Branch

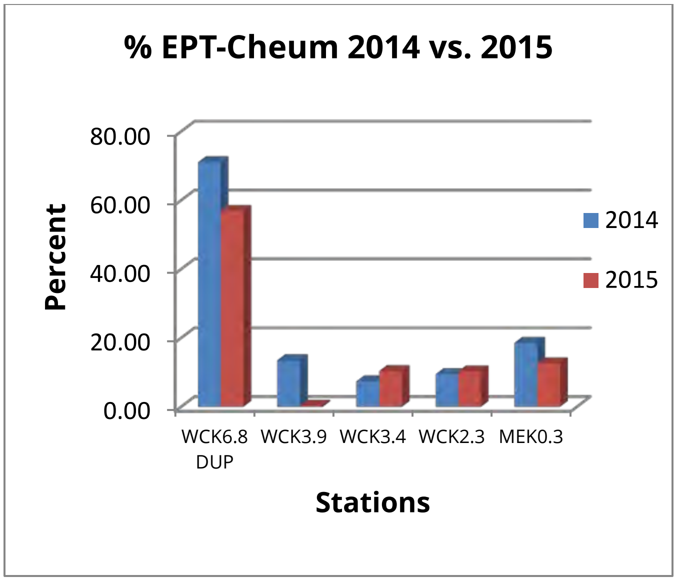


Figure 3.1.3.7.31 % EPT-Cheum White Oak Creek and Melton Branch

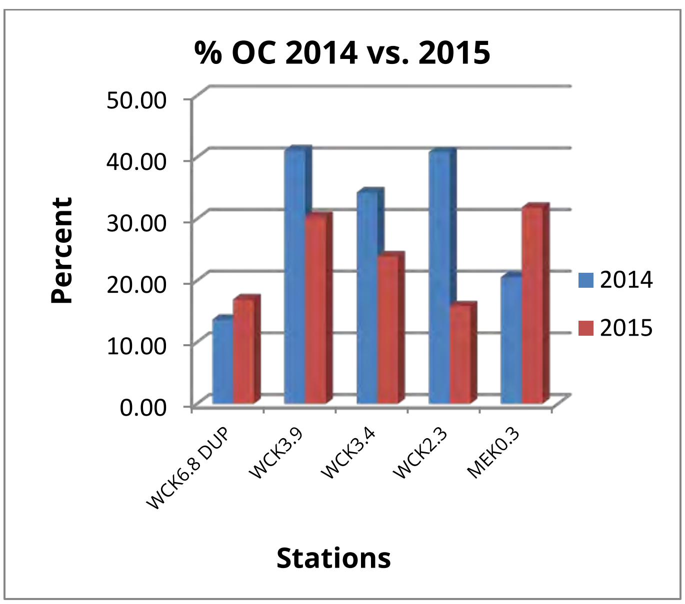


Figure 3.1.3.7.32 % OC White Oak Creek and Melton Branch

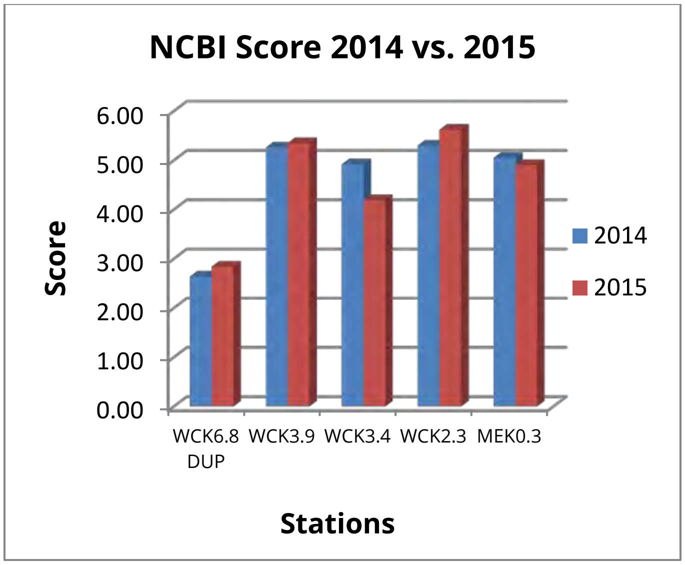


Figure 3.1.3.7.33 NCBI Score White Oak Creek and Melton Branch

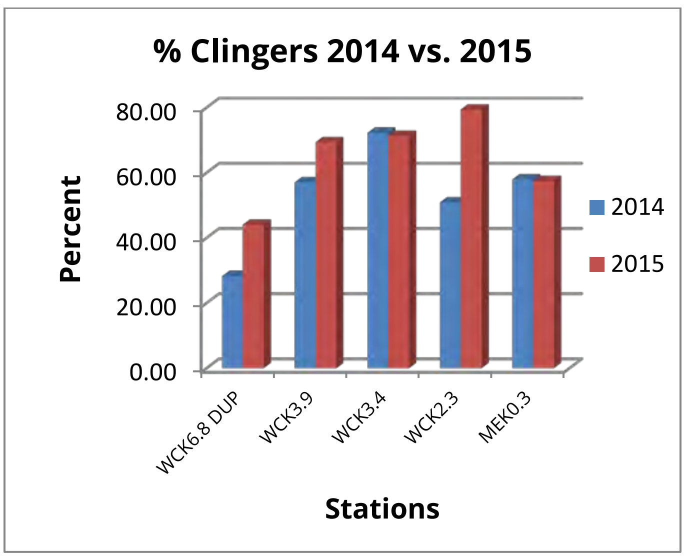


Figure 3.1.3.7.34 % Clingers White Oak Creek and Melton Branch

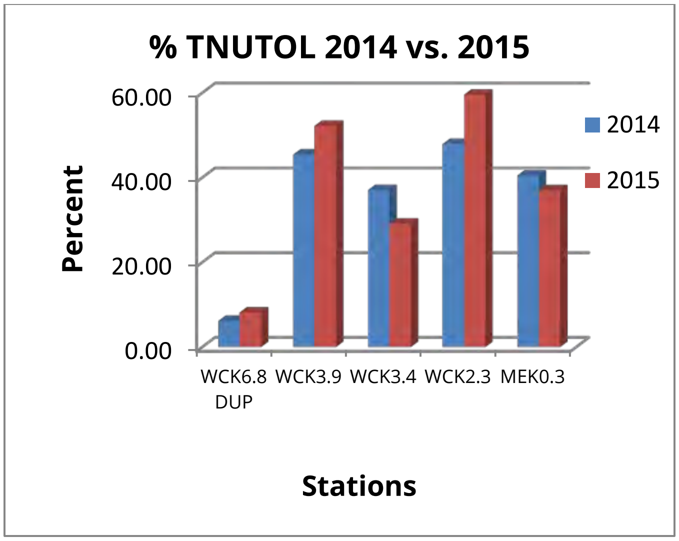


Figure 3.1.3.7.35 % TNUTOL White Oak Creek and Melton Branch

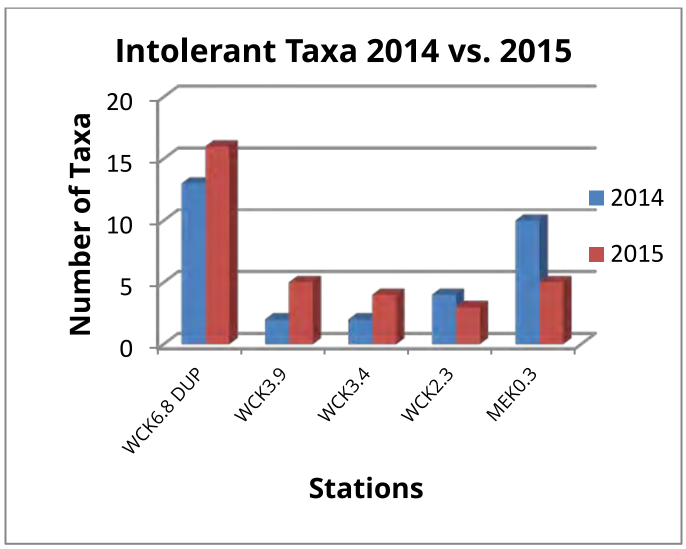


Figure 3.1.3.7.36 Intolerant Taxa White Oak Creek and Melton Branch

As indicated above, both the reference station WCK 6.8 DUP and MEK 0.3 score high on the TMI (Figure 3.1.3.7.28). The remaining White Oak Creek stations also score fairly well; however, their scores are indicative of some degree of impairment. As in 2014, the 2015 data show Taxa Richness (Figure 3.1.3.7.29) is higher for the reference station (WCK 6.8 DUP) and MEK 0.3, with the remaining White Oak Creek stations (WCK 3.9, WCK 3.4, WCK 2.3) possessing considerably fewer total taxa. WCK 6.8 DUP and MEK 0.6 also compare well in terms of EPT Richness (Figure 3.1.3.7.30). In terms of EPT-Cheum (Figure 3.1.3.7.31), % OC (Figure 3.1.3.7.32), NCBI Score (Figure 3.1.3.7.33), % Clingers (Figure 3.1.3.7.34), % TNUTOL (Figure 3.1.3.7.35), and Intolerant Taxa (Figure 3.1.3.7.36), MEK 0.3 is more similar to the other White Oak Creek stations (WCK 3.9, WCK 3.4 and WCK 2.3) than to the reference station WCK 6.8 DUP. Parameters % TNUTOL, NCBI and % EPT-Cheum may be indicative of

greater organic loading present at MEK 0.3. The major differences between the impacted White Oak Stream Stations (WCK 3.9, WCK 3.4, and WCK 2.3) and the reference station (WCK 6.8 DUP) are apparent in the reduced number of EPT taxa at impacted stations (Figure 3.1.3.7.30), and the decrease in the % EPT-Cheum (Figure 3.1.3.7.31) at the impacted stations. More differences include the increased % OC at the impacted stations (Figure 3.1.3.7.32), the significantly higher NCBI score at the impacted stations (Figure 3.1.3.7.33), and the decreased number of Intolerant Taxa at the impacted stations (Figure 3.1.3.7.36). All these differences indicate that the White Oak Creek stations (WCK 3.9, WCK 3.4, and WCK 2.3) continue to be biologically impaired.

Quality Control Results

A duplicate sample was collected at the Clear Creek 1.45 station as a quality control check for field sampling and laboratory sample processing during 2015. As seen in Table 3.1.3.7.6, the Clear Creek 1.45 station and its duplicate sample returned similar results, both attaining the same TMI score (Alternative Reference Stream Method). These results indicate that both field sampling and lab processing were done with a high rate of consistency.

Table 3.1.3.7.6 Metric Values, Scores, and Biological Condition Ratings for Quality Control Duplicates

2015 RESULTS	QUALITY CONTROL DUPLICATES			
Stream station	CCK 1.45		CCK 1.45 DUP	
METRIC	VALUE	SCORE	VALUE	SCORE
Taxa Richness	50	6	58	6
EPT Richness	26	6	26	6
% EPT-Cheum	55.11	6	39.38	6
% OC	14.10	6	9.52	6
NCBI	3.06	6	3.37	6
% Clingers	28.45	4	37.66	6
% TNUTOL	9.43	6	20.76	6
Intolerant Taxa	17		19	
TMI INDEX SCORE		40		42
RATING		A		A

TMI = Tennessee Macroinvertebrate Index
A = Supporting / Non Impaired (TMI Scores ≥32)
B = Partially Supporting / Slightly Impaired (TMI Scores 21-31)
C = Partially Supporting / Moderately Impaired (TMI Scores 10-20)
D = Non Supporting / Severely Impaired (TMI Scores <10)

3.1.4 Drinking Water

3.1.4.1 Oak Ridge Reservation Potable Water Distribution

Y-12

Ten routine inspections were made at Y-12 during 2015. The inspections focused on the facility's free chlorine residual levels. The dates for the inspections were as follows: January 8, February 10, March 11, April 10, May 13, June 2, July 7, August 25, September 16, and October 21. The chlorine residual levels were in compliance with drinking water regulations.

ORNL

Ten routine inspections were made at ORNL during 2015. The inspections again focused on the facility's free chlorine residual levels. The dates for the inspections were as follows: January 8, February 10, March 11, April 10, May 13, June 2, July 7, August 25, September 16, and October 21. The chlorine residual levels were in compliance with drinking water regulations.

ETTP

No routine inspections were made at ETTP in 2015.

3.1.5 Groundwater

3.1.5.1 Springs

Inorganics

Inorganic constituents consist of metals and general inorganics (Table 3.1.5.1.1). Four metals (lithium, boron, strontium and uranium) were not analyzed at several springs due to transcription errors when filling out the sample request forms. Lithium was analyzed at 14 of 26 locations and boron, strontium and uranium were analyzed at 24 of the 26 locations. General inorganic constituents (Table 3.1.5.1.1) were analyzed for each spring except nitrate and nitrite (18 locations of 26) and total hardness (15 of 26 locations). Volatile organic compounds were analyzed at each spring except SD-430. The SD-430 spring sample collected in March 2015 was analyzed only for radiochemical analytes. Radiochemical analyses were performed for all samples. This analysis included gross alpha activity, gross beta activity, gamma radionuclides, strontium-89/90, technetium-99, and tritium.

Table 3.1.5.1.1 contains the sampling summary for the inorganic, radiochemical and volatile organic analytes. The table shows the total number of samples and the number of analysis detections, and the minimum and maximum concentrations or radiochemical activities and the national primary drinking water regulations (NPDWR). Several metals, (arsenic, cadmium, mercury, and selenium) were not measured during analysis above their detection limits.

Analyses at all sampling locations included cation/anion parameters (Table 3.1.5.1.1), bicarbonate (alkalinity as $CaCO_3$), and carbonate (hardness as $CaCO_3$).

The list of non-metal inorganics is seen in Table 3.1.5.1.1. Two of these analytes exceeded NPDWR levels for nitrate and nitrate and nitrite by ion chromatography (IC) (10 mg/L) in one spring

(2015SPGEMP-31). The table also points out the maximum, and minimum, of the concentrations measured. The analytes on the list are constituents in natural water. The analytes can be used to determine if the water is affected by manmade pollutants.

Metals

Table 3.1.5.1.1 lists the metals requested for analysis and the additional analytes requested in the 2015 Environmental Monitoring Plan. The table also lists the maximum and minimum concentrations for the metals collected. For example, aluminum measurements ranged from 17 to 1800 micrograms per liter (µg/L).

Chromium was not detected except for four springs with low concentrations. Iron has always been a variable constituent and ranged from non-detect to 2400 milligrams per liter (mg/L). The concentration of lead in the 26 water samples collected was not detected for 18 of the samples and estimated for six, while two samples had low concentrations. Lithium was detected in 12 of the 14 samples and showed the highest concentrations (3.0 -12 µg/L) in the Y-12 area. Manganese was detected across the ORR (U-1400 µg/L), but the two highe... The highest nickel concentrations (8.6 and 5.6 µg/L) were near ETTP disposal areas.

Sodium was seen in all samples and ranged from 0.44 -18 mg/L. Strontium was measured in all 24 samples with a range of 16 to 260 µg/L. Uranium ... The lowest concentration was 0.42 µg/L and the highest concentration was 40 µg/L. The highest concentrations of metals appear to reside in the springs downgradient from active or legacy waste disposal areas.

Volatile Organic Compounds

VOCs are not naturally found in pristine waters in measurable amounts. EPA has set limits in regulations for finished water from public water systems. These regulations are NPDWR limits, formally called maximum concentration limits (MSLs). Primary standards protect public health by limiting the levels of contaminants in drinking water.

Table 3.1.5.1.1 lists those VOCs that were detected during analysis. The laboratory method for analysis was EPA's 524.2, for drinking water constituents. Of the 26 springs sampled, only four indicated VOCs above the NPDWR for three VOCs. Table 3.1.5.1.2 shows the springs that measured constituents above the EPA's NPDWR and their concentrations and the analytes. Three analytes are above the NPDWR limits: cis-1,2-dichloroethene in three springs, trichloroethene in three springs, and vinyl chloride in two springs.

Radiochemical / Radiological

Water from all springs visited was sampled and analyzed for radiological constituents. The analyses consisted of measuring the gross alpha activity, the gross beta activity, and the activity of gamma emitting isotopes. Individual isotopes were also analyzed in samples. Table 3.1.5.1.1 lists the total numbers of samples and the isotopes determined. Technetium-99 was requested for analysis in all 27 samples. Strontium-89 and strontium-90 were analyzed in water from 18 springs and tritium was

requested in 23 springs. Three springs west of Y-12 in Bear Creek Valley were analyzed for radon-222 and isotopic uranium.

Water from spring 2015SPGEMP-31(SS-4) measured the highest gross alpha activity (16 pCi/L) and also for gross beta at 80.0 pCi/L. These activities are both above the NPDWR (15 pCi/L and 4 millirem or 50 pCi/L respectively). At this spring, technetium-99 was measured at 52.8 pCi/L, radon-222 at 310 pCi/L, and uranium-238 at 16.8 pCi/L. Radon is a product of the decay of uranium and has a short half-life of 3.82 days. Radon-222 and uranium-238 are alpha-emitters.

Water from spring SD-430 was analyzed for gross alpha, gross beta, and technetium-99. The results for gross beta and technetium-99 were 79.6 and 76.6 pCi/L respectively. The source for the gross beta activity is likely technetium-99. This spring drains areas of ETTP where a release of Technetium-99 was reported.

For the remainder of the samples, gross alpha activity ranged from a -1.05 pCi/L(SD 430 spring) to 16 pCi/L (2015EMPSPG-31), gross beta activity ranged from -0.2 (2015EMPSPG-03) to 80 pCi/L (2015EMPSPG-31), and, of 26 samples, there were two springs that did not measure any gamma radiation (2015SPGEMP-14 and 2015SPGEMP-18). Eighteen springs were analyzed for strontium-89 and strontium-90. The range of values is -0.55 to 0.78 pCi/L (2015EMPSPG-17) for strontium-89 and -0.42 to 0.6 pCi/L (2015EMPSPG-28) for strontium-90. Tritium was analyzed in 23 of the 27 samples and ranged from -32 (2015EMPSPG-14) to 366 pCi/L (2015EMPSPG-04). The NPDWR for tritium, a beta particle emitter, is four mrem/year. The EPA derived concentration for tritium at four mrem/year is 20,000 pCi/L.

NPDWR Exceedances

NPDWR exceedances as shown in Table 3.1.5.1.2 indicate 2015SPGEMP-31 (SS-4) is the spring containing more constituents above the regulatory limits for finished drinking water. 2015SPGEMP-31 is downstream from Y-12, adjacent to Bear Creek on the ORR. Nitrate and nitrite, uranium, trichloroethene, gross alpha activity and gross beta activity all exceeded their respective NPDWR limits in 2015SPGEMP-31(SS-4). 2015SPGEMP-24 had three exceedances, cis-1,2-dichloroethene , trichloroethene, and vinyl chloride. 2015SPGEMP-16 had two exceedances, cis-1,2-dichloroethene , and vinyl chloride. 2015SPGEMP-32 had one exceedance of trichloroethene.

Parameters

As mentioned previously, parameters are collected before, during, and after sample collection using a YSI Professional Plus® multi-parameter water quality instrument that reads temperature in degrees centigrade, dissolved oxygen in mg/L, specific conductivity in microsiemens, pH in standard units and oxidation reduction potential (ORP) in millivolts. Table 3.1.5.1.3, in Appendix C, lists these parameters and the springs where they were measured.

Turbidity was not measured due to equipment availability problems. The parameters measured give a snapshot of the water quality.

Table 3.1.5.1.1 Spring Sampling Summary

INORGANIC ANALYTES	Number of Samples Analyzed	Number of Analytes Detected	Min. Conc. /Activity	Max. Conc. /Activity	NPDWR (P) NSDWR (S)	Units
Aluminum	26	25	15	1800	50 - 200 S	□g/L
Arsenic	26	0	0	0	10 P	□g/L
Barium	26	26	20	140	2000 P	□g/L
Boron	24	6	14	85	No Criteria	□g/L
Cadmium	26	0	0	0	5 P	□g/L
Calcium	26	26	22	97	No Criteria	mg/L
Chromium	26	4	1.3	1.5	100 P	□g/L
Iron	26	25	9	2400	300 S	□g/L
Lead	26	8	0.42	1.1	15 P	□g/L
Lithium	14	12	0.46	3	No Criteria	□g/L
Magnesium	26	26	3.4	32	No Criteria	mg/L
Manganese	26	25	0.63	1400	50 S	□g/L
Mercury	26	0	0	0	2 P	□g/L
Nickel	26	26	0.63	8.6	100 TDEC	□g/L
Potassium	26	26	0.6	3.6	No Criteria	mg/L
Selenium	26	0	0	0	50 P	□g/L
Sodium	26	26	0.44	18	No Criteria	mg/L
Strontium	24	24	16	260	No Criteria	□g/L
Uranium	24	8	0.42	40	30 P	□g/L
Calcium Hardness BC	22	22	55	240	No Criteria	mg/L
Chloride by IC	26	26	1.6	38	250 S	mg/L
BL						
Nitrate and Nitrite	18	18	0.031	12	10 P	mg/L
Nitrate by IC	26	26	0.038	14	10 P	mg/L
Sulfate	26	26	2.2	55	250 S	mg/L
Total Alkalinity	26	26	110	260	No Criteria	mg/L
Total Dissolved Solids	26	26	106	380	500 S	mg/L
Total Hardness	15	15	130	260	No Criteria	mg/L
RADIOCHEMICAL ANALYTES						
Gross Alpha	27	27	-1.05	16	15 P	pCi/L
Gross Beta	27	27	-0.2	80	4 mrem/yr ~50 pCi/L P	pCi/L
Gamma Radionuclides	26	24	NDA	-	4	mrem/yr
Bi-214	26	18	11.4	161	4	mrem/yr
Pb-214	26	18	15.2	163	4	mrem/yr
Sr-89	18	18	-0.55	0.78	4	mrem/yr
Sr-90	18	18	-0.42	0.6	4	mrem/yr
Tc-99	27	15	-0.14	76.6	4	mrem/yr
Tritium	23	23	-32	366	4	mrem/yr
Radon-222	3	3	210	546	15 P	pCi/L
U-233/234	3	3	0.988	6.21	15 P	pCi/L
U-235	3	3	0.161	0.876	15 P	pCi/L
U-238	3	3	2.7	16.8	15 P	pCi/L
ORGANIC ANALYTES						
1,1,1-Trichloroethane	26	1	0.49	0.49	200 P	□g/L
1,1,2-Trichloro-1,2,2-trifluoroethane	26	3	1.51	15.3	No Criteria	□g/L
1,1-Dichloroethane	26	2	1.85	2.54	No Criteria	□g/L
1,1-Dichloroethene	26	5	0.26	2.61	7 P	□g/L
Bromodichloromethane	26	1	0.44	0.44	No Criteria	□g/L
Carbon tetrachloride	26	1	3.14	3.14	5 P	□g/L
Chloroform	26	6	0.23	3.82	No Criteria	□g/L
Chloromethane	26	1	0.35	0.35	No Criteria	□g/L
cis-1,2-Dichloroethene	26	5	1.48	183	70 P	□g/L
Dichlorodifluoromethane	26	1	1.31	1.31	No Criteria	□g/L
Tetrachloroethene	26	2	0.28	1.14	5 P	□g/L
trans-1,2-Dichloroethene	26	2	0.54	2.2	100 P	□g/L
Trichloroethene	26	7	0.42	99.9	5 P	□g/L

INORGANIC ANALYTES	Number of Samples Analyzed	Number of Analytes Detected	Min. Conc. /Activity	Max. Conc. /Activity	NPDWR (P) NSDWR (S)	Units
Vinyl chloride	26	2	8.69	15.3	2 P	□g/L
QA/QC SAMPLES						
4-Isopropyltoluene	7	2	0.34J	2.35J	No Criteria	□g/L
Radon-222	1	1	307	307	15 P	pCi/L

Max. - maximum
Conc. - concentration
□g/L= micrograms per liter
□mhos/cm = micrmhos per centimeter
QA/QC = Quality Assurance/Quality Control
NPDWR (P) = National Primary Drinking Water Regulations
pCi/L = pCi/L is one trillionth (10E-12) of a Curie
TDEC = Determined by the State of Tennessee Rule 0400-40-03-.03j

Min. - minimum
mg/L - milligram per liter
BC = By Calculation
BL = By Laboratory
IC = Ion Chromatography
J = Estimated Concentration
NSDWR (S) = National Secondary Drinking Water Regulations
mrem/yr = A millirem is 1/1000 of the calculated radioactive dose equivalent to the Total Body or any Critical Organ

Table 3.1.5.1.2 NPDWR Exceedances

Analyte Exceeding NPDWR	Nitrate and Nitrite	Nitrate	Uranium	Gross Alpha	Gross Beta	cis-1,2-Dichloroethene	Trichloroethene	Vinyl Chloride
NPDWR	10 mg/L	10 mg/L	0.030 mg/L	15 pCi/L	4 mrem/yr	0.07 mg/L	0.005 mg/L	0.002 mg/L
Station Name (Alias)								
2015SPGEMP-16 (JA Jones Spring)						0.0841		0.00869
2015SPGEMP-24 (Tomsseep Spring)						0.183	0.0999	0.0153
2015SPGEMP-31 (SS-4 Spring)	12	14	0.04	16.0	80.0		0.00565	
2015SPGEMP-32 (21-002 Spring)							0.0215	
SD-430 Spring					79.6			

NPDWR = EPA National Primary Drinking Water Regulations
mg/L = milligrams per liter
pCi/L = picoCuries per liter
yr = year
mrem = millirem
millirem = A millirem is 1/1000 of the calculated radioactive dose equivalent to the Total Body or any Critical Organ and is related to cancer risk and significant hereditary effects

3.1.5.2 Background Residential Well Monitoring

This project was postponed.

3.1.5.3 Offsite Residential Well Monitoring

3.1.5.3.2 2015 Sampling

Results were compared to EPA NPDWR and NSDWRS drinking water standards, and data from the USGS's NWQA (DeSimone 2009).

The NWQA study gathered data from all major aquifers in the United States. Concentrations of contaminants in the study are separated by percentiles results. TDEC sample results are compared to the 90th percentile as reported in NWQA. This comparison is made in order to determine if a particular contaminant is present at concentrations above what may be considered background for the East Tennessee aquifers sampled.

Radionuclide Results

No fission or activation products were reported to be present in the eleven offsite wells sampled by TDEC. Analysis from seven of eleven wells reported transuranic isotopes at concentrations above the minimum detectable activity (MDA) and the error (Table 3.1.5.3.2.1). The reported transuranic isotopes were neptunium-237 (^{237}Np), americium-241 (^{241}Am), plutonium-238 (^{238}Pu), plutonium-239/240 ($^{239/240}$Pu).

All concentrations of the transuranics reported were in the hundredths of a picoCurie per liter (pCi/L). DOE results from three co-samples reported similar concentrations of the transuranic isotopes ^{237}Np (well RWA-127) and $^{239/240}$Pu (wells RWA-118 and RWA-129). The relevant EPA primary drinking water standard for alpha emitting radionuclides such as the transuranic isotopes is 15 pCi/L. Reported concentrations are below this standard.

Table 3.1.5.3.2.1 Transuranic Isotopes Reported in Offsite Residential Wells

ISOTOPE	RWA-047	CRBR-067	RWA-118	RWA-127	RWA-129	RWA-136	RWA-139
^{237}Np pCi/L	9.41E-02	3.76E-02	3.27E-02			4.76E-02	4/02E-02
CE pCi/L	6.53E-02	2.34E-02	2.28E-02			3.49E-02	2.44E-02
MDA pCi/L	8.44E-02	2.31E-02	3.06E-02			3.89E-02	2.60E-02
^{241}Am pCi/L		U	4.02E-02				
CE pCi/L		U	2.35E-02				
MDA pCi/L		U	3.04E-02				
^{238}Pu pCi/L		6.33E-02	2.58 E-02				
CE pCi/L		3.30E-02	1.79E-02				
MDA pCi/L		3.62E-02	1.90E-02				
$^{239/240}$Pu pCi/L	4.18E-02	3.91E-02	2.02E-02	2.02E-02	6.36E-02		
CE pCi/L	3.33E-02	2.35E-02	1.62E-02	1.63E-02	5.29E-02		
MDA pCi/L	3.58E-02	2.22E-02	1.73E-02	1.73E-02	5.45E-02		

^{237}Np = neptunium-237
^{241}Am = americium-241
^{238}Pu = plutonium-238
$^{239/240}$Pu = plutonium-239/240

pCi/L = pico Curies per Liter
MDA = Minimum Detectable Activity
U = Not detected above the MDA
CE = counting error

Inorganic Results

Lead concentrations exceeded the primary drinking water standard in one well (RWA-047) at 0.068 mg/L compared to the EPA NPDWR of 0.015 mg/L. Secondary standards for iron, aluminum, and zinc were exceeded in four wells (RWA-047, RWA-118, RWA-142, and RWA-143). The NWQA 90th percentile was met or exceeded in seven of the sampled residential wells for aluminum, barium, boron, copper, iron, lead, lithium, and zinc.

Table 3.1.5.3.2.2 Results for Selected Metals Compared to Different Criteria

Location	Analyte	Results	NWQA 90th Percentile	NPDWR or Health Advisory	NSDWS
CRBR-067	Boron	0.91	0.218	2	NA
	Lithium	0.063	0.0438		
	Sodium	150	78.8		
RWA-047	Iron	0.43	1.11	NA	0.3
	Copper*	0.34	0.0123	1.3	1
	Lead*	0.68	0.00109	0.015	NA
	Zinc	0.24	0.0999	NA	5
RWA-118	Iron	0.39	1.11	NA	0.3
	Aluminum	0.2	0.00528	NA	0.2
RWA-140	Lead	0.0024	0.0019	0.015	NA
	Zinc	0.65	0.0999	NA	5

Location	Analyte	Results	NWQA 90th Percentile	NPDWR or Health Advisory	NSDWS
RWA-141	Barium	0.27	0.219	2.0?	NA
	Copper*	0.032	0.0123	NA	1
	Lead*	0.0014	0.00109	0.015	NA
RWA-142	Iron	1.4	1.11	NA	0.3
	Aluminum	0.88	0.00528	NA	0.2
RWA-143	Zinc	0.29	0.0999	NA	5

* Lead and copper are regulated by a treatment technique that requires systems to control the corrosiveness of their water. If more than 10% of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/L, and for lead is 0.015 mg/L.

Field Parameter Results

Elevated field parameters (pH and turbidity) were reported from two residential wells, CRBR-047 and RWA-047. The pH in residential well CRBR-067 located offsite of Melton Valley approximately five kilometers (three miles) southwest of the ORR was reported at 9.3 standard units (s.u.) and exceeds the EPA NPDWRS of pH 8.5 s.u. Turbidity in RWA-047 was reported at 158 NTU.

Two wells, RWA-047 offsite of Bear Creek Valley and CRBR-067 offsite of Melton Valley, reported an exceedance of EPA drinking water standards for lead and pH respectively. RWA-047 exceeded the EPA NPDWR for lead (0.015 mg/L) with a reported concentration 0.068 mg/L. The secondary standard for iron (0.300 mg/L) was exceeded with a reported concentration of 0.430 mg/L. The NAWQA 90th percentile was exceeded for iron, copper, lead and zinc (Table 3.1.5.3.2.2). Barium was reported below the NAWQA 90th percentile at a concentration of 0.210 mg/L. Turbidity in this well was also elevated and reported at 158 NTU. TDEC analysis reported ^{237}Np and $^{239/240}$Pu (Table 3.1.5.3.2.1).

While it is possible the metals and transuranics are associated with the turbidity of groundwater, it has been noted in literature that contaminants may be transported with suspended particles in groundwater (Puls and Barcelona, 1989).

Well RWA-047 is not an isolated example of metals contamination in groundwater. Elevated levels of lead, arsenic, cadmium, and beryllium were reported from DOE and TDEC sampling of residential wells in the offsite study area across from Bear Creek Valley. RWA-047 and the associated wells are emplaced within the Ordovician Conasauga Group of the Valley and Ridge province of East Tennessee (Hatcher, 1992). The Conasauga Group is not known as a host to metallic deposits as are the Knox Group Dolomites of East Tennessee (Purdue, 1912). Further investigation is ongoing to determine if detected levels can be attributed to naturally occurring deposits.

CRBR-067 exceeded the EPA secondary standard for pH (8.5 s.u.). The NAWQA 90th percentile concentrations were exceeded for boron, lithium and sodium (Table 3.1.5.3.2.2). Transuranics 237Np, 238Pu, 239/240Pu were reported (Table 3.1.5.3.2.1). Elevated pH, sodium, lithium, and boron have been reported from analysis of water from both residential and monitoring wells in the area

southwest of the Melton Valley waste disposal sites from 2007 to present (TDEC, 2007) Project Environmental Measuring System (PEMS).

3.1.6 Surface Water/Sediment

3.1.6.1 Benthic Macroinvertebrates Surface Water Component

Bear Creek

BCK 12.3 had a TMI rating of B (partially supporting/slightly impaired) compared to the downstream site at BCK 9.6, which had a TMI rating of A (supporting/non-impaired). Nitrate and nitrite nitrogen, total hardness, total dissolved solids, nickel, cadmium, zinc, copper, and manganese concentrations (Figures 3.1.6.1.1 and 3.1.6.1.2) could, along with the highly channelized nature of the Bear Creek at km 12.3, have had an impact on benthic macroinvertebrate metrics. Gross alpha and gross beta activities (Figure 3.1.6.1.3 and 3.1.6.1.4) were higher at BCK 12.3 than at BCK 9.6, which may have factored into the lower TMI rating at BCK 12.3.

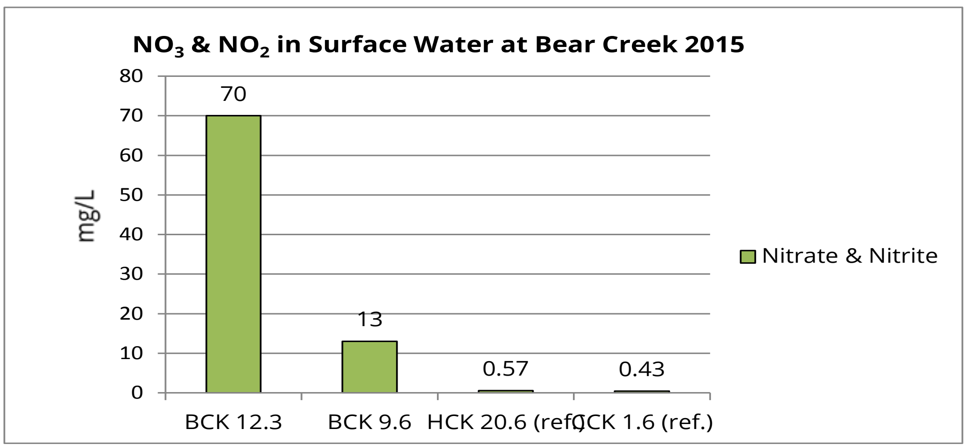


Figure 3.1.6.1.1 NO_3 & NO_2 in surface water at Bear Creek 2015

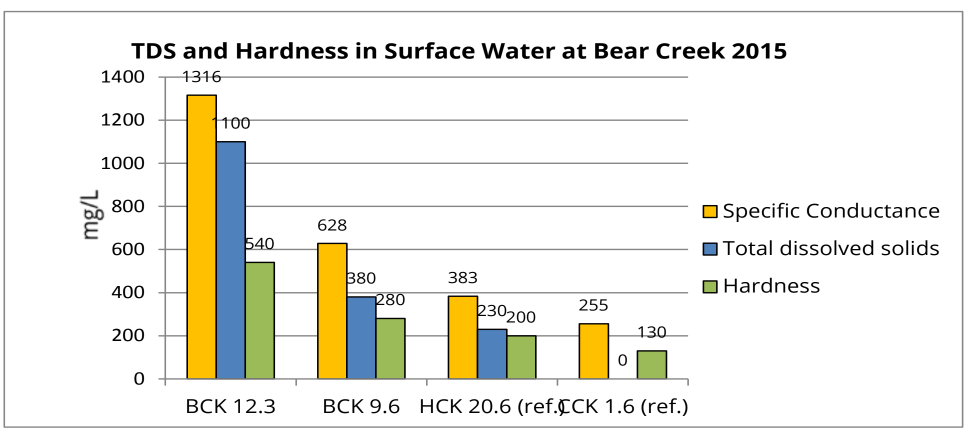


Figure 3.1.6.1.2 TDS and hardness in surface water at Bear Creek 2015

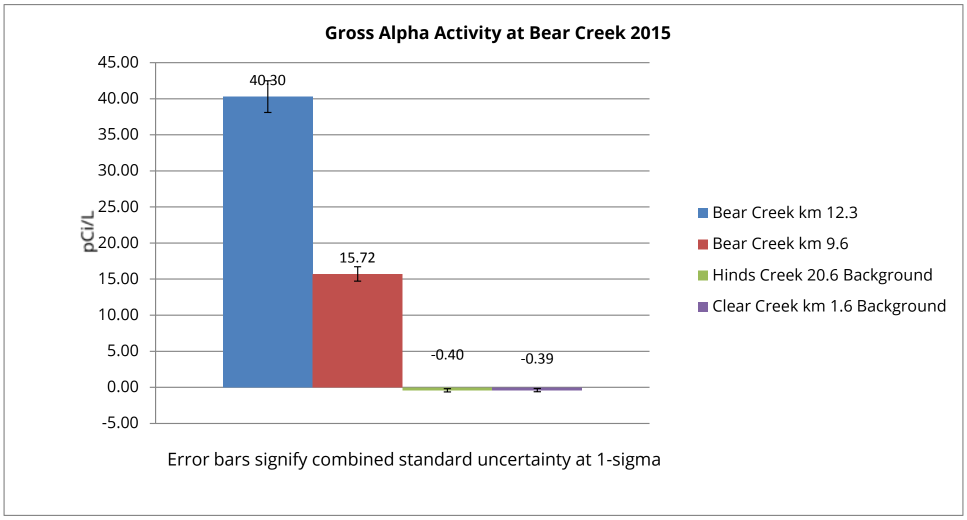


Figure 3.1.6.1.3 Gross Alpha Activity at Bear Creek 2015

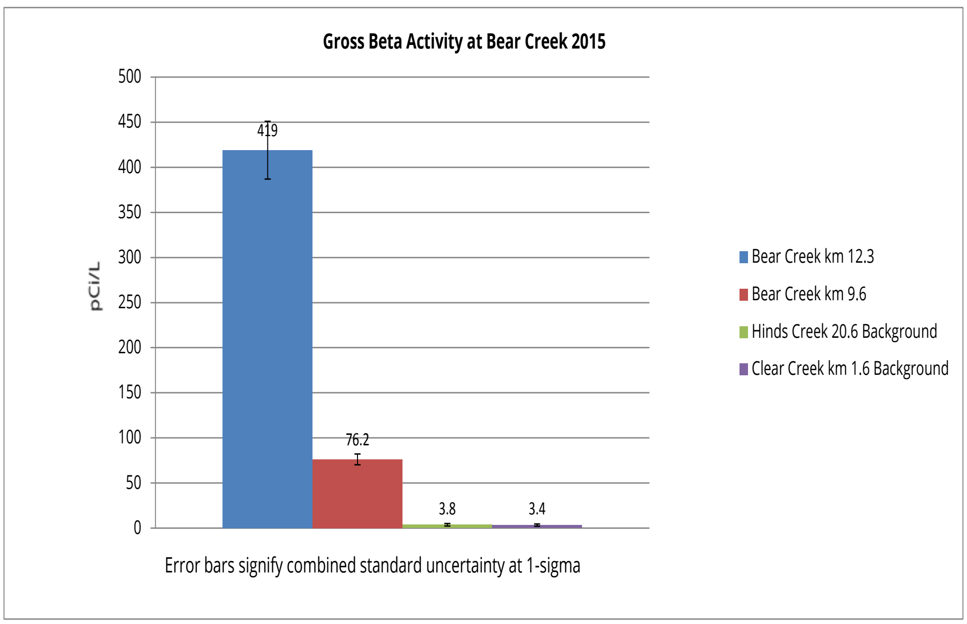


Figure 3.1.6.1.4 Gross Beta Activity at Bear Creek 2015

East Fork Poplar Creek

The higher mercury levels at upstream sampling sites may have had an effect on some of the metrics of the benthic macroinvertebrate results (Figure 3.1.6.1.5). Other factors, such as the pronounced channelization of the stream and the lower primary productivity in the area of the upstream sampling location (EFK 25.1) should also be taken into consideration. In addition, it is not known if the elevated radiological values at upstream sites (Figures 3.1.3.1.6 and 3.1.6.1.7) have had any impact on the benthic macroinvertebrate communities.

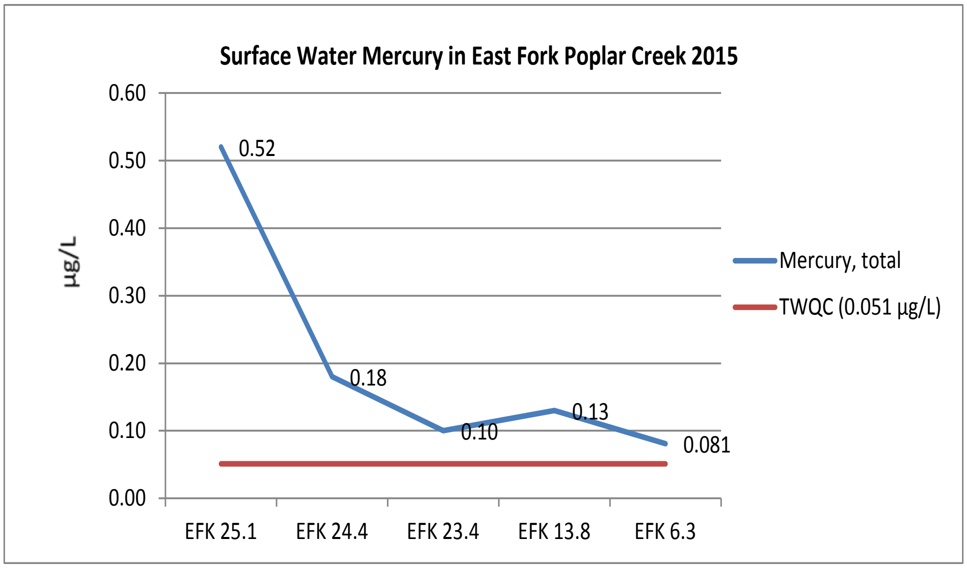


Figure 3.1.6.1.5 Surface Water Mercury in East Fork Poplar Creek 2015

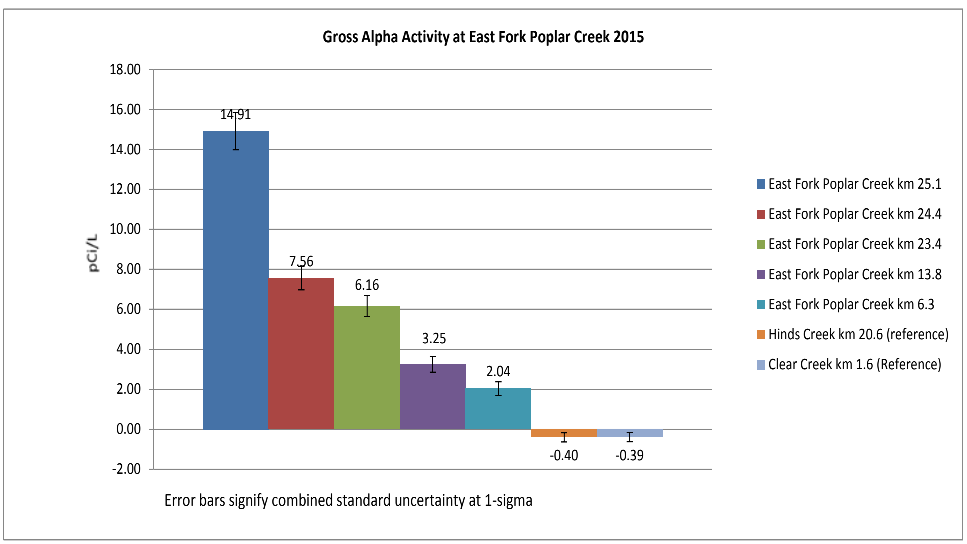


Figure 3.1.6.1.6 Gross alpha activity in surface water at East Fork Poplar Creek 2015

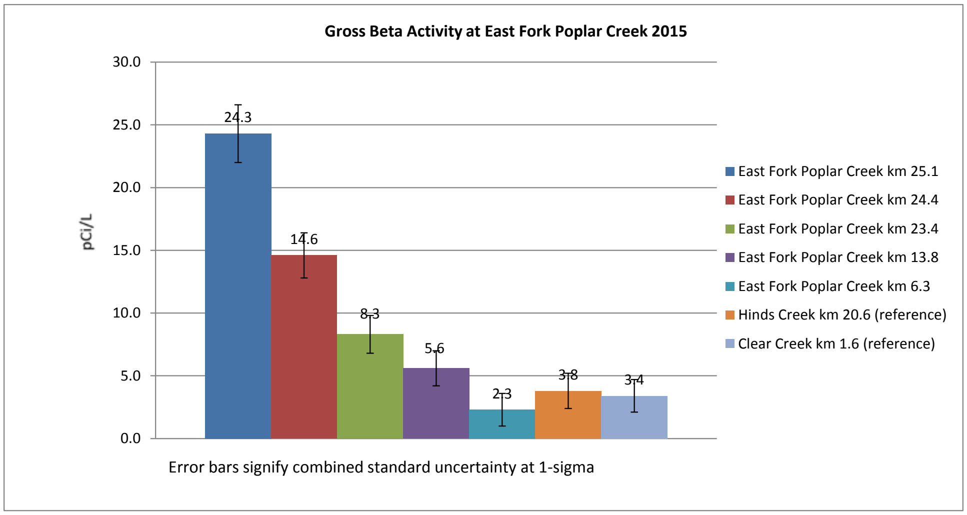


Figure 3.1.6.1.7 Gross beta activity at East Fork Poplar Creek 2015

Mitchell Branch

In terms of surface water chemistry affecting benthic macroinvertebrate communities on Mitchell Branch, the role the relatively higher levels of gross alpha and beta activities (figures 3.1.6.1.7 and 3.1.6.1.8) at MIK 0.71 and MIK 0.45 play, if any, is unknown.

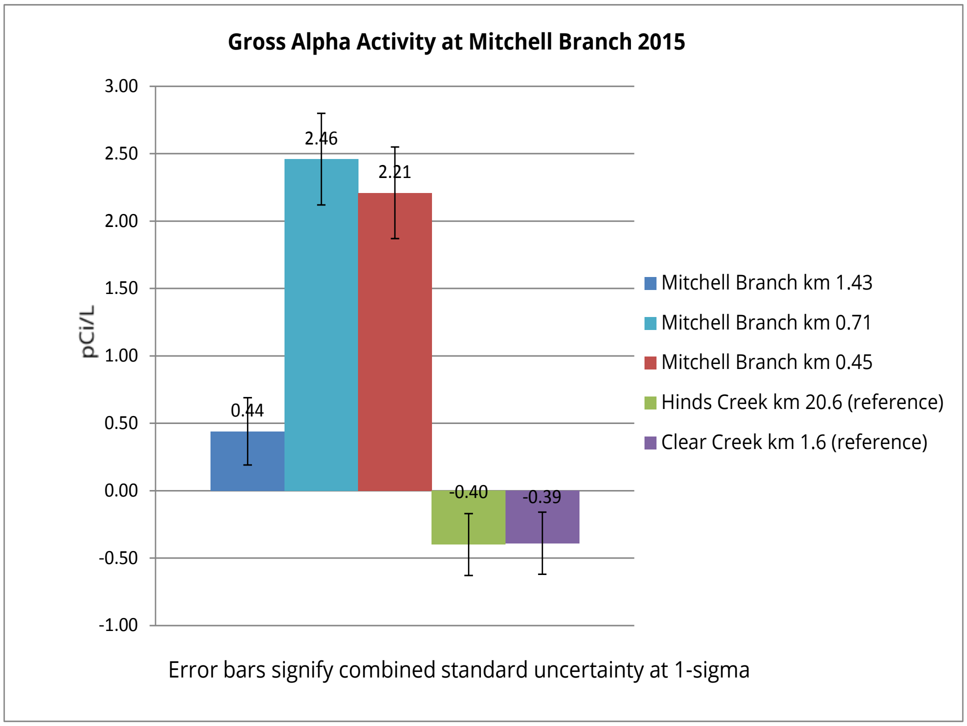


Figure 3.1.6.1.7 Gross alpha activity at Mitchell Branch 2015

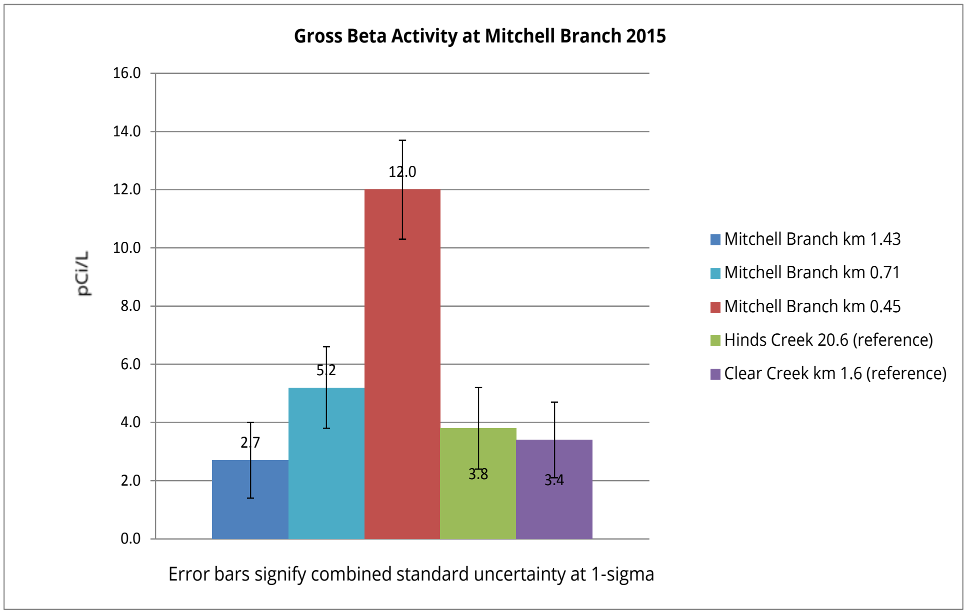


Figure 3.1.6.1.8 Gross beta activity at Mitchell Branch 2015

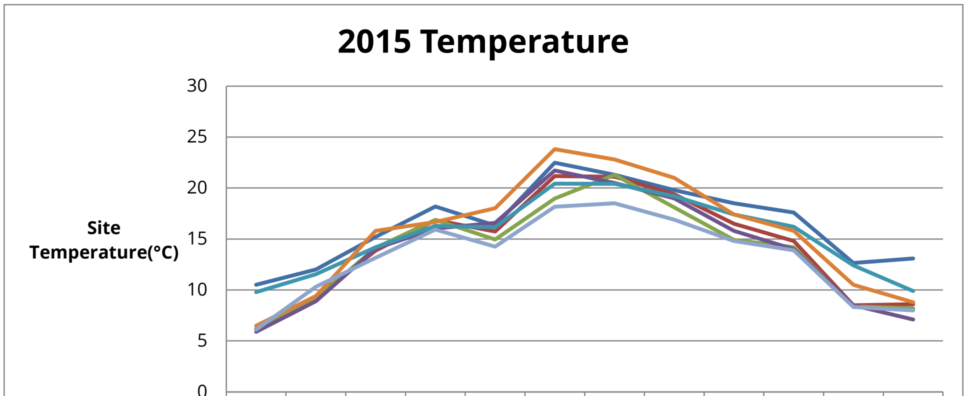
White Oak Creek / Melton Branch

The TMI rating for all lower White Oak Creek sites was B (partially supporting/slightly impaired). Both the Melton Branch site (MEK 0.3) and the headwaters site of White Oak Creek (WCK 6.8) had scores of A (supporting/non-impaired).

3.1.6.2 Surface Water Physical Parameters

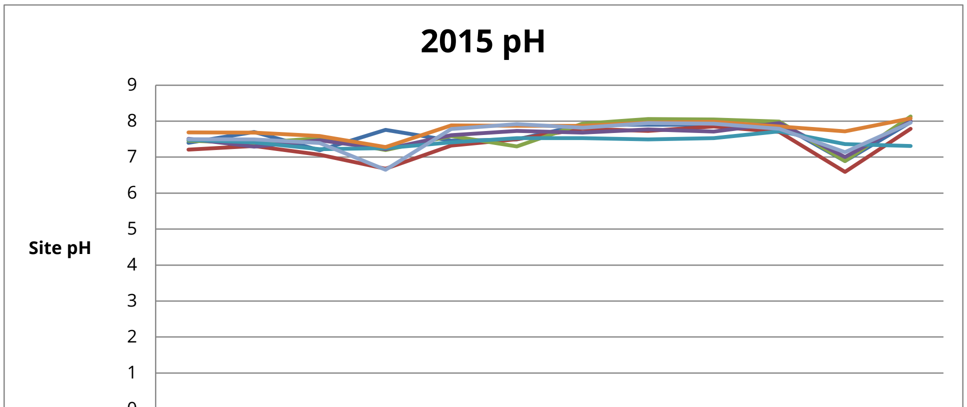
Discrete Ambient Surface Water Physical Monitoring

Field data was collected on a monthly basis from the seven monitoring sites. Figures 3.1.6.2.1 through 3.1.6.2.4 provide monthly temperature, pH, conductivity, and dissolved oxygen data.



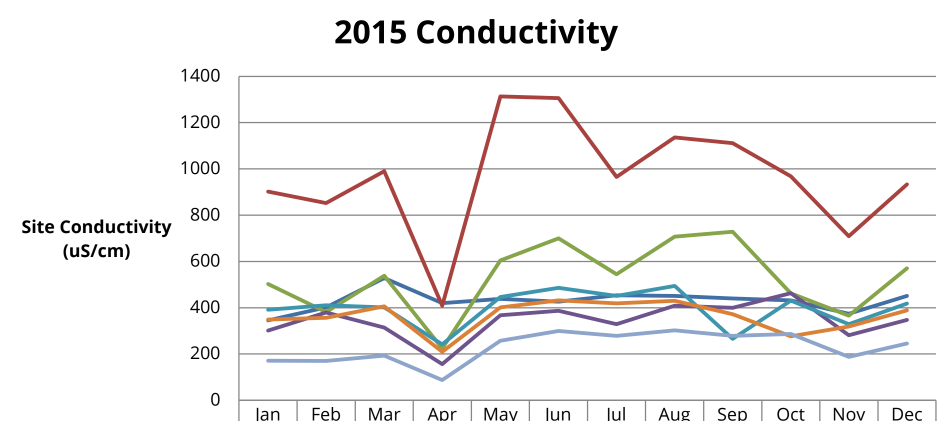
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
EFK 23.4	10.5	12.01	15.21	18.19	16.32	22.48	21.3	19.8	18.5	17.6	12.65	13.1
BCK 12.3	6.2	9.34	13.85	16.85	15.73	21.18	21.1	19.4	16.5	14.8	8.49	8.6
BCK 9.6	6.2	9.16	14.13	16.87	14.95	18.97	21.3	18.1	14.9	14.2	8.39	8.2
BCK 4.5	5.9	8.91	14.07	16.03	16.59	21.72	20.5	19.0	15.8	14	8.51	7.1
MIK 0.1	9.8	11.54	14.19	16.29	16.16	20.43	20.4	19.2	17.4	16.2	12.41	9.9
EFK 13.8	6.5	9.41	15.79	16.66	18.01	23.81	22.8	21	17.4	15.8	10.51	8.8
MBK 1.6	6.1	10.32	13.15	15.92	14.25	18.17	18.5	16.9	14.8	13.9	8.32	8.0

Figure 3.1.6.2.1 2015 monthly temperature



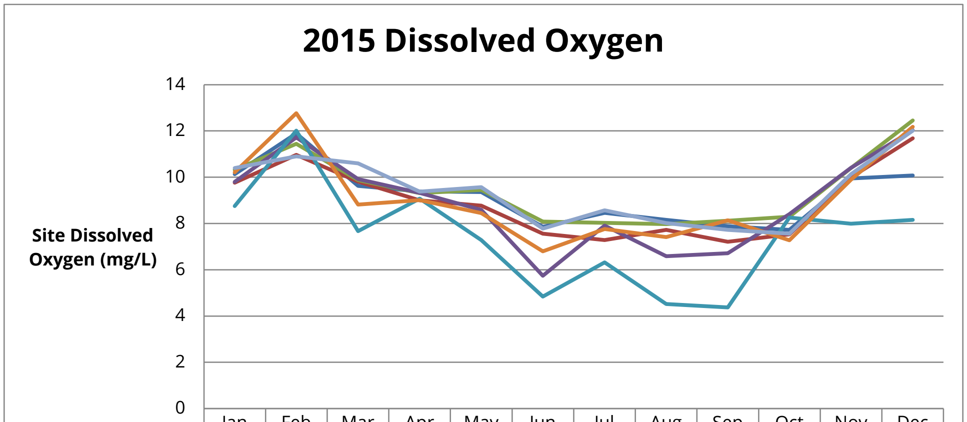
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
EFK 23.4	7.4	7.7	7.19	7.76	7.46	7.49	7.9	7.9	7.9	7.91	6.89	7.97
BCK 12.3	7.21	7.31	7.07	6.68	7.32	7.5	7.79	7.73	7.85	7.7	6.59	7.79
BCK 9.6	7.46	7.39	7.53	7.2	7.59	7.3	7.93	8.06	8.05	7.99	6.89	8.13
BCK 4.5	7.51	7.29	7.47	7.22	7.61	7.73	7.68	7.77	7.71	7.95	7.00	8.00
MIK 0.1	7.48	7.41	7.22	7.25	7.41	7.53	7.53	7.49	7.53	7.72	7.36	7.31
EFK 13.8	7.69	7.68	7.59	7.28	7.88	7.87	7.87	7.96	7.98	7.85	7.72	8.08
MBK 1.6	7.5	7.49	7.39	6.65	7.78	7.92	7.82	7.95	7.93	7.79	7.14	7.96

Figure 3.1.6.2.2 2015 monthly site pH



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
EFK 23.4	345	401	528	420	438	426	454	451.4	439.9	431.9	374	450.6
BCK 12.3	902	852	990	409	1313	1306	965	1136	1111	968	709	933
BCK 9.6	502	381	538	224	604	700	545	707	728	462.1	366	570.3
BCK 4.5	301	379	314	156	367	387	329	408.5	400	462.6	281	346.9
MIK 0.1	391	411	401	242	446	486	451	494.4	265.3	430.6	329	417.8
EFK 13.8	349	356	406	209	401	432	419	430.1	371.9	276.9	319	388.1
MBK 1.6	171	170	193	87	257	299	278	301.9	278.6	286.4	187	245.7

Figure 3.1.6.2.3 2015 monthly site conductivity



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
EFK 23.4	10.13	11.89	9.63	9.39	9.36	7.85	8.46	8.16	7.88	7.72	9.95	10.08
BCK 12.3	9.76	10.97	9.81	9	8.77	7.56	7.28	7.72	7.21	7.53	9.99	11.68
BCK 9.6	10.32	11.44	9.87	9.31	9.45	8.08	8.03	7.97	8.12	8.29	10.4	12.45
BCK 4.5	9.8	11.72	9.92	9.32	8.59	5.74	7.91	6.59	6.71	8.4	10.41	12.03
MIK 0.1	8.75	12.01	7.67	9.07	7.28	4.84	6.32	4.52	4.37	8.26	7.99	8.16
EFK 13.8	10.21	12.77	8.82	9.01	8.45	6.8	7.76	7.41	8.14	7.27	9.89	12.18
MBK 1.6	10.4	10.9	10.6	9.38	9.57	7.78	8.57	8.02	7.72	7.56	10.13	12.01

Figure 3.1.6.2.4 2015 monthly dissolved oxygen

Sites BCK 12.3, BCK 9.6, and BCK 4.5 (all in Bear Creek) show elevated conductivity values. There are no Tennessee water quality criteria for conductivity. All three Bear Creek sites are located downstream of the legacy capped S-3 ponds and the Y-12 West End water treatment facility.

Continuous Surface Water Physical Monitoring

Data downloads and weekly checks were collected at the three continuous monitoring sites. Figures 3.1.6.2.5 through 3.1.6.2.7 provide temperature, pH, specific conductivity, dissolved oxygen, and oxidation reduction potential data along Upper East Fork Poplar Creek at Third Street Bridge and EFK 22.74, and Bear Creek (BCK 12.3), respectively.

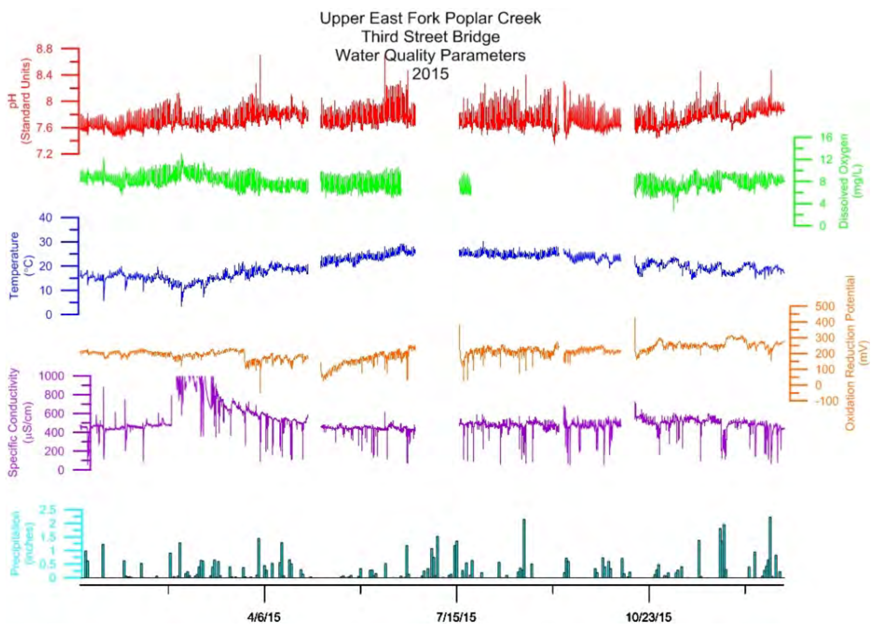


Figure 3.1.6.2.5 Water quality parameters (temperature, pH, DO, specific conductivity, and ORP) along Upper East Fork Poplar Creek at Third Street Bridge

C –Centigrade; **mg/L** – milligrams per liter; **mv** = millivolts; **µS/cm** – microSiemens per centimeter

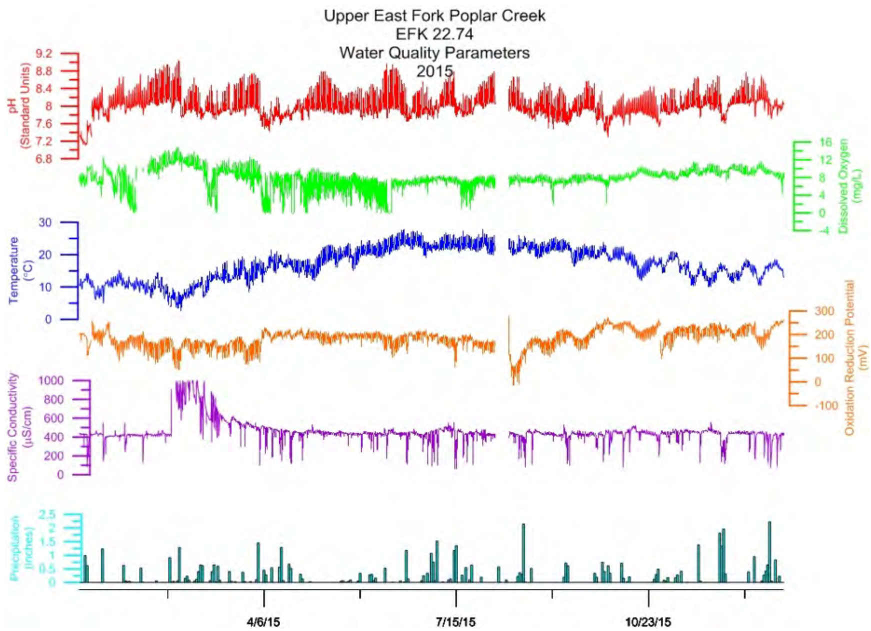


Figure 3.1.6.2.6 Water quality parameters (temperature, pH, DO, specific conductivity, and ORP) along Upper East Fork Poplar Creek at EFK 22.74

C –Centigrade; **mg/L** – milligrams per liter; **mv** = millivolts; **µS/cm** – microSiemens per centimeter

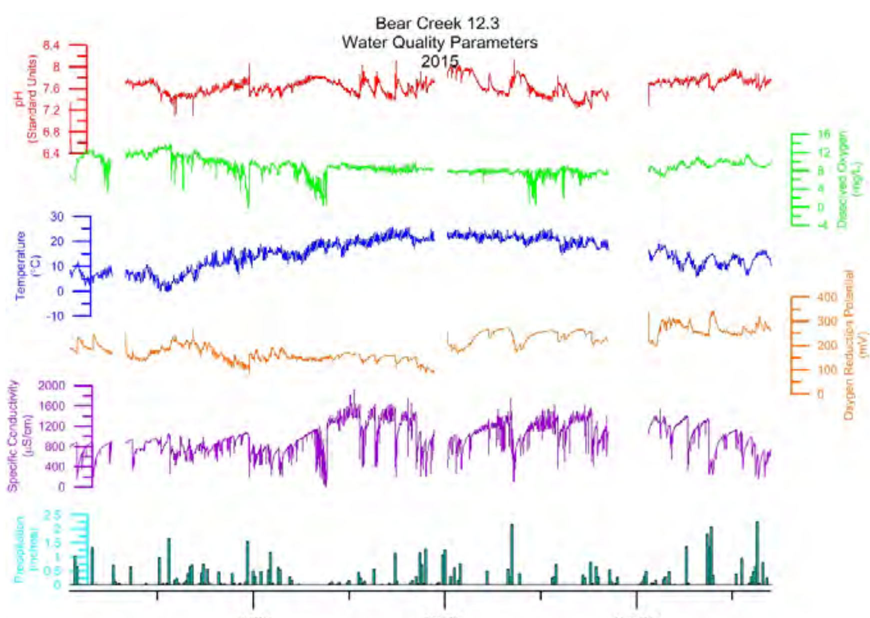


Figure 3.1.6.2.7 Water quality parameters (temperature, pH, DO, specific conductivity, and ORP) at Bear Creek (BCK 12.3)

C –Centigrade; **mg/L** – milligrams per liter; **mv** = millivolts; **µS/cm** – microSiemens per centimeter

Upper East Fork Poplar Creek at Third Street Bridge

As shown in Figure 3.1.6.2.5, there are diurnal cycles for temperature, pH, ORP, and DO. There are observed decreases in conductivity during rain events along with increases in conductivity due to runoff from effects of the salting of roadways during cold weather events in February through March 2015. Upper East Fork Poplar Creek is spring fed with no surface water augmentation. The temperature variations seem consistent with seasonal variations, which are understated due to the thermal properties of the spring water. Dissolved oxygen shows there is a consistent amount of oxygen in the system.

Upper East Fork Poplar Creek at EFK 22.74

This station is downstream from the Third Street Bridge location and serves as a data verification point and helps tracks stream recovery along EFPC. As shown in Figure 3.1.6.2.6, there are diurnal cycles for temperature, pH, ORP, and DO. The same specific conductivity events were recorded from February to March along with the dips associated with rain events. The dissolved oxygen readings recorded several decreases that were associated with sedimentation covering the DO sensor and not water quality. A nylon screen around the stilling well was removed on July 16, 2015; however, some sedimentation around the probe still occurred. The temperature readings have greater variations due to the distance from the springs, and the location is influenced by other surface water features, e.g., canopy, outfalls, flow rate.

Bear Creek at BCK 12.3

As shown in Figure 3.1.6.2.7, there are diurnal cycles for temperature, pH, ORP, and DO. Dissolved oxygen shows there is a consistent amount of oxygen in the system. Dips in the DO data were caused by sedimentation build up after rain events that covered up the DO sensor. BCK 12.3 location is impacted by high specific conductivity from the S3 pond area. Dips in conductivity are only recorded during rain events. Highest conductivity was observed during periods of low precipitation.

3.1.6.3 Surface Water Monitoring

Bear Creek

Tables 3.1.6.3.1 and 3.1.6.3.2 present a summary of the 2015 surface water sample results for Bear Creek. BCK 12.3 is just to the west of the Y-12 legacy S-3 ponds, which are now capped. In the past, the S-3 ponds were used as holding basins for nitric acid and some other wastes. In the 1980s, within the Bear Creek Burial Grounds, it is estimated that approximately 20,500 tons of depleted uranium were buried.

Table 3.1.6.3.1 2015 Bear Creek Surface Water Data Summary (non-radiological)

Parameter	BCK 12.3	BCK 9.6	HCK 20.6 (ref.)	CCK 1.6 (ref.)	TWQC*	Units
pH	7.60	7.86	7.85	7.58	5.5-9[a]	None
Specific conductance	1316	628	383	255	n.a.	□S/cm
Temperature, water	18.48	16.79	18.3	15.15	<=30.5	°C
Dissolved oxygen (DO)	8.53	9.25	8.52	9.89	5.0[a]	mg/l
Ammonia-nitrogen	U	U	U	U	n.a.	mg/l
Inorganic nitrogen (nitrate and nitrite)	70	13	0.57	0.43	n.a.	mg/l
Total dissolved solids	1100	380	230	140	500[b]	mg/l
Total suspended solids	U	10	U	U	n.a.	mg/l
Kjeldahl nitrogen	0.43	0.30	U	U	n.a.	mg/l
Phosphorus	U	U	0.028	0.010	n.a.	□g/l
Iron	120	190	400	27	n.a.	□g/l
Arsenic	U	U	U	U	10[c]	□g/l
Cadmium	1.3	U	U	U	2.0[d]	□g/l
Chromium	U	U	1.5	1.2	16[e]	□g/l
Copper	0.79	U	U	U	13[d]	□g/l
Lead	U	U	0.39	U	5[f]/65[a]	□g/l
Manganese	120	19	47	9.0	n.a.	□g/l
Nickel	12	5.7	1.5	0.74	n.a.	□g/l
Zinc	2.3	U	2.0	U	120[d]	□g/l
Mercury	U	U	U	U	0.051[c]	□g/l
Hardness, Ca, Mg	540	280	200	130	n.a.	mg/l

*Tennessee Water Quality Criteria:
[a] Fish and Aquatic Life (FAL), applies to all sites
[b] Industrial Water Supply, applies only to Clinch River Sites
[c] Recreation (organisms only), applies to all sites
[d] Fish and Aquatic Life (FAL), applies to all sites, this value is for total hardness of 100mg/L
[e] FAL (Chromium VI)
[f] This value is for Domestic Water Supply, which applies only to Clinch River Sites.
μS/cm - microSiemens per centimeter
n.a. - not applicable

Table 3.1.6.3.2 2015 Bear Creek Surface Water Data Summary (radiological)

Parameter	BCK 12.3	BCK 9.6	HCK 20.6 (ref.)	CCK 1.6 (ref.)	PRG[1]
Gross alpha radioactivity, (Thorium-230 ref std)	40.30	15.72	-0.40	-0.39	n.a.
Gross beta radioactivity, (Cesium-137 ref std)	419	76.2	3.8	3.4	n.a.

Units are pCi/L
[1] DOE Preliminary Remediation Goals (PRGs), Recreator: TR=1.0E-6, last updated 11/20/2013

Non-Radiological Parameters

Nitrate and nitrite nitrogen, total hardness, total dissolved solids, nickel, cadmium, zinc, copper, and manganese concentrations were the highest at BCK 12.3 and decreased as the stream flowed to BCK 9.6. See Table 3.1.6.3.1 and Figures 3.1.6.3.1 and 3.1.6.3.2. Figure 3.1.6.3.2 shows how specific conductivity was elevated compared to reference sites at BCK 12.3 (1316 microSiemens per centimeter [μS/cm]), then decreased downstream to BCK 9.6 (628 μS/cm).

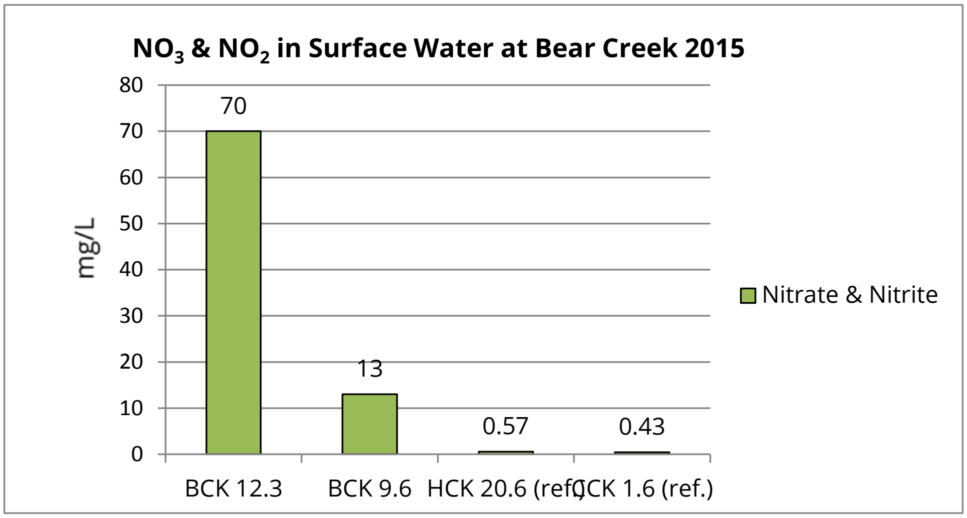


Figure 3.1.6.3.1 NO_3 and NO_2 in surface water at Bear Creek

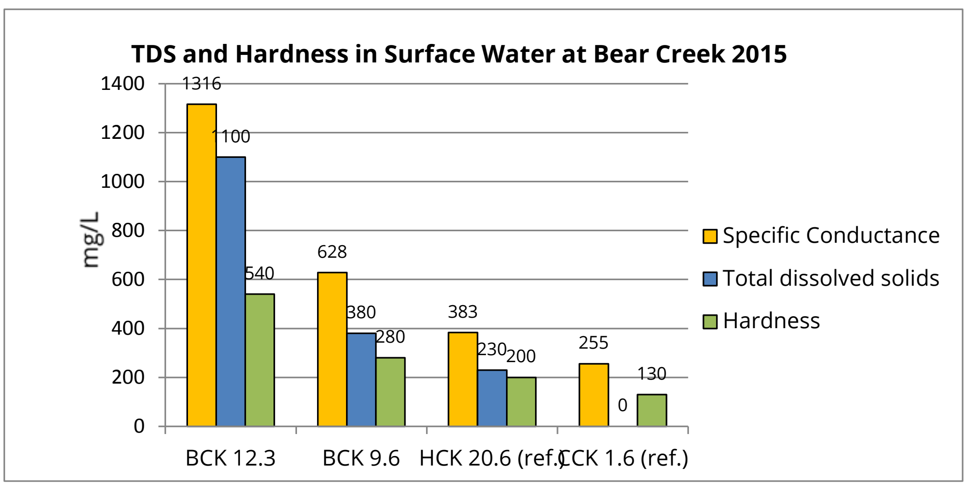


Figure 3.1.6.3.2 TDS and hardness in surface water at Bear Creek

Radiological Parameters

Figure 3.1.6.3.3 shows that gross alpha activities were the highest at BCK 12.3 [40.3 picocuries per liter (pCi/L)] and decreased as the stream flowed downstream to BCK 9.6 (15.72 pCi/L). Reference sites HCK 20.6 and CCK 1.45 had alpha values of -0.40 and -0.39 pCi/L respectively. Gross beta activities were the highest at BCK 12.3 (419 pCi/L), and decreased as the stream flowed downstream to BCK 9.6 (76.2 pCi/L). Reference sites HCK 20.6 and CCK 1.45 had beta values of 3.8 and 3.4 pCi/L respectively. (Figure 3.1.6.3.4)

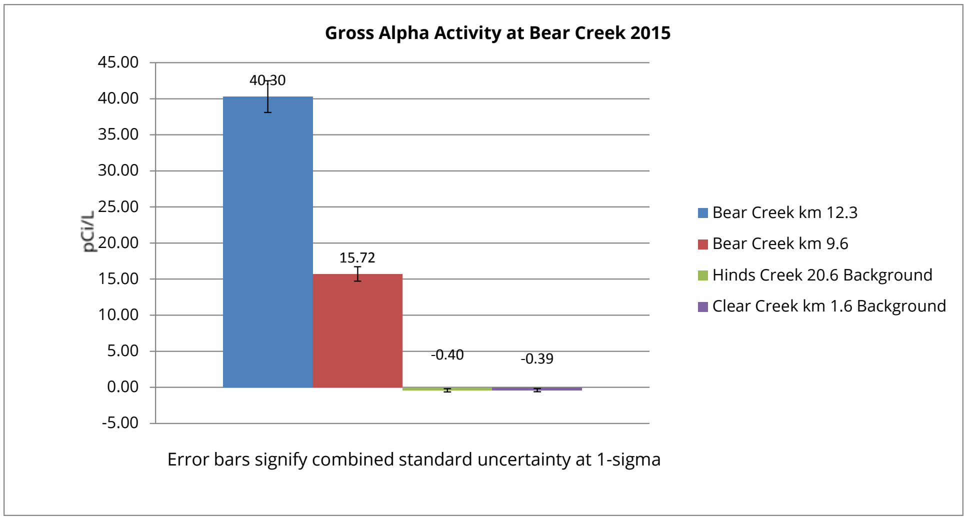


Figure 3.1.6.3.3 Gross alpha activity in surface water at Bear Creek

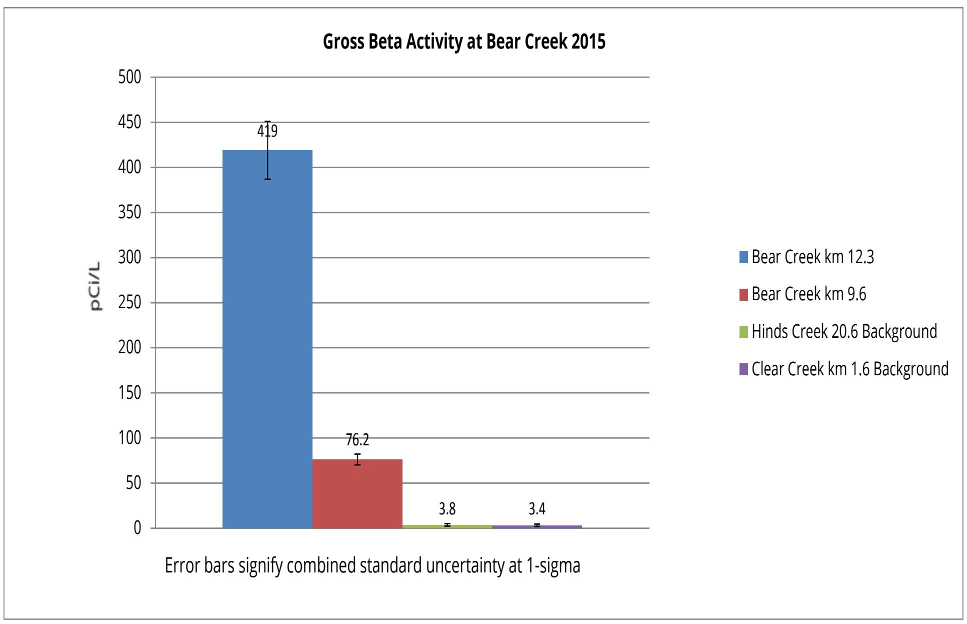


Figure 3.1.6.3.4 Gross beta activity in surface water at Bear Creek

East Fork Poplar Creek

Tables 3.1.6.3.2 and 3.1.6.3.3 present a summary of the 2015 surface water samples results for East Fork Poplar Creek.

Table 3.1.6.3.2 2015 East Fork Poplar Creek Surface Water Data Summary (non-radiological)

Parameter	EFK 25.1	EFK 24.4	EFK 23.4	EFK 13.8	EFK 6.3	HCK 20.6 (ref.)	CCK 1.6 (ref.)	TWQC*	Units
pH	7.44	7.41	8.13	7.82	7.41	7.85	7.58	5.5-9[a]	None
Specific conductance	490	484	443	404	404	383	255	n.a.	□S/cm
Temperature, water	24.01	19.35	17.65	18.28	20.11	18.3	15.15	<=30.5	°C

Parameter	EFK 25.1	EFK 24.4	EFK 23.4	EFK 13.8	EFK 6.3	HCK 20.6 (ref.)	CCK 1.6 (ref.)	TWQC*	Units
Dissolved oxygen (DO)	5.46	7.88	10.80	8.65	8.18	8.52	9.89	5.0[a]	mg/l
Ammonia-nitrogen	1.8	0.078	U	U	U	U	U	n.a.	mg/l
Inorganic nitrogen (nitrate and nitrite)	4.3	3.70	2.6	1.3	3.8	0.57	0.43	n.a.	mg/l
Total dissolved solids	300	270	250	230	270	230	140	500[b]	mg/l
Total suspended solids	U	U	U	U	10	U	U	n.a.	mg/l
Kjeldahl nitrogen	2.50	0.46	0.23	0.20	U	U	U	n.a.	mg/l
Phosphorus	0.12	0.22	0.19	0.063	0.79	0.028	0.010	n.a.	□g/l
Iron	94	75	79	140	190	400	27	n.a.	□g/l
Arsenic	U	U	U	0.87	U	U	U	10[c]	□g/l
Cadmium	0.73	U	U	U	U	U	U	2.0[d]	□g/l
Chromium	1.5	1.9	2.2	0.0	0.0	1.5	1.2	16[e]	□g/l
Copper	5.0	5.8	6.5	1.5	2.2	U	U	13[d]	□g/l
Lead	U	U	U	U	U	0.39	U	5[f]/65[a]	□g/l
Manganese	77	25	22	24	22	47	9.0	n.a.	□g/l
Nickel	4.1	3.4	3.3	2.5	2.3	1.5	0.74	n.a.	□g/l
Zinc	30	23	17	U	13	2.0	U	120[d]	□g/l
Mercury	0.52	0.18	0.10	0.13	0.081	0.0	0.0	0.051[c]	□g/l
Hardness, Ca, Mg	190	200	190	190	170	200	130	n.a.	mg/l
TWQC	0.051	0.051	0.051	0.051	0.051				

*Tennessee Water Quality Criteria:
[a] Fish and Aquatic Life (FAL), applies to all sites
[b] Industrial Water Supply, applies only to Clinch River Sites
[c] Recreation (organisms only), applies to all sites
[d] Fish and Aquatic Life (FAL), applies to all sites. This value is for total hardness of 100mg/L
[e] FAL (Chromium VI)
[f] This value is for Domestic Water Supply, which applies only to Clinch River Sites.
□S/cm- microSiemens per centimeter
n.a. - not applicable

Table 3.1.6.3.3 2015 East Fork Poplar Creek Surface Water Data Summary (radiological)

Parameter	EFK 25.1	EFK 24.4	EFK 23.4	EFK 13.8	EFK 6.3	HCK 20.6 (ref.)	CCK 1.6 (ref.)	PRG[1]
Gross alpha radioactivity, (Thorium-230 ref std)	14.91	7.56	6.16	3.25	2.04	-0.40	-0.39	n.a.
Gross beta radioactivity, (Cesium-137 ref std)	24.3	14.6	8.3	5.6	2.3	3.8	3.4	n.a.

Units are pCi/L
[1] DOE Preliminary Remediation Goals (PRGs), Recreator: TR=1.0E-6, last updated 11/20/2013
n.a. - not available

Non-Radiological Parameters
The mercury value for EFK 25.1 exceeded the TNWQC for mercury (.051 µg/L). Mercury values were J values. A J value is an estimate between the minimum detection limit (MDL) and the method quantitation limit (MQL). See Figure 3.1.6.3.5.

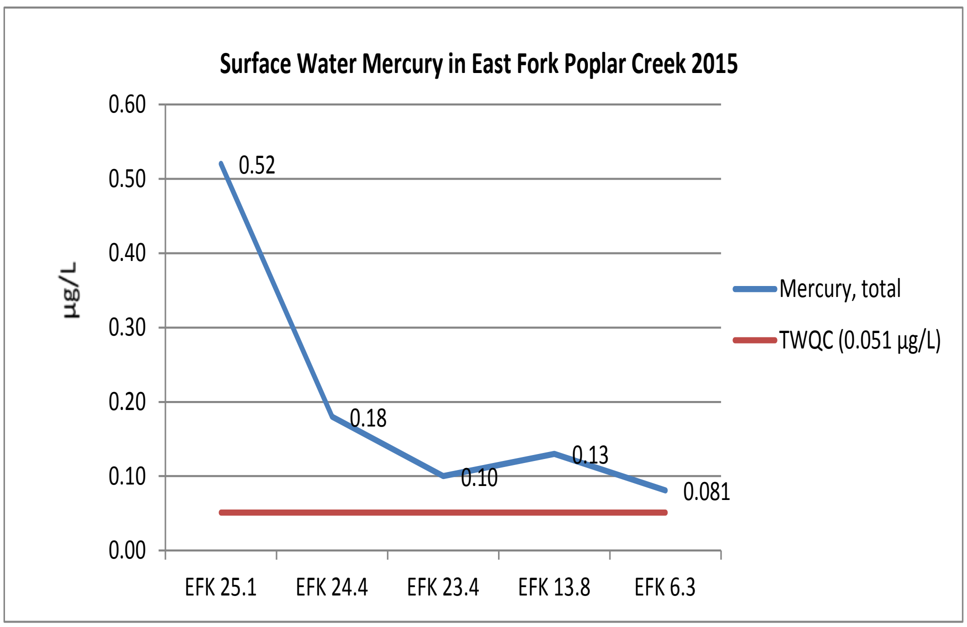


Figure 3.1.6.3.5 Surface water mercury in East Fork Poplar Creek 2015

Radiological Parameters
Gross alpha activity was highest at EFK 25.1 and gradually decreased downstream as seen in Figure 3.1.6.3.6. Figure 3.1.6.3.7 shows a similar gradient downstream of gross beta activity. At EFK 6.3, gross beta values are similar to the reference sites.

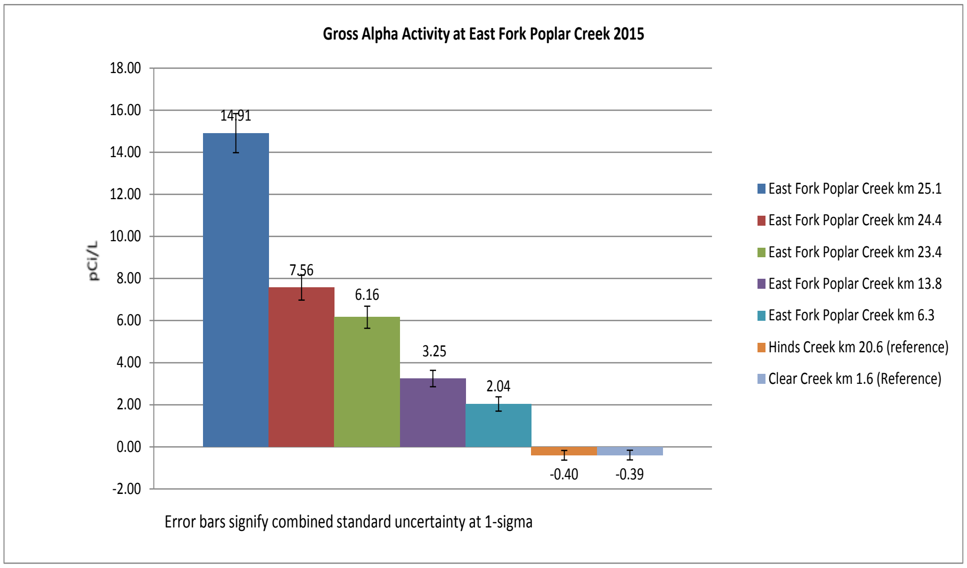


Figure 3.1.6.3.6 Gross alpha activity at East Fork Poplar Creek 2015

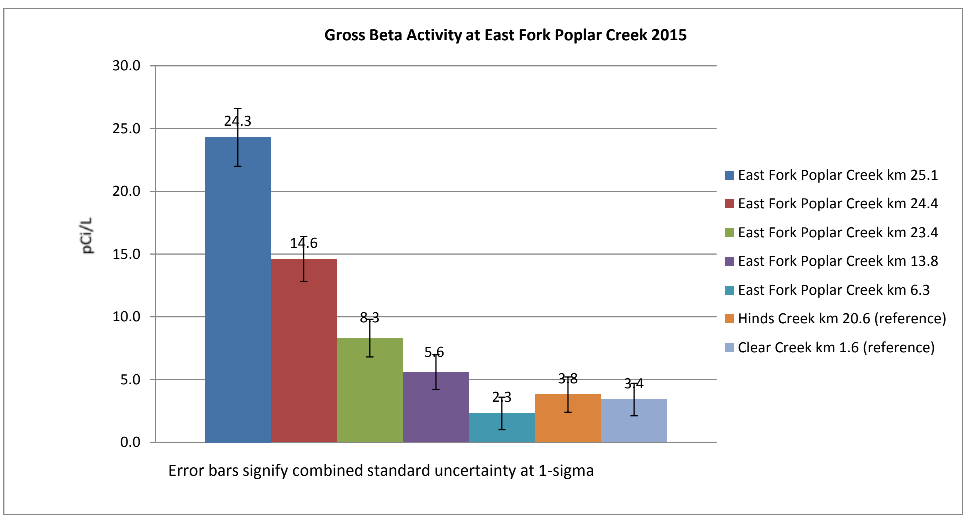


Figure 3.1.6.3.7 Gross beta activity in East Fork Poplar Creek 2015

Mitchell Branch

Tables 3.1.6.3.4 and 3.1.6.3.5 present a summary of the 2015 surface water sampling results for Mitchell Branch.

Table 3.1.6.3.4 2015 Mitchell Branch Surface Water Data Summary (non-radiological)

Parameter	MIK 1.43 (ref.)	MIK 0.71	MIK 0.45	CCK 1.6 (ref.)	TWQC*	Units
pH	7.43	7.14	7.08	7.58	5.5-9[a]	None
Specific conductance	182	307	351	255	n.a.	mS/cm
Temperature, water	16.68	18.31	17.79	15.15	<=30.5	°C
Dissolved oxygen (DO)	9.27	7.37	7.29	9.89	5.0[a]	mg/l

Parameter	MIK 1.43 (ref.)	MIK 0.71	MIK 0.45	CCK 1.6 (ref.)	TWQC*	Units
Ammonia-nitrogen	U	0.045	U	U	n.a.	mg/l
Inorganic nitrogen (nitrate and nitrite)	0.059	0.30	0.34	0.43	n.a.	mg/l
Total dissolved solids	120	190	230	140	500[b]	mg/l
Total suspended solids	U	U	U	U	n.a.	mg/l
Kjeldahl nitrogen	U	0.20	0.21	U	n.a.	mg/l
Phosphorus	0.014	0.028	0.032	0.010	n.a.	mg/l
Iron	330	390	250	27	n.a.	mg/l
Arsenic	U	U	U	U	10[c]	mg/l
Cadmium	U	U	U	U	2.0[d]	mg/l
Chromium	1.2	1.2	1.5	1.2	16[e]	mg/l
Copper	U	3.1	3.0	U	13[d]	mg/l
Lead	U	0.052	0.38	U	5[f]/65[a]	mg/l
Manganese	29	120	64	9.0	n.a.	mg/l
Nickel	0.85	3.9	3.9	0.74		mg/l
Zinc	U	10	7.4	U	120[d]	mg/l
Mercury	U	U	U	U	0.051[c]	mg/l
Hardness, Ca, Mg	93	150	160	130	n.a.	mg/l

*Tennessee Water Quality Criteria:
[a] Fish and Aquatic Life (FAL), applies to all sites
[b] Industrial Water Supply, applies only to Clinch River Sites
[c] Recreation (organisms only), applies to all sites
[d] Fish and Aquatic Life (FAL), applies to all sites, this value is for total hardness of 100mg/L
[e] FAL (Chromium VI)
[f] This value is for Domestic Water Supply, which applies only to Clinch River Sites
□S/cm- microSiemens per centimeter
n.a. - not applicable

Table 3.1.6.3.5 2015 Mitchell Branch Surface Water Data Summary (radiological)

Parameter	MIK 1.43	MIK 0.71	MIK 0.45	HCK 20.6 (ref.)	CCK 1.6 (ref.)	PRG[1]
Gross alpha radioactivity, (Thorium-230 ref std)	0.44	2.46	2.21	-0.40	-0.39	n.a.
Gross beta radioactivity, (Cesium-137 ref std)	2.7	5.2	12.0	3.8	3.4	n.a.

Units are pCi/L
[1] DOE Preliminary Remediation Goals (PRGs), Recreator: TR=1.0E-6, last updated 11/20/2013
n.a. - not available

Non-Radiological Parameters

Specific conductivity, total hardness, and dissolved residue values/concentrations were lower at MIK 1.43 (reference) and increased as the Mitchell Branch flowed downstream.

Radiological Parameters
Gross alpha concentration at MIK 0.71 (2.46 pCi/L) and MIK 0.45 (2.21 pCi/L) were higher than the reference sites; reference sites MIK 1.43 and CCK 1.45 had alpha values of 2.68 and 0.0 pCi/L respectively (Figure 3.1.6.3.8). Gross beta concentration at MIK 0.45 (12.0 pCi/L) was higher than the reference sites; reference sites MIK 1.43, HCK 2.06, and CCK 1.45 had beta values of 2.7, 3.8, and 3.4 pCi/L respectively (Figure 3.1.6.3.9).

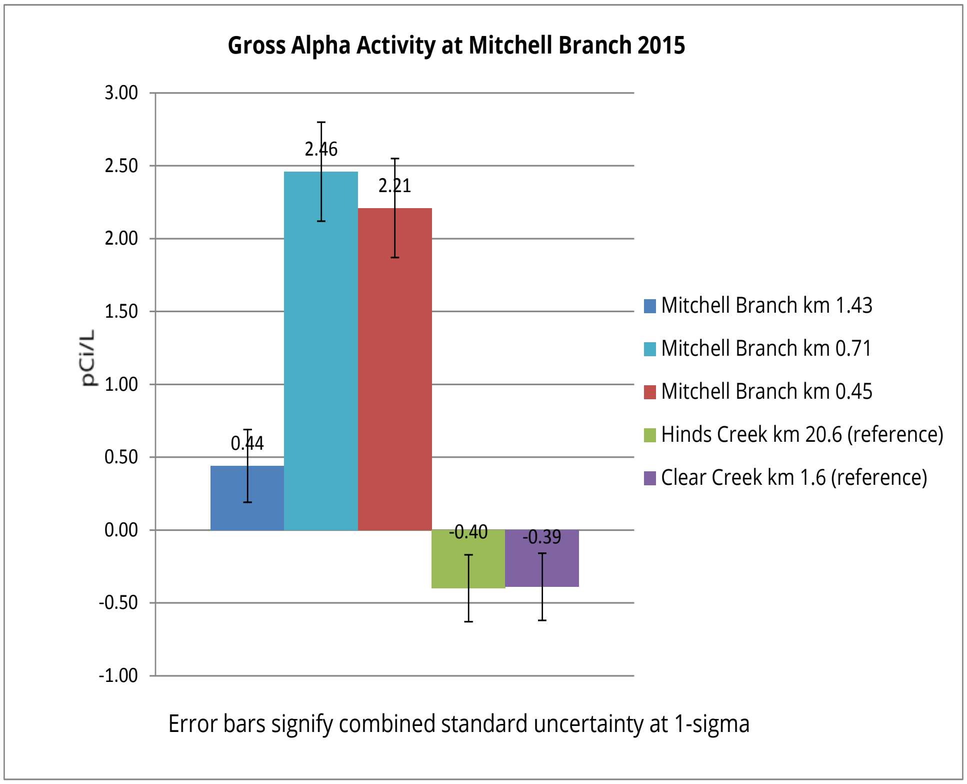


Figure 3.1.6.3.8 Gross alpha activity at Mitchell Branch 2015

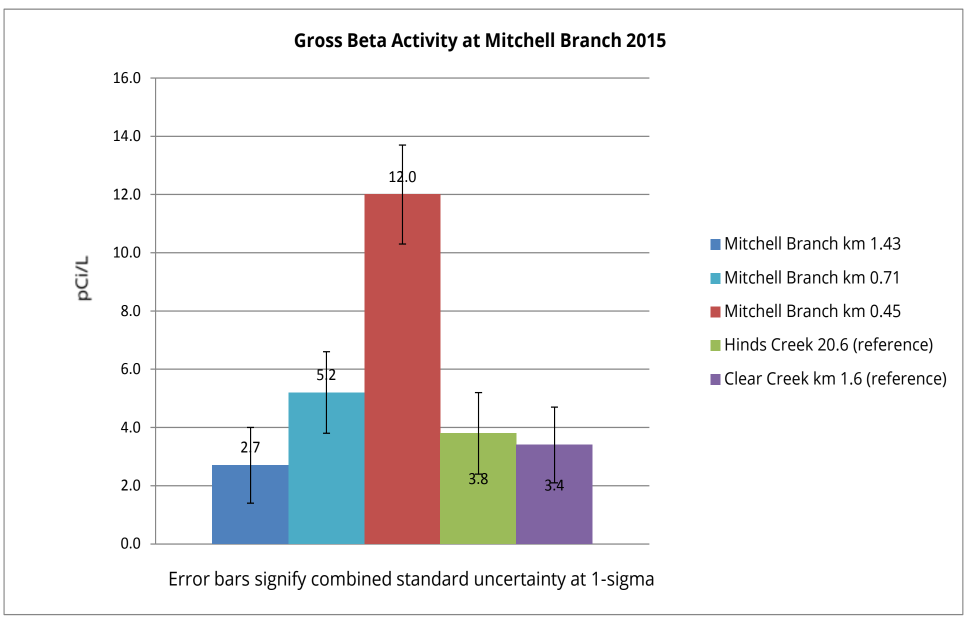


Figure 3.1.6.3.9 Gross beta activity at Mitchell Branch 2015

White Oak Creek / Melton Branch

Tables 3.1.6.3.6 and 3.1.6.3.7 present a summary of the 2015 ambient surface water sampling results for White Oak Creek and Melton Branch.

Table 3.1.6.3.6 2015 White Oak Creek Surface Water Data Summary (non-radiological)

Parameter	WCK 6.8 (ref.)	WCK 3.9	WCK 3.4	WCK 2.3	MEK 0.3	CCK 1.6 (ref.)	TWQC*	Units
pH	6.26	7.79	7.70	7.56	7.81	7.58	5.5-9[a]	None
Specific conductance	290	440	458	290	381	255	n.a.	mS/cm
Temperature, water	15.57	19.30	19.75	15.57	20.68	15.15	<=30.5	°C
Dissolved oxygen (DO)	9.95	8.48	8.21	9.95	7.96	9.89	5.0[a]	mg/l
Ammonia-nitrogen	U	U	U	U	U	U	n.a.	mg/l
Inorganic nitrogen (nitrate and nitrite)	0.15	0.99	1.8	1.6	0.47	0.43	n.a.	mg/l
Total dissolved solids	180	260	290	270	250	140	500[b]	mg/l
Total suspended solids	U	U	U	U	U	U	n.a.	mg/l
Kjeldahl nitrogen	U	0.24	0.28	0.29	0.19	U	n.a.	mg/l
Phosphorus	U	0.22	0.58	0.50	0.57	0.010	n.a.	mg/l
Iron	79	97	110	160	170	27	n.a.	mg/l
Arsenic	U	U	U	U	U	U	10[c]	mg/l
Cadmium	U	U	U	U	U	U	2.0[d]	mg/l
Chromium	1.3	U	U	U	U	1.2	16[e]	mg/l
Copper	U	16	7.7	4.8	0.71	U	13[d]	mg/l
Lead	U	U	U	U	U	U	5[f]/65[a]	mg/l
Manganese	11	22	32	58	34	9.0	n.a.	mg/l
Nickel	0.83	1.9	2.1	2.0	2.1	0.74	120[d]	mg/l
Zinc	U	21	16	6.5	3.2	U	120[d]	mg/l
Mercury	U	U	U	U	U	U	0.051[c]	mg/l
Hardness, Ca, Mg	140	170	170	170	160	130	n.a.	mg/l

*Tennessee Water Quality Criteria:

[a] Fish and Aquatic Life (FAL), applies to all sites

[b] Industrial Water Supply, applies only to Clinch River Sites

[c] Recreation (organisms only), applies to all sites

[d] Fish and Aquatic Life (FAL), applies to all sites, this value is for total hardness of 100mg/L

[e] FAL (Chromium VI)

[f] This value is for Domestic Water Supply, which applies only to Clinch River Sites

□S/cm- microSiemens per centimeter

n.a. - not applicable

Table 3.1.6.3.7 2015 White Oak Creek Surface Water Data Summary (radiological)

Parameter	WCK 6.8	WCK 3.9	WCK 3.4	WCK 2.3	MEK 0.3	HCK 20.6 (ref.)	CCK 1.6 (ref.)	PRG[1]
Gross alpha radioactivity, (Thorium-230 ref std)	0.06	0.82	2.18	1.53	0.20	-0.40	-0.39	n.a.
Gross beta radioactivity, (Cesium-137 ref std)	3.8	150	132	159	44.2	3.8	3.4	n.a.

Units are pCi/L
[1] DOE Preliminary Remediation Goals (PRGs), Recreator: TR=1.0E-6, last updated 11/20/2013
n.a. - not available

Non-Radiological Parameters
Phosphorus, zinc, manganese, copper, nickel, total hardness, and total dissolved solids values were lower at WCK 6.8 and CCK 1.6 (reference sites) than at WCK 2.3.

Radiological Parameters
Figure 3.1.6.3.10 shows the gross alpha concentration at WCK 3.4 (2.18 pCi/L) was higher than the reference sites; reference sites WCK 6.8, HCK 20.6, and CCK 1.45 had alpha values of 0.06, -0.40 and -0.39 pCi/L respectively.

Gross beta concentration at WCK 2.3 (159 pCi/L) was higher than the reference sites; reference sites WCK 6.8, HCK 20.6, and CCK 1.45 had beta values of 3.8, 3.8, and 3.4 pCi/L respectively (Figure 3.1.6.3.11).

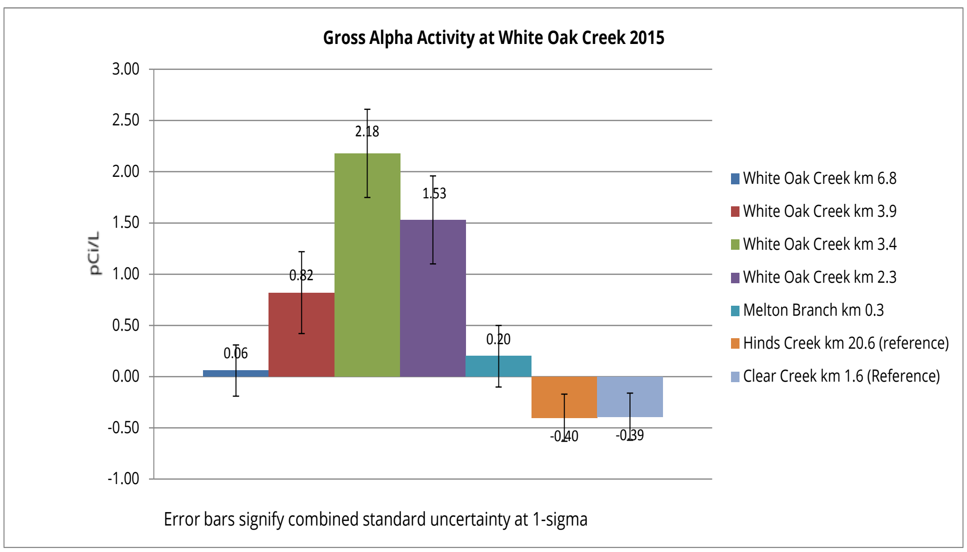


Figure 3.1.6.3.10 Gross alpha activity at White Oak Creek 2015

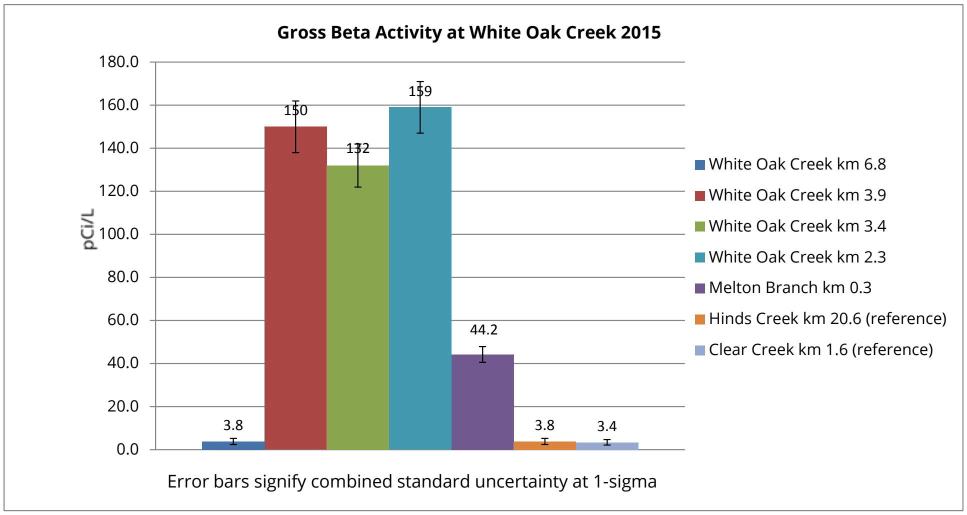


Figure 3.1.6.3.11 Gross beta activity at White Oak Creek 2015

Raccoon Creek

Strontium-89 specific analysis from the samples collected at Raccoon Creek showed activity of 1.02 pCi/L. This value is below the EPA strontium-90 MCL for drinking water of 8 pCi/L. Radiological data, other than the strontium-89 detection show nothing of concern. Gross alpha and gross beta values were similar to reference conditions. Radiological data are shown in Table 3.1.6.3.9. Most other non-radiological parameters were similar to reference stream data. Lead was detected at 1.7 µg/l; this is higher than the reference streams, but below Tennessee water quality criteria (Table 3.1.6.3.8).

Table 3.1.6.3.8 2015 Raccoon Creek Surface Water Data Summary (non-radiological)

Parameter	RCK 2.6	HCK 20.6 (ref.)	CCK 1.6 (ref.)	TWQC*	Units
pH	6.81	7.85	7.58	5.5-9[a]	None
Specific conductance	293	383	255	n.a.	mS/cm
Temperature, water	13.69	18.3	15.15	<=30.5	°C
Dissolved oxygen (DO)	8.40	8.52	9.89	5.0[a]	mg/l
Ammonia-nitrogen	U	U	U	n.a.	mg/l
Inorganic nitrogen (nitrate and nitrite)	0.033J	0.57	0.43	n.a.	mg/l
Total dissolved solids	220	230	140	500[b]	mg/l
Total suspended solids	22	U	U	n.a.	mg/l
Kjeldahl nitrogen	U	U	U	n.a.	mg/l
Phosphorus	0.052	0.028J	0.010	n.a.	mg/l
Iron	1100	400	27	n.a.	mg/l
Arsenic	U	U	U	10[c]	mg/l
Cadmium	U	U	U	2.0[d]	mg/l
Chromium	1.2	1.5J	1.2	16[e]	mg/l
Copper	0.98J	U	U	13[d]	mg/l

Parameter	RCK 2.6	HCK 20.6 (ref.)	CCK 1.6 (ref.)	TWQC*	Units
Lead	1.7	0.39J	U	5[f]/65[a]	mg/l
Manganese	43	47	9.0	n.a.	mg/l
Nickel	2.1	1.5	0.74		mg/l
Zinc	4.8J	2.0J	U	120[d]	mg/l
Mercury	U	U	U	0.051[c]	mg/l
Hardness, Ca, Mg	140	200	130	n.a.	mg/l

*Tennessee Water Quality Criteria:
[a] Fish and Aquatic Life (FAL), applies to all sites
[b] Industrial Water Supply, applies only to Clinch River Sites
[c] Recreation (organisms only), applies to all sites
[d] Fish and Aquatic Life (FAL), applies to all sites. This value is for total hardness of 100mg/L
[e] FAL (Chromium VI)
[f] This value is for Domestic Water Supply, which applies only to Clinch River Sites.
mS/cm - microSiemens per centimeter
n.a. - not applicable

Table 3.1.6.3.9 2015 Raccoon Creek Surface Water Data Summary (radiological)

Parameter	RCK 2.6	HCK 20.6 (ref.)	CCK 1.6 (ref.)	PRG[1]
Gross alpha radioactivity, (Thorium-230 ref std)	-0.35	-0.40	-0.39	n.a.
Gross Alpha combined standard uncertainty at 1-sigma	0.23	0.23	0.23	
Gross beta radioactivity, (Cesium-137 ref std)	4.7	3.8	3.4	n.a.
Gross Beta combined standard uncertainty at 1-sigma	1.2	1.4	1.3	
Strontium-89	1.02	n.a.	n.a.	1150
Strontium-89 combined standard uncertainty at 1-sigma	0.41	n.a.	n.a.	
Strontium-90	-0.21	n.a.	n.a.	265
Strontium-90 combined standard uncertainty at 1-sigma	NR	n.a.	n.a.	
Technetium-99	0.02	n.a.	n.a.	5380
Technetium-99 combined standard uncertainty at 1-sigma	0.25	n.a.	n.a.	

Units are pCi/L
[1] DOE Preliminary Remediation Goals (PRGs), Recreator: TR=1.0E-6, last updated 11/20/2013
n.a. - not available
NR - not reported

Clinch River

All ORR Clinch River tributaries drain into the Clinch River. To obtain public drinking water and industrial plant processing water, many of the local municipalities, facilities, and industries utilize the surface waters of the Clinch River. TDEC conducts annual surface water sampling at seven sites on

the Clinch River to collect reference data and to detect possible contamination from ORR DOE facilities.

Non-Radiological Parameters
There are no concerns with water quality in the Clinch River in terms of nutrients, metals and physical parameters (Table 3.1.6.3.10).

Radiological Parameters
There are no concerns about water quality in the Clinch River in terms of radiological contamination (Table 3.1.6.3.11). Gross alpha radioactivity is slightly higher at the farthest downstream site (CRK 16.10) than the upstream sites, but the activity (1.01 pCi/L) is low (Figure 3.1.6.3.12). Alpha radiation in water can be in the form of naturally occurring dissolved minerals, or in the case of radon, as a gas. Gross beta is higher at a background sampling site (CRK 126.7) than it is in the river downstream of the ORR (Figure 3.1.6.3.13).

Table 3.1.6.3.10 2015 Clinch River Surface Water Data Summary (non-radiological)

Parameter	CRK 126.7 CRM 78.7	CRK 84.7 CRM 52.6	CRK 66.3 CRM 41.2	CRK 57.1 CRM 35.5	CRK 28.8 CRM 17.9	CRK 23.0 CRM 14.3	CRK 16.1 CRM 10.0	TWQC*	Units
pH	7.77	7.60	7.89	7.69	7.64	7.67	7.74	5.5-9[a]	None
Specific conductance	281	2183	295	280	286	285	311	n.a.	mS/cm
Temperature, water	6.19	14.20	19.40	10.41	18.70	18.40	16.55	<=30.5	°C
Dissolved oxygen (DO)	11.80	7.21	7.55	11.33	6.47	6.76	10.08	5.0[a]	mg/l
Ammonia-nitrogen	U	0.047J	U	U	0.055J	0.033J	No data	n.a.	mg/l
Inorganic nitrogen (nitrate and nitrite)	0.540	0.58	0.46	0.56	0.52	0.52	No data	n.a.	mg/l
Total dissolved solids	140	150	180	160	No data	No data	No data	500[b]	mg/l
Total suspended solids	U	10	U	U	No data	No data	No data	n.a.	mg/l
Kjeldahl nitrogen	U	U	0.38J	U	U	U	No data	n.a.	mg/l
Phosphorus	U	U	0.013J	0.040J	0.01J	0.013J	No data	n.a.	mg/l
Iron	34	46	71	150	29	U	U	n.a.	mg/l
Arsenic	U	U	U	U	U	U	U	10[c]	mg/l
Cadmium	U	U	U	U	U	U	U	2.0[d]	mg/l
Chromium	U	U	U	U	U	U	1.8J	16[e]	mg/l
Copper	U	U	0.87J	0.70J	0.54J	U	U	13[d]	mg/l
Lead	U	U	U	U	U	U	U	5[f]/65[a]	mg/l
Manganese	3	83J	44J	43.0	13.0	12.0	U	n.a.	mg/l
Nickel	1.2	1.9	2.3	1.80	2.10	1.70	1.50	100[b]/470[d]	mg/l
Zinc	U	U	U	U	U	U	29.0	120[d]	mg/l
Mercury	U	U	U	U	U	U	U	0.051[c]	mg/l
Hardness, Ca, Mg	130	130	140	130	130	130	150	n.a.	mg/l

*Tennessee Water Quality Criteria:
[a] Fish and Aquatic Life (FAL), applies to all sites
[b] Industrial Water Supply, applies only to Clinch River Sites
[c] Recreation (organisms only), applies to all sites
[d] Fish and Aquatic Life (FAL), applies to all sites. This value is for total hardness of 100mg/L
[e] FAL (Chromium VI)
[f] This value is for Domestic Water Supply, which applies only to Clinch River Sites.
mS/cm - microSiemens per centimeter
n.a. - not applicable

Table 3.1.6.3.11 2015 Clinch River Surface Water Data Summary (radiological)

Parameter	CRK 126.7 CRM 78.7	CRK 84.7 CRM 52.6	CRK 66.3 CRM 41.2	CRK 57.1 CRM 35.5	CRK 28.8 CRM 17.9	CRK 23.0 CRM 14.3	CRK 16.1 CRM 10.0	PRG[1]
Gross alpha radioactivity, (Thorium-230 ref std)	-0.02	-0.51	0.32	-0.24	0.33	0.17	1.01	n.a.
Gross Alpha combined standard uncertainty at 1-sigma	0.25	0.30	0.33	0.39	0.33	0.32	0.37	
Gross beta radioactivity, (Cesium-137 ref std)	4.3	2.3	1.0	1.4	2.2	1.8	2.5	n.a.
Gross Beta combined standard uncertainty at 1-sigma	1.4	1.8	1.8	1.2	1.8	1.8	1.8	

Units are pCi/L

[1] DOE Preliminary Remediation Goals (PRGs), Recreator: TR=1.0E-6, last updated 11/20/2013

n.a. - not available

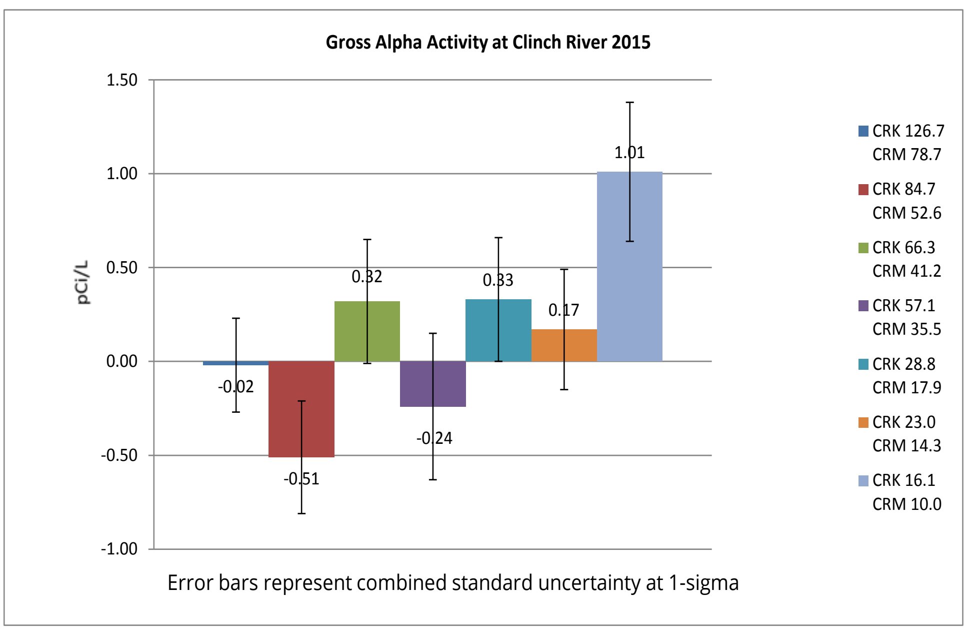


Figure 3.1.6.3.12 Gross alpha activity at Clinch River 2015

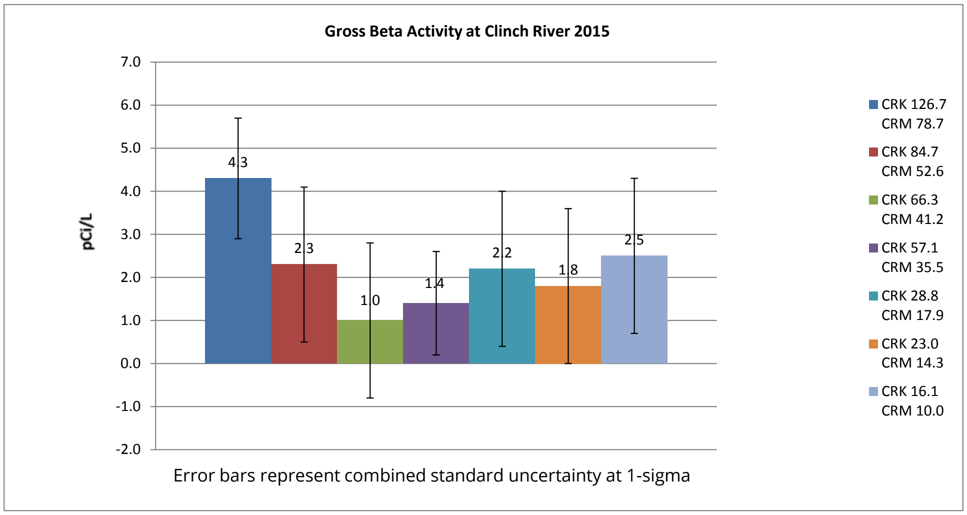


Figure 3.1.6.3.13 Gross beta activity at Clinch River 2015

3.1.6.4 Rain Event Surface Water Monitoring

An overview of the pH, temperature, specific conductivity, and dissolved oxygen for each site sampled is provided in Figures 3.1.6.4.1 through 3.1.6.4.4. Figure 3.1.6.4.5 shows the rainfall amounts recorded at NOAA for Oak Ridge. Table 3.1.6.4.1 shows the results for metals analysis. Table 3.1.6.4.2 shows the three-year average metal concentration from the four sites that are sampled in the surface water program (East Fork Popular Creek, Mitchell Branch, White Oak Creek, and Bear Creek.) Table 3.1.6.4.3 shows the results for the gross alpha/gross beta activity. Table 3.1.6.4.4 shows the results for gamma radionuclide analysis. Table 3.1.6.4.5 shows the results for the strontium, technetium and tritium from the respective sample sites. Table 3.1.4.6.6 shows three years of gross alpha and gross beta results from the four sites that are sampled in the surface water program (East Fork Poplar Creek, Mitchell Branch, White Oak Creek, and Bear Creek.)

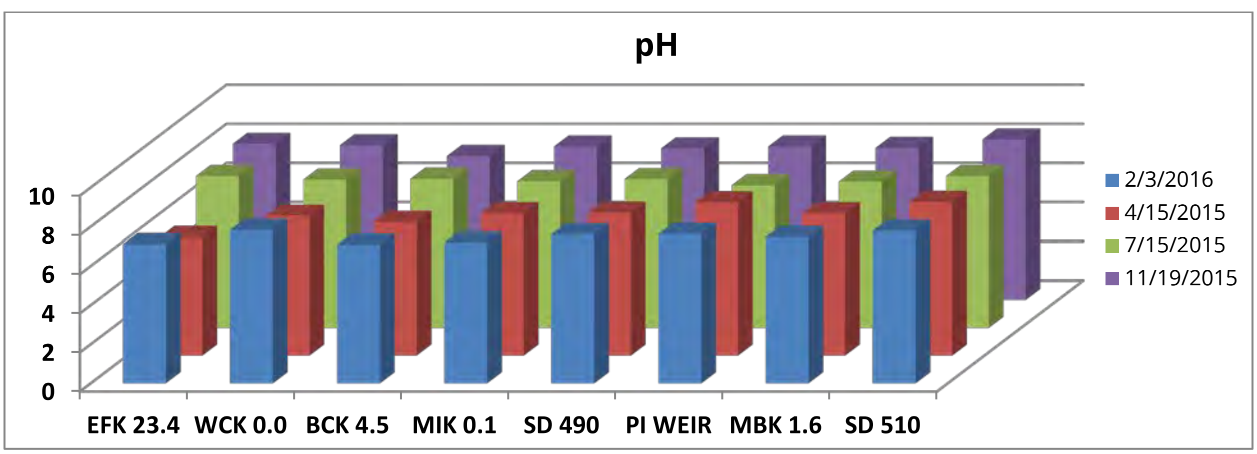


Figure 3.1.6.4.1 pH measurements

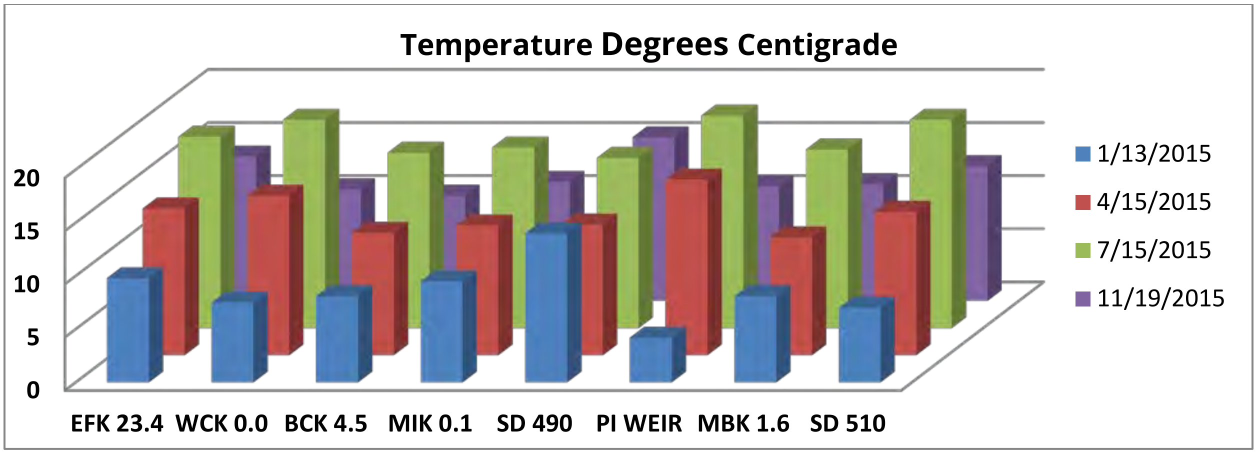


Figure 3.1.6.4.2 Temperature measurements

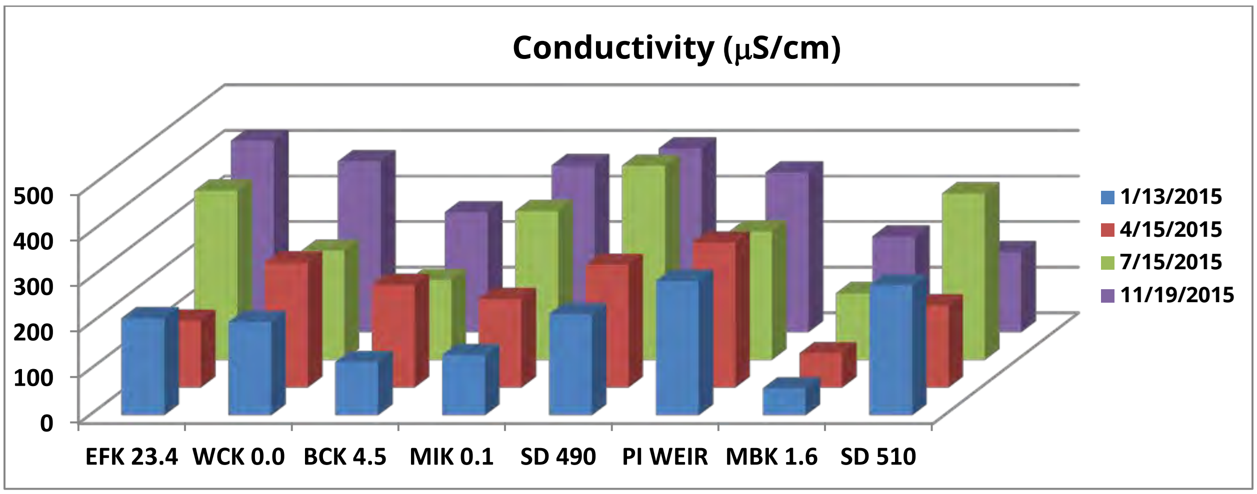


Figure 3.1.6.4.3 Conductivity measurements

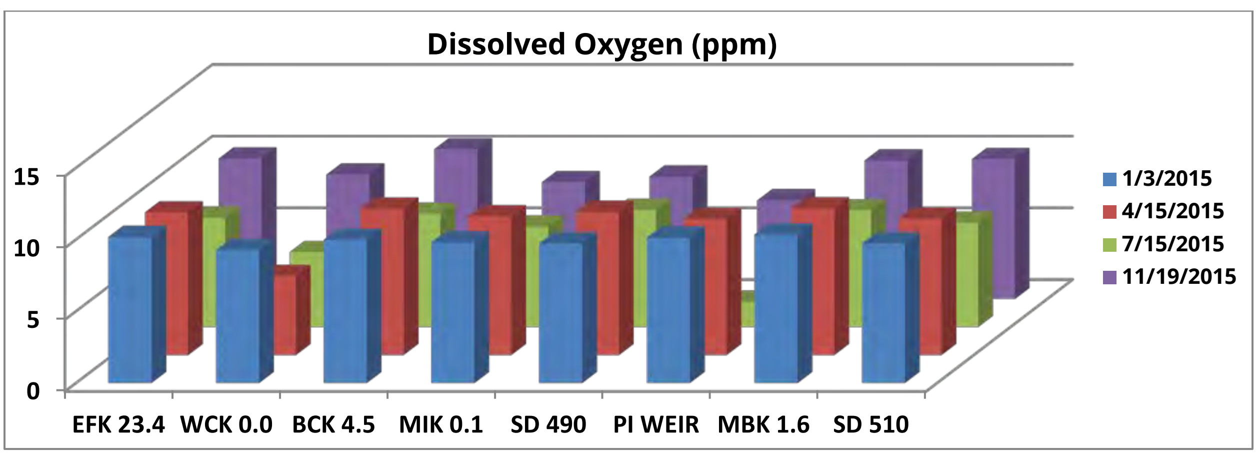


Figure 3.1.6.4.4 Dissolved oxygen measurements

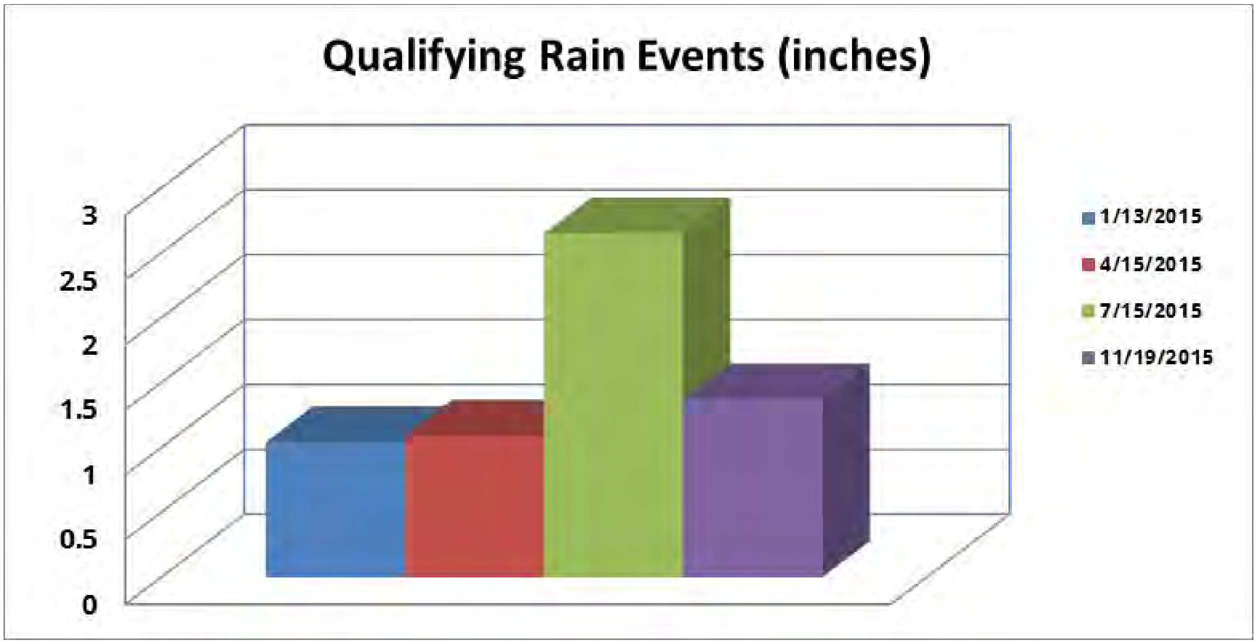


Figure 3.1.6.4.5 Qualifying rain events

Table 3.1.6.4.1 Results for Metals Analysis

SITE	As	Cd	Cr	Cr(hex)	Cu	Fe	Pb	Mn	Hg	Zn	U
1/13/2015											
EFK 23.4	U	0.23	1.2		6	140	U	21	U	19	
WCK 0.0	U	U	2		2.1	1100	0.97	52	U	7.9	U
BCK 4.5	U	U	1.2		0.71	640	U	27	U	2.5	
MIK 0.1	U	U	3.2	U	8.9	680	1.4	85	U	11	
SD 490	U	U	1.9	U	0.95	140	2.8	100	U	10	
P1 WEIR	U	U	0.82	U	1.1	420	1.2	37	U	11	0.41
MBK 1.6	U	U	0.89		0.59	440	U	22	U	2.1	U
SD 510	U	U	12	U	6.2	530	4.1	8	U	36	2.2
4/15/2015											
EFK 23.4	1.1J	U	2.2J		8.2	1600	3.8	300	1.3	55	
WCK 0.0	0.59J	U	2.2J		2	1300	1.4	270	U	7.1	
BCK 4.5	0.83J	U	3.0J		2.7	2900	4	500	U	13	
MIK 0.1	2.4J	U	2.5J	U	6.3	1500	2.3	140	U	19	
SD 490	U	U	1.4J	U	3.2	320	1.1	37	U	25	1.6
P1 WEIR	U	U	1.3J	U	0.62J	140	U	64	U	U	0.45J
MBK 1.6	U	U	1.8J		2	2100	2.3	170	U	6.6	U
SD 510	2.1J	U	50	70.3	8.5	3900	11	63	U	11	1.3
7/15/2015											
EFK 23.4	U	U	1.2J		3.5	340	0.68J	52	0.3	15	
WCK 0.0	U	U	4.2J		5	1900	3	230	U	19	
BCK 4.5	U	U	1.7J		2.3	1300	1.9	180	U	7.7	
MIK 0.1	U	U	2.2J	U	4.6	560	1.1	88	U	10	

SITE	As	Cd	Cr	Cr(hex)	Cu	Fe	Pb	Mn	Hg	Zn	U
SD 490	U	U	1.9J	U	1.6	74	U	64	U	14	2.4
P1 WEIR	U	U	U	U	U	270	U	300	U	6.3	U
MBK 1.6	U	U	U		1	480	0.52J	58	U	3.1J	U
SD 510	1.0J	U	12	U	7.1	1900	3.6	37	U	39	2.1
11/19/2015											
EFK 23.4	U	U	1.2J		2.6	160	U	31	0.23	13	
WCK 0.0	U	U	2.3J		4.3	670	0.93J	90	U	10	
BCK 4.5	0.53J	U	1.6J		1.7	770	0.93J	69	U	5.4	
MIK 0.1	0.81J	U	2	U	3.1	460	0.67J	88	U	8.3	
SD 490	U	U	2.4J	U	1.8	120	U	140	U	14	1.8
P1 WEIR	U	U	1.1J	U	U	280	U	88	U	0	0.64J
MBK 1.6	U	U	0.99J		0.65J	450	U	42	U	20.J	U
SD 510	0.82J	U	3.7J	U	3.1	1600	1.8	25	U	19	1.7

U - undetected
J - Estimated

Table 3.1.6.4.2 Three-Year Metals Averages

Analyte	East Fork Poplar Creek	Mitchell Branch	White Oak Creek	Bear Creek	Units
Fe	141	288	125	463	□g/L
As	0.29	0	0.67	0	□g/L
Cd	0.24	0	0	1.23	□g/L
Cr	1.02	1.35	0	0	□g/L
Cu	2.21	2.08	3.57	0.77	□g/L
Pb	0	0.07	0	0	□g/L
Mn	26.7	85	30.5	113	□g/L
Zn	14	4.63	9.96	4.17	□g/L
Hg	0.11	0	0	0	□g/L

Table 3.1.6.4.3 Gross Alpha and Gross Beta Activities

SITE	Gross Alpha	Gross Alpha Error	Gross Beta	Gross Beta Error	Units
1/13/2015					
EFK 23.4	20.8	1.3	18.8	2.6	pCi/L
WCK 0.0	0.93	0.61	53	2.8	pCi/L
BCK 4.5	36.6	1.5	14.8	2.6	pCi/L
MIK 0.1	4.49	0.69	28.5	2.6	pCi/L
SD 490	-15.7	1	524	5.4	pCi/L
P1 WEIR	-0.99	0.54	26.8	2.6	pCi/L
MBK 1.6	7.07	0.77	25.6	2.6	pCi/L
SD 510	0.1	0.54	5.7	2.5	pCi/L

SITE	Gross Alpha	Gross Alpha Error	Gross Beta	Gross Beta Error	Units
4/15/2015					
EFK 23.4	2.81	0.36	6.8	1.3	pCi/L
WCK 0.0	1.07	0.35	110	9.4	pCi/L
BCK 4.5	5.94	0.51	15.4	1.8	pCi/L
MIK 0.1	3.2	0.38	8.7	1.4	pCi/L
SD 490	-13.66	0.82	630	54	pCi/L
P1 WEIR	-2.16	0.26	90	7.2	pCi/L
MBK 1.6	-0.68	0.25	31.4	3.5	pCi/L
SD 510	0.68	0.26	1.3	1.2	pCi/L
7/15/2015					
EFK 23.4	9.06	0.84	15.4	1.7	pCi/L
WCK 0.0	0.79	0.47	106.4	8.5	pCi/L
BCK 4.5	3.37	0.54	3.5	1.3	pCi/L
MIK 0.1	6.56	0.73	20.8	2.1	pCi/L
SD 490	-14.5	1.1	502	34	pCi/L
P1 WEIR	-0.39	0.4	32.5	2.8	pCi/L
MBK 1.6	1.22	0.44	20.7	2.1	pCi/L
SD 510	2.25	0.47	2.4	1.3	pCi/L
11/19/2015					
EFK 23.4	13.2	1.5	18.5	1.9	pCi/L
WCK 0.0	1.76	0.52	168.3	3.9	pCi/L
BCK 4.5	4.1	0.58	15.8	1.9	pCi/L
MIK 0.1	10.9	1.2	26.7	2	pCi/L
SD 490	-4.43	0.61	233.4	4.9	pCi/L
P1 WEIR	-0.6	0.33	29	2	pCi/L
MBK 1.6	0.77	0.35	2.9	1.8	pCi/L
SD 510	-0.14	0.32	3.3	1.8	pCi/L

Table 3.1.6.4.4 Gamma Radionuclides Results

SITE	All Gamma Radio-nuclides	Gamma Pb-212	Gamma Pb-212 Error	Gamma Pb-214	Gamma Pb-214 Error	Gamma Bi-214	Gamma Bi-214 Error	Gamma Cs-137	Gamma Cs-137 Error	Units
1/13/2015										
EFK 23.4						29.4	8.2			pCi/L
WCK 0.0	NDA									pCi/L
BCK 4.5	NDA									pCi/L
MIK 0.1				20	8.3	17.2	7.7			pCi/L
SD 490				14.8	7.3	15.8	8.3			pCi/L
P1 WEIR	NDA									pCi/L
MBK 1.6	NDA									pCi/L
SD 510	NDA									pCi/L
4/15/2015										
EFK 23.4	NDA									pCi/L
WCK 0.0	NDA									pCi/L
BCK 4.5				10.9	5.6					pCi/L
MIK 0.1	NDA									pCi/L
SD 490	NDA									pCi/L
P1 WEIR	NDA									pCi/L
MBK 1.6	NDA									pCi/L
SD 510	NDA									pCi/L
7/15/2015										
EFK 23.4	NDA									pCi/L
WCK 0.0	NDA									pCi/L
BCK 4.5	NDA									pCi/L
MIK 0.1	NDA									pCi/L
SD 490				15.8	8.5					pCi/L
P1 WEIR	NDA									pCi/L
MBK 1.6	NDA									pCi/L
SD 510	NDA									pCi/L
11/19/2015										
EFK 23.4	N/S									pCi/L
WCK 0.0						14.4	7.5	18.5	4.7	pCi/L
BCK 4.5	N/S									pCi/L
MIK 0.1	N/S									pCi/L
SD 490	N/S									pCi/L
P1 WEIR	N/S									pCi/L
MBK 1.6	N/S									pCi/L
SD 510	N/S									pCi/L

NDA - No detectable activity
N/S - No sample taken or test not requested

Table 3.1.6.4.5 Tritium and Technetium-99 Results

SITE	Tritium	Tritium Error	Tc-99	Tc-99 Error	Units
1/13/2015					
SD 490	87	36	395	19	pCi/L
P1 WEIR	0	34	19.22	0.83	pCi/L
SD 510			12.42	0.57	pCi/L
4/15/2015					
SD 490	60	36	655	40	pCi/L
P1 WEIR	126	50	88.5	3.1	pCi/L
SD 510			28	0.97	pCi/L
7/15/2015					
SD 490	87	32	532	30	pCi/L
P1 WEIR	100	33	31.6	1.1	pCi/L
SD 510			19.13	0.7	pCi/L
11/19/2015					
SD 490	139	36	216	9	pCi/L
P1 WEIR	198	42	17.3	0.66	pCi/L
SD 510	N/S		2.64	0.29	pCi/L

NDA - No detectable activity
N/S - No sample taken or test not requested
pCi/L - pico Curies per Liter

Table 3.1.6.4.6 Prior Three Years Gross Alpha and Gross Beta Results

Analyte	East Fork Poplar Creek	Mitchell Branch	White Oak Creek	Bear Creek	Units
2013					
Gross Alpha	2.2	10.7	0.1	49.35	pCi/L
Gross Beta	2.3	19	218	76.7	pCi/L
2014					
Gross Alpha	2.61	9.7	14.4	46.05	pCi/L
Gross Beta	2.4	29.3	10.9	102.75	pCi/L
2015					
Gross Alpha	6.784	1.7	1.15	28.01	pCi/L
Gross Beta	11.02	6.63	111.2	247.6	pCi/L

Laboratory results indicate certain metals analyzed are found at a higher concentration after rain events than during non-rain events.

3.1.6.5 Ambient Sediment Monitoring

Metals Analyses

The only metals found above the probable effects concentration (PEC) were mercury and nickel (Table 3.1.6.5.1). The Probable Effects Concentrations (PECs) are Consensus Based Sediment Quality Guidelines (CBSQGs) that were established as concentrations of individual chemicals above which adverse effects in sediments are expected to frequently occur (Ingersoll et al. 2000). Adverse effects,

in this case, refer to effects on benthic macroinvertebrate species only (WDNR 2003). The CBSQGs are considered to be protective of human health and wildlife, except where bioaccumulative or carcinogenic organic chemicals, such as PCBs or methylmercury, are involved. In these cases, other tools such as human health and ecological risk assessments, bioaccumulation-based guidelines, bioaccumulation studies, and tissue residue guidelines should be used in addition to the CBSQGs to assess direct toxicity and food chain effects (WDNR 2003). The threshold effects concentrations (TECs) are concentrations below which adverse effects are not expected to occur (Ingersoll *et al.* 2000).

The East Fork Poplar Creek Mile 3.9 sediment mercury value (7.1 mg/kg) exceeds the PEC of 1.06 mg/kg (MacDonald et al. 2000). The mercury in East Fork Poplar Creek and Poplar Creek sediments results from historical activities at Y-12 and to a lesser extent ETTP. Figure 3.1.6.5.1 shows the effect of the East Fork Poplar Creek mercury contamination on the Clinch River sediments. East Fork Poplar Creek empties into Poplar Creek at Poplar Creek Mile 5.5; the mouth of Poplar Creek is located at approximately Clinch River Mile (CRM) 12. Mercury levels are highest at East Fork Poplar Creek km 6.3 and generally decrease downstream. All sites sampled on East Fork Poplar Creek and Poplar Creek had mercury values above the PEC.

Figure 3.1.6.5.2, total mercury in sediment grab samples at Mitchell Branch km 0.1 (1992-2015), gives a chronological view of changes in sediment mercury content over the years 1992 to 2015. The graph incorporates data obtained from OREIS and includes DOE Environmental Surveillance Soil and Sediment Data, DOE Remedial Effectiveness Reports, and data from DOE Environmental Monitoring Plans. Sometime between 2004 and 2008, sediment mercury levels increased, as seen in the data in Figure 3.1.6.5.2. Similarly, nickel, chromium, boron, and barium concentrations increased during the same time period at this location (Figures 3.1.6.5.3, 3.1.6.5.4, 3.1.6.5.5, and 3.1.6.5.6).

Table 3.1.6.5.1 Summary of Metals Data

Parameter	Units	Mean	Median	Standard Deviation	Range	Minimum	Maximum	Count	TEC*	PEC**
Arsenic	mg/kg	4.4	3.5	3.2	9.8	1.2	11	8	9.79	33
Barium	mg/kg	91.8	98	39	96	44	140	8		
Beryllium	mg/kg	0.545	0.595	0.421	1.3	0	1.3	8		
Boron	mg/kg	40.8	40.5	13.6	36	21	57	8		
Cadmium	mg/kg	0.337	0.44	0.271	0.73	0	0.73	7	0.99	4.98
Chromium	mg/kg	22.2	14	24.9	75.1	7.9	83	8	43.4	111
Copper	mg/kg	14.6	13	9.2	27.2	5.8	33	7	31.6	149
Lead	mg/kg	14.8	15	4.5	10.2	9.8	20	6	358	128
Mercury	mg/kg	1.8	0.42	2.51	7.04	0.056	7.1	8	0.18	1.06
Nickel	mg/kg	45.4	14	90.9	262.8	7.2	270	8	22.7	48.6
Clay: 0.002 mm	%	13	13	5.5	18	4	22	8		
Silt: 0.007 mm	%	53.1	53.5	16.4	46	29	75	8		
Sand: 0.150 mm	%	33.4	28.5	16.3	42	13	55	8		
Gravel:	%	0.5	0	0.8	2	0	2	8		

Parameter	Units	Mean	Median	Standard Deviation	Range	Minimum	Maximum	Count	TEC*	PEC**
12.5 mm										

*Consensus based Sediment Quality Criteria, Threshold Effects Concentration (McDonald et al 2000)
**Consensus based Sediment Quality Criteria, Probable Effects Concentration (McDonald et al 2000)

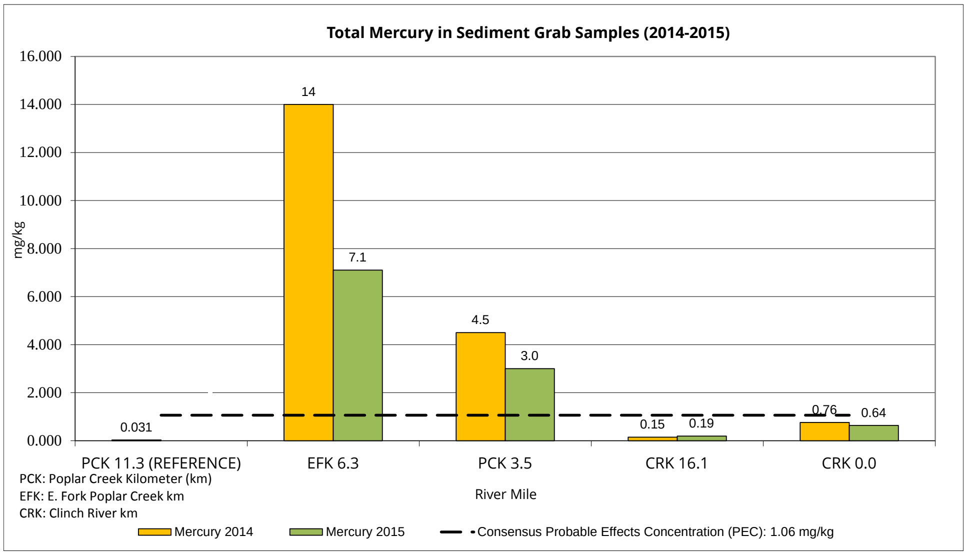


Figure 3.1.6.5.1 Total mercury in sediment grab samples Clinch River and Poplar Creek (2014-2015)

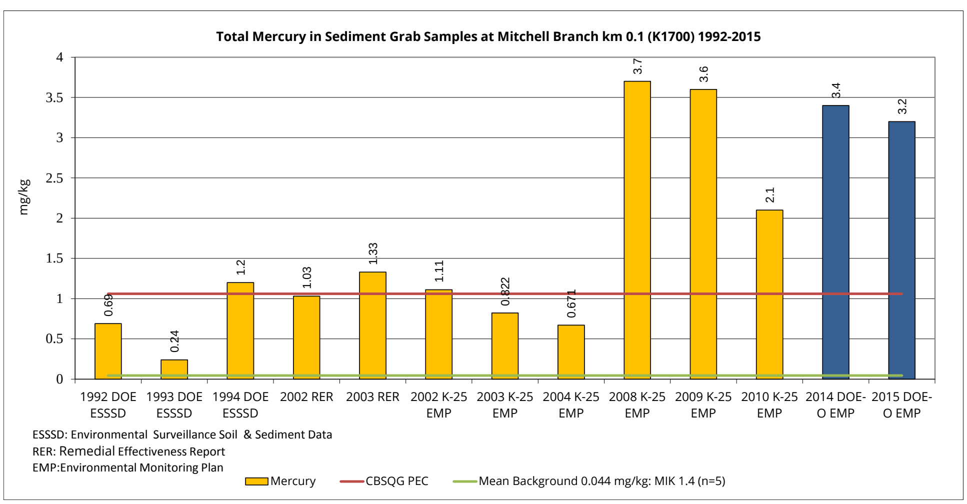


Figure 3.1.6.5.2 Total mercury in sediment grab samples at Mitchell Branch km 0.1 (1992-2015)

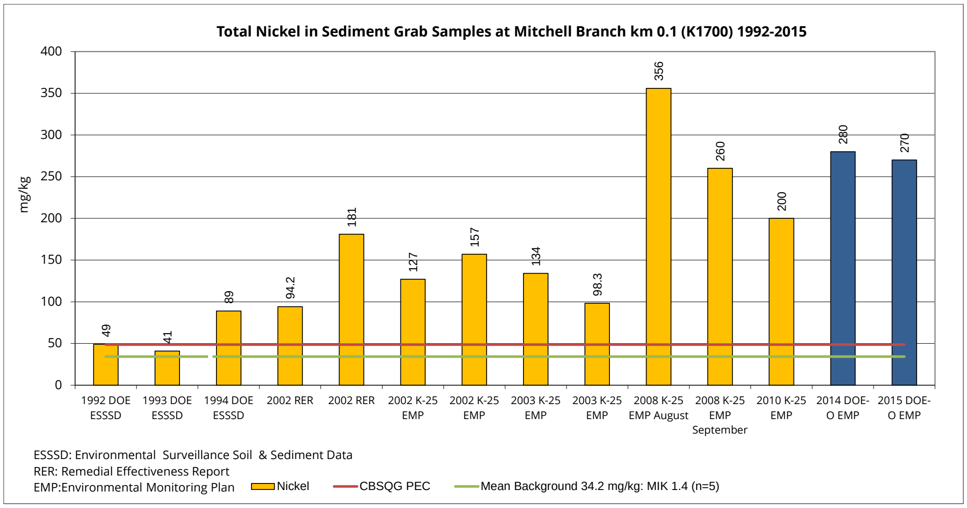


Figure 3.1.6.5.3 Total nickel in sediment grab samples at Mitchell Branch km 0.1 (1992-2015)

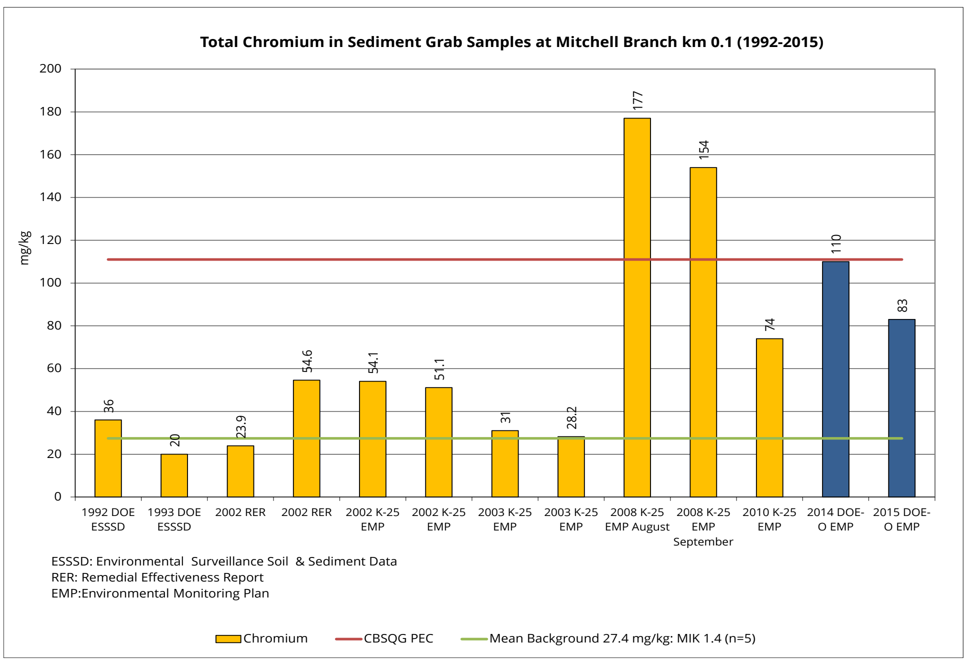


Figure 3.1.6.5.4 Total chromium in sediment grab samples at Mitchell Branch km 0.1 (1992-2015)

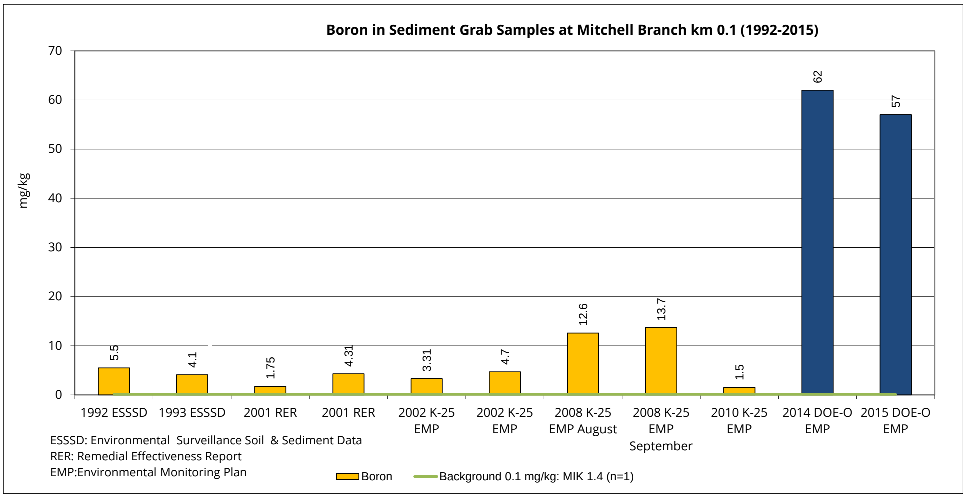


Figure 3.1.6.5.5 Boron in sediment grab samples at Mitchell Branch km 0.1 (1992-2015)

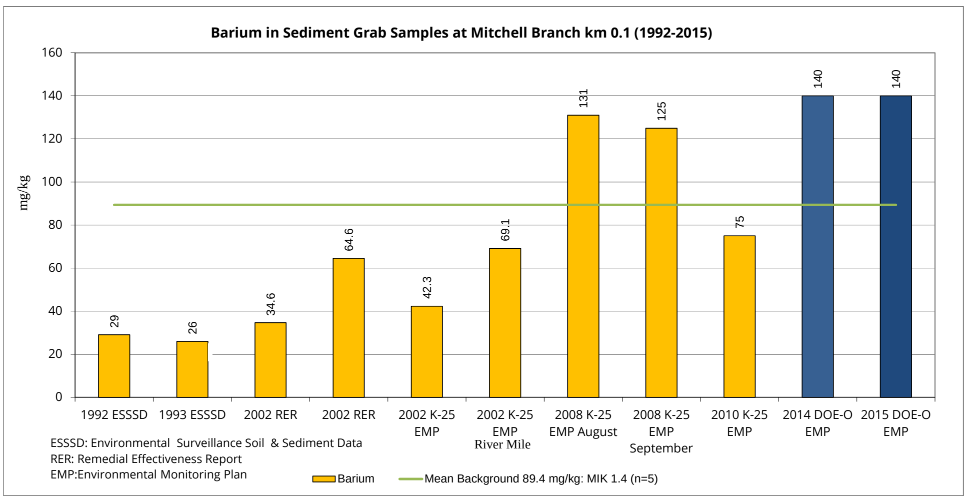


Figure 3.1.6.5.6 Barium in sediment grab samples at Mitchell Branch km 0.1 (1992-2015)

Radiological Analyses

The radiological sediment data show that radiological parameters are below DOE PRGs. In 2015, Cs-137 was detected in the Clinch River samples at river miles 14.5, 10.0, 0.0, and in the Mitchell Branch sample. The recreational PRG for Cs-137 is 117 pCi/g (total soil/sediment TR 1.0E-06) (DOE 2013).The highest Cs-137 value was 1.54 pCi/g at CRM 14.5. Gross alpha activity was also highest at the Mitchel Branch location (11.0 pCi/g) (Figure 3.1.6.5.7). Gross beta activity was highest at the Mitchell Branch location (248 pCi/g) (Figure 3.1.6.5.8). Figures 3.1.6.5.9 and 3.1.6.5.10 show a chronological view of changes in sediment gross alpha and gross beta activities over the years 1992 to 2015. These graphs incorporate data obtained from OREIS and include DOE Environmental Surveillance Soil and Sediment Data and DOE Remedial Effectiveness Reports, as well as 2014 and 2015 TDEC data.

Table 3.1.6.5.2 Summary of Radiological Data

Parameter	Units	Mean	Median	Standard Deviation	Range	Minimum	Maximum	Count
Radioactivity, alpha	pCi/g	4.53	3.8	2.76	8.58	2.42	11	8
Radioactivity, beta	pCi/g	35.8	5.5	85.8	245	3	248	8

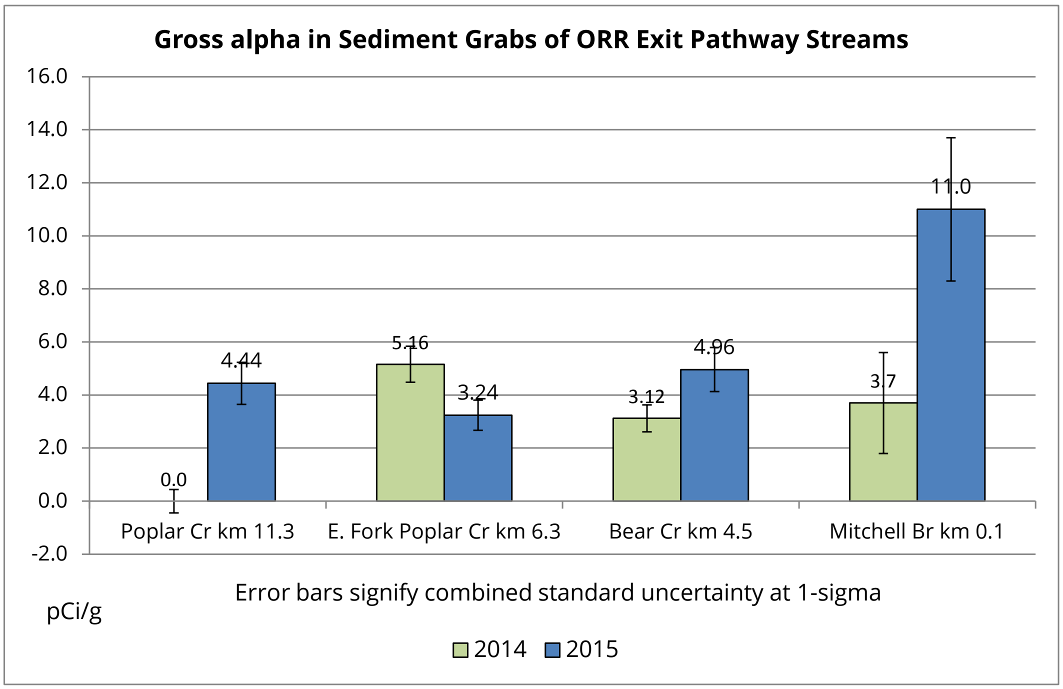


Figure 3.1.6.5.7 Gross alpha in sediment grabs of ORR exit pathway streams

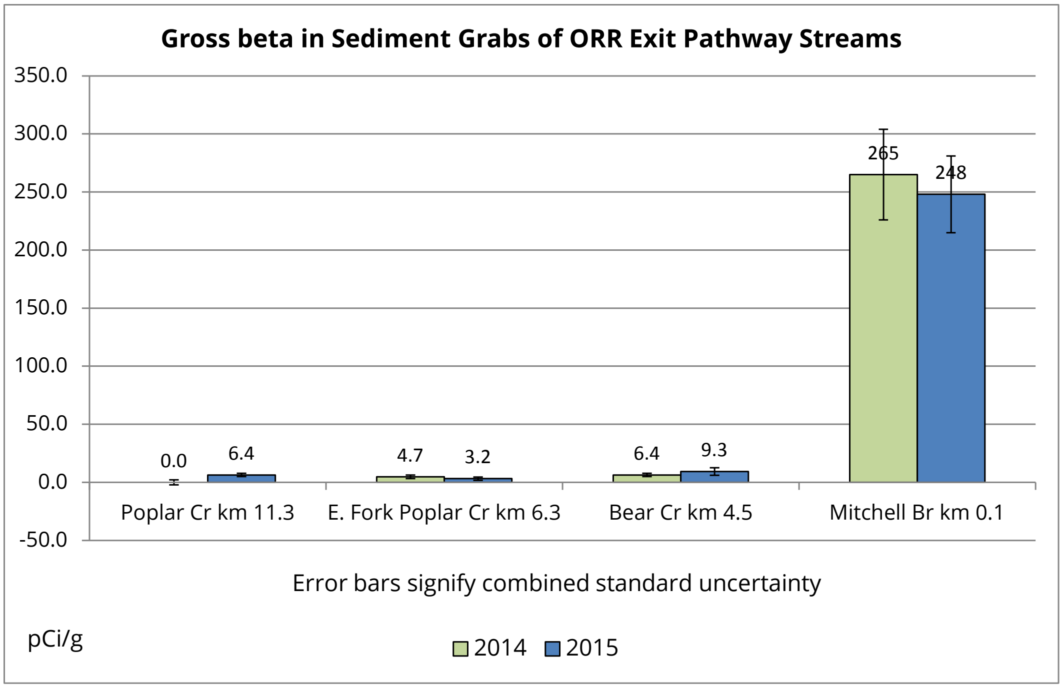


Figure 3.1.6.5.8 Gross beta in sediment grabs of ORR exit pathway streams

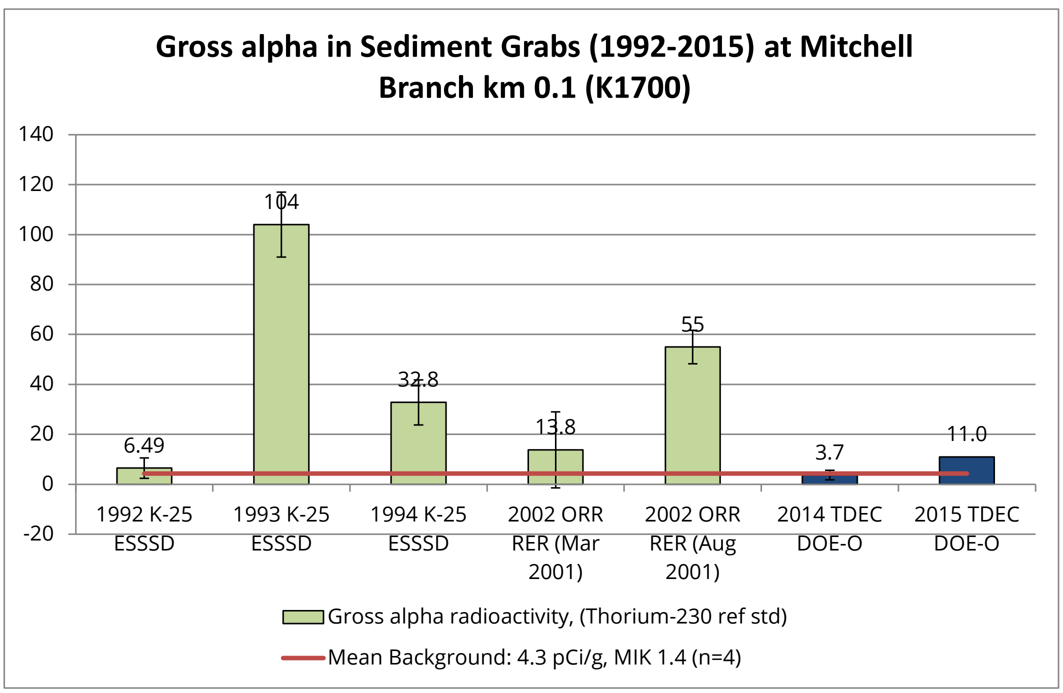


Figure 3.1.6.5.9 Gross alpha in sediment grabs (1992-2015) at Mitchell Branch km 0.1 (K1700)

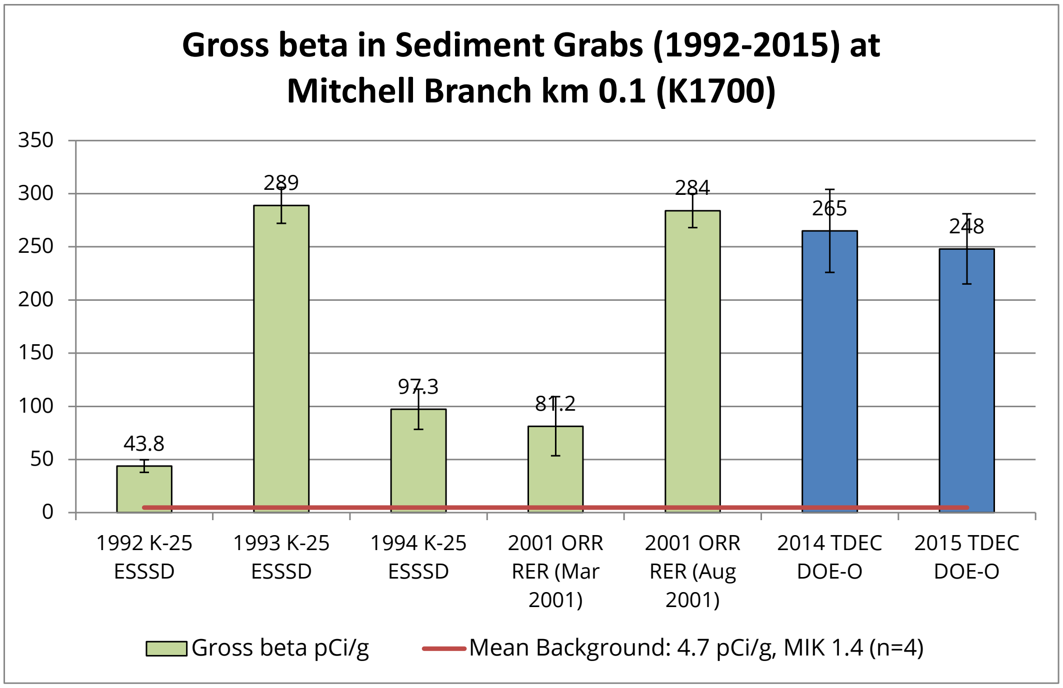


Figure 3.1.6.5.10 Gross beta in sediment grabs (1992-2015) at Mitchell Branch km 0.1

3.1.6.6 Ambient Trapped Sediment Monitoring

Figure 3.1.6.6.1 shows the total mercury results for EFPC for 2014 and 2015. Concentrations have the general trend of decreasing downstream. All East Fork Poplar Creek samples exceed the PEC for mercury (1.06 mg/kg). A background value of 0.04 mg/kg from Hinds Creek km 20.6 is used for comparison. Figure 3.1.6.6.2 shows methyl mercury results for 2014 and 2015. In 2014, methyl mercury values increased going downstream, but in 2015 the trend is reversed with methyl mercury values starting off high at EFK 23.4 and decreasing downstream. Figure 3.1.6.6.3 shows total mercury at NT5 and Bear Creek. Concentrations decrease downstream on Bear Creek. At NT5, the total mercury concentration remains low as in 2014. Methyl mercury concentration levels at NT5 and Bear Creek are shown in Figure 3.1.6.6.4. In 2014, there was an increase in methyl mercury going downstream. In 2015, there was a slight decrease in methyl mercury from BCK 7.6 to BCK 4.5. At NT5, both total and methyl mercury remain low relative to the Bear Creek and East Fork Poplar Creek data. There is currently not a PEC for methyl mercury.

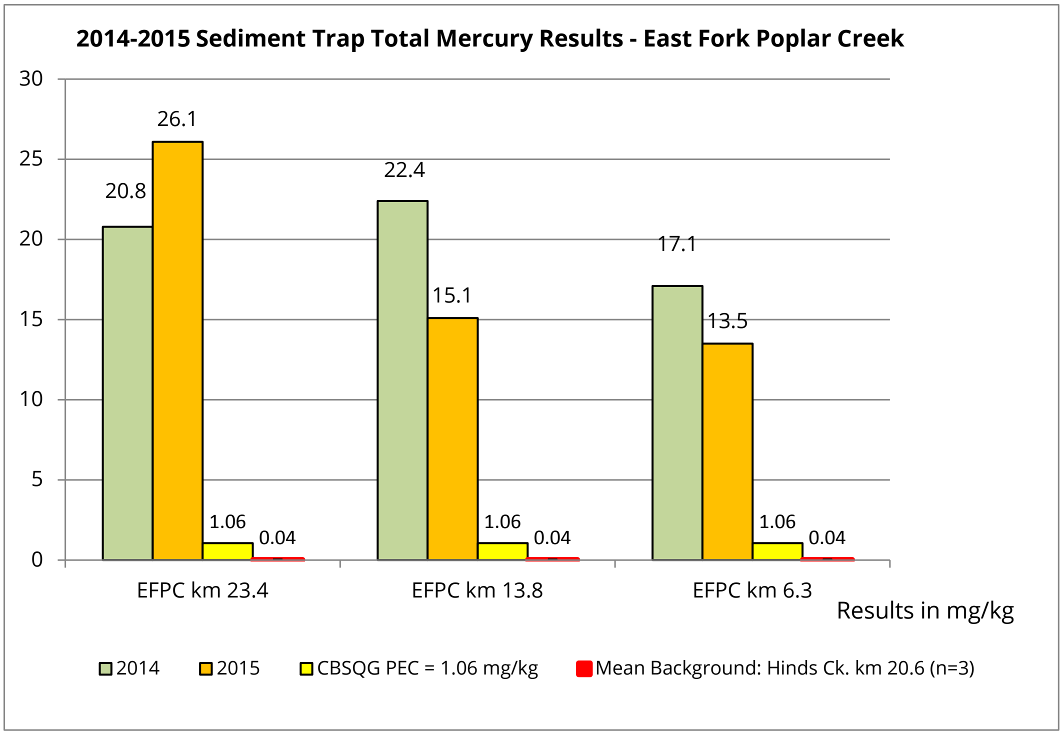


Figure 3.1.6.6.1 2014-2015 Sediment trap total mercury results East Fork Poplar Creek

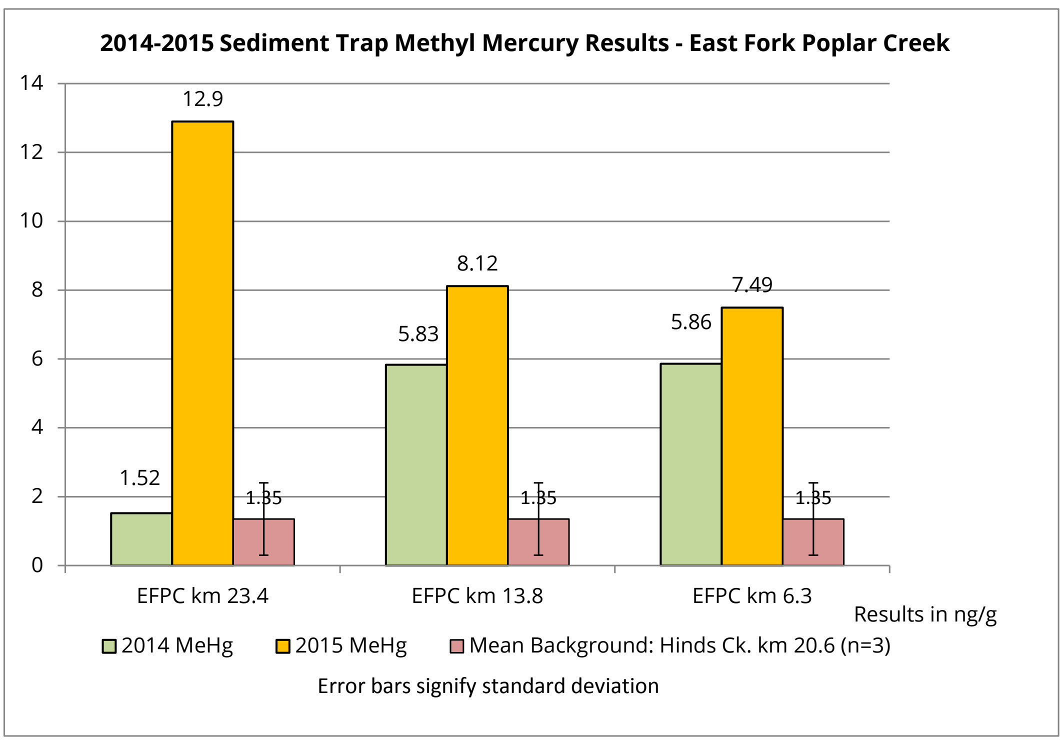


Figure 3.1.6.6.2 2014-2015 Sediment trap methyl mercury results East Fork Poplar Creek

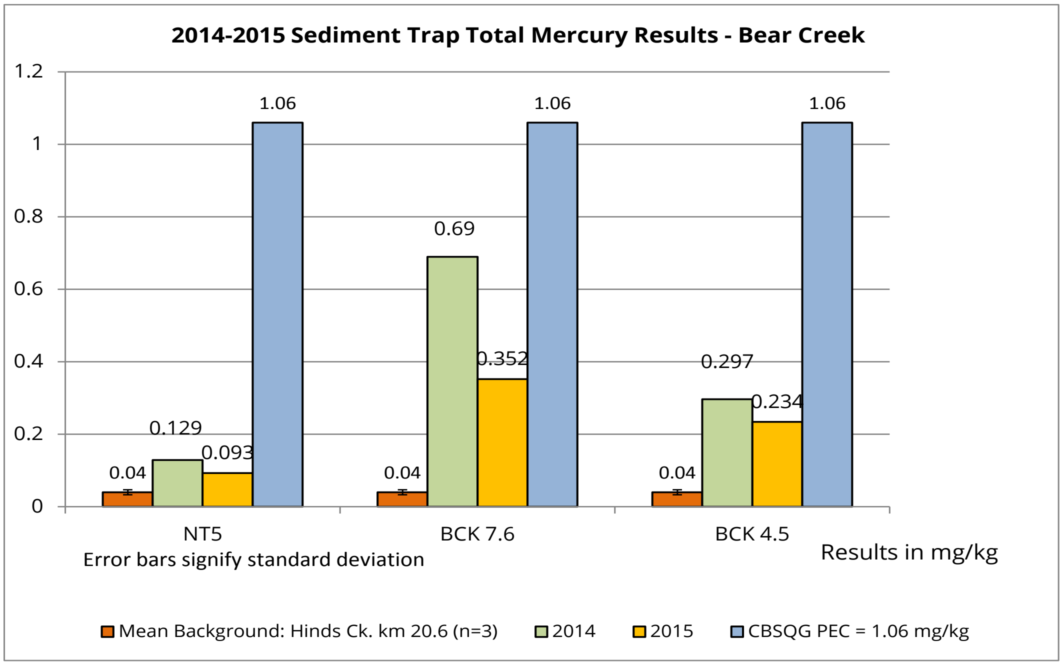


Figure 3.1.6.6.3 2014-2015 Sediment trap total mercury results NT5 and Bear Creek

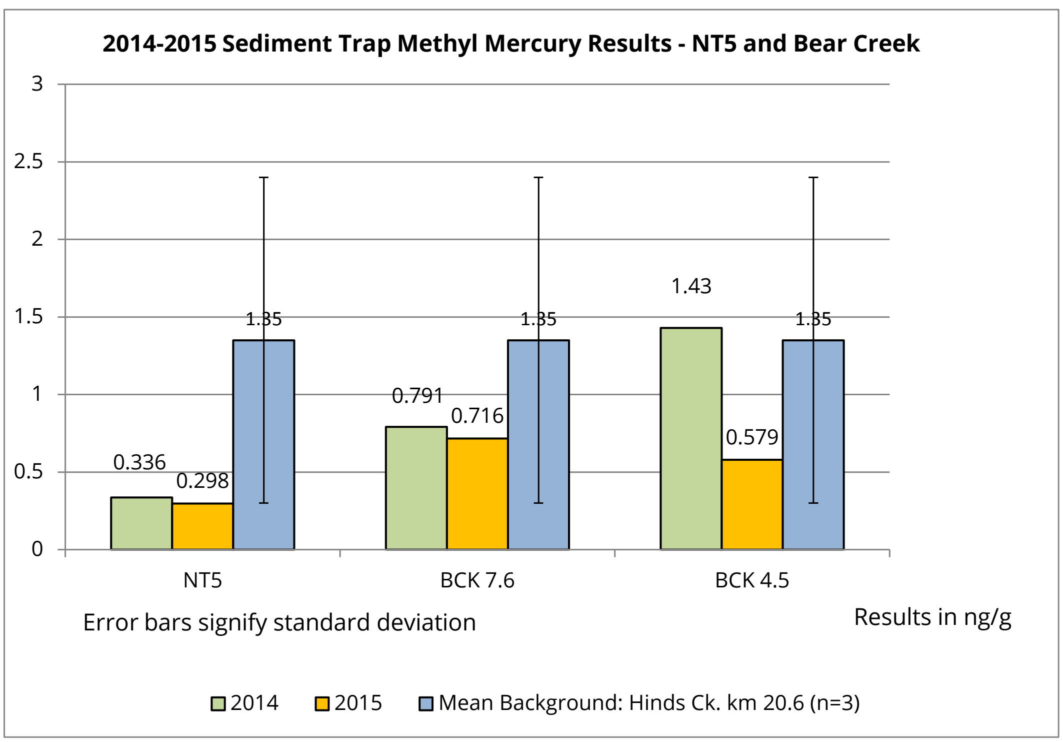


Figure 3.1.6.6.4 2014-2015 Sediment trap methyl mercury results NT5 and Bear Creek

Total Uranium results are shown in Figure 3.1.6.6.5. Uranium concentrations are higher at EFK 23.4 than at the two downstream sampling locations. ORNL sediment data (1994-1996) was obtained from OREIS for comparison to TDEC data at EFPC km 6.3.

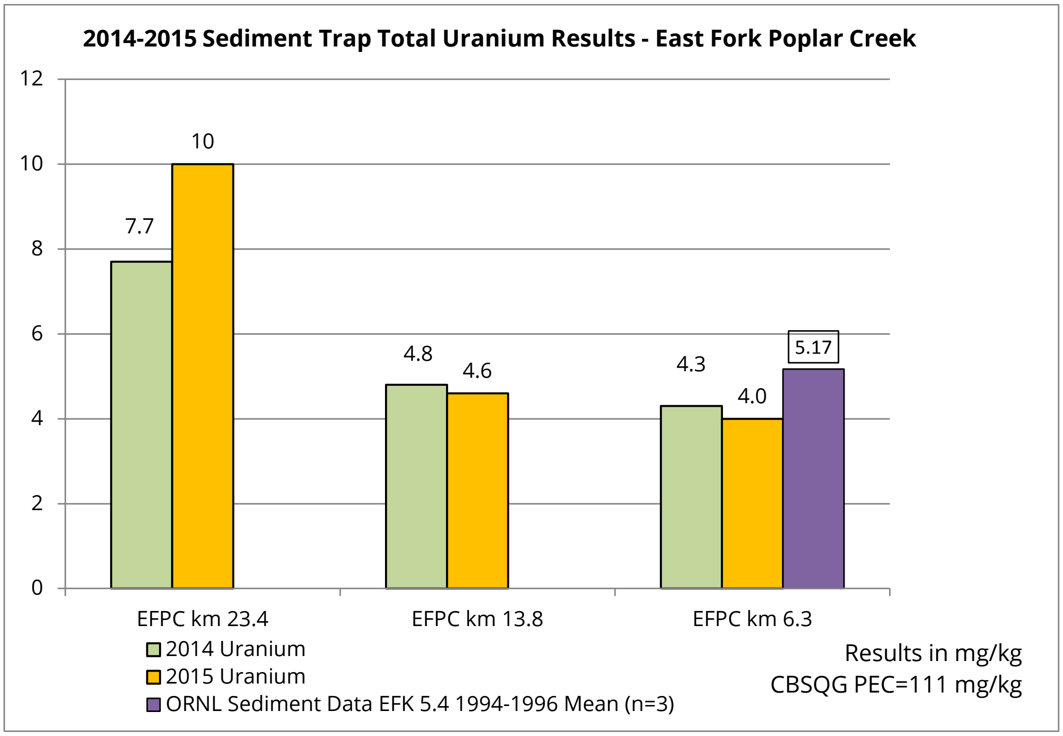


Figure 3.1.6.6.5 2014-2015 Sediment trap total uranium results East Fork Poplar Creek

Figure 3.1.6.6.6 shows the downward gradient of EFPC barium concentrations at the three sampling sites downstream from Y-12, much like the graphs of chromium (figure 3.1.6.6.7), and nickel (figure 3.1.6.6.8). Background sediment nickel data from Clear Creek (n=8) in Anderson County is displayed in Figure 3.1.6.6.8. All EFPC nickel values are less than the CBSQG PEC of 48.6 mg/kg, but are above background.

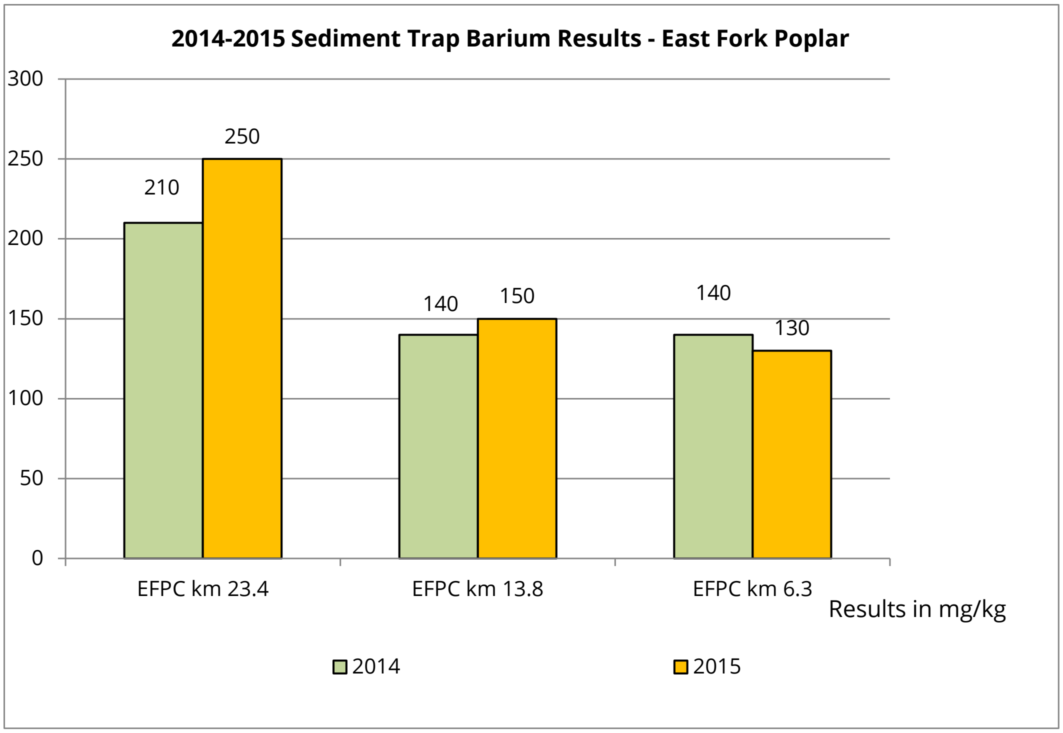


Figure 3.1.6.6.6 2014-2015 sediment trap barium results East Fork Poplar Creek

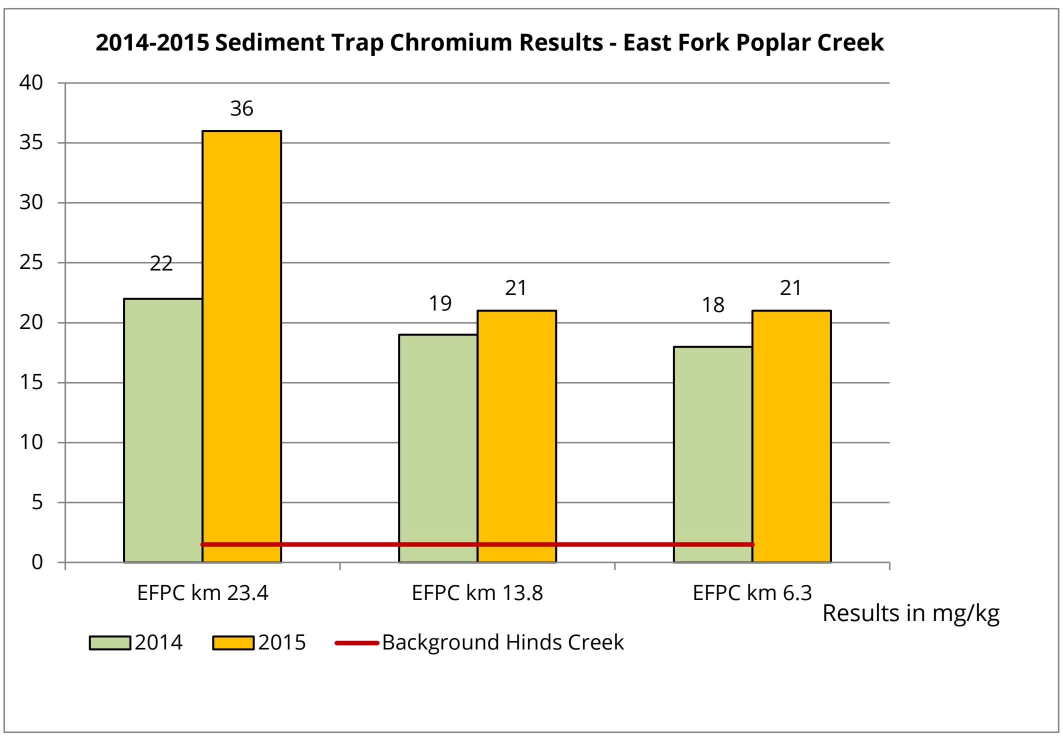


Figure 3.1.6.6.7 2014-2015 sediment trap chromium results East Fork Poplar Creek

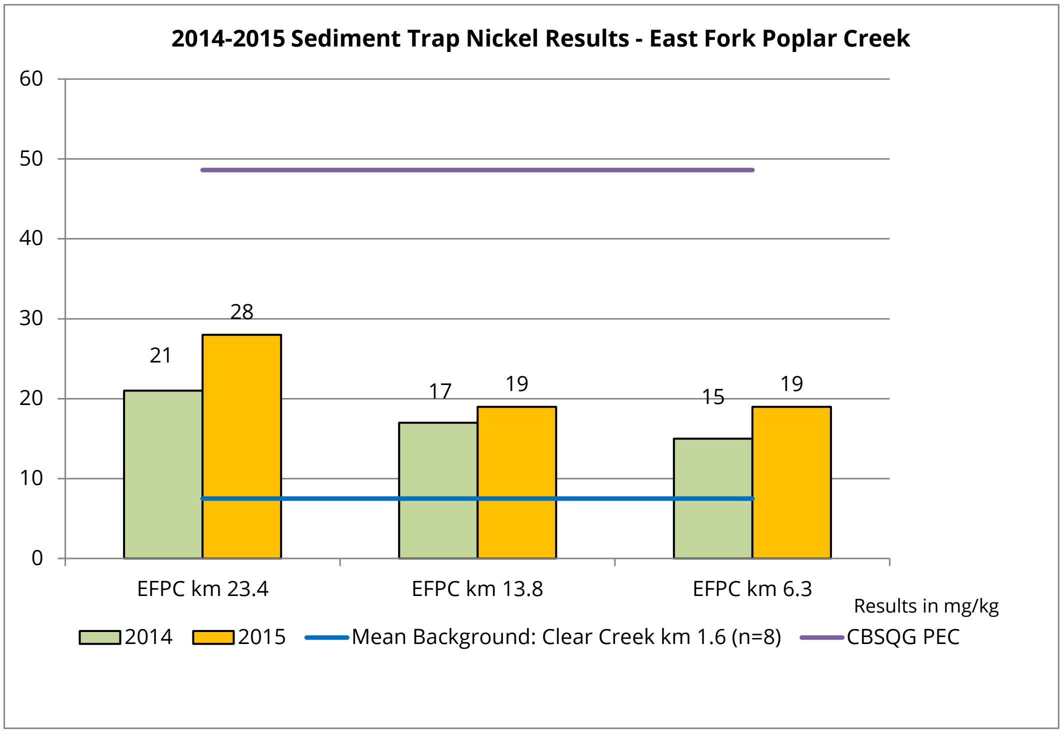


Figure 3.1.6.6.8 2015-2015 sediment trap nickel results East Fork Poplar Creek

Radiological Results

Radiological analyses included gross alpha, gross beta, gamma radionuclides, and isotopic uranium. Gross alpha values increased downstream in East Fork Poplar Creek and fluctuated in Bear Creek with the highest amounts at EFK 6.3 and BCK 7.6 (Figures 3.1.6.6.9 and 3.1.6.6.11). Gross beta values generally showed a decreasing trend downstream with the highest amounts at NT5 on the Bear Creek watershed and EFK 23.4 on East Fork Poplar Creek (Figures 3.1.6.6.10, 3.1.6.6.12). All gamma radionuclides detected are naturally-occurring (Pb-212, K-40, etc.). Isotopic uranium analyses received for the fall harvested sediments suggest enrichment at the NT5 sampling location, which indicates 2.6 to 3.7% U-235 enrichment (Rad Pro Calculator, 2016) (Figures 3.1.6.6.13, 3.1.6.6.14) (Table 3.1.6.6.1). NT5 is the main outfall for EMWMF.

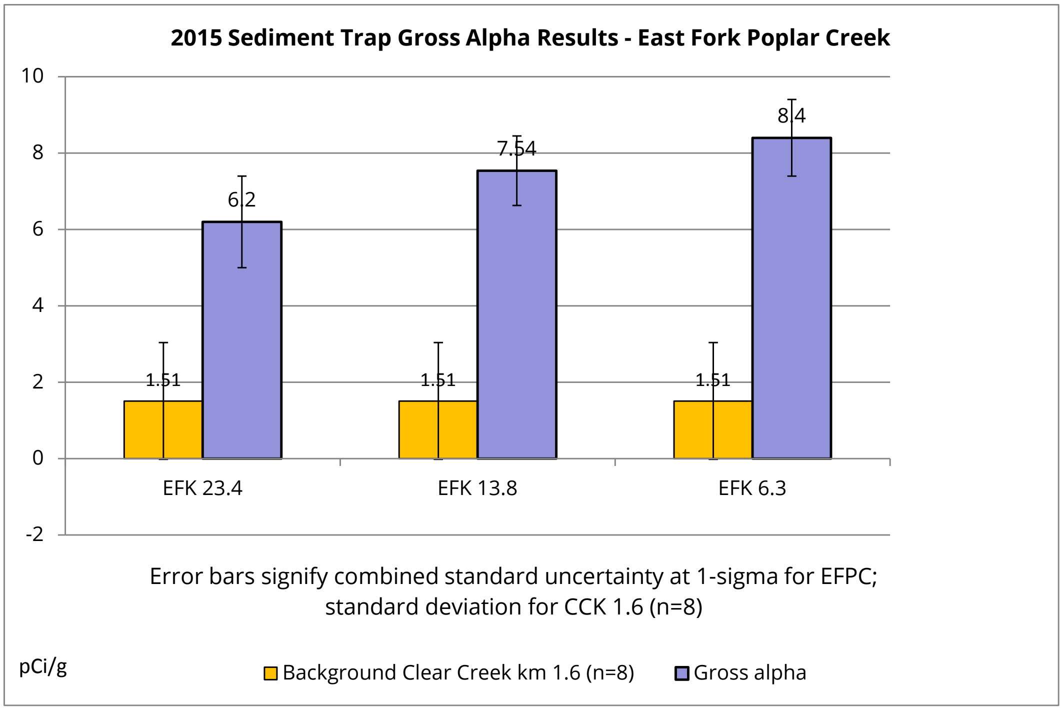


Figure 3.1.6.6.9 2015 Sediment trap gross alpha results East Fork Poplar Creek

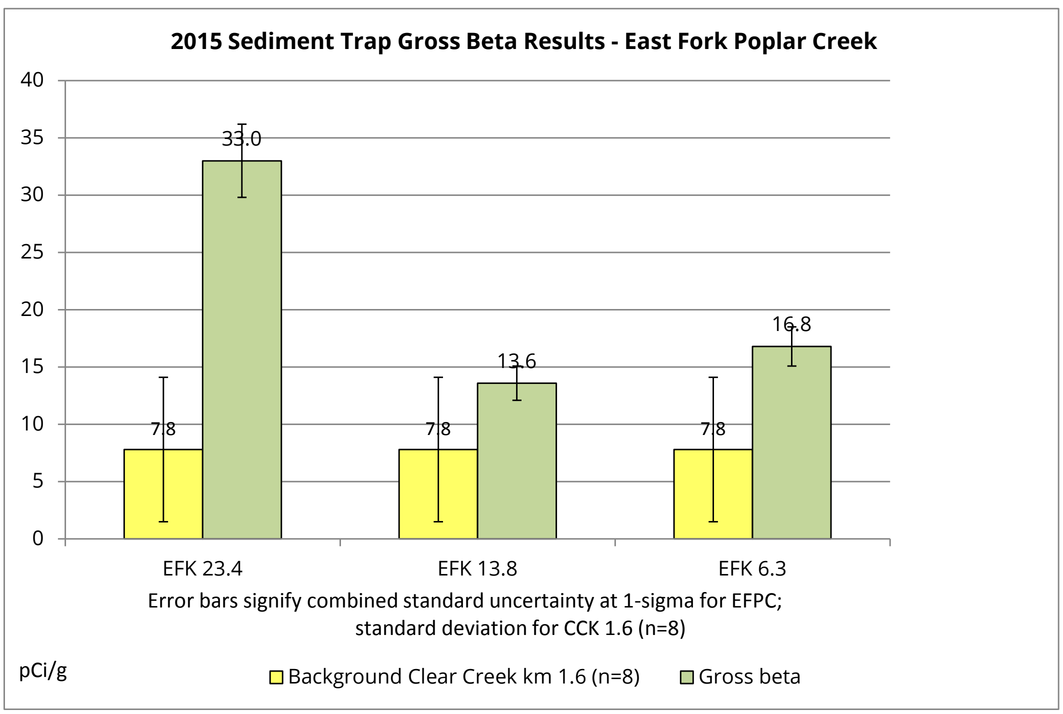


Figure 3.1.6.6.10 2015 Sediment trap gross beta results East Fork Poplar Creek

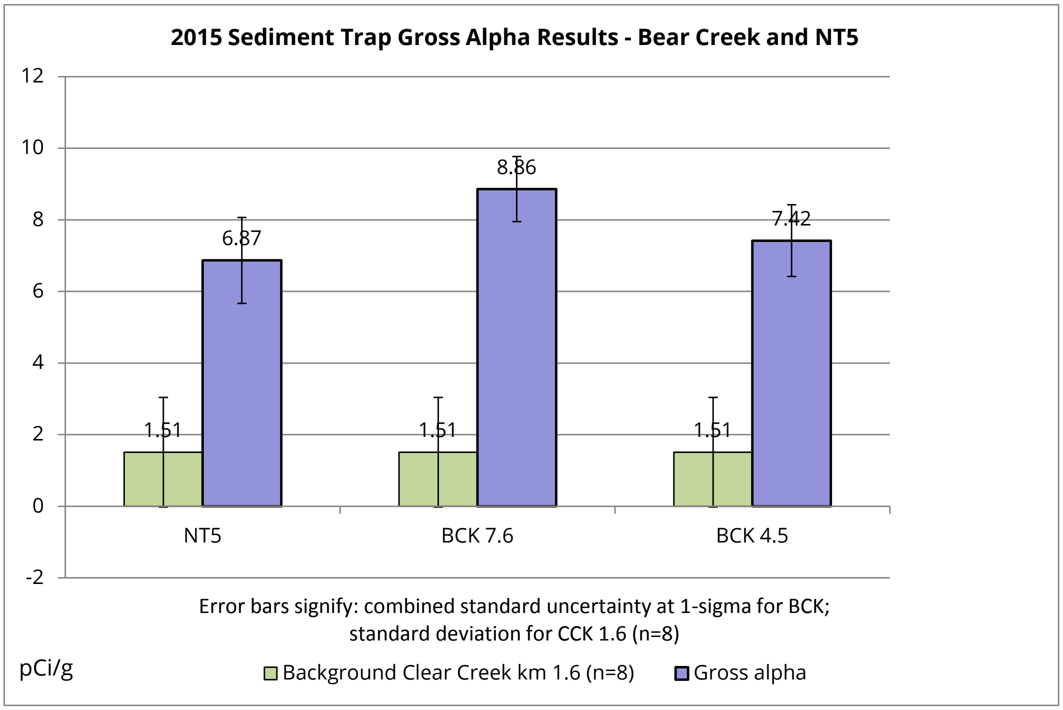


Figure 3.1.6.6.11 2015 Sediment trap gross alpha results NT5 and Bear Creek

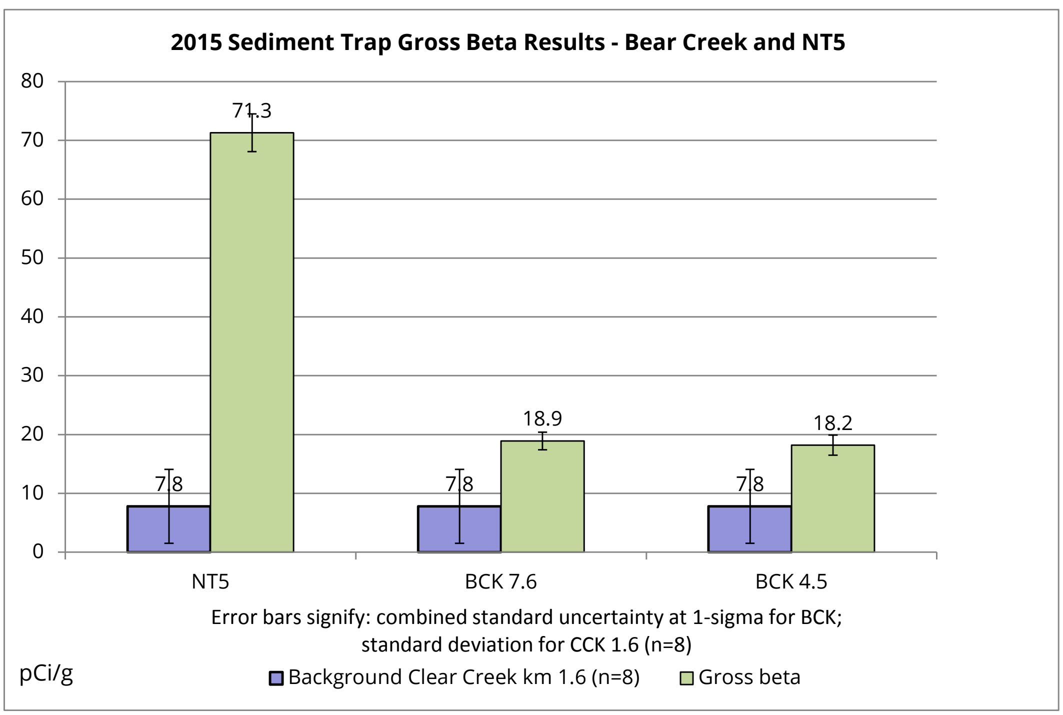


Figure 3.1.6.6.12 2015 Sediment trap gross beta results NT5 and Bear Creek

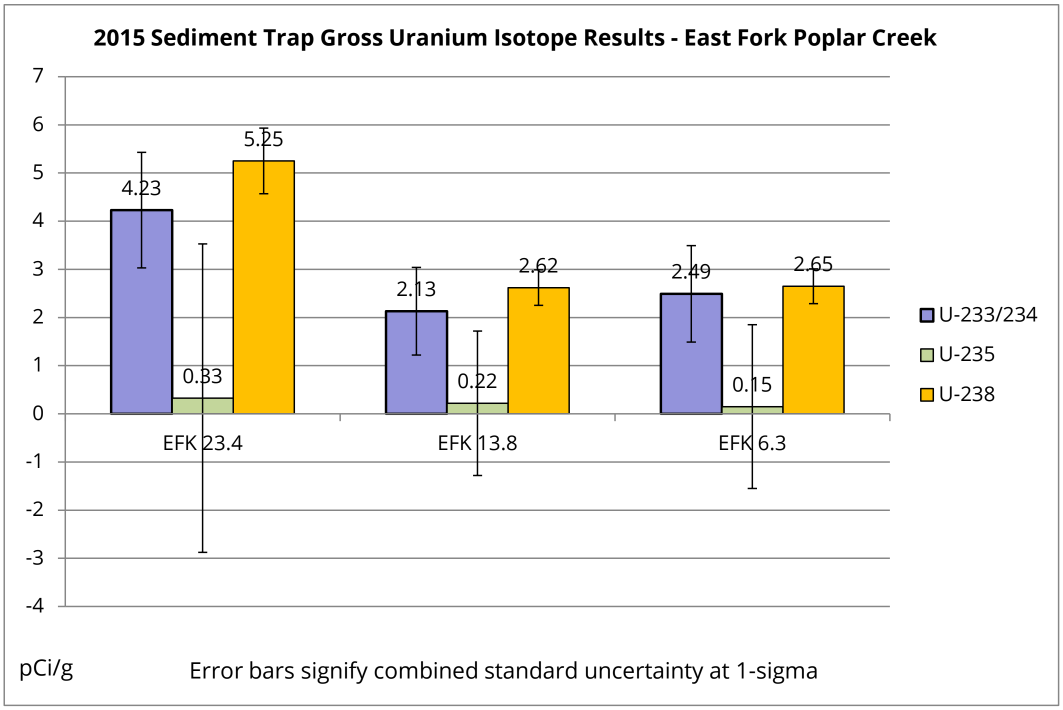


Figure 3.1.6.6.13 2015 Sediment trap gross uranium isotope results East Fork Poplar Creek

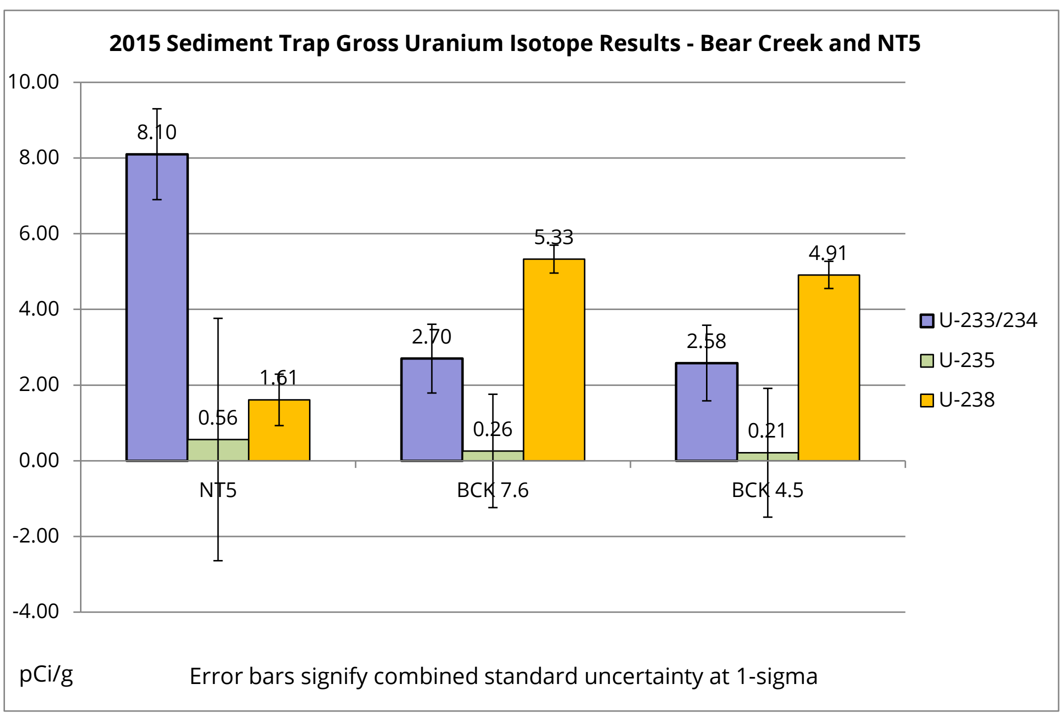


Figure 3.1.6.6.14 2015 Sediment trap gross uranium isotope results Bear Creek

Table 3.1.6.6.1 Calculated U-235 Mass % Enrichment

Location	Analyte	Result	Units	Uncertainty	Detection Limit	Calculated U-235 Mass % Enrichment	Uncertainty Range
EFK 23.4	U-233/234	4.23	pCi/g	0.559	0.0328	0.55	0.48 to 0.62
	U-235	0.326	pCi/g	0.0768	0.0248		
	U-238	5.25	pCi/g	0.0683	0.0326		
EFK 13.8	U-233/234	2.13	pCi/g	0.309	0.0263	0.56	0.45 to 0.67
	U-235	0.223	pCi/g	0.0619	0.0209		
	U-238	2.62	pCi/g	0.371	0.0169		
EFK 6.3	U-233/234	2.49	pCi/g	0.337	0.0179	0.64	0.52 to 0.76
	U-235	0.147	pCi/g	0.0492	0.0423		
	U-238	2.65	pCi/g	0.357	0.0291		
NT 5	U-233/234	8.1	pCi/g	0.992	0.0281	3.15	2.60 to 3.68
	U-235	0.561	pCi/g	0.102	0.0318		
	U-238	1.61	pCi/g	0.222	0.0198		
BCK 7.6	U-233/234	2.7	pCi/g	0.356	0.0173	0.35	0.29 to 0.42
	U-235	0.262	pCi/g	0.0628	0.0214		
	U-238	5.33	pCi/g	0.668	0.0253		
BCK 4.5	U-233/234	2.58	pCi/g	0.342	0.0335	0.37	0.3 to 0.43
	U-235	0.205	pCi/g	0.0544	0.0215		
	U-238	4.91	pCi/g	0.619	0.0355		

3.2 Site Specific Monitoring

3.2.1 Haul Road

The Haul Road was constructed for, and is dedicated to, trucks transporting CERCLA radioactive and hazardous waste from remedial activities on the Oak Ridge Reservation for disposal at EMWMF in Bear Creek Valley. TDEC performs weekly walk over surveys of the different segments of the nine-mile road and associated access roads. Anomalous items noted are surveyed for radiological contamination, documented, and their description and location submitted to DOE for disposition. During 2015, thirteen items were documented. None of the items exhibited radioactivity in excess of free release limits and all were removed expeditiously after being reported to DOE.

3.2.2 EMWMF

3.2.2.1 Monitoring Liquid Effluents, Surface Water, Groundwater

Task 1

TDEC recorded water quality parameters twice weekly at EMWMF-2 (underdrain) and EMWMF-3 (outfall) stations using a YSI© Professional Plus multi-parameter water quality instrument. Table 3.2.2.1.1 provides a summary of the data recorded at the two sites with the YSI© Professional Plus. Results are shared in the text below.

Table 3.2.2.1.1 2015 Data Summary of Water Quality Parameters Measured

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
EMWMF-2 UNDERDRAIN													
pH	high	6.8	6.6	6.54	6.64	6.63	6.45	6.74	6.97	6.64	6.67	6.66	6.55
	low	6.22	6.56	6.34	6.35	6.24	6.05	6.34	6.35	6.17	6.14	6.44	6.44
	avg	6.56	6.58	6.44	6.42	6.4	6.29	6.48	6.49	6.44	6.42	6.56	6.55
DO	high	6.29	7.83	5.6	4.84	4.51	4.28	4.9	1.67	2.97	5.18	3.95	4.58
	low	4.87	5.75	3.06	3.32	1.95	1.06	1.31	1.35	1.09	0.59	2.53	2.55
	avg	5.69	6.67	4.26	3.9	3.02	2.15	2.23	1.48	1.75	2.68	3.6	3.6
COND	high	573	531	569	578	548	523	601	540	517	522	520	654
	low	400	506	534	539	519	497	523	513	497	492	497	532
	avg	524	516	552	562	535	511	559	523	506	507	507	583
TEMP	high	15	15.3	15.8	16.9	16.9	17.6	18.2	18.2	18.5	18.3	17.9	17.3
	low	14.1	13.6	14.7	15.5	16.1	16.9	17.4	18	18	16.7	15.9	15.8
	avg	14.5	14.5	15.3	16	16.6	17.3	17.8	18.1	18.2	17.8	17	16.4
ORP	high	313.4	275.1	279.4	303.8	2775.8	288.3	280.4	266.7	384.2	312.6	344.8	394.8
	low	198.1	206	117.4	179.1	189.5	166.7	196.5	197.7	179.8	225.2	283.7	253.8
	avg	239.7	246.7	222.3	227.8	222.2	226	248.3	234	264.5	252	319	325.9
Visits		7	4	7	8	7	8	8	8	7	7	6	7
EMWMF-3 OUTFALL													
pH	high	8.15	8.29	8.43	8.91	8.94	7.68	8.29	8.14	8.49	8.35	9.25	8.63
	low	6.61	7.94	7.73	7.49	7.33	7.36	7.61	7.41	7.41	7.12	7.61	7.95
	avg	7.28	8.08	8	7.99	8.22	7.54	7.99	7.74	7.88	7.68	8.19	8.26
DO	high	14.17	14.62	13.3	9.89	9.24	6.17	7.25	7.26	7.16	9.7	12.61	12.63
	low	12.24	12.62	8.64	7.91	3.87	2.4	4.59	5	5.8	6.07	7.95	8.96
	avg	13.27	13.69	10.23	8.65	6.85	4.92	6.13	6.18	6.42	8	10.07	10.7
COND	high	554	641	854	867	894	726	469	681	569	560	438	435
	low	157	554	257	234	377	293	159	319	325	278	207	147
	avg	386	608	530	460	713	408	300	520	494	421	334	314
TEMP	high	6.8	7.4	18.3	20.8	26.1	25	31.1	28.5	28.9	22.1	19.8	15.2
	low	3	4	8.5	15.4	21.2	21.3	24.9	23.9	22	13.6	6.4	8.2
	avg	5	5.6	13.6	18	23.9	23.3	28.7	26.5	24.7	18.4	13.5	11.3
ORP	high	292.2	295.1	267.3	267.1	240.6	258.2	219.7	249.7	289.6	333.5	295.9	318
	low	187.3	188.8	145.2	116.8	184.3	185.3	146.8	178.3	165.2	188.4	217.7	204.5
	avg	229.4	234.8	197.6	196.9	203.2	228.6	198.4	212.3	214.7	263	261.8	264.9
Visits		7	4	4	8	7	6	8	8	7	8	7	7

DO – Dissolved Oxygen; COND – Specific Conductivity; TEMP – temperature; ORP-Oxidation Reduction Potential

EMWMF-2

The pH was relatively constant. The DO dropped a little during the summer and fall seasons as expected with slightly higher temperatures. The conductivity kept a consistent average. 2015 data was consistent with the 2014 data.

EMWMF-3

The pH was relatively constant throughout the year. The pH was found to be above the release criteria (>9) during one monitoring event in November. EMWMF personnel checked the pH and found it to be below nine. No other instances of high pH were observed during monitoring events. The DO dropped as the temperatures rose during the weather cycle. Conductivity displayed small spikes throughout the year. No correlation to conditions was determined. Overall conductivity numbers increased in 2015.

Continuous monitoring utilizing the In-Situ® multi-parameter water quality data logger was used at EMWMF2 (underdrain) and EMWMF-3 (sediment basin outfall). Results are shared in the text and graphs below.

EMWMF-2 (underdrain)

The parameters monitored with the In-Situ® multi-parameter water quality data logger were temperature, pH, DO, specific conductivity, water surface height (calculated to discharge), and turbidity (Figure 3.2.2.1.1). Monitoring was performed to determine the integrity of the liners of the disposal cells. Any leaks in the liner should have displayed changes (whether gradual or sudden) to pH, DO, specific conductivity, and possibly discharge. Monitoring the discharge in conjunction with the surrounding groundwater levels should help determine the long term effectiveness of the underdrain.

Temperature

There is a diurnal cycle (a regular 24 hour daily cycle) with the data. This fluctuation is due to the fact that the underdrain is monitoring groundwater discharge, which is being exposed to atmospheric conditions at the discharge point. There is a gentle temperature increase beginning in March continuing to early October. In October, the temperature is slightly decreasing. This gentle temperature change is expected and is seasonal.

pH

The pH data has a slight diurnal cycle. Generally, the groundwater pH was between 6.3 to 6.8 standard units. The only noted peaks with the pH data were associated with a sizeable precipitation event. These pH spikes are thought to be the result of surface water runoff.

Dissolved Oxygen

Dissolved oxygen has a slight diurnal cycle that varies with temperature. As the temperature decreases, more oxygen can be dissolved in solution. The DO probe appeared more sensitive to temperature and this could be due to the limited water column above the probe. Groundwater typically has low DO values. The spikes in DO were associated with the groundwater runoff during precipitation events. The lowest DO values were consistently recorded from June through September.

Specific Conductivity

Specific conductivity varies based on the length of time the groundwater is exposed to stratigraphic units (rock formations). The specific conductivity values at the underdrain indicate a recessional curve after several major rain events. When there was a recessional curve, there was a lag before higher conductivity values peaked for the rain events. This higher conductive groundwater (older water) is being displaced from the infiltration of fresh rainwater in the hours following the precipitation event; however, there are several other rain events with no observed recessional curve. It is possible that during the dry period, the rainwater percolated into storage and did not displace the older formation water. The low specific conductivity values suggest that some surface water during rain events backs up into the underdrain.

Turbidity

EMWMF-2 is near surface water runoff, open to the atmosphere, and shallow. During all rain events, initial placement of the YSI© Professional Plus water quality meter, and servicing of the data logger, the turbidity values were anomalously high. The highest values do suggest that some surface water during rain events backs up into the underdrain. All other turbidity readings were consistently below 10 NTUs.

Discharge

There is a V-weir associated with EMWMF-2. The discharge was fairly constant, with some increase during wetter periods. There were slight recessional curves noted with the discharge data with major precipitation events. For December 6, there was a 6-hour lag before the highest flow rate was observed. The largest discharge peaks observed in Figure 3.2.2.1.1 were associated with precipitation events and water entering EMWMF-2 from surface water runoff.

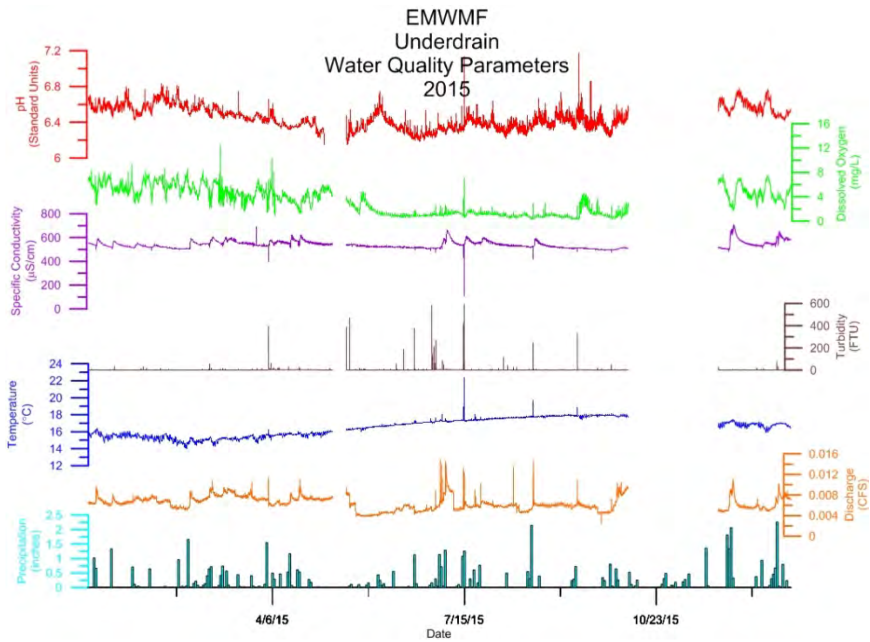


Figure 3.2.2.1.1 Water Quality Parameters (temperature, pH, DO, specific conductivity, discharge, and turbidity) and precipitation at EMWMF-2

C –Centigrade; **mg/L** – milligrams per liter; **µS/cm** – microSiemens per centimeter; **NTU** - nephelometric *turbidity units; CFS – cubic feet per second*

EMWMF-3 (V-weir)

The parameters monitored (see Figure 3.2.2.1.2) with the In-Situ® multiparameter water quality data logger at EMWMF-3 from March 17 to December 31 were temperature, pH, DO, specific conductivity, water surface height (calculated to discharge), and turbidity.

Temperature

Along with the daily surface water temperature fluctuation, seasonal temperature fluctuations were observed. Increased surface water temperatures were expected for the impoundment. The shallow surface water is affected by the ambient air temperatures. Surface water temperature increase was observed during April through September 2015, which correlated to the ambient air temperature increase for 2015. The daily temperature fluctuations (diurnal cycle) were subdued during times when the flow at the V-weir stopped.

pH

The pH data has a pronounced diurnal cycle. The pH data can vary with temperature. Generally, the surface water pH during times of discharge varied between 6.94 and 9.35 standard units, with the average pH around 8.078 standard units. Four times during the year, flow ceased at the V-weir. During the no flow times, the water remaining in the covered V-weir structure and pH settled to a base pH ranging from seven to 7.5 standard units. The pH was observed above 9.0 standard units at the V-weir during discharges 31 times, which was less than last year. During the day, underwater photosynthesis exceeds respiration, so pH rises as carbon dioxide is extracted from the water. As the sun begins to set, photosynthesis decreases and eventually stops, so pH falls throughout the

night as respiring organisms add carbon dioxide to the water. The daily interplay of respiration and photosynthesis caused pH to cycle up and down during a 24-hour period. Extended episodes of high pH are particularly common in ponds where filamentous algae dominate the plant community. High pH in aquiculture ponds appears to occur more frequently and with greater severity in waters with low total hardness and moderate to high total alkalinity (Tucker and D'Abramo, 2008). These 31 discharges were above the stormwater release criteria.

Dissolved Oxygen

Dissolved oxygen (DO) has a diurnal cycle and it varies with temperature. Generally, as the temperature decreases, more oxygen is dissolved from the atmosphere to the surface water; however, at the sediment basin, DO increases as temperature increases. The observed DO increase is due to biological (photosynthesis) or rapid non-laminar flow conditions. The lower levels of DO are probably associated with the elevated atmospheric and water temperatures. The higher observed DO readings during the day support the conclusion about the observed pH issue being biological in nature.

Specific Conductivity

Specific conductivity has a slight diurnal cycle; the warmer the water, the more ions in solution. The graph shows this fluctuation with temperature. There were also changes in conductivity due to significant rain events, the length of time the water was exposed to soil in the sediment basin, and the origin of the surface water (contact water pond discharge or precipitation).

Turbidity

There were several peaks in the graph for turbidity confirmed with visual observations. There is not a release criterion for turbidity. The data logger recorded turbidity values above 280 NTU several times. Reviews of EMWMF stormwater measures were initiated at the site after several heavy rain events to ensure best management practices were functioning as designed.

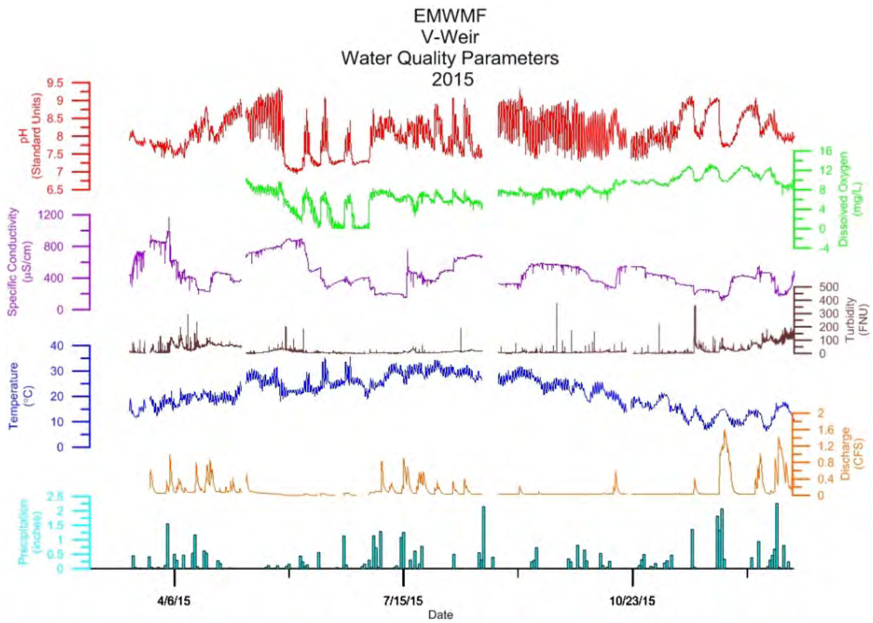


Figure 3.2.2.1.2 Water quality parameters (temperature, pH, DO, specific conductivity, discharge, and turbidity) and precipitation at EMWMF-3

C –Centigrade; **mg/L** – milligrams per liter; **µS/cm** –microSiemens per centimeter; **NTU** - nephelometric *turbidity units; CFS – cubic feet per second; in – inches.*

Discharge

Discharge at EMWMF-3 corresponded with precipitation events, contact water ponds/contact water tank discharges, and uncontaminated stormwater discharges. The parameters of discharge, pH, DO, and turbidity indicate potential issues at EMWMF-3, particularly with biological activity (high pH and DO) and surface water runoff (high turbidity). Algal blooms or mats have the potential to increase the pH above the release criteria at EMWMF-3.

Task 2

To ensure contaminants from the cell are not adversely affecting the surrounding environment, sediment samples from the sediment basin and water samples from monitoring locations connected with EMWMF were collected to determine if levels leaving the facility are over previously established limits or if nearby tributaries have potentially been affected by processes associated with EMWMF.

Radiological Sediment Samples

In 2015, three sediment samples were collected from different locations within the sediment basin on the same day. Samples are collected to determine if any deposition of radiological contaminants has occurred in the sediment basin. Two sediment samples were collected in 2013 and two sediment samples were collected in 2012. The results of this data are shown in Table 3.2.2.1.2. Data from the past three years are shown for comparison. Samples were analyzed for gross alpha, gross beta, strontium-90, total uranium, and technetium-99. Data points to an upward trend of gross beta and technetium-99 specifically. The sediment basin last had sediment removed in 2011. The sediments were placed in cell 5.

Table 3.2.2.1.2 EMWMF Sediment Basin Sample Results

Station ID	Date	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Technetium-99 (pCi/g)	Strontium-90 (pCi/g)	Total Uranium (pCi/g)
SB-1	6/22/2012	5.53	5.9	1.22	0	2.8
SB-2	9/14/2012	5.73	11.8	1.54	0.53	4.27
SB-1	9/19/2013	19.5	36.2	0.56	0.42	19.32
SB-2	9/19/2013	14	24.4	0.45	0.73	23.25
SB-1	6/7/2015	9.4	117.4	34.6	-0.06	14.82
SB-2	6/7/2015	14.4	311	49.2	0.56	27.17
SB-3	6/7/2015	19.3	171	20.5	0.4	12.78

pCi/g - picoCuries per gram

Radiological Water Samples

Five location groupings were consistently sampled at EMWMF. The samples were analyzed for radionuclides. The analyses varied and included gross alpha, gross beta, gamma, strontium-90, technetium-99, tritium, and isotopic uranium.

EMWMF-1 (GW-918)

Two samples were collected at the background location, EMWMF-1. This location was co-sampled during the quarterly groundwater sampling events for EMWMF-1 at GW-918. The samples were analyzed for gross alpha, gross beta, gamma radionuclides, strontium-90, technetium-99, isotopic uranium, and tritium. Results are shown in Table 3.2.2.1.3. 2014 data is shown for comparison.

Table 3.2.2.1.3 EMWMF-1 (GW918) Sample Results

Date	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Strontium-90 (pCi/L)	Technetium-99 (pCi/L)	Total Uranium (pCi/L)	Tritium (pCi/L)
2/18/2014	0	0	0.37	0.55	0.145	0
5/14/2014	0	0	0.23	2.86	0.154	139
8/13/2014	1.95	13.3	-0.26	0.49	0.103	0
2/25/2015	-0.02	6.8	0.58	0.17	0.71	-13
8/11/2015	0.61	1.5	-0.34	0.02	0.045	58

pCi/L - picoCuries per liter

EMWMF-2 (Underdrain Discharge)

Ten samples were collected at EMWMF-2. The samples were analyzed for technetium-99, tritium, strontium-90, and isotopic uranium. The sample results are presented in Table 3.2.2.1.4. While the levels do not raise a health concern/risk, the presence of Tc-99 activity as well as uranium will be watched closely for upward trends and potential seeps in the liner. Tc-99 values have come down since 2014 while total uranium numbers remain statistically neutral.

Table 3.2.2.1.4 EMWMF2 (Underdrain Discharge) Sample Results

Date	Technetium-99 (pCi/L)	Tritium (pCi/L)	Strontium-90 (pCi/L)	Uranium (pCi/L)
1/13/2015	0.69	38	0.218	0.42
2/4/2015	0.14	-56	0.18	0.53
4/9/2015	-0.25	3	-0.38	0.695
5/7/2015	0.06	36	-0.06	0.59
6/11/2015	0.38	-10	0.21	0.447
7/20/2015	-0.12	4	-0.05	0.468
8/6/2015	-0.17	54	-0.26	0.409
10/1/2015	0.16	71	0.9	0.318
11/10/2015	0.61	50	0.12	0.356
12/1/2015	0.16	57	pending	0.841
2014 avg	0.95	81.3	0.78	0.438
2013 avg	0	102	0.47	0.59

pCi/L - picoCuries per liter

EMWMF-3 (Sediment Basin Discharge)

Ten samples were collected at EMWMF-3. The samples were analyzed for gross alpha, gross beta, strontium-90, technetium-99, isotopic uranium, and tritium. The sample results are presented in Table 3.2.2.1.5. The results at EMWMF-3 were elevated in all the analyses indicating, some radionuclides are being discharged at EMWMF-3. Compared to the 2014 average, alpha and Sr-90 decreased while beta, Tc-99, total uranium and tritium increased.

Table 3.2.2.1.5 EMWMF-3 Sample Results

Date	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Strontium-90 (pCi/L)	Technetium-99 (pCi/L)	Total Uranium (pCi/L)	Tritium (pCi/L)
1/13/2015	0.37	48.3	0.48	34.3	2.4	183
2/4/2015	29.5	1009.8	0.8	1234	82.4	859
4/9/2015	13.02	108	0.26	85.8	22.39	846
5/7/2015	12.2	390	1.58	393	35.85	1460
6/11/2015	7.75	77.7	0.79	62.7	15.44	90
7/20/2015	4.04	88.6	-0.22	81.2	7.18	447
8/6/2015	0.54	312.5	0.66	327	12.37	1639
10/1/2015	-4.23*	334.8	1.9	0.47	6.56	706
11/10/2015	4.15	44	0.51	33.1	7.1	577
12/10/2015	13.4	82.2	pending	63.4	2.78	1059
2014 avg	12.99	85.34	2.47	64.8	12.04	276

pCi/L - picoCuries per liter
avg. - average

DOE Order 5400.5 establishes DCGs for radionuclides in process effluents (Table 3.2.2.1.6), which are used as reference concentrations for conducting environmental protection programs. Per DOE agreement with TDEC, annual average (sum of fractions) SOF calculations for stormwater discharge into Bear Creek are based on 25% of the 100 millirem per year DCG specified under DOE Order 5400.5, which corresponds to an SOF of 1.042. In addition to the TDEC limit for SOF, a modified annual average sum of fractions of 0.625 serves as the environmental as low as reasonably achievable (ALARA) goal for EMWMF. The stormwater SOF is calculated each calendar year using radiological COC results reported for monthly surface water, monthly stormwater, other stormwater, quarterly surface water, and miscellaneous surface water samples collected at the discharge point of the EMWMF stormwater retention and sedimentation ponds. The annual stormwater sum of factions result is 0.42, and is within compliance with the TDEC limit of 25 millirem per year (mrem/yr) specified under TDEC Rule 0400-20-11-.16.

Table 3.2.2.1.6 Derived Concentration Guides (DCGs) For Selected Isotopes

Isotope	DCG (100 mrem/year)	¼ of DCG (25 mrem/year)
Tritium	2,000,000 pCi/L	500,000 pCi/L
Strontium-90	1,000 pCi/L	250 pCi/L
Technetium-99	100,000 pCi/L	25,000 pCi/L
Uranium-234	500 pCi/L	125 pCi/L
Uranium-235	600 pCi/L	150 pCi/L
Uranium-238	600 pCi/L	150 pCi/L

pCi/L - picoCuries per liter
DCG - Derived Concentration Guides
mrem/yr - millirem per year

EMWMF-4/4B (uncontaminated stormwater discharge)
Five samples were collected at EMWMF-4/4B. The samples were analyzed for gross alpha, gross beta, strontium-90, total uranium, technetium-99, and tritium. The sample results are presented in Table 3.2.2.1.7. EMWMF-4/4B discharges rainwater collected in cell 6, which is currently inactive. This location is subject to the release criteria shown in Table 3.2.2.1.6, as it is discharged to EMWMF-3. The samples at EMWMF-4/4B did not exceed the release criteria.

Table 3.2.2.1.7 EMWMF-4/4B Sample Results

Date	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Strontium-90 (pCi/L)	Technetium-99 (pCi/L)	Total Uranium (pCi/L)	Tritium (pCi/L)
3/9/2015	-0.16	4.2	0.31	0.6	0.317	-41
4/21/2015	0.14	1.3	-0.5	0.19	0.427	44
7/9/2015	0.01	-1.3	2.7	0.46	0.155	-12
10/8/2015	-0.28	5.8	0.026	-0.27	0.313	59
12/1/2015	-0.14	6.8	pending	0.15	1.111	-23

pCi/L - picoCuries per liter

Surface Water Runoff

Three samples were collected at tributaries NT-3A, NT-4 and NT-5. The samples were analyzed for gross alpha, gross beta, strontium-90, technetium-99, isotopic uranium, and tritium. The sample results are presented in Table 3.2.2.1.8. The results from the tributaries do not indicate a concern at this time. TDEC will continue to monitor the tributaries for changing conditions. This location is subject to the release criteria shown in Table 3.2.2.1.9. The surface water runoff enters Bear Creek.

Table 3.2.2.1.8 Surface Water Results

Station ID	Date	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Strontium-90 (pCi/L)	Technetium-99 (pCi/L)	Total Uranium (pCi/L)	Tritium (pCi/L)
NT-3A	4/2/2015	1.46	1.8	37	-0.36	0.09	77
NT-4	4/2/2015	1.54	8.1	-0.34	-0.66	1.989	44
NT-5	4/2/2015	0.72	5.3	0.23	-0.19	0.409	47

pCi/L - picoCuries per liter

Table 3.2.2.1.9 Stormwater Monitoring Criteria

Parameter	Release Criteria Level*
5-day Biological Oxygen Demand	40 mg/L
Total Suspended Solids (TSS)	110 mg/L
Ammonia as Nitrogen	0.2 mg/L
Oil and Grease	30 mg/L
pH	6.0-9.0 (standard units)
Gross Alpha	15 pCi/L
Gross Beta	50 pCi/L
Radiological COCs	25% of Nuclide specific DCG from DOE Order 5400.5

*Safe Drinking Water Act, TDEC 0400-40-03-.03[3(g)] and 0400-20-11-.16

mg/L - milligram per liter

pCi/L - picoCuries per liter

COCs - contaminant of concern

DCG - Derived Concentration Guides

DOE - Department of Energy

Contact Water Pond / Tank samples

Three samples were collected at the contact water ponds or contact water tanks. The samples were analyzed for gross alpha, gross beta, strontium-90, technetium-99, isotopic uranium, and tritium. The radionuclide sample results are presented in Table 3.2.2.1.10. The results from the contact water ponds or contact water tanks are elevated for gross alpha, gross beta, strontium-90, technetium-99, uranium, and tritium compared to background. Contact water was either disposed of at the ORNL Process Waste Treatment Facility or was discharged to the sediment pond. The release criteria for uranium from the contact water is 480 pCi/L. All contact water pond samples met or were conditioned to meet the release criteria and were discharged to the sediment pond. The sediment pond discharge then follows the procedures discussed for EMWMF-3.

Table 3.2.2.1.10 Contact Water Pond Sample Results

Station ID	Date	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Strontium-90 (pCi/L)	Technetium-99 (pCi/L)	Total Uranium (pCi/L)	Tritium (pCi/L)
CWP-4	3/26/2015	11.3	1250	pending	1065	139.7	2989
CWP-3	5/5/2015	27.3	532	0.84	386	76.48	1735
CWP-1	7/16/2015	5.56	321	77	255	18.85	1350

pCi/L - picoCurie per liter
Pending - Data not available from the Laboratory

Task 3
Groundwater elevations and specific conductivity values recorded for each well are provided in Figures 2.2.2.1.3 and 2.2.2.1.4, respectively. Water elevation, temperature, and specific conductivity at each well are subsequently graphed and discussed by well. Figure 2.2.2.1.2 shows the complex hydrogeologic setting in the vicinity of EMWMF.

Water level elevations progress in order from the highest in the well most up-gradient (GW-918) to lowest in the well most down-gradient (GW-922). A consistent upward gradient is confirmed in well pair GW-917/GW-927. The conductivity pattern in well GW-917 is different from other wells (more variability). Conductivity values on average range from over 1000 microsiemens/cm (µS/cm) at GW-952 to approximately 110 µS/cm at GW-918.

Task 4
On a bi-weekly basis TDEC visits EMWMF to perform general monitoring of the site. In addition to measuring water parameters, collecting water samples/sediment samples and data logger acquisition, TDEC monitors the water levels in the contact water ponds/tanks, notes discharges and water condition, observes the condition of the sediment basin and notes daily activity of the cell. Any concerns are brought to the attention to EMWMF personnel. Field notes are recorded and events reported in the monthly report.

Water samples were collected from the sediment basin outfall and analyzed for chrome. The results were zero.

EMWMF personnel performed erosion control measures on site to reduce potential loading into Bear Creek. Of note was the addition of concrete at the underdrain stairs to eliminate an erosion control problem.

A tear occurred in the liner in cell 5. EMWMF personnel responded promptly by covering the area and limiting access until proper materials and expertise could be obtained and repairs performed.

There was a notable positive difference in the appearance of water discharged from EMWMF 4/4B. EMWMF personnel have made an effort to remove clays and allow particles to settle out prior to discharge.

TDEC will continue to monitor and note concerns to EMWMF personnel.

Task 5

Due to state and EPA concerns with shallow groundwater at EMWMF, DOE agreed to maintain a 10-foot geologic buffer between the EMWMF liner and the groundwater table [based on TDEC Rule 1200-01-07(c), now 0400-11-01-.04(4)] and emplace a contingency plan to be implemented should groundwater intrude into the buffer. The contingency plan was implemented in 2003, resulting in the construction of the underdrain reestablishing the drainage previously provided by the NT-4 channel prior to it being filled. Currently, DOE contractors take quarterly water level measurements at thirty-two wells and piezometers at the site to assess the height of the water table. To evaluate EMWMF monitoring, this data is reviewed as it becomes available and used to model the potentiometric surface of the water table beneath the facility relative to the bottom of the geologic buffer. Historical data collected by DOE indicates a potential for incursion of groundwater into the geologic buffer. Discussions with DOE, EPA, and TDEC are ongoing to determine extent and identify next steps.

3.2.2.2 Monitoring of Waste using a Portal Monitor

Over the 70 years since the ORR was established, a variety of production and research activities have generated numerous radioactive wastes, most of which are eligible for disposal at EMWMF. Contaminants include activation and fission products from isotope production facilities, reactor operations, and nuclear research at the ORNL; and uranium (U), technetium-99 (Tc-99), and associated radionuclides generated by uranium enrichment operations and the manufacturing of nuclear weapons components at K-25 and Y-12 respectively. As these radionuclides decay, they emit one or more types of ionizing radiation. Ionizing radiation is any form of radiation that has enough energy to knock electrons out of atoms or molecules, creating ions. Of these, three are most often considered of concern at EMWMF: alpha (large positively charged particles), beta (smaller negatively charged electrons), and gamma/x-rays (small packets of energy called photons). Due to their size, weight, and charge, alpha and beta particles tend to interact with nearby atoms over short distances. Consequently, alpha and beta radiation are easily shielded and would not be expected to penetrate the steel side walls of truck beds carrying waste into EMWMF for disposal or, to a large degree, the waste itself. Gamma radiation is pure electromagnetic energy with no mass or charge, capable of traveling long distances through various materials before depleting its energy. The radiation portal monitor is only capable of measuring gamma radiation.

Most radionuclides emit gamma radiation, although the frequency of emissions and associated energies vary, depending on the nuclear characteristics of the particular radionuclide. Radionuclides that are predominately alpha emitters emit gamma less frequently than beta emitters and radionuclides considered pure alpha or beta emitters only give off gamma radiation a small percentage of the time, or not at all. The waste lots disposed of in EMWMF contain mixtures of radionuclides that as a whole emit all three kinds of radiation. Since there are no pure gamma emitters, it is assumed for screening that anomalous increases in gamma measurements are accompanied by increased alpha/beta radiation and concentrations of associated radionuclides. The higher the energy of the gamma emissions, the more likely the gamma photons of any given radioisotope will penetrate through the waste and truck bed to be counted by the portal monitor's

detectors. The higher the frequency of emissions and concentrations of gamma emitting radioisotopes in the waste, the greater the number of counts measured (the count rate).

To a large degree, the mixtures of radionuclides in wastes from the different ORR facilities are characteristic of the primary mission at each site. For example, wastes from ORNL typically include a long list of man-made radionuclides produced by irradiating uranium in reactors, along with their progeny (radionuclides to which they decay). Included in this mix are the most prolific gamma emitters typically found on the ORR (cesium-137, cobolt-60), along with many other radionuclides produced during nuclear reactions. Consequently, ORNL wastes are expected to have higher count rates than the other sites and typically a larger variety of isotopes in the mix. Conversely, uranium isotopes and technetium-99 are the dominate radionuclides in waste from ETTP and Y-12. Uranium isotopes are primarily alpha emitters and technetium-99 is a pure beta emitter. Decay products of uranium are removed during processing of the ore, so only the immediate progeny of the uranium isotopes that grow-in over relatively short time periods are generally present in ETTP and Y-12 wastes (thorium-231, thorium-234, and protactinium-234m). As a result, the count rates are expected to be much lower and anomalies more difficult to detect. When reviewing the results generated by the RPM, TDEC attempts to identify deviations from the norm, which, for the reasons above, change from site to site and from waste lot to waste lot. In most cases, the anomalous results can be resolved based on preliminary information, in others it cannot. In such instances, the results and preliminary information are submitted to TDEC for disposition.

In 2015, no anomalies were noted in any of the wastes delivered from the three ORR facilities, much of which consisted of demolition material from the D&D of the K-27 and K-31 process buildings at ETTP. These facilities housed production facilities for the enrichment of uranium, initially for nuclear weapons and later to fuel commercial and government-owned reactors. In most cases, a large proportion of the demolition waste is clean material mixed with surficial contaminated material during the demolition process. So, the concentrations would be expected to be low, compared to process equipment, which typically contains the higher concentrations of contaminants. While there were no anomalous increases observed in the results, it was noted that in some instances the measurements for ETTP wastes were less than the background measurements reported by the RPM, as well as clean soils carried into the site for fill. The only anomalies observed in the results during 2015 where due to a nuclear density gauge, which contains sealed and shielded cesium-137 and americium-241 sources. The instrument is used to measure compaction of the waste, a requirement to assure stability of the facility over time. The density gauge is not a waste, but a tool transported into EMWMF disposal cells as needed and otherwise stored outside the facility.

3.3 RadNet

3.3.1 Air Monitoring

As seen in Figure 3.3.1.1, the results for the gross beta analysis in 2015 were generally similar for each of the five ORR RadNet monitoring stations and most were similar to the results reported for the Knoxville RadNet air station used as background for comparison. There were some exceptions

to this in 2015, which are seen in Figure 3.3.1.1. The cause of the slightly elevated and slightly lower results is unknown. The general fluctuations that are seen in the results in Figure 3.3.1.1 are largely attributable to natural phenomena (wind and rain) that influence the amount of particulates suspended in the air and, thus, what is ultimately deposited on the filters. The 2015 gross beta results are all below 1.0 pCi/m^3, which is the screening level requiring further analysis.

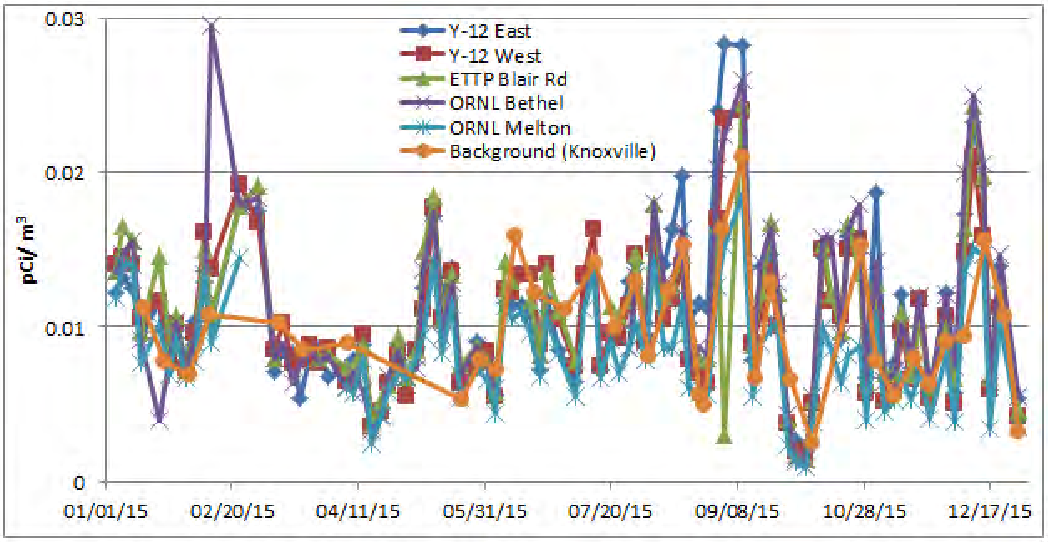


Figure 3.3.1.1 2015 Gross beta results from air samples taken on the ORR in association with EPA's RadNet air monitoring program and background measurements from the RadNet station in Knoxville

Note: This figure is intended to convey the correlation of the results for the various monitoring stations, not to depict individual results. Individual measurements are available at the TDEC Oak Ridge office.

Figure 3.3.1.2 depicts the 2015 average gross beta results for each of the five stations in the ORR RadNet Program, the average background concentration measured at the Knoxville RadNet location, and the CAA environmental limit for strontium-90.

The CAA specifies that exposures to the public from radioactive materials released to the air from DOE facilities shall not cause members of the public to receive an effective dose equivalent greater than 10 mrem above background measurements in a year. For point-source emissions, compliance with this standard is generally determined with air dispersion models that predict the dose at offsite locations. The CAA also provides environmental concentrations for radionuclides equivalent to a dose of 10 mrem in a year (EPA 2010). TDEC uses these concentrations to assess the compliance of the emissions measured with the CAA dose limit.

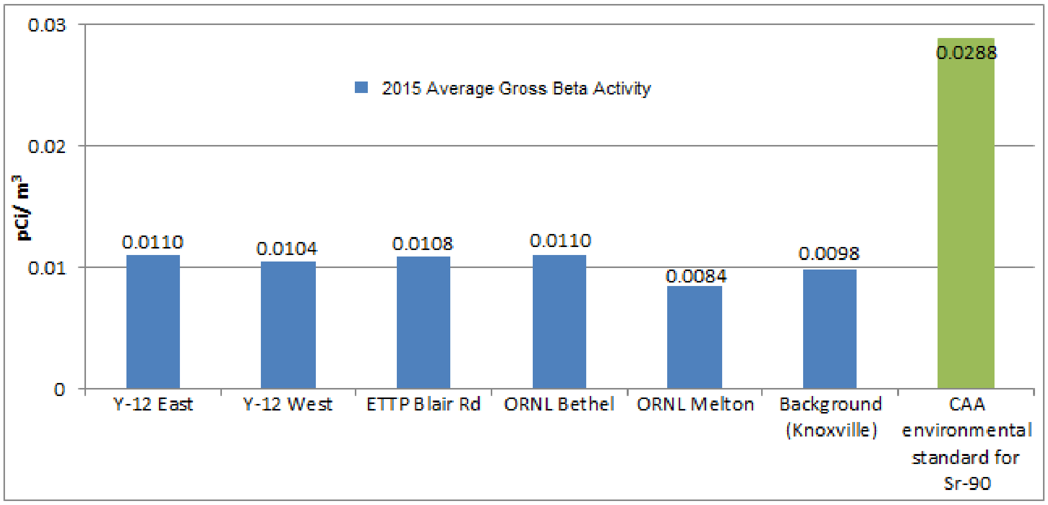


Figure 3.3.1.2 2015 Average gross beta results for air samples taken on the ORR in association with EPA's RadNet air monitoring program

Note: Typical background values for gross beta range from 0.005- 0.1 pCi/m^3 (ORISE, 1993). The standards provided by the Clean Air Act apply to the dose above background; therefore, the standard provided for reference in this figure has been adjusted to include the average of the background measurements taken from the RadNet station in Knoxville for 2015 (CAA value for Sr-90 [0.019 pCi/ m^3] + annual average gross beta at a background location=CAA environmental standard for Sr-90).The CAA's Environmental Limit for strontium-90 is used as a screening mechanism and is provided here for comparison. It is unlikely that this isotope contributes a major proportion of the gross beta activity reported for the samples.

To evaluate the RadNet data, TDEC compares the average gross beta results reported for the program to the CAA limit for strontium-90, which has one of the most stringent standards of the beta-emitting radionuclides. The standards apply to the dose above background, so the limit represented in Figure 3.3.1.2 has been adjusted to include the average gross beta measurement taken at the RadNet station in Knoxville, as a background. It is important to note that strontium-90 is unlikely to be a large contributor to the total beta measurements reported here and is used only as a reference point to determine if further analysis is warranted.

While the 2015 results at all the RadNet air stations are largely comparable (results showed that all sites responded in a similar pattern during each sampling period), the average gross beta results for the RadNet program in 2015 were lower, overall, at the ORNL Melton Valley and Y-12 West locations. The stations with the highest gross beta average for 2015 on the ORR, the Y-12 East and ORNL Bethel Valley locations, were just slightly over that seen at the ETTP Blair Road location. The average results from each of the ORR RadNet monitoring stations fall below the strontium-90 limit (Figure 3.3.1.2).

In 2015, none of the gross beta results reported for the program exceeded the screening level (1.0 pCi/m^3) leading to analysis by gamma spectrometry. The 2013 results for the uranium and plutonium analysis performed on annual composites of the air filters are shown in Table 3.3.1.1, using the RadNet station in Knoxville as the background.

Table 3.3.1.1: 2013 Composite Results for Uranium and Plutonium in RadNet Air (pCi/m^3)

	Y-12 East	Y-12 West	ETTP Blair Rd	ORNL Bethel	ORNL Melton	Background (Knoxville RadNet)	CAA Standard (amount includes background)
Pu238	-7.00E-08	-2.60E-07	-3.00E-08	-2.10E-07	2.60E-07	4.00E-07	4.00E-07
Pu239	3.70E-07	2.60E-07	-8.00E-08	2.10E-07	0.00E+00	3.30E-07	3.30E-07
U234	2.03E-05	4.63E-05	4.32E-05	1.34E-05	5.10E-06	6.10E-06	6.10E-06
U235	1.86E-06	2.00E-06	2.90E-06	1.35E-06	8.10E-07	3.80E-07	3.80E-07
U238	8.20E-06	2.36E-05	1.04E-05	6.50E-06	4.00E-06	6.30E-06	6.30E-06

Note: The colored bars can be used as a quick comparison of results of the same isotope (same color). Negative values are not compared for simplicity's sake.

The annual composite uranium and plutonium values for the five ORR RadNet air stations were compared to the values from the RadNet air station in Knoxville as the background location. The background levels of each isotope seen at the Knoxville location were generally comparable to the composite results seen at the five stations on the ORR. The CAA standard is an amount over background. All values in Table 3.3.1.1 are below the Clean Air Act standards for each isotope.

3.3.2 Precipitation

For 2015, results from gamma spectrometry analysis were available through October. The gamma isotopes for which there were data for the first ten months of 2015 were beryllium-7, cobalt-60, cesium-137, potassium-40, radium-228 and radium-226. For all isotopes except beryllium-7 and one potassium-40 result, the reported results were less than the minimum detectable concentration. As stated in the RadNet User Guide: The Minimum Detectable Concentration (MDC) reflects the ability of the analytical process to detect the analyte for a given sample. The MDC is the activity concentration for which the analytical process detects the radioactive material in a given sample that provides a 95% chance that the radioactive material will be detected.

The average result for beryllium-7 for the three ORR samplers in 2015 was 52.7 pCi/L, compared to an average minimum detectable concentration of 25.6 pCi/L. The national average for the same time period was 46.2 pCi/L. The highest beryllium-7 result for the ORR stations in the first 10 months of 2015, was 93 pCi/L. Beryllium-7; however, is a cosmogenic isotope, formed by the action of cosmic rays on the atmosphere. When compared to the relatively conservative EPA drinking water limit for beryllium-7 of 6,000 pCi/L, the values seen in the monthly composite precipitation samples on the ORR are relatively small.

Overall, the highest values seen for the first ten months of 2015 in the composited monthly precipitation samples for each of the three ORR stations, were all below the MCLs set by the EPA for drinking water. All results for barium-140, cobalt-60, cesium-137, and radium-228 for this time period were less than the minimum detectable concentrations (MDCs). While there are not regulatory limits for radionuclides in precipitation, the comparison to EPA's drinking water limits can be used as a conservative reference value.

3.3.3 Drinking Water

Many radioactive contaminants that are transported off the ORR in surface water enter the Clinch River by way of White Oak Creek, which drains the ORNL complex and associated waste disposal areas in Bethel and Melton Valleys. When contaminants carried by White Oak Creek and other ORR streams enter the Clinch River, their concentrations are significantly lowered by the dilution provided by the river. With exceptions, contaminant levels are further reduced in finished drinking water by conventional water treatment practices used by area water treatment plants. Consequently, the levels of radioactive contaminants measured in the Clinch River and at area water supplies are far below the concentrations measured in White Oak Creek and many of the other streams on the ORR.

Since the Kingston Water Treatment Plant is now the closest water supply downstream of White Oak Creek, this facility would be expected to exhibit the highest concentrations of radioactive contaminants of the four utilities monitored by the ORR RadNet Drinking Water program. Previously, the ETTP Water Treatment Plant, run by the city of Oak Ridge, was the closest water supply downstream of White Oak Creek, but that plant was permanently closed at the end of September 2014. Conversely, the Anderson County facility (located upstream of the Oak Ridge Reservation) would be expected to be the least vulnerable of the facilities to ORR pollutants. The data collected since the Oak Ridge RadNet program began in July of 1996, indicates that this is the case; however, all results for these water treatment facilities have remained below applicable MCL drinking water standards set by EPA (Table 3.3.3.1).

Table 3.3.3.1 EPA Drinking Water Standards (pCi/L)

Isotope	EPA MCL (pCi/L)
Iodine-131 (I-131)	3
Strontium-90	8
Tritium (H-3)	20,000
Cobalt -60	100
Cesium-137 (Cs-137)	200

EPA - Environmental Protection Agency
MCL - National Primary Drinking Water Regulation limits

Tritium results for all four quarters of 2015 were available from the Envirofacts website. These data are similar to the results received in past years. NAREL typically performs tritium analysis on each of the quarterly samples taken at the facilities in the program. Tritium is not readily removed by conventional treatment processes and is one of the most prevalent contaminants discharged by White Oak Creek into the Clinch River. Of the quarterly samples taken in 2015 from each of the four area water treatment plants, all were below the MDC.

The results below the MDC are shown in gray in Table 3.3.3.2. The average MDC for the 2015 quarterly tritium samples was 133 pCi/L and ranged from 120 to 160 pCi/L. Historically, the results of the tritium analyses are often below the MDC. The results for tritium at the drinking water plants monitored since the program's inception range from undetected to 1,000 pCi/L. The drinking water

standard for tritium is 20,000 pCi/L, so even the highest levels of tritium that have been detected by this program in the Oak Ridge area are below this limit.

Since the net tritium results are obtained by subtracting the value of a tritium-free sample from that of the actual sample, negative numbers can be present. For a group of samples with no tritium, the results (positive and negative) should be distributed symmetrically around 0 pCi/L. Negative values are especially useful for unbiased statistical data, but can also be used to get a better picture of the range of results. The same is true for the analysis of other isotopes.

Table 3.3.3.2 Quarterly Tritium Results from the Four Water Treatment Facilities in pCi/L

Utilities	2015 RadNet Drinking Water- Tritium			
	QTR 1	QTR 2	QTR 3	QTR 4
Anderson	-4	-46	-16	-34
Y-12 (OR)	-42	-29	-27	6
West Knox	30	-31	-9	-43
Kingston	58	-12	46	-84

I-131 analysis is performed on one quarterly sample per location each year. I-131 analysis for 2015 was done for the first quarter at each of the four stations. All results were below the MDC for the analytical method used, as seen in Table 3.3.3.3.

Table 3.3.3.3 Iodine-131 Results from the Four Water Treatment Facilities in pCi/L

Utilities		Result	MDC	Units
Anderson	QTR 1	-0.051	0.32	pCi/L
Y-12 (OR)	QTR 1	0.062	0.27	pCi/L
West Knox	QTR 1	-0.01	0.33	pCi/L
Kingston	QTR 1	0.108	0.31	pCi/L

QTR 1 - First quarter
MDC - Minimum Detectable Concentration
Values below the MDC are in gray

Gross alpha, gross beta, gamma, and strontium-90 analyses are performed annually on a composite of the quarterly samples taken from each of the monitored facilities. Results of the 2015 composite analyses are not yet available, as it can be well into the following year before they are able to be composited. The available 2014 annual composite results are noted below.

In 2014, there were no gross alpha results above the sample-specific MDC as seen in Table 3.3.3.4. EPA's drinking water standard for gross alpha in drinking water is 15 pCi/L (MCL). The five samples from 2014 were all below this amount.

Table 3.3.3.4 2014 Annual Gross Alpha Composite Results in pCi/L

Utilities	Result	MDC	Units
Anderson	0.1	2.8	pCi/L
Y-12 (OR)	-0.9	3.3	pCi/L
West Knox	2.7	2.9	pCi/L
ETTP (OR)	0.5	3.2	pCi/L
Kingston	0.9	2.6	pCi/L

MDC - Minimum Detectable Concentration
Values below the MDC are in gray

The 2014 gross beta results are listed in Table 3.3.3.5. The drinking water standard for beta emitters depends on the specific radionuclides present, but radionuclide specific analysis is generally not required at gross beta measurements below 50 pCi/L. While there are no drinking water limits for gross beta, one can use strontium-90 limits as a conservative comparison, although strontium-90 is unlikely to make up a large percentage of the total gross beta result, if any. The gross beta results for the 2014 annual composites from drinking water sampling location near and on the ORR are below EPA's drinking water standard for strontium-90 (limit 8.0 pCi/L).

Table 3.3.3.5 2014 Annual Gross Beta Composite Results in pCi/L

Utilities	Result	MDC	Units
Anderson	2.8	4	pCi/L
Y-12 (OR)	4.3	4.1	pCi/L
West Knox	4.4	4.3	pCi/L
ETTP (OR)	4.4	4	pCi/L
Kingston	4.9	4.3	pCi/L

MDC - Minimum Detectable Concentration
Values below the MDC are in gray

The gamma spectrometry on the annual composites for 2014 showed no values above MDCs. This was the case for cobalt-60 (Co-60), cesium-137 (Cs-137), radium-228 (Ra-228), and potassium-40 (K-40). The MCL for cobalt-60 is 100 pCi/L and the MCL for cesium-137 is 200 pCi/L. The 2014 results were below these EPA drinking water standards and below the sample specific MDCs.

The annual composite analysis for strontium-90 of drinking water samples for 2014 was not yet available at the time this report was written. The data from 2013 are below the minimum detectable concentrations. The highest strontium-90 in 2013 was 0.33 pCi/L (from West Knox). This was below the 8.0 pCi/L EPA drinking water limit for strontium-90.

All samples analyzed from this program for the Oak Ridge area since its inception have been below the associated drinking water standards and often below the minimum detectable concentrations.

4.0 Conclusions

4.1 Oak Ridge Reservation

4.1.1 Radiation Monitoring

4.1.1.1 Ambient Gamma Radiation Monitoring of the Oak Ridge Reservation Using Environmental Dosimetry

Overall, the radiation doses measured in the environmental dosimetry program in 2015 decreased or remained statistically the same as in 2014. A total of eighteen locations exceeded the 100 mrem screening level over the year: seventeen at ORNL and one at SNS. Seven of these sites are located on the main campus of ORNL but are away from the most heavily traveled areas of the facility except for station D-14 (Table 3.1.1.1.7 and Figure 3.1.1.1.7).

4.1.1.2 Real Time Monitoring of Gamma Radiation

Based on the data collected in 2015, the following conclusions were reached.

- EMWMF gamma levels were consistent with background measurements.
- ORNL Central Campus D&D (3000 Area) gamma levels were consistent with background measurements.
- Measurements taken at the MSRE did not indicate any releases during the period. Exposure levels measured during the year have been attributed to a contaminated salt probe stored near the monitor.
- Gamma levels at SNS varied substantially depending on the power level at which the accelerator was operating. During periods that the accelerator was shut down, the gamma rate returned to approximately background levels. The gamma rate is attributed to noble gases being expelled. Members of the public do not have access to the area.

4.1.1.3 Surplus Material Verification

During 2015, no items with elevated levels of alpha and beta radiological contamination requiring further evaluation were discovered during the surveys.

4.1.2 Air Monitoring

4.1.2.1 Fugitive Air Monitoring

During 2015, the results were similar to background. The yearly average concentrations for all sites were below the federal standards.

4.1.3 Biological Monitoring

4.1.3.1 Threatened and Endangered Species Monitoring

Botanical fieldwork remains to be completed on the ORR and all 3,000 acres of the BORCE, particularly to map additional rare habitat and associated plant communities, and to document American chestnut locations and exotic pest-plant invasions. TDEC will continue to report new rare plant findings to the Resource Management Division (RMD, Natural Areas Program and Natural Heritage Inventory Program) and to the TWRA, and provide field support as needed.

4.1.3.2 Acoustic Monitoring of Bats

TDEC monitored 48 sites on the ORR with acoustic detectors through the course of 37 dusk to dawn surveys. Over 226,000 bat call files were collected over 209 survey nights. Approximately 12,567 bats were identified to species; 2,249 were not identified. Threatened and endangered bats were detected at 25 of 48 sites surveyed. Information will be used to facilitate the protection of these species.

4.1.3.3 White-tailed Deer Monitoring

TDEC found that the eight deer for this year's report remained on the ORR, with the exception of Teresa's migration to Jones Island in November 2015. All of the collars retrieved were found on the ORR, often near where the deer was originally captured.

4.1.3.4 Fungi Monitoring in East Fork Poplar Creek

Overall, TDEC collected 147 mushroom/fungi samples during 2015: 51 samples from EFPC plots and 96 control samples. The EFPC mercury result was an order of magnitude greater than the control samples.

4.1.3.5 Fish Tissue Monitoring

Approximately thirty-six fish gut samples were collected during 2015 from ORR and control streams, rivers, and reservoirs by the ORNL ESD fisheries team. Laboratory processing of fish samples was not completed in time to meet the 2015 Environmental Monitoring Report publishing deadline; therefore, these results will be presented in the 2016 Fish Tissue EMR.

4.1.3.6 Aquatic Vegetation Monitoring

The data collected suggests limited areas of elevated radionuclide concentrations in the vegetation associated with surface water on the Oak Ridge Reservation. Areas with previously elevated sampling results will likely continue to be monitored.

4.1.3.7 Benthic Macroinvertebrate Monitoring

The biotic integrity of most impacted streams on the Oak Ridge Reservation is less than optimal compared to reference conditions. Of all sites sampled during 2015, only two locations (EFK 25.1 and EFK 23.4) received the lowest TMI scores and ratings, partially supporting/moderately impaired (TMI equals 10-20, C rating). The reasons for these stations ranking far below reference stations in score are varied. In part, the poor scores are likely due to continuing pollutional inputs from Y-12. Remarkably, three of the impacted stations show scores that favorably compare to those of reference sites. These include BFK 9.6, EFK 13.8, and MEK 0.3. The high ranking of some of the impacted sites and the improvement in others is encouraging and, shows the positive results of the remediation work that has been completed at both Y-12 and ORNL.

4.1.4 Drinking Water

4.1.4.1 Oak Ridge Reservation Potable Water Distribution

The results of the inspections revealed that the three potable distribution systems for the ORR provide water that meets state regulatory levels; however, the potential exists for a cross connection

between the distribution systems and contamination from the surrounding environmental media when breaks/leaks occur in the system. For this reason, emphasis in this program has been shifted away from monitoring of the chlorine in the potable water to oversight and sampling of repairs in the potable water system.

4.1.5 Groundwater

4.1.5.1 Springs

TDEC sampled and analyzed groundwater from selected springs on the ORR and its environs to evaluate water quality. This project sampled springs to collect information on the ambient health of the groundwater on the ORR and along geologic strike to the northeast and southwest.

TDEC compared the results to the EPA's NPDWRs since there are no regulations concerning natural groundwater concentrations of constituents. Five of 27 springs sampled (Table 3.1.5.1.2) contained constituents that exceeded comparable NPDWRs limits. All five springs are located on the ORR. Four of the five springs are located near ETTP. The fifth spring (2015SPGEMP-31), located below EMWMF in Bear Creek Valley, contained six constituents that exceeded the NPDWRs. Results for the springs located off the ORR did not indicate constituents above the NPDWR.

4.1.5.2 Off Site Residential Well Monitoring

Results indicate groundwater southwest of the Clinch River and the ORR above NPDWRs. While it is possible these results could be influenced by naturally occurring elements or radioactive fallout, given the significant sources at ORR, more investigation is warranted.

4.1.6 Surface Water/Sediment

4.1.6.1 Benthic Macroinvertebrate Monitoring Surface Water Component

In Bear Creek, inorganic constituents could, along with the channelized nature of the BCK 12.3, have an impact on benthic macroinvertebrate metrics. In East Fork Poplar Creek, the higher mercury levels at the upstream sampling sites may have an effect on some of the metrics of the benthic macroinvertebrate results. In terms of surface water chemistry affecting benthic macroinvertebrate communities on Mitchell Branch, the role the relatively higher levels of gross alpha and beta activities at MIK 0.71 and MIK 0.45 plays, if any, is unknown. High gross beta activities at the lower White Oak Creek sites may have been a factor in the slightly lower rating, although other factors may enter into the answer to what is causing the rating drop to B.

4.1.6.2 Surface Water Physical Parameters

The continuous monitoring of the physical parameters is providing a baseline of water quality parameters and how they react to changes in precipitation and other inputs along EFPC and Bear Creek. The continuous monitoring of water quality parameters provides an indicator of conditions that may need to be addressed in the future. For the surface water physical parameters data, all samples met TWQC for the parameters observed at the seven monitoring stations on the ORR. The elevated conductivity values observed in Bear Creek are of concern. Legacy DOE ORR pollution has negatively impacted EFPC, Bear Creek, and Mitchell Branch.

4.1.6.3 Surface Water Monitoring

Bear Creek

None of the non-radiological results were greater than the TWQC. In addition, none of the radiological results were greater than DOE PRG goals. Contaminant levels are highest at BCK 12.3 and decrease as Bear Creek flows downstream. It is possible the concentrations are being decreased by dilution as the contaminants travel farther downstream.

East Fork Poplar Creek

Except for mercury, none of the other non-radiological results were greater than the TWQC. Mercury's TWQC limit in surface water is < 0.051 μg/L. This result was expected due to the Y-12 legacy mercury contamination of East Fork Poplar Creek.

Mitchell Branch

None of the non-radiological results were greater than the TWQC. Contaminant levels are lowest at MIK 1.43 and increase as Mitchell Branch flows downstream and enters the contaminated footprint of the ETTP complex.

White Oak Creek and Melton Branch

None of the non-radiological results were greater than the TWQC. In addition, none of the radiological results were greater than DOE PRG goals.

Raccoon Creek

Strontium-89-specific analysis from the samples collected at Raccoon Creek showed activity of 1.02 pCi/L. Radiological data, other than the strontium-89 were similar to reference conditions. Most other non-radiological parameters were similar to reference stream data. Lead was detected at 1.7 μg/l. This is higher than the reference streams but below Tennessee water quality criteria.

Clinch River

There are no concerns about water quality in the Clinch River in terms of nutrients, metals, physical parameters and radiological contamination. Gross alpha radioactivity is slightly higher at the farthest downstream site (CRK 16.10) than the upstream sites, but the activity (1.01 pCi/L) is low. Alpha radiation in water can be in the form of naturally occurring dissolved minerals, or in the case of radon, as a gas. Gross beta is higher at a background sampling site (CRK 126.7) than in the river downstream of the ORR.

4.1.6.4 Rain Event Surface Water Monitoring

Laboratory results indicate certain metals measured are being found at a higher concentration after rain events than during non-rain events. Due to the length of time involved between initial rain commencement and sampling time, the effect of any flushing from drainage pipes can be discounted. Other factors, such as the amount of sediment in the streams, have not been taken into consideration on this project. Future sampling should take into consideration solids in the stream flow, time between first recorded rain fall, and sampling event and rain per hour for event.

4.1.6.5 Ambient Sediment Monitoring

The East Fork Poplar Creek Mile 3.9 sediment mercury value (14 mg/kg) exceeds the PEC of 1.06 mg/kg (MacDonald *et al.* 2000). The mercury in East Fork Poplar Creek and Poplar Creek sediments results from historical activities at Y-12 and to a lesser extent ETTP. Mercury levels are highest at East Fork Poplar Creek km 6.3 and generally decrease downstream. All of the sites sampled on East Fork Poplar Creek and Poplar Creek had mercury values above the PEC.

Historical data obtained from Oak Ridge Environmental Information System (OREIS), along with 2015 TDEC sediment data indicate that, sometime between 2004 and 2008, sediment mercury levels increased significantly at Mitchell Branch km 0.1 (K1700). Similarly, nickel, chromium, boron, and barium concentrations increased during the same time period at this location. These increases, which are below DOE PRGs, may be due to D&D activities at the ETTP site.

All radiological parameters are below DOE PRGs. In 2015, Cs-137 was detected in the Clinch River samples at river miles 14.5, 10.0, 0.0, and in the Mitchell Branch sample. The recreational PRG for Cs-137 is 117 pCi/g (total soil/sediment TR 1.0E-06) (DOE 2013) while the highest Cs-137 value was 1.54 pCi/g at CRM 14.5. Gross beta activity was highest at the Mitchell Branch location (248 pCi/g).

4.1.6.6 Ambient Trapped Sediment Monitoring

The general trend for total mercury at East Fork Poplar Creek shows a decrease in concentration as one moves downstream from Y-12. In 2014, methyl mercury values increased going downstream but in 2015, the trend is reversed with methyl mercury values starting off high at EFK 23.4 and decreasing downstream. All samples from East Fork Poplar Creek exceeded the CBSQGs PEC (1.06 mg/kg) for mercury.

The general trend for some metals (uranium, barium, chromium, and nickel) at East Fork Poplar Creek is to decrease as one travels downstream from Y-12. Arsenic was only detected at EFK 23.4 at 5.1 mg/kg and had non-detects at the two downstream sampling locations. Boron concentrations were similar at all three of the sampling locations and were not at levels of concern (60-77 mg/kg).

Radiological analyses included gross alpha, gross beta, gamma radionuclides, and isotopic uranium. Gross beta values generally showed a decreasing trend downstream with the highest amounts at NT5 on the Bear Creek watershed and EFK 23.4 on East Fork Poplar Creek. All of the gamma radionuclides detected are naturally-occurring in the environment (Pb-212, K-40, etc.). Isotopic uranium analysis suggests enrichment at the NT5 sampling location, which indicates 2.6 to 3.7% U-235 enrichment (Rad Pro Calculator, 2016). NT5 is the main outfall for EMWMF. EMWMF has received waste resulting from ETTP D&D activities in recent years.

4.2 Site Specific Monitoring

4.2.1 Haul Road

During 2015, thirteen items were documented. None of the items exhibited radioactivity in excess of free release limits and all were removed expeditiously after being reported to DOE.

4.2.2 EMWMF

4.2.2.2 Monitoring Liquid Effluents, surface water, groundwater

Task 1

There still are inconsistencies with pH at EMWMF-3. Continuous water quality parameters are important for documenting discharges, changing conditions, and monitoring releases at EMWMF-2 and EMWMF-3.

Task 2

The results from the radiological water samples suggest radionuclides are being discharged from EMWMF-3; however, those discharges are within compliance under TDEC Rule 0400-20-11-.16. TDEC will continue to monitor sediment samples downstream of EMWMF-3 to determine potential impacts to Bear Creek.

TDEC will continue to monitor sediments in the sediment basin to determine if levels of contaminants are increasing to numbers that could cause ecological risks. DOE will be notified of any potential concerns.

Task 3

Water level elevations progress in order from the highest in the well most up-gradient (GW-918) to lowest in the well most down-gradient (GW-922). A consistent upward gradient is confirmed in well pair GW-917/GW-927. The conductivity pattern in well GW-917 is different from other wells (more variability). Conductivity values on average range from over 1000 microsiemens/cm (μS/cm) at GW-952 to approximately 110 μS/cm at GW-918.

Task 4

Water samples were collected from the sediment basin outfall and analyzed for chrome. The results were zero, indicating conditioning efforts by DOE of the contact water ponds are effective. EMWMF personnel performed erosion control measures onsite to reduce potential loading into Bear Creek. Of note was the addition of concrete at the underdrain stairs to eliminate an erosion control problem. EMWMF personnel responded promptly to a tear in the liner of cell 5 by covering the area and limiting access until proper materials and expertise could be obtained and repairs performed. EMWMF personnel have made an effort to remove clays and allow particles to settle out prior to discharge. There was a notable positive difference in the appearance of water discharged from EMWMF 4B. TDEC will continue to monitor and note concerns to EMWMF personnel.

Task 5

TDEC has conducted reviews of the last two PCCRs for EMWMF. Findings indicate DOE has determined from modeled groundwater level data the potential exists for incursion of groundwater into the geologic buffer. Discussions with DOE, EPA, and TDEC are ongoing to determine if this is an issue and identify next steps.

4.2.2.3 Monitoring of Waste using a Portal Monitor

In 2015, most of the waste delivered to EMWMF for disposal was derived from the demolition of uranium enrichment facilities at ETTP. Associated contaminants were primarily uranium isotopes (predominately alpha emitters) and Tc-99 (a pure beta emitter). The radiation levels measured were low. The only elevated results observed were due to a nuclear density gauge that contains sealed and shielded cesium-137 and americium-241 sources used to measure compaction of the waste. The density gauge is not a waste, but a tool transported to the EMWMF disposal cells as needed and otherwise stored outside the facility.

4.3 RadNet

4.3.1 Air Monitoring

The 2015 gross beta results for each of the five RadNet air monitoring stations generally exhibited similar trends and concentrations. The available RadNet data for 2015 do not indicate a significant impact on the environment or public health from ORR emissions.

4.3.2 Precipitation

The first 10 months of 2015 gamma data show results below EPA drinking water limits and often below the minimum detectable concentration for each sample. These data indicate that levels of gamma radiation in precipitation at the three monitored locations are much lower than EPA drinking water limits and therefore can be considered protective of human health and the environment.

4.3.3 Drinking Water

Radioactive contaminants migrate from the ORR to the Clinch River, which serves as a raw water source for area public drinking water supplies. The impact of these contaminants is diminished by the dilution provided by the waters of the Clinch River. Contaminant concentrations are further reduced in finished drinking water by conventional water treatment practices employed by area water treatment plants. Results of samples collected from public water supplies on and in the vicinity of the ORR in association with EPA's RadNet program have all been below drinking water standards, since the inception of the project in 1996.

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Appendix A

Natural Resources Monitoring on the Oak Ridge Reservation and Bat Monitoring Locations and Species Identified

3.1.3.1.2. ORR Flora

Cryptogams (Non-seed, spore-producing plants): Ferns

Figure 9 Hay-scented Fern
Dennstaedtia punctilobula (Michx.) T. Moore 1857

Figure 10 Rock Fern
Polypodium virginianum L. 1753

Figure 11 Maidenhair Fern
Adiantum pedatum L. 1753

Figure 12 Broad Beech Fern
Phegopteris hexagonoptera (Michx.) Fée 1852

Figure 13 Ground Cedar
Lycopodium sp. L. 1753

Figure 14 Shining Club Moss
Huperzia lucidula (Michx.) Trevis. 1875

Figure 15 Lady Fern
Athyrium filix-femina (L.) Roth ex Mert. 1799

Figure 16 Sensitive Fern
Onoclea sensibilis L. 1753

Figure 17 Marginal Wood Fern
Dryopteris marginalis (L.) A. Gray 1848

Figure 18 Rattlesnake Fern
Botrychium virginianum (L.) Sw. 1801

Figure 19 Climbing Fern
Lygodium palmatum (Bernh.) Sw. 1806

Figure 20 Cinnamon Fern
Osmundastrum cinnamomeum (L.) C. Presl 1847

Cryptogams (Non-Seed, Spore-Producing Plants): Fungi

Figure 21 Stalked Scarlet Cup
Sarcoscypha occidentalis (Schwein.) Sacc. 1889

Figure 23 Destroying Angel Mushroom
Amanita sp. Pers. 1794

Figure 22 Devils Urn
Urnula craterium (Schwein.) Fr. 1851

Figure 24 Coral Fungi
Clavaria sp. Vaill. ex L. 1753

Figure 25 Morel Mushroom
Morchella esculenta (L.) Pers. 1801

Figure 26 Bracket (Shelf) Fungi
Polyporales Gäum 1926 (Scientific Order)

Figure 27 Chocolate Slime Mold
Stemonitis fusca Roth 1787

Figure 28 Varnish Bracket Fungi
Ganoderma sp. P. Karst. 1881

Figure 29 Green Elfcup
Chlorociboria aeruginascens (Nyl.) Kanouse ex C.S. Ramamurthi, Korf & L.R. Batra 1957

Figure 30 Bearded-tooth Fungi
Hericium sp. Pers. 1794

Phanerogams—Flowering Seed Plants (Angiosperms / Spermatophytes):

Figure 31 Blue Star
Amsonia tabernaemontana Walter var. *tabernaemontana* 1788

Figure 32 Butterfly Weed
Asclepias tuberosa L. 1753

Figure 33 White Crownbeard
Verbesina virginica L. 1753

Figure 34 Pinxter Flower
Rhododendron periclymenoides (Michx.) Shinners 1962

Figure 35 Cardinal Flower
Lobelia cardinalis L. 1753

Figure 36 Chickory
Cichorium intybus L. 1753

Figure 37 Ginseng (TDEC-listed Special Concern)
Panax quinquefolius L. 1753

Figure 38 Dwarf Larkspur
Delphinium tricorne Michx. 1803

Figure 39 Stonecrop
Sedum sp. L. 1753

Figure 40 Blue Cohosh
Caulophyllum thalictroides (L.) Michx. 1803

Figure 41 Phlox
Phlox sp. L. 1753

Figure 42 Chickweed
Stellaria sp. L. 1753

Figure 43 Hearts-a-Bustin'
Euonymus americanus L. 1753

Figure 44 White Baneberry/Dolls-eyes
Actaea pachypoda Elliott 1821

Figure 45 Early Meadow Rue
Thalictrum dioicum L. 1753

Figure 46 Wind Flower
Thalictrum thalictroides (L.) Eames & B. Boivin 1957

Figure 47 Spring Beauty
Claytonia virginica L. 1753

Figure 48 Trout Lily
Erythronium umbilicatum C. R. Parks & Hardin 1963

Figure 49 Pinesap (saprophyte)
Monotropa hypopithys L. 1753

Figure 50 Indian Pink
Spigelia marilandica L. 1753

Figure 51 Passion Flower
Passiflora incarnata L. 1753

Figure 52 Bee Balm
Monarda didyma L. 1753

Figure 53 Goldenseal
Hydrastis canadensis L. 1753

Figure 54 Large-flowered Trillium
Trillium grandiflorum (Michx.) Salisb. 1805

Figure 55 Pink Trillium
Trillium sp. L. 1753

Figure 56 Red Trillium
Trillium erectum L. 1753

Figure 57 Spotted Mandarin
Prosartes maculata (Buckley) A. Gray 1844

Figure 58 Wood Betony
Pedicularis canadensis L. 1753

Figure 59 Hepatica (Liverwort)
Hepatica acutiloba DC. 1873

Figure 60 Skullcap
Scuttellaria sp. L. 1753

Figure 61 Toothwort
Cardamine sp. (L.) 1753

Figure 62 Red Sessile Trillium
Trillium sessile L. 1753

Figure 63 Dwarf-crested Iris
Iris cristata Sol. ex Aiton 1789

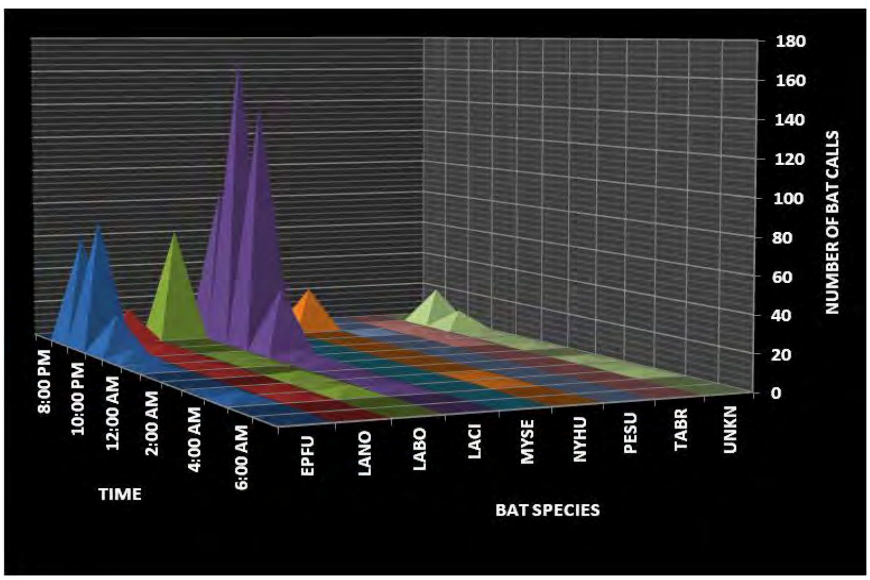
Figure 64 Squaw Corn
Conopholis americana (L.) Wallr. 1767

Figure 65 Lemon Trillium
Trillium luteum (Muhl.) Harb. 1901


Figure 66 Pink Lady Slipper
Cypripedium acaule Aiton 1789

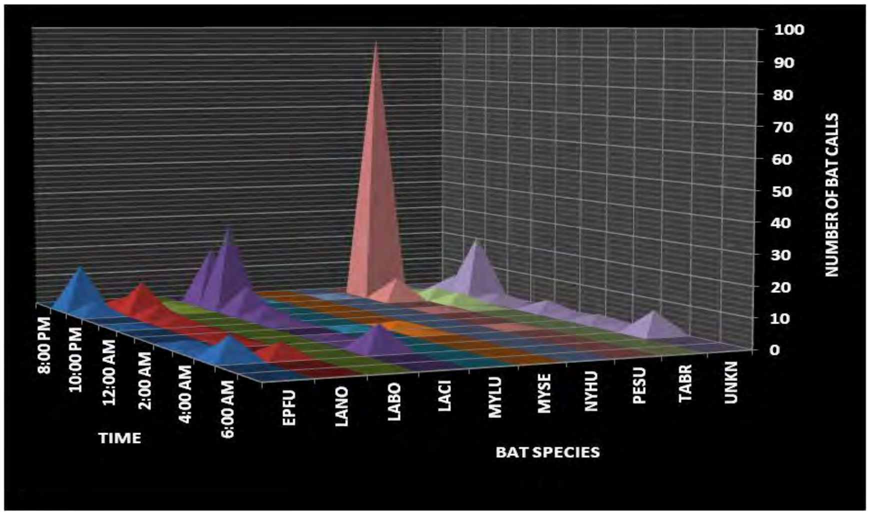
Bat Monitoring Locations and Species Identified

Figure 3.1.3.2.2 Haw Ridge Park acoustic survey map



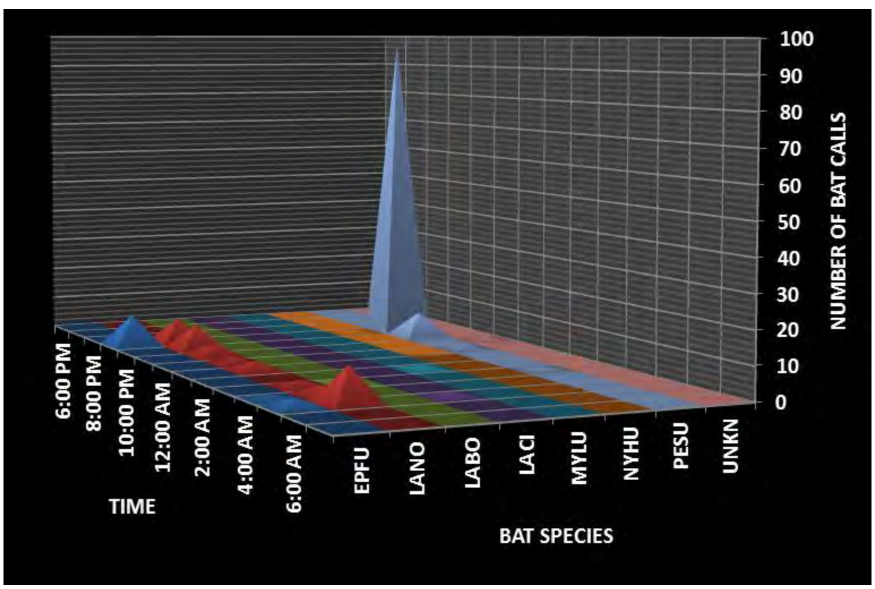
Graph ORR-01: Haw Ridge Park/Red Shore Trail embayment area
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		NYHU	*Nycticeius humeralis*	Evening bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
LABO	*Lasiurus borealis*	Eastern Red bat		TABR	*Tadarida brasiliensis*	Mexican Free-tailed bat
LACI	*Lasiurus cinereus*	Hoary bat		UNKN	Unknown species (bat detected but not identified)	
MYSE	*Myotis septentrionalis* (Threat.)	Northern Long-eared bat				



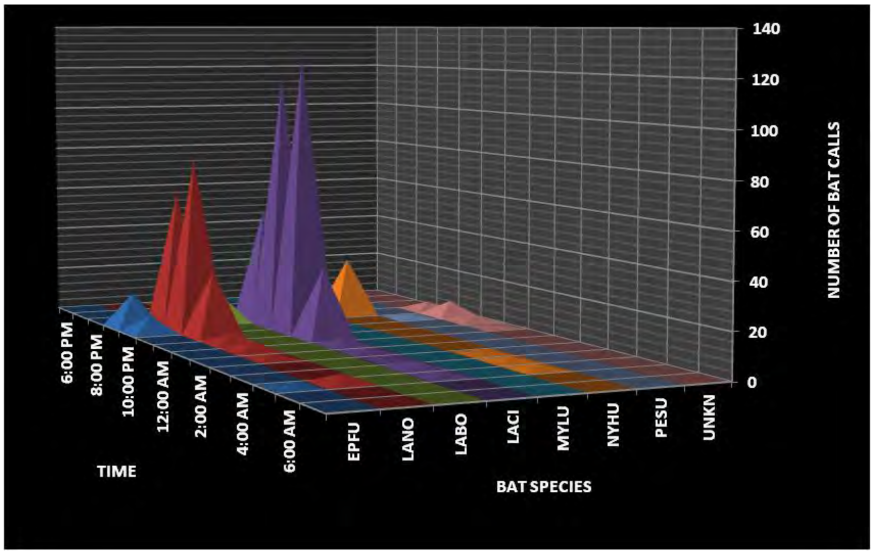
Graph ORR-02: Haw Ridge Park/Red Shore Trail embayment area
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		MYSE	*Myotis septentrionalis* (Threat.)	Northern Long-eared bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		NYHU	*Nycticeius humeralis*	Evening bat
LABO	*Lasiurus borealis*	Eastern Red bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
LACI	*Lasiurus cinereus*	Hoary bat		TABR	*Tadarida brasiliensis*	Mexican Free-tailed bat
MYLU	*Myotis lucifugus*	Little Brown bat		UNKN	Unknown species (bat detected but not identified)	



Graph ORR-03: Haw Ridge Park/Red Shore Trail pond
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		MYLU	*Myotis lucifugus*	Little Brown bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		NYHU	*Nycticeius humeralis*	Evening bat
LABO	*Lasiurus borealis*	Eastern Red bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
LACI	*Lasiurus cinereus*	Hoary bat		UNKN	Unknown species (bat detected but not identified)	



Graph ORR-04: Haw Ridge Park/East Shore Trail embayment (number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		MYLU	*Myotis lucifugus*	Little Brown bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		NYHU	*Nycticeius humeralis*	Evening bat
LABO	*Lasiurus borealis*	Eastern Red bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
LACI	*Lasiurus cinereus*	Hoary bat		UNKN	Unknown species (bat detected but not identified)	

Bethel Valley (ORNL)

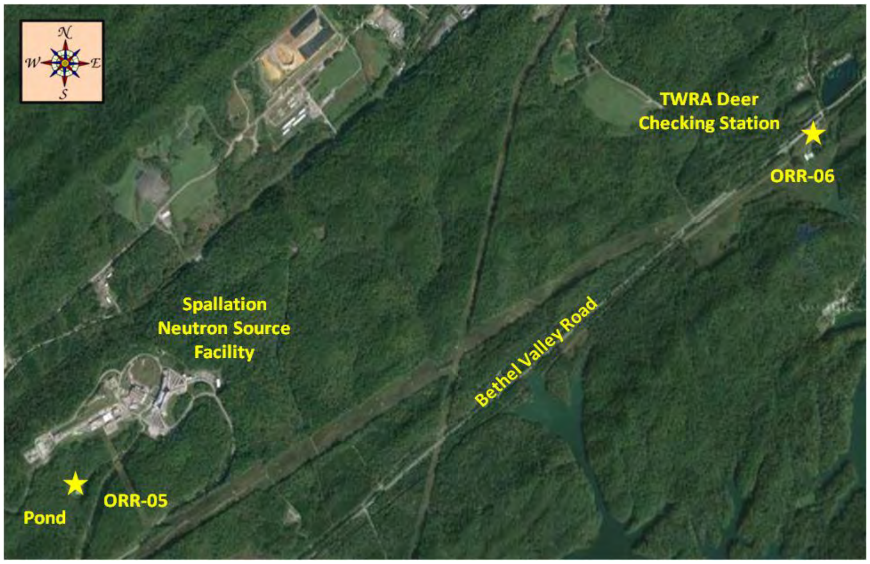
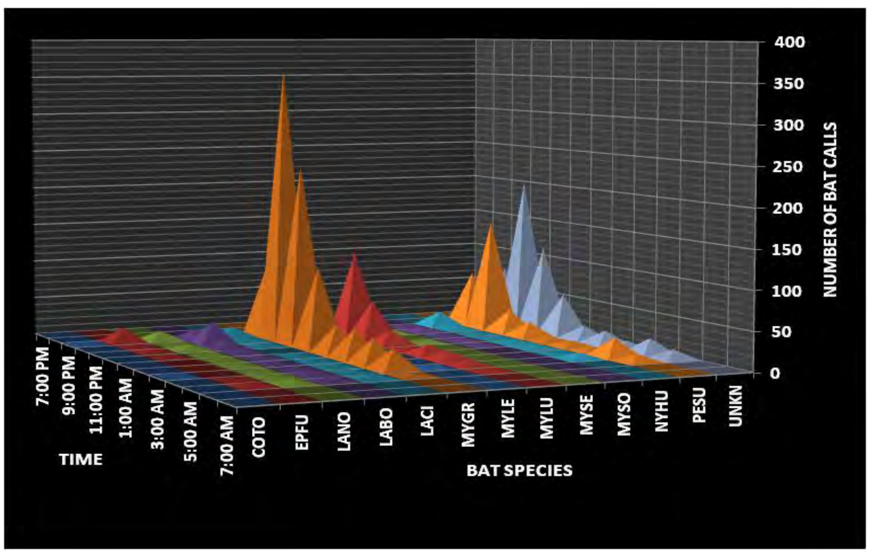
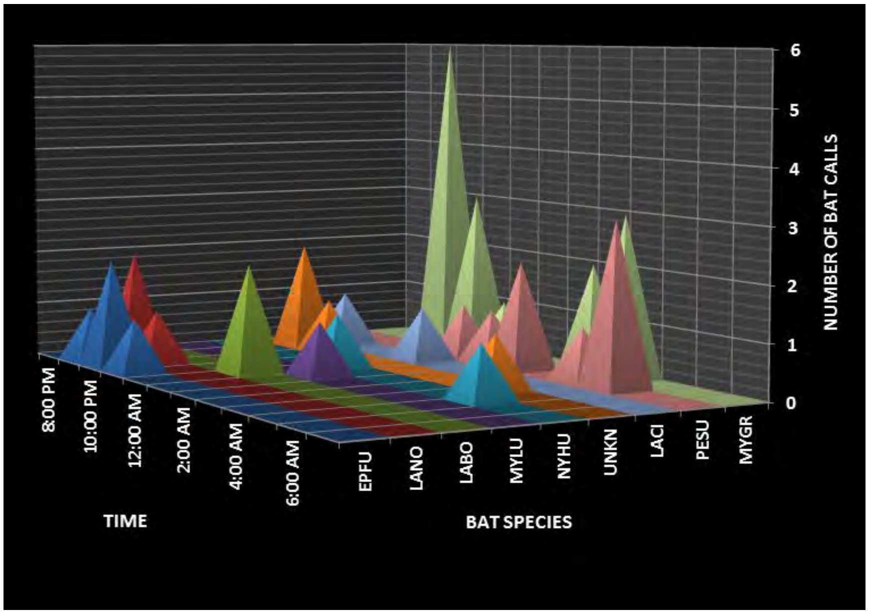


Figure 3.1.3.2.3 Bethel Valley (Oak Ridge National Laboratory) acoustic survey map



Graph ORR-05: Spallation Neutron Source (SNS) sedimentation pond (number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
COTO	*Corynorhinus townsendii*	Townsend's Big-eared bat		MYLU	*Myotis lucifugus*	Little Brown bat
EPFU	*Eptesicus fuscus*	Big Brown bat		MYSE	*Myotis septentrionalis* (Threat.)	Northern Long-eared bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		MYSO	*Myotis sodalis* (Endang.)	Indiana bat
LABO	*Lasiurus borealis*	Eastern Red bat		NYHU	*Nycticeius humeralis*	Evening bat
LACI	*Lasiurus cinereus*	Hoary bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
MYGR	*Myotis grisescens* (Endang.)	Gray bat		UNKN	Unknown species (bat detected but not identified)	
MYLE	*Myotis leibii*	Eastern Small-footed bat				

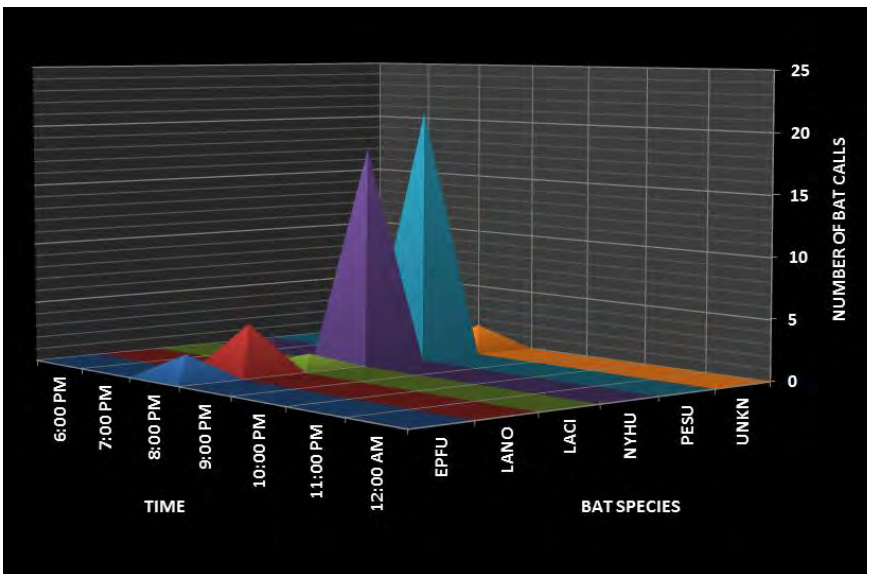


Graph ORR-06: ORR TWRA deer checking station
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		UNKN	Unknown species (bat detected but not identified)	
LANO	*Lasionycteris noctivagans*	Silver-haired bat		LACI	*Lasiurus cinereus*	Hoary bat
LABO	*Lasiurus borealis*	Eastern Red bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
MYLU	*Myotis lucifugus*	Little Brown bat		MYGR	*Myotis grisescens* (Endang.)	Gray bat
NYHU	*Nycticeius humeralis*	Evening bat				

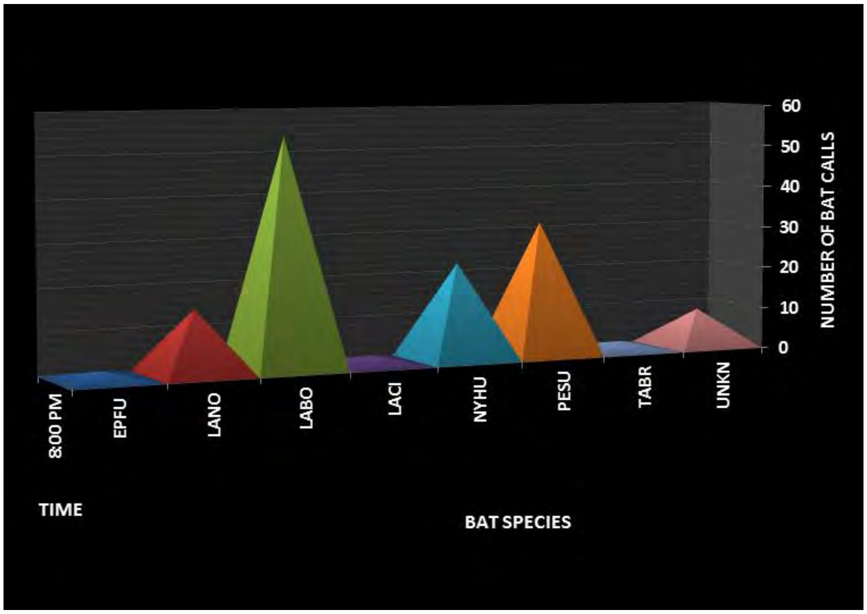
ETTP West Ponds Area

Figure 3.1.3.2.4 East Tennessee Technology Park (ETTP) west ponds area



Graph ORR-07: ETTP west ponds area
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		NYHU	*Nycticeius humeralis*	Evening bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
LACI	*Lasiurus cinereus*	Hoary bat		UNKN	Unknown species (bat detected but not identified)	

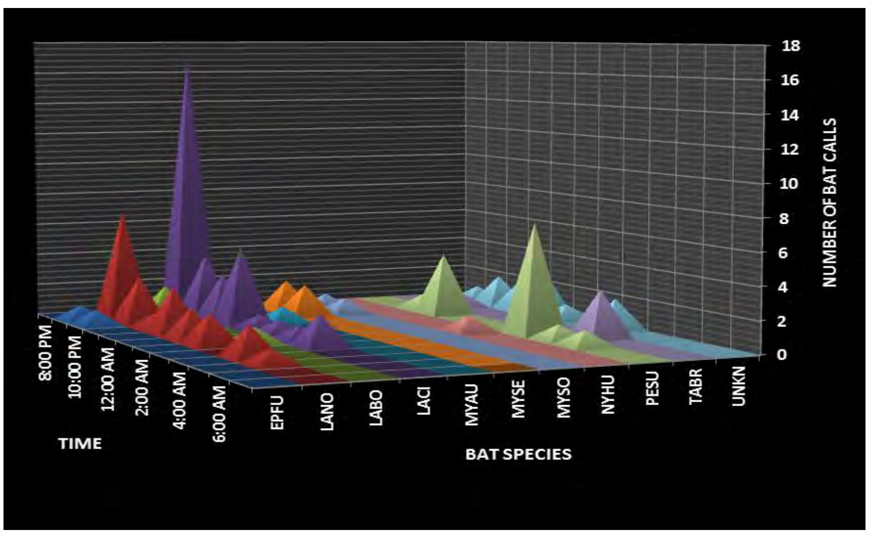


Graph ORR-08: ETTP open field area (near west ponds)
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		NYHU	*Nycticeius humeralis*	Evening bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
LABO	*Lasiurus borealis*	Eastern Red bat		TABR	*Tadarida brasiliensis*	Mexican Free-tailed bat
LACI	*Lasiurus cinereus*	Hoary bat		UNKN	Unknown species (bat detected but not identified)	

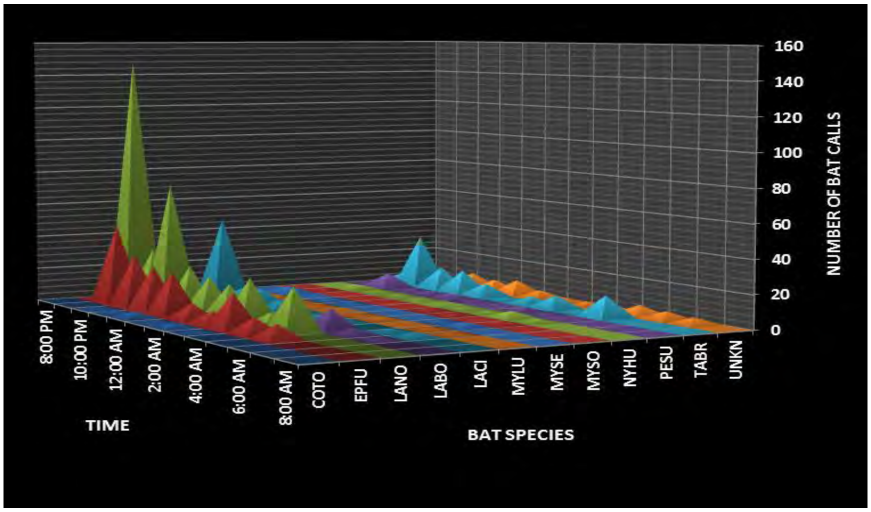
Upper East Fork Poplar Creek

Figure 3.1.3.2.5 Upper East Fork Poplar Creek (EFPC) area



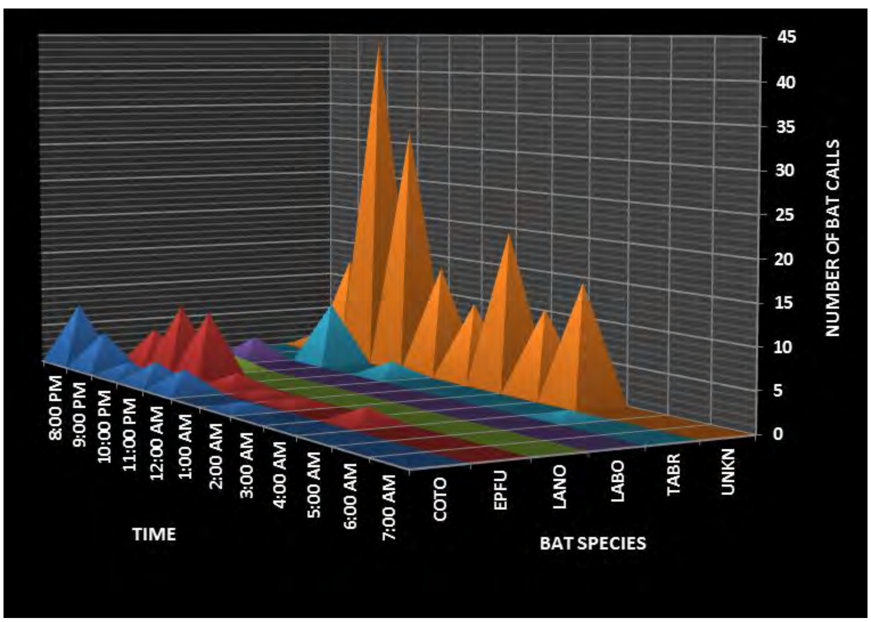
Graph ORR-9: Upper EFPC km 22.0/riparian zone
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		MYSO	*Myotis sodalis* (Endang.)	Indiana bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		NYHU	*Nycticeius humeralis*	Evening bat
LABO	*Lasiurus borealis*	Eastern Red bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
LACI	*Lasiurus cinereus*	Hoary bat		TABR	*Tadarida brasiliensis*	Mexican Free-tailed bat
MYAU	*Myotis austroriparius*	Southeastern bat		UNKN	Unknown species (bat detected but not identified)	
MYSE	*Myotis septentrionalis* (Threat.)	Northern Long-eared bat				



Graph ORR-10: Upper EFPC km 21.0/open field adjacent to riparian zone
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name	Bat Species Code	Scientific Name	Common Name
COTO	*Corynorhinus townsendii*	Townsend's Big-eared bat	MYSE	*Myotis septentrionalis* (Threat.)	Northern Long-eared bat
EPFU	*Eptesicus fuscus*	Big Brown bat	MYSO	*Myotis sodalis* (Endang.)	Indiana bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat	NYHU	*Nycticeius humeralis*	Evening bat
LABO	*Lasiurus borealis*	Eastern Red bat	PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
LACI	*Lasiurus cinereus*	Hoary bat	TABR	*Tadarida brasiliensis*	Mexican Free-tailed bat
MYLU	*Myotis lucifugus*	Little Brown bat	UNKN	Unknown species (bat detected but not identified)	



Graph ORR-11: Upper EFPC/City of Oak Ridge Water Treatment Plant
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name	Bat Species Code	Scientific Name	Common Name
COTO	*Corynorhinus townsendii*	Townsend's Big-eared bat	LABO	*Lasiurus borealis*	Eastern Red bat
EPFU	*Eptesicus fuscus*	Big Brown bat	TABR	*Tadarida brasiliensis*	Mexican Free-tailed bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat	UNKN	Unknown species (bat detected but not identified)	

White Wing Scrap Yard Area

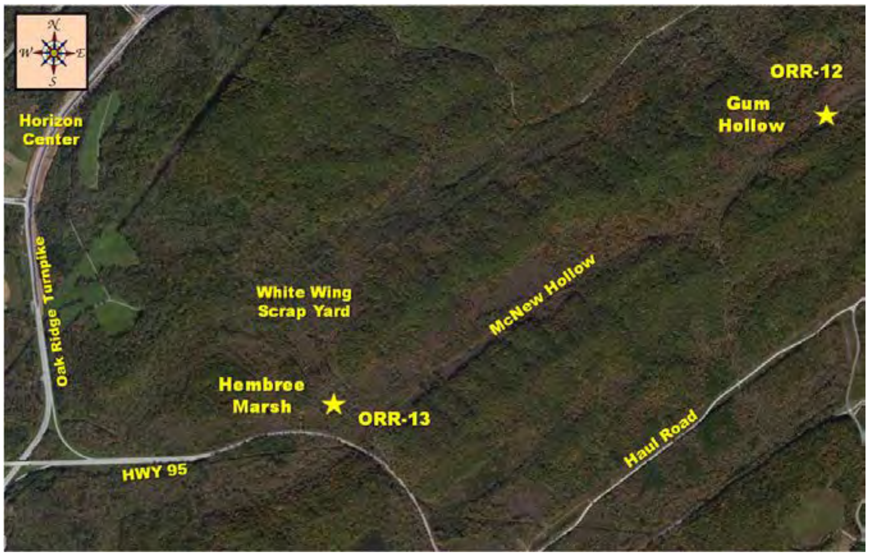
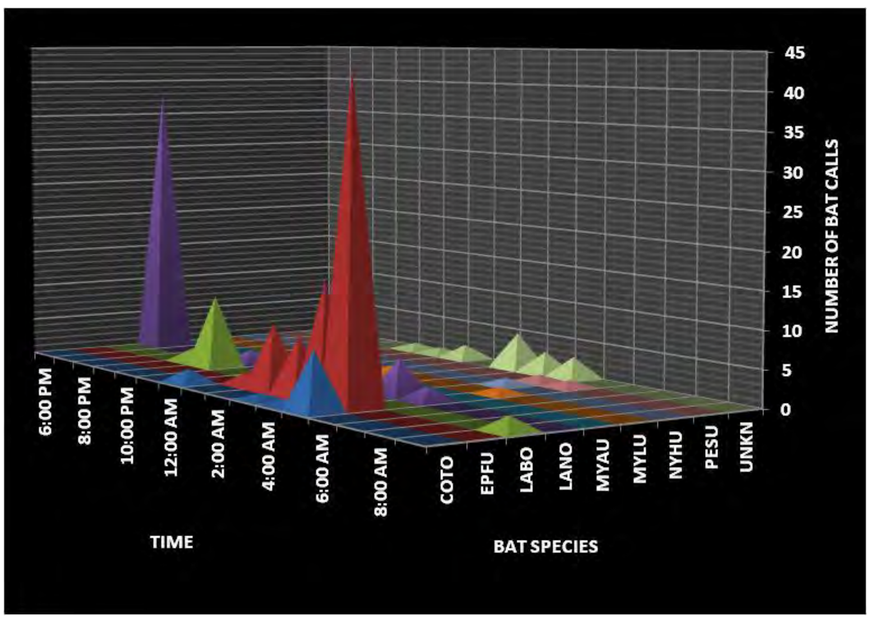
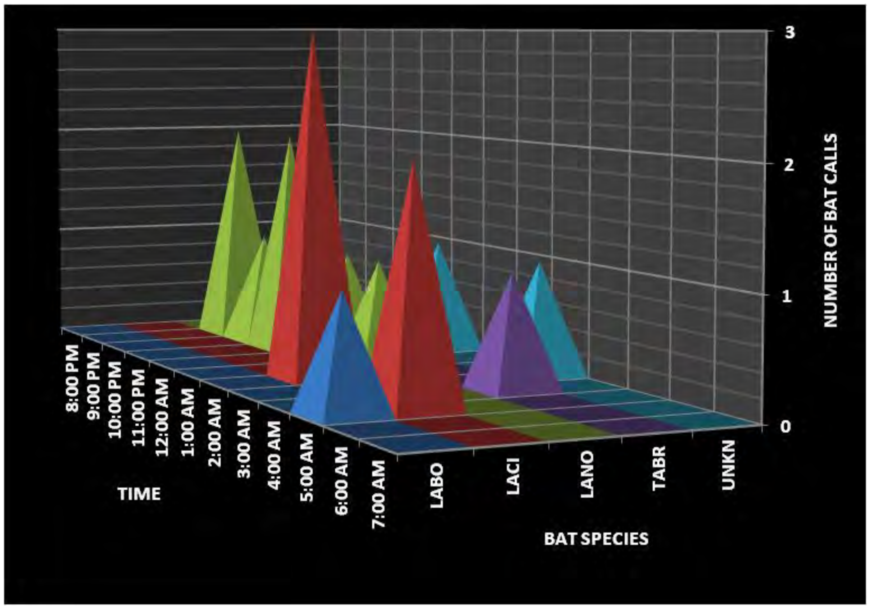


Figure 3.1.3.2.6 White Wing Scrap Yard (WWSY) area



Graph ORR-12: Gum Hollow access road near spring/White Wing Scrap yard (number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
COTO	*Corynorhinus townsendii*	Townsend's Big-eared bat		MYLU	*Myotis lucifugus*	Little Brown bat
EPFU	*Eptesicus fuscus*	Big Brown bat		NYHU	*Nycticeius humeralis*	Evening bat
LABO	*Lasiurus borealis*	Eastern Red bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		UNKN	Unknown species (bat detected but not identified)	
MYAU	*Myotis austroriparius*	Southeastern bat				



Graph ORR-13: Hembree Marsh/White Wing Scrap Yard area
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
LABO	*Lasiurus borealis*	Eastern Red bat		TABR	*Tadarida brasiliensis*	Mexican Free-tailed bat
LACI	*Lasiurus cinereus*	Hoary bat		UNKN	Unknown species (bat detected but not identified)	
LANO	*Lasionycteris noctivagans*	Silver-haired bat				

ETTP Proposed Airport Area

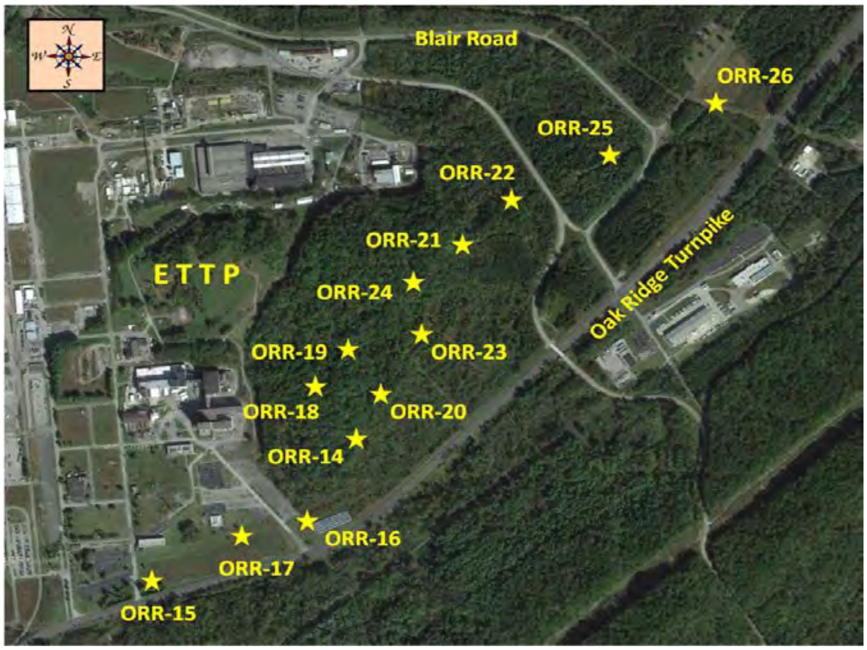
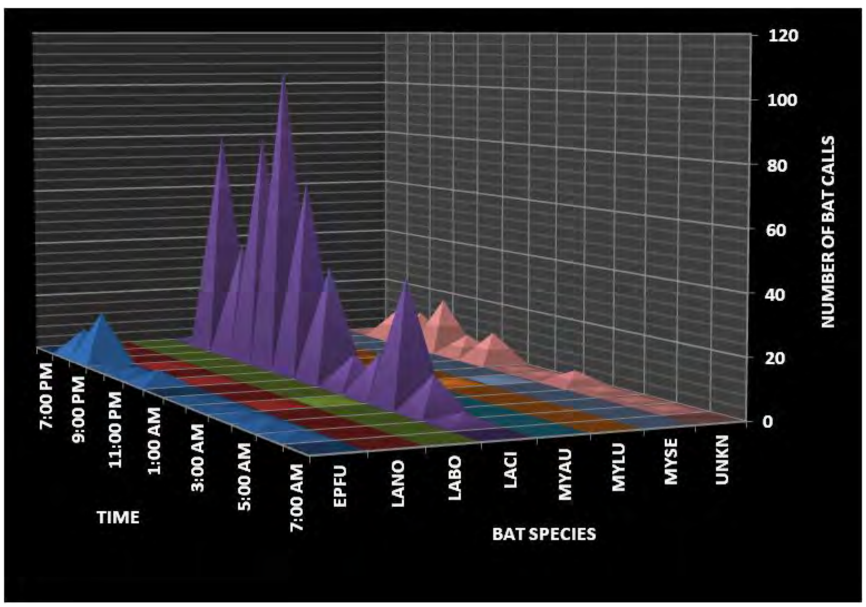
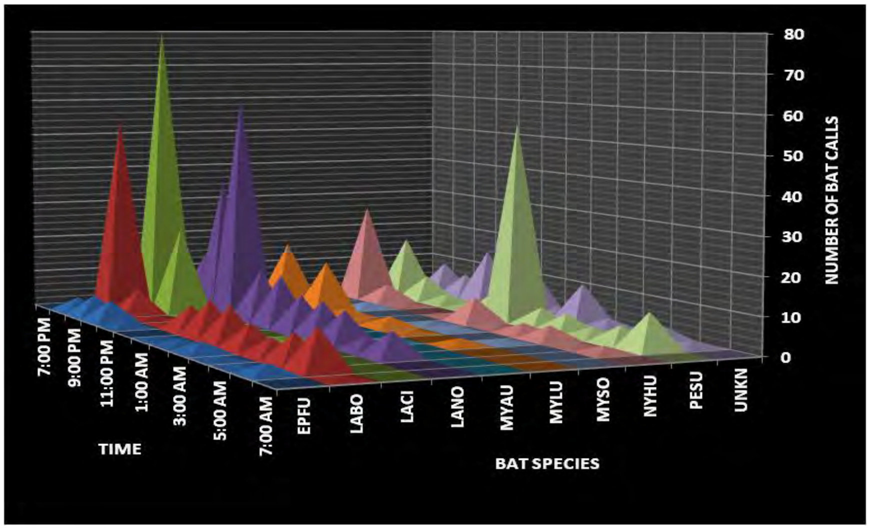


Figure 3.1.3.2.7 ETTP proposed airport site



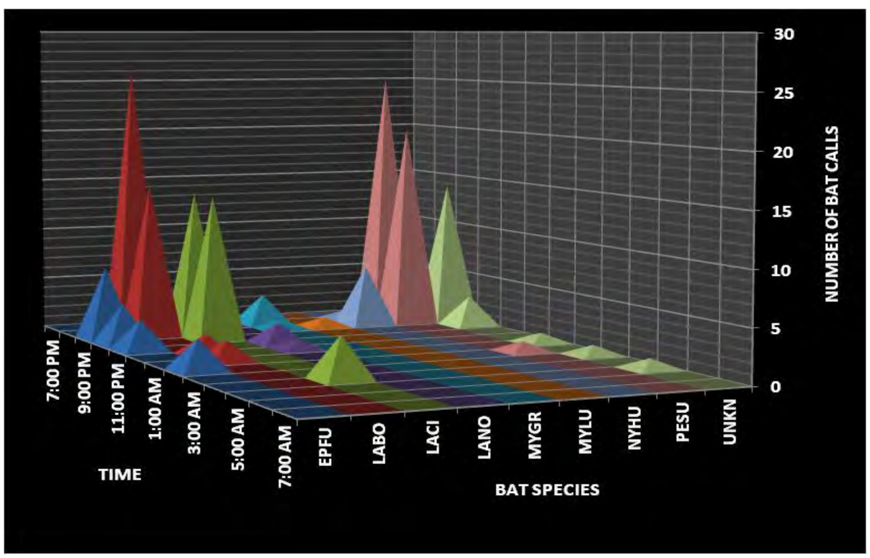
Graph ORR-14: ETTP airport site/forested ridge north of Oak Ridge Turnpike (number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		MYAU	*Myotis austroriparius*	Southeastern bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		MYLU	*Myotis lucifugus*	Little Brown bat
LABO	*Lasiurus borealis*	Eastern Red bat		MYSE	*Myotis septentrionalis* (Threat.)	Northern Long-eared bat
LACI	*Lasiurus cinereus*	Hoary bat		UNKN	Unknown species (bat detected but not identified)	



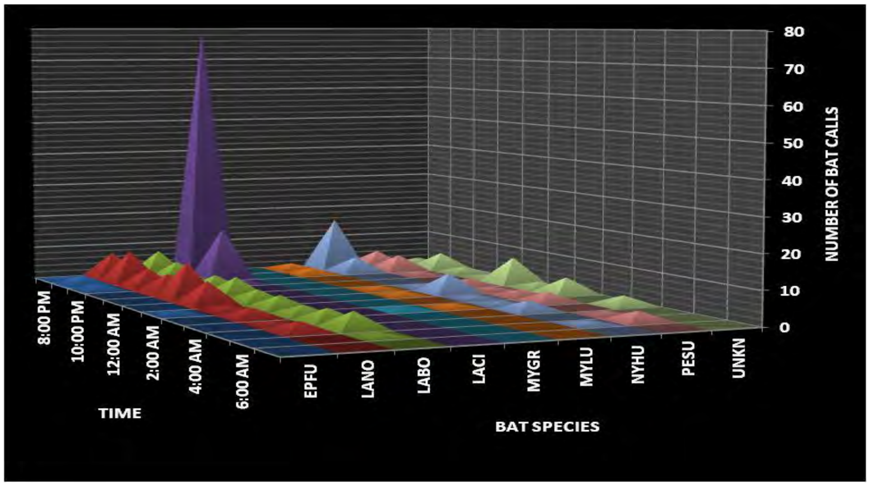
Graph ORR-15: ETTP airport site/small pond near turnpike
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		MYLU	*Myotis lucifugus*	Little Brown bat
LABO	*Lasiurus borealis*	Eastern Red bat		MYSO	*Myotis sodalis* (Endang.)	Indiana bat
LACI	*Lasiurus cinereus*	Hoary bat		NYHU	*Nycticeius humeralis*	Evening bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
MYAU	*Myotis austroriparius*	Southeastern bat		UNKN	Unknown species (bat detected but not identified)	



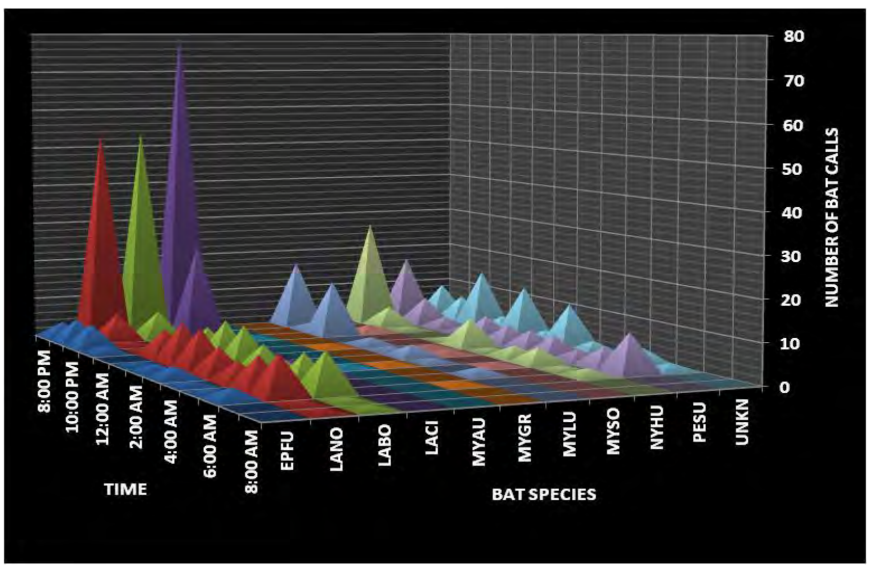
Graph ORR-16: ETTP airport site/RSI Brightfield near Oak Ridge Turnpike
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		MYLU	*Myotis lucifugus*	Little Brown bat
LABO	*Lasiurus borealis*	Eastern Red bat		NYHU	*Nycticeius humeralis*	Evening bat
LACI	*Lasiurus cinereus*	Hoary bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		UNKN	Unknown species (bat detected but not identified)	
MYGR	*Myotis grisescens* (Endang.)	Gray bat				



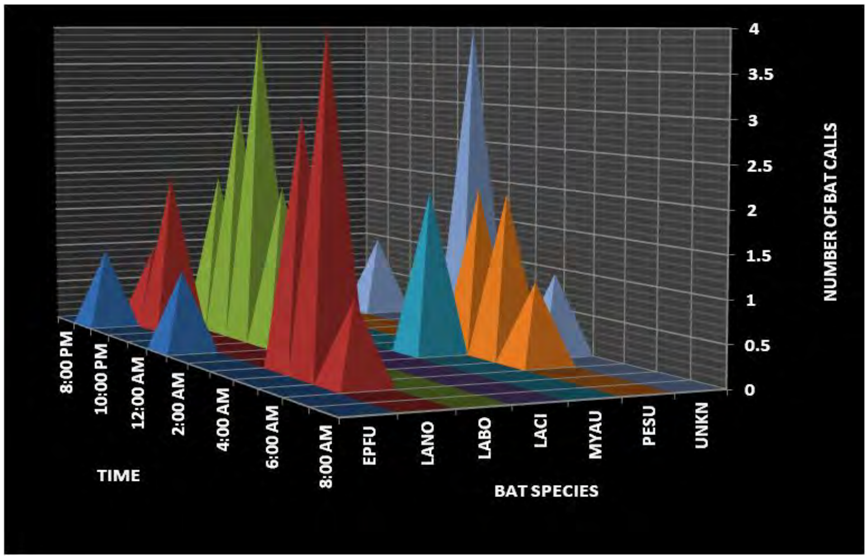
Graph ORR-17: ETTP airport site/office building near open field
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		MYLU	*Myotis lucifugus*	Little Brown bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		NYHU	*Nycticeius humeralis*	Evening bat
LABO	*Lasiurus borealis*	Eastern Red bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
LACI	*Lasiurus cinereus*	Hoary bat		UNKN	Unknown species (bat detected but not identified)	
MYGR	*Myotis grisescens* (Endang.)	Gray bat				



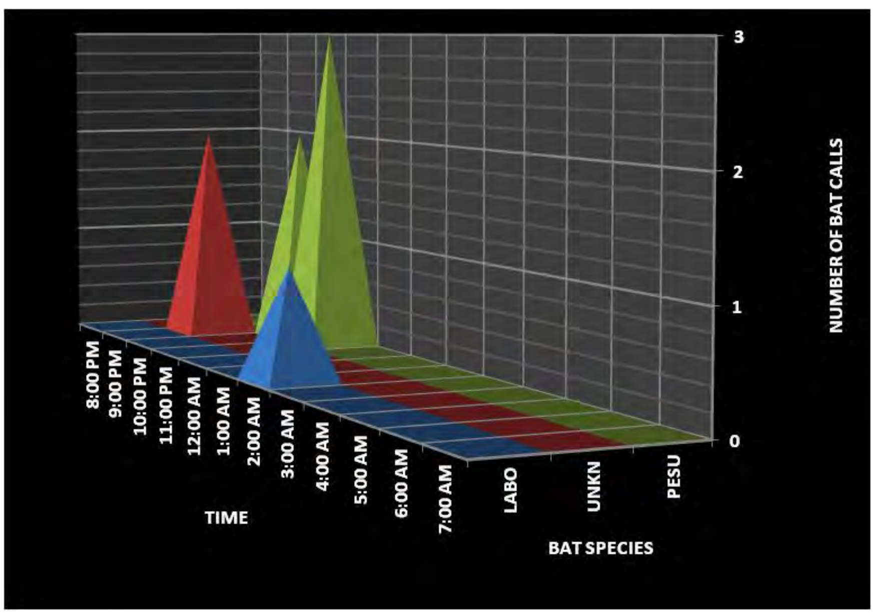
Graph ORR-18: ETTP airport site/forested ridge north of Oak Ridge Turnpike
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		MYLU	*Myotis lucifugus*	Little Brown bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		MYSO	*Myotis sodalis* (Endang.)	Indiana bat
LABO	*Lasiurus borealis*	Eastern Red bat		NYHU	*Nycticeius humeralis*	Evening bat
LACI	*Lasiurus cinereus*	Hoary bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
MYAU	*Myotis austroriparius*	Southeastern bat		UNKN	Unknown species (bat detected but not identified)	
MYGR	*Myotis grisescens* (Endang.)	Gray bat				



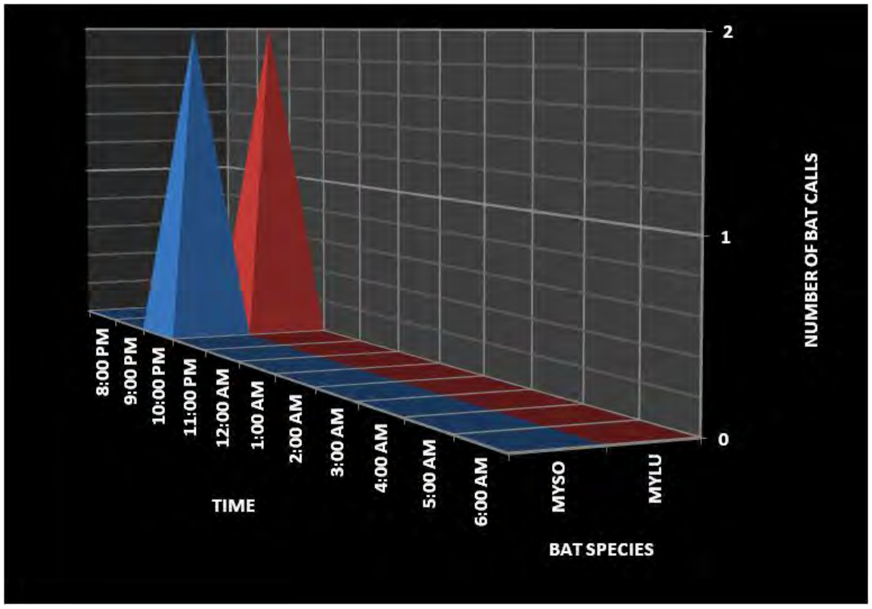
Graph ORR-19: ETTP airport site/wetlands in low-lying section of forested ridge (number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		MYAU	*Myotis austroriparius*	Southeastern bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
LABO	*Lasiurus borealis*	Eastern Red bat		UNKN	Unknown species (bat detected but not identified)	
LACI	*Lasiurus cinereus*	Hoary bat				



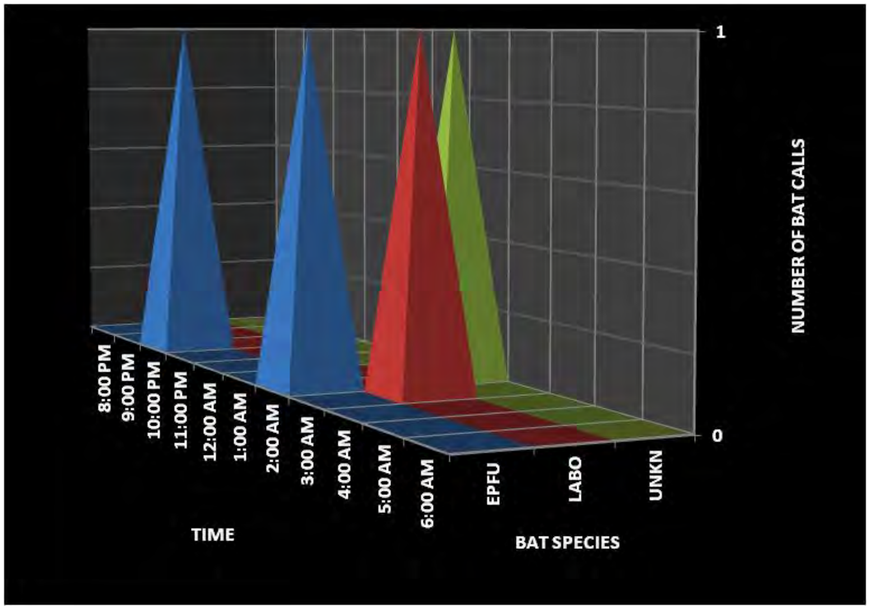
Graph ORR-20: ETTP airport site/forested ridge north of Oak Ridge Turnpike (number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
LABO	*Lasiurus borealis*	Eastern Red bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
UNKN	Unknown species (bat detected but not identified)					



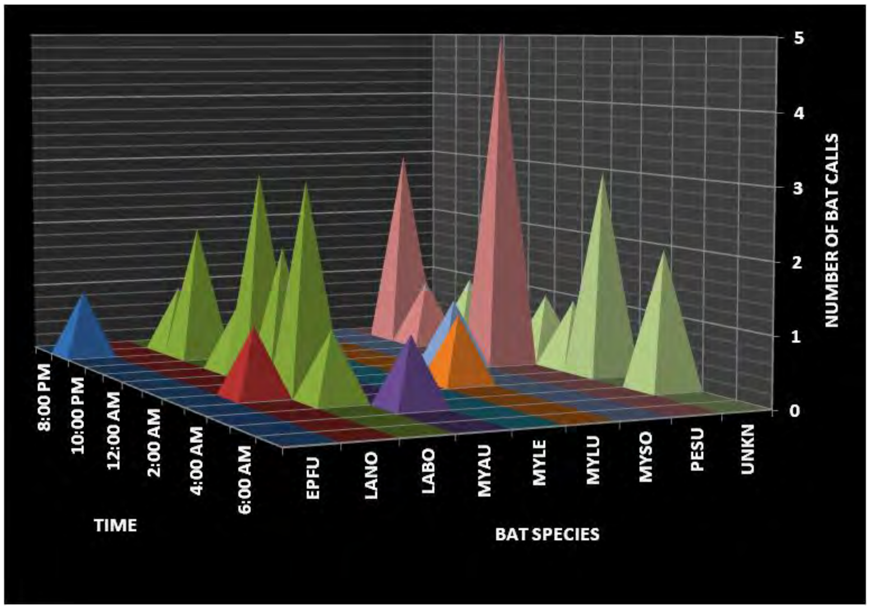
Graph ORR-21: ETTP airport site/large abandoned water tank on forested ridge (number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
MYSO	*Myotis sodalis* (Endang.)	Indiana bat		MYLU	*Myotis lucifugus*	Little Brown bat



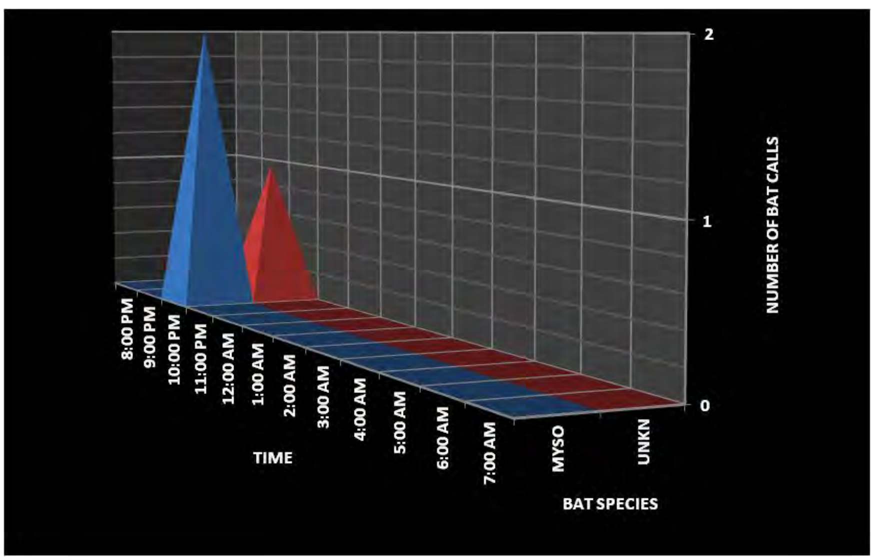
Graph ORR-22: ETTP airport site/wetlands in low-lying section of forested ridge (number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		UNKN	Unknown species (bat detected but not identified)	
LABO	*Lasiurus borealis*	Eastern Red bat				



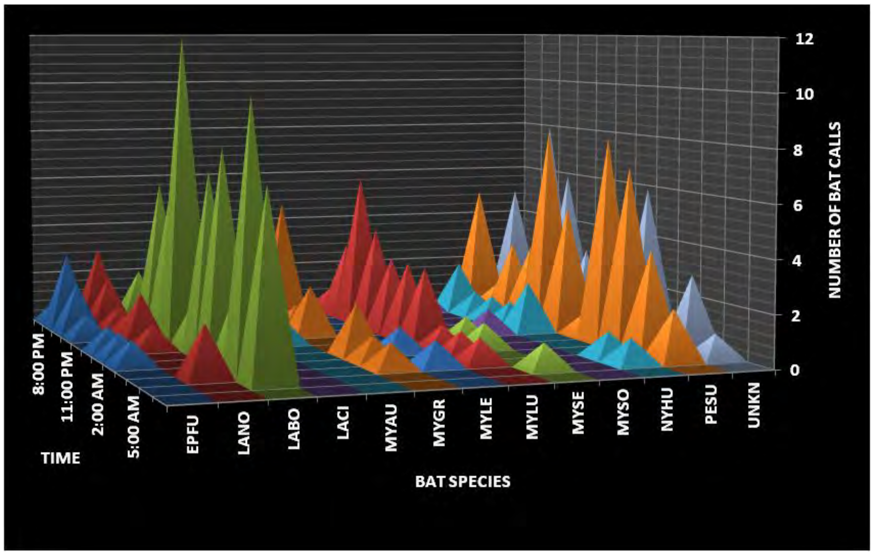
Graph ORR-23: ETTP airport site/pine plantation north of Oak Ridge Turnpike (number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		MYLU	*Myotis lucifugus*	Little Brown bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		MYSO	*Myotis sodalis* (Endang.)	Indiana bat
LABO	*Lasiurus borealis*	Eastern Red bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
MYAU	*Myotis austroriparius*	Southeastern bat		UNKN	Unknown species (bat detected but not identified)	
MYLE	*Myotis leibii*	Eastern Small-footed bat				



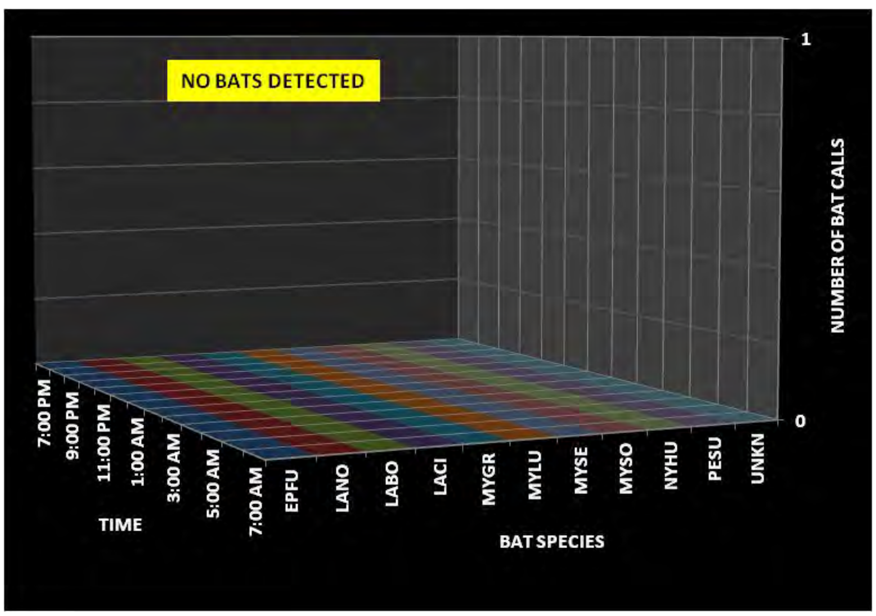
Graph ORR-24: ETTP airport site/wetlands in low-lying section of forested ridge (number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
MYSO	*Myotis sodalis* (Endang.)	Indiana bat		UNKN	Unknown species (bat detected but not identified)	



Graph ORR-25: ETTP airport site/groundwater well access trail near Blair Road (number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		MYLU	*Myotis lucifugus*	Little Brown bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		MYSE	*Myotis septentrionalis* (Threat.)	Northern Long-eared bat
LABO	*Lasiurus borealis*	Eastern Red bat		MYSO	*Myotis sodalis* (Endang.)	Indiana bat
LACI	*Lasiurus cinereus*	Hoary bat		NYHU	*Nycticeius humeralis*	Evening bat
MYAU	*Myotis austroriparius*	Southeastern bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
MYGR	*Myotis grisescens* (Endang.)	Gray bat		UNKN	Unknown species (bat detected but not identified)	
MYLE	*Myotis leibii*	Eastern Small-footed bat				



Graph ORR-26: ETTP airport site/pipeline ROW near George Jones Church (number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
	no bats detected				no bats detected	

Parcel ED-5 Area

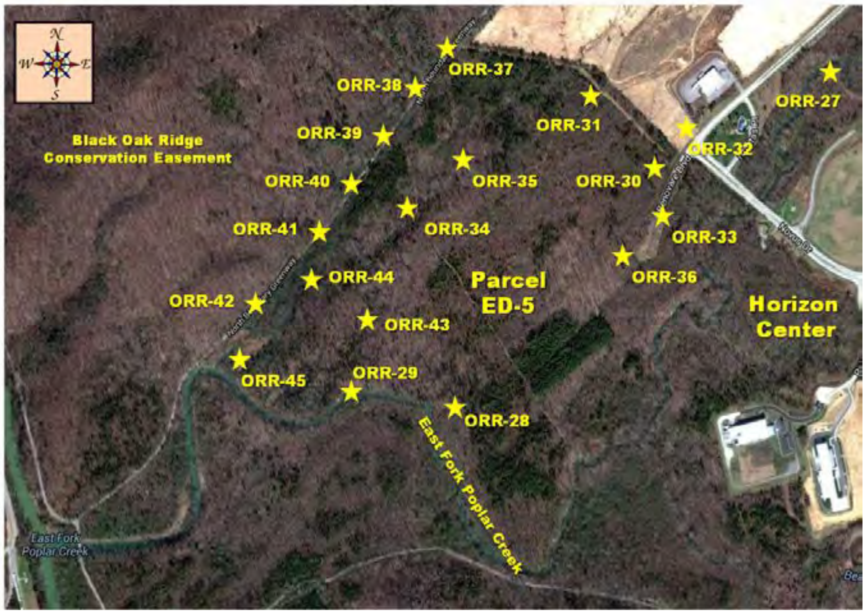
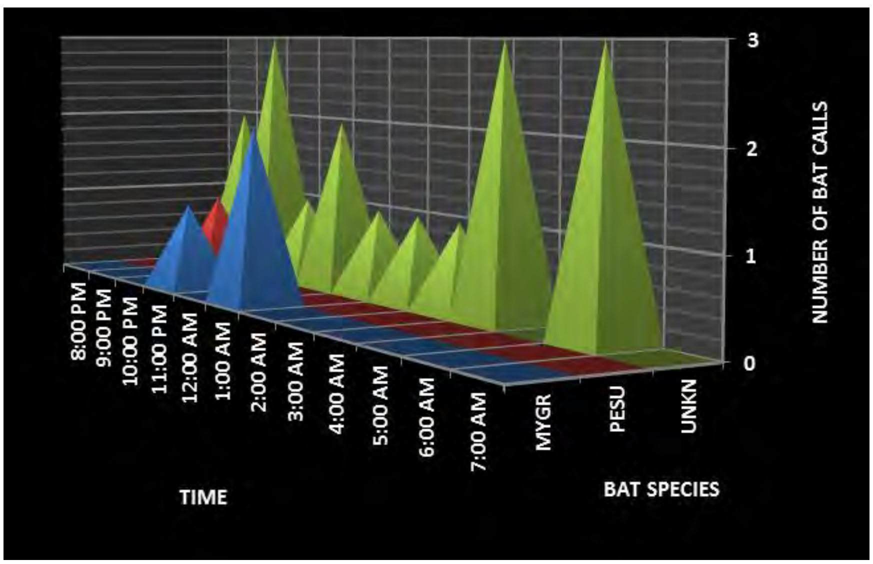
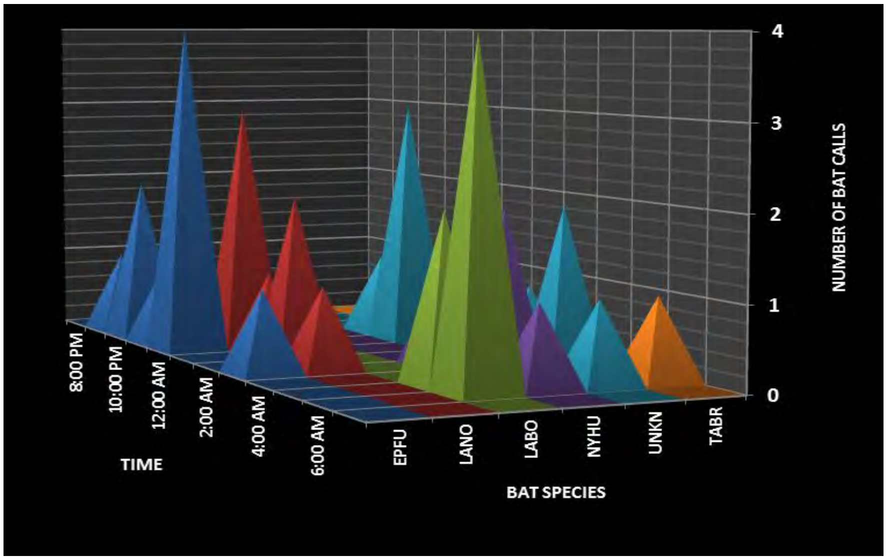


Figure 3.1.3.2.8 Parcel ED-5 (proposed area to be cleared of trees)



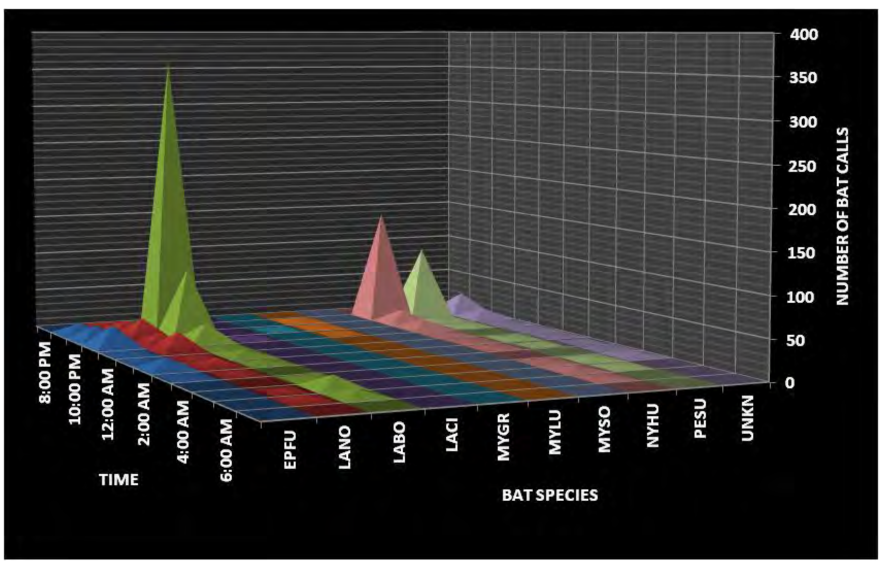
Graph ORR-27: Horizon Center/EFPC 6.3 km/ limestone bluff w/white oaks (number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
MYGR	*Myotis grisescens* (Endang.)	Gray bat		UNKN	Unknown species (bat detected but not identified)	
PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat				



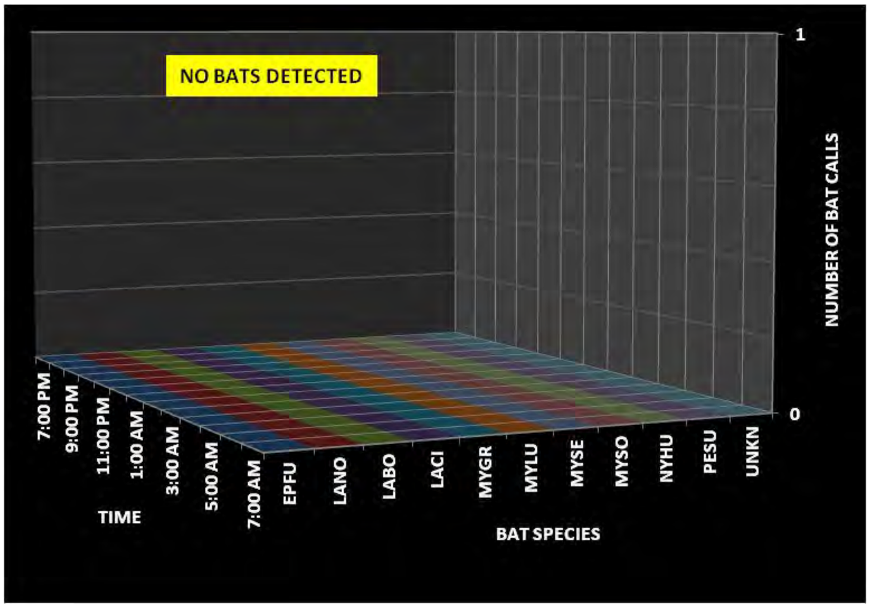
Graph ORR-28: ED-5 parcel/wetlands in forest near East Fork Poplar Creek (number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		NYHU	*Nycticeius humeralis*	Evening bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		UNKN	Unknown species (bat detected but not identified)	
LABO	*Lasiurus borealis*	Eastern Red bat		TABR	*Tadarida brasiliensis*	Mexican Free-tailed bat



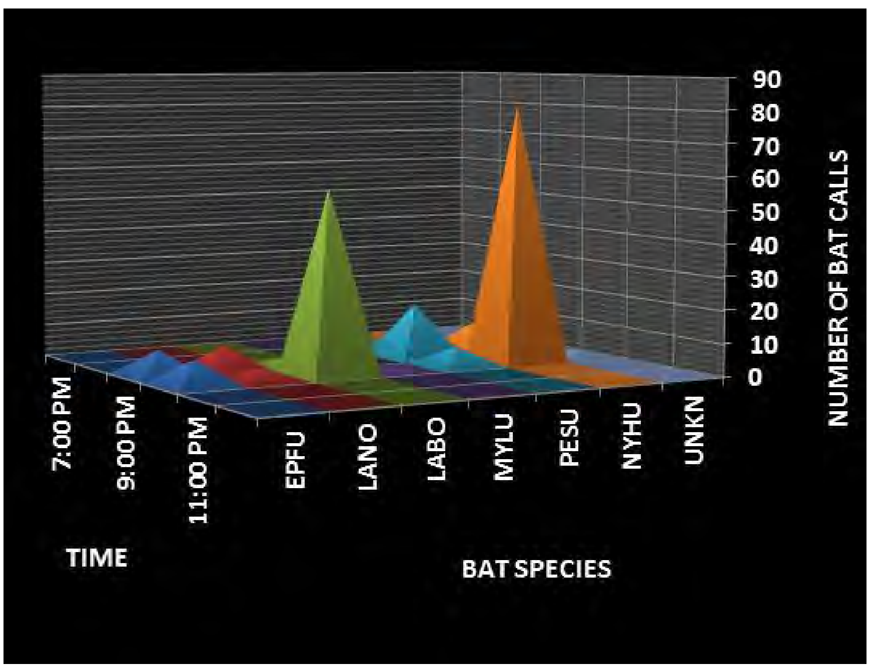
Graph ORR-29: ED-5 parcel/East Fork Poplar Creek shoreline embankment (number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		MYLU	*Myotis lucifugus*	Little Brown bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		MYSO	*Myotis sodalis* (Endang.)	Indiana bat
LABO	*Lasiurus borealis*	Eastern Red bat		NYHU	*Nycticeius humeralis*	Evening bat
LACI	*Lasiurus cinereus*	Hoary bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
MYGR	*Myotis grisescens* (Endang.)	Gray bat		UNKN	Unknown species (bat detected but not identified)	



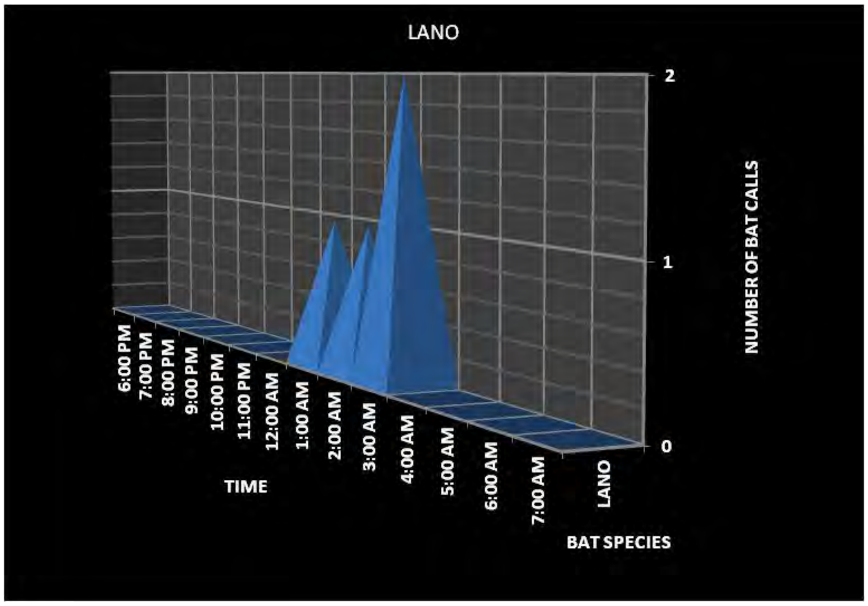
Graph ORR-30: ED-5 parcel/gas pipeline right-of-way (ROW).
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
	no bats detected				no bats detected	



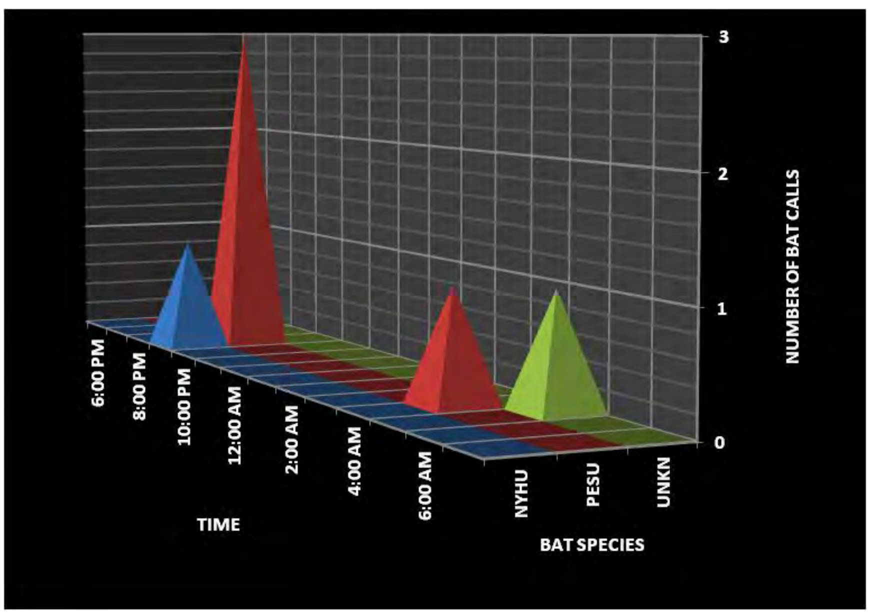
Graph ORR-31: ED-5 parcel/gas pipeline right-of-way (ROW)
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		NYHU	*Nycticeius humeralis*	Evening bat
LABO	*Lasiurus borealis*	Eastern Red bat		UNKN	Unknown species (bat detected but not identified)	
MYLU	*Myotis lucifugus*	Little Brown bat				



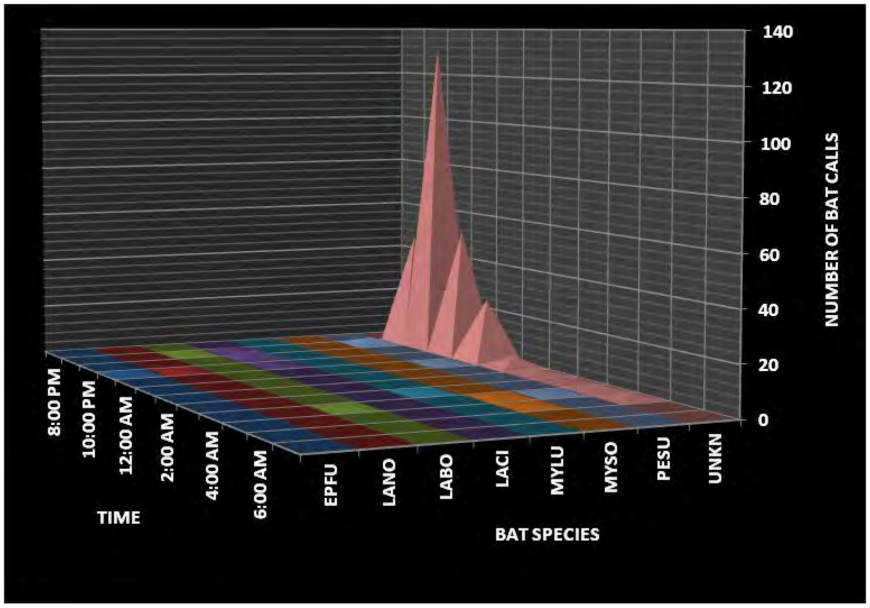
Graph ORR-32: Horizon Center/open field near Horizon Center office building (number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
LANO	*Lasionycteris noctivagans*	Silver-haired bat				



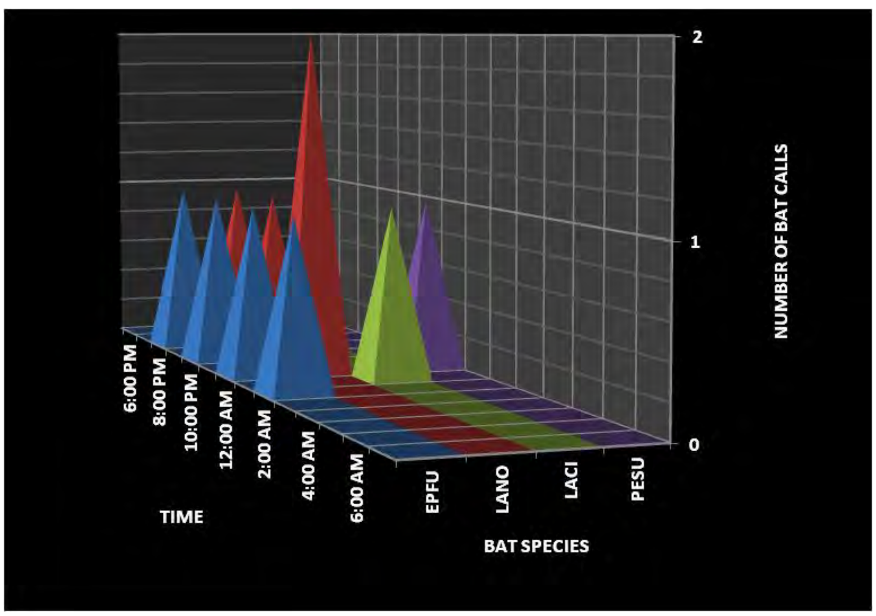
Graph ORR-33: Horizon Center/open area at gated dead-end road (number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
NYHU	*Nycticeius humeralis*	Evening bat		UNKN	Unknown species (bat detected but not identified)	
PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat				



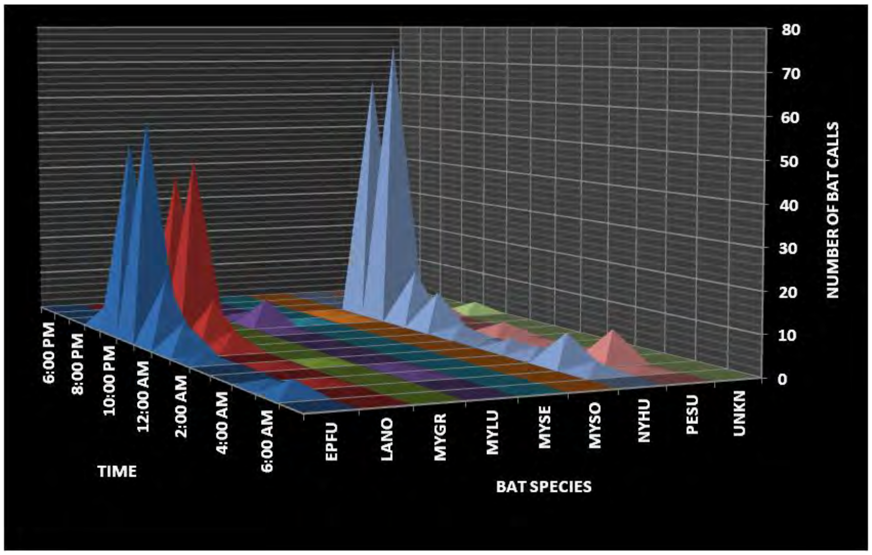
Graph ORR-34: ED-5 parcel/interior forested area along old access trail (number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		MYLU	*Myotis lucifugus*	Little Brown bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		MYSO	*Myotis sodalis* (Endang.)	Indiana bat
LABO	*Lasiurus borealis*	Eastern Red bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
LACI	*Lasiurus cinereus*	Hoary bat		UNKN	Unknown species (bat detected but not identified)	



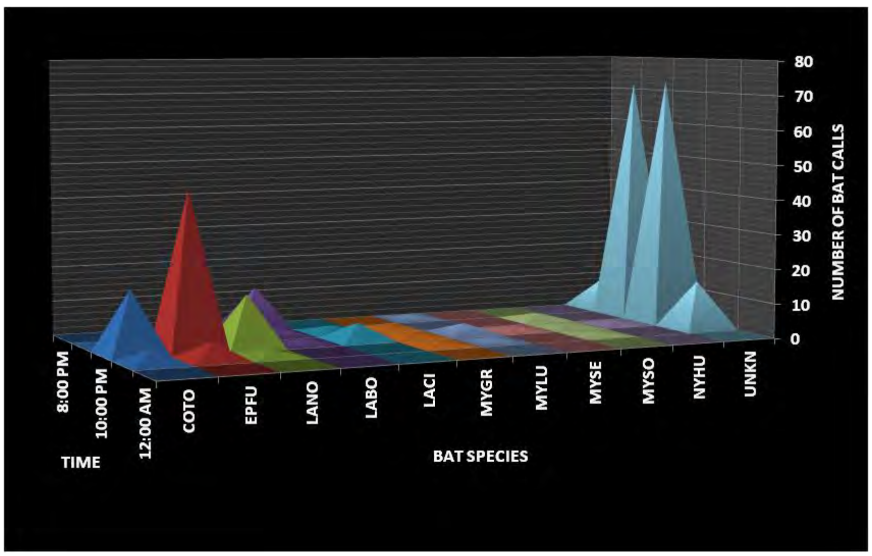
Graph ORR-35: ED-5 parcel/interior forested area (number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		LACI	*Lasiurus cinereus*	Hoary bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat



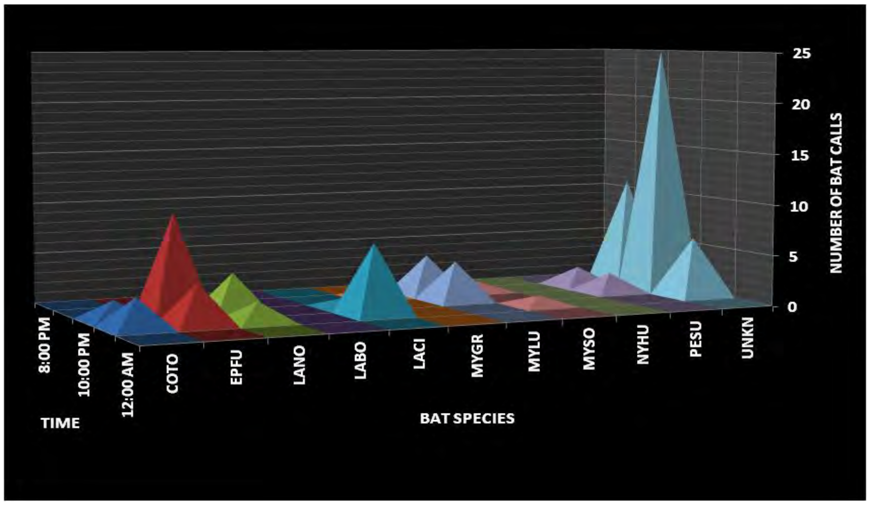
Graph ORR-36: Horizon Center/open area at gated dead-end road
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		MYSO	*Myotis sodalis* (Endang.)	Indiana bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		NYHU	*Nycticeius humeralis*	Evening bat
MYGR	*Myotis grisescens* (Endang.)	Gray bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
MYLU	*Myotis lucifugus*	Little Brown bat		UNKN	Unknown species (bat detected but not identified)	
MYSE	*Myotis septentrionalis* (Threat.)	Northern Long-eared bat				



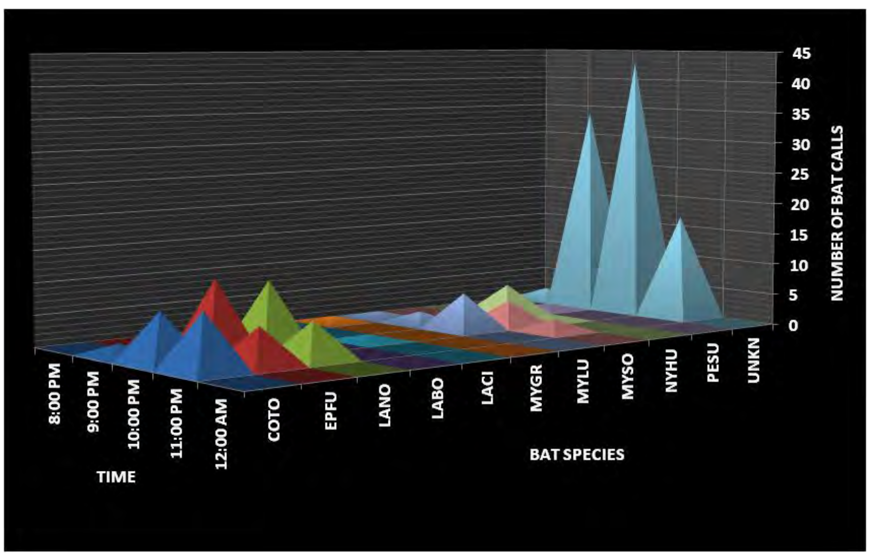
Graph ORR-37: ED-5 parcel/EFPC access road
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
COTO	*Corynorhinus townsendii*	Townsend's Big-eared bat		MYLU	*Myotis lucifugus*	Little Brown bat
EPFU	*Eptesicus fuscus*	Big Brown bat		MYSE	*Myotis septentrionalis* (Threat.)	Northern Long-eared bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		MYSO	*Myotis sodalis* (Endang.)	Indiana bat
LABO	*Lasiurus borealis*	Eastern Red bat		NYHU	*Nycticeius humeralis*	Evening bat
LACI	*Lasiurus cinereus*	Hoary bat		UNKN	Unknown species (bat detected but not identified)	
MYGR	*Myotis grisescens* (Endang.)	Gray bat				



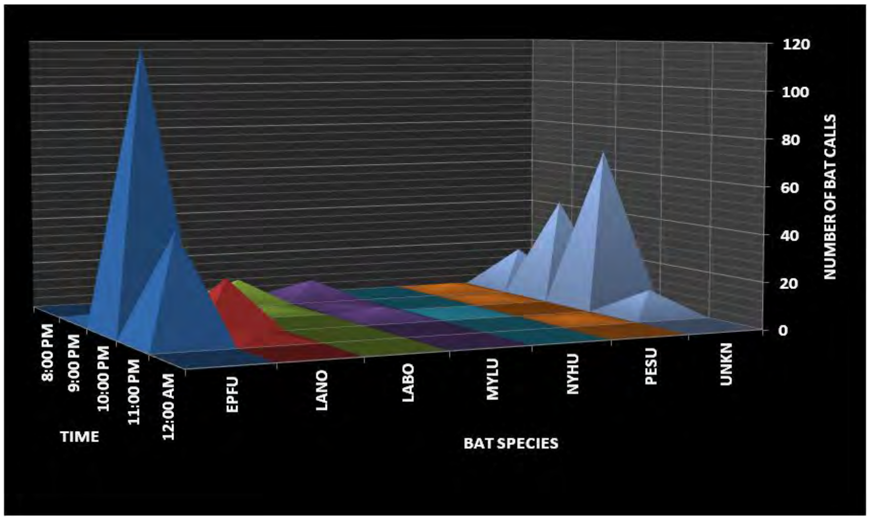
Graph ORR-38: ED-5 parcel/EFPC access road
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
COTO	*Corynorhinus townsendii*	Townsend's Big-eared bat		MYLU	*Myotis lucifugus*	Little Brown bat
EPFU	*Eptesicus fuscus*	Big Brown bat		MYSO	*Myotis sodalis* (Endang.)	Indiana bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		NYHU	*Nycticeius humeralis*	Evening bat
LABO	*Lasiurus borealis*	Eastern Red bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
LACI	*Lasiurus cinereus*	Hoary bat		UNKN	Unknown species (bat detected but not identified)	
MYGR	*Myotis grisescens* (Endang.)	Gray bat				



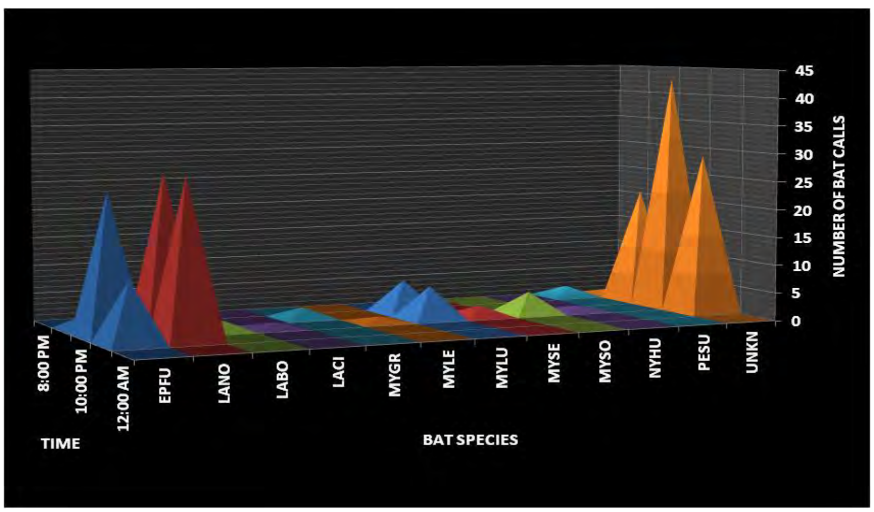
Graph ORR-39: ED-5 parcel/EFPC access road
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
COTO	*Corynorhinus townsendii*	Townsend's Big-eared bat		MYLU	*Myotis lucifugus*	Little Brown bat
EPFU	*Eptesicus fuscus*	Big Brown bat		MYSO	*Myotis sodalis* (Endang.)	Indiana bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		NYHU	*Nycticeius humeralis*	Evening bat
LABO	*Lasiurus borealis*	Eastern Red bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
LACI	*Lasiurus cinereus*	Hoary bat		UNKN	Unknown species (bat detected but not identified)	
MYGR	*Myotis grisescens* (Endang.)	Gray bat				



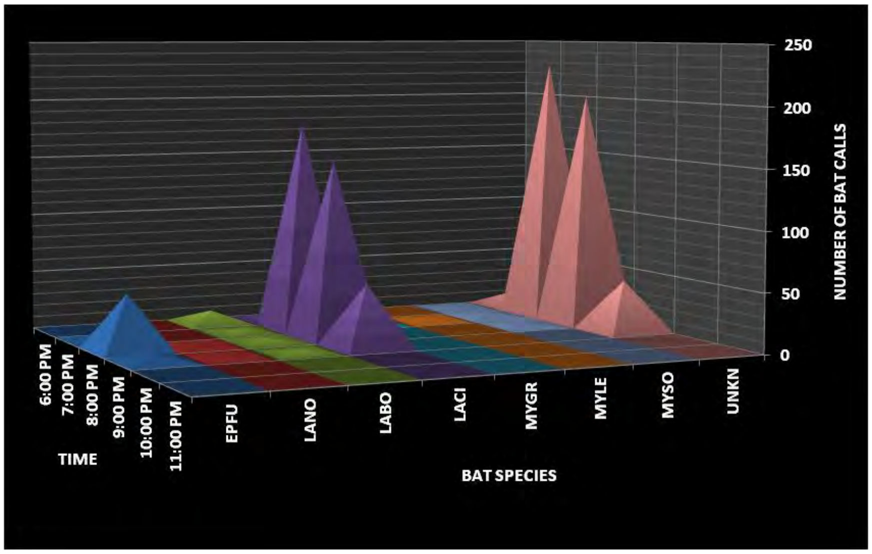
Graph ORR-40: ED-5 parcel/EFPC access road
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		NYHU	*Nycticeius humeralis*	Evening bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
LABO	*Lasiurus borealis*	Eastern Red bat		UNKN	Unknown species (bat detected but not identified)	
MYLU	*Myotis lucifugus*	Little Brown bat				



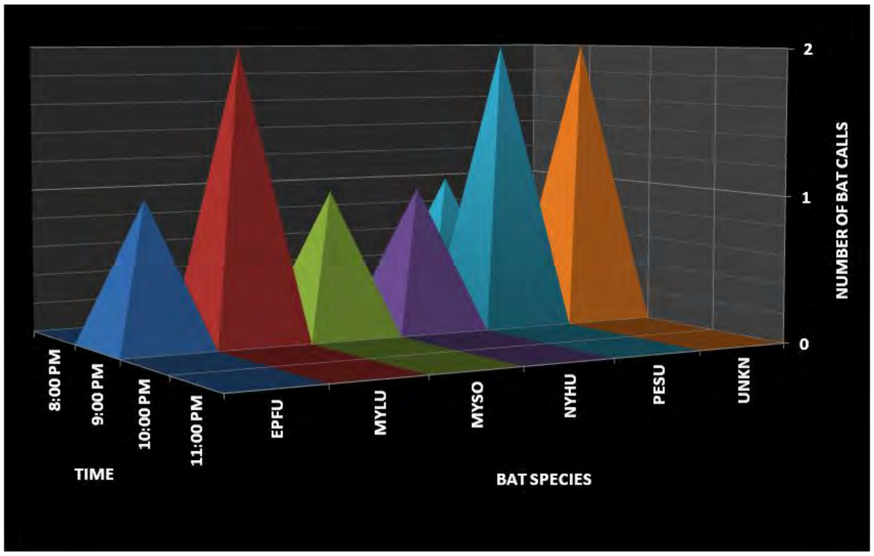
Graph ORR-41: ED-5 parcel/EFPC access road
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		MYLU	*Myotis lucifugus*	Little Brown bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		MYSE	*Myotis septentrionalis* (Threat.)	Northern Long-eared bat
LABO	*Lasiurus borealis*	Eastern Red bat		MYSO	*Myotis sodalis* (Endang.)	Indiana bat
LACI	*Lasiurus cinereus*	Hoary bat		NYHU	*Nycticeius humeralis*	Evening bat
MYGR	*Myotis grisescens* (Endang.)	Gray bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
MYLE	*Myotis leibii*	Eastern Small-footed bat		UNKN	Unknown species (bat detected but not identified)	



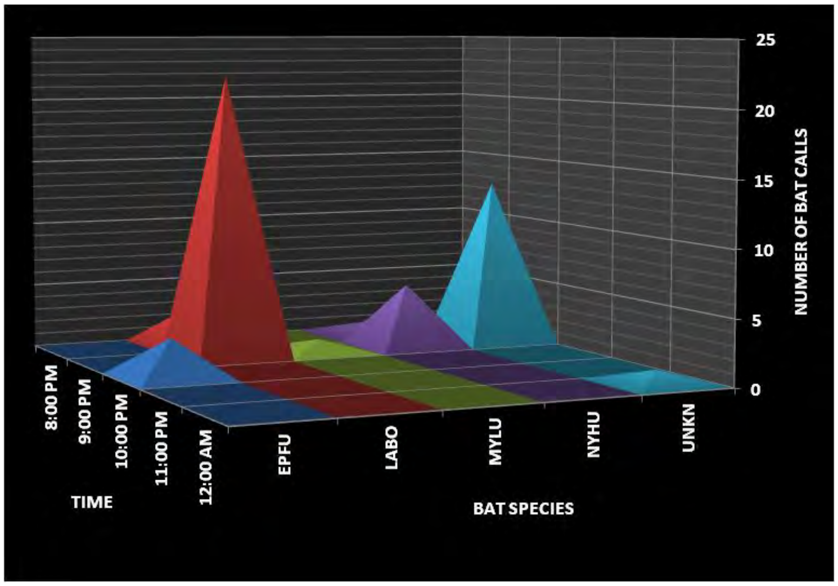
Graph ORR-42: ED-5 parcel/EFPC access road
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		MYGR	*Myotis grisescens* (Endang.)	Gray bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		MYLE	*Myotis leibii*	Eastern Small-footed bat
LABO	*Lasiurus borealis*	Eastern Red bat		MYSO	*Myotis sodalis* (Endang.)	Indiana bat
LACI	*Lasiurus cinereus*	Hoary bat		UNKN	Unknown species (bat detected but not identified)	



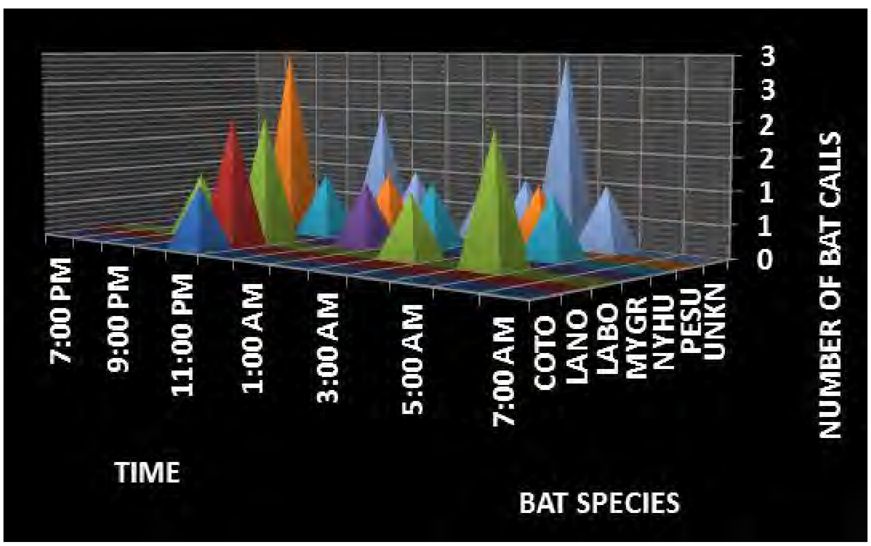
Graph ORR-43: ED-5 parcel/interior forested ridge area
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		NYHU	*Nycticeius humeralis*	Evening bat
MYLU	*Myotis lucifugus*	Little Brown bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
MYSO	*Myotis sodalis* (Endang.)	Indiana bat		UNKN	Unknown species (bat detected but not identified)	



Graph ORR-44: ED-5 parcel/interior forested ridge area
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		NYHU	*Nycticeius humeralis*	Evening bat
LABO	*Lasiurus borealis*	Eastern Red bat		UNKN	Unknown species (bat detected but not identified)	
MYLU	*Myotis lucifugus*	Little Brown bat				



Graph ORR-45: ED-5 parcel/large wetland area near EFPC access road
(number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
COTO	*Corynorhinus townsendii*	Townsend's Big-eared bat		NYHU	*Nycticeius humeralis*	Evening bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
LABO	*Lasiurus borealis*	Eastern Red bat		UNKN	Unknown species (bat detected but not identified)	
MYGR	*Myotis grisescens* (Endang.)	Gray bat				

Freels Bend Wildlife Management Area

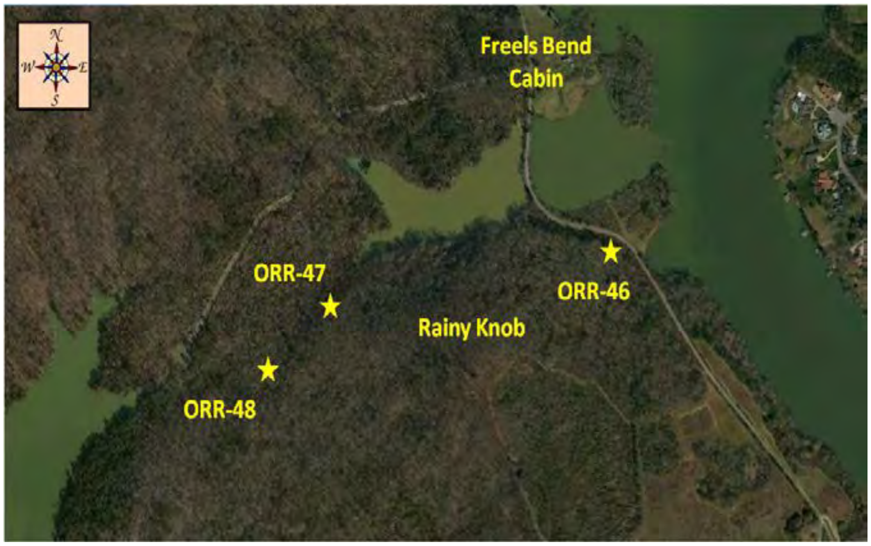
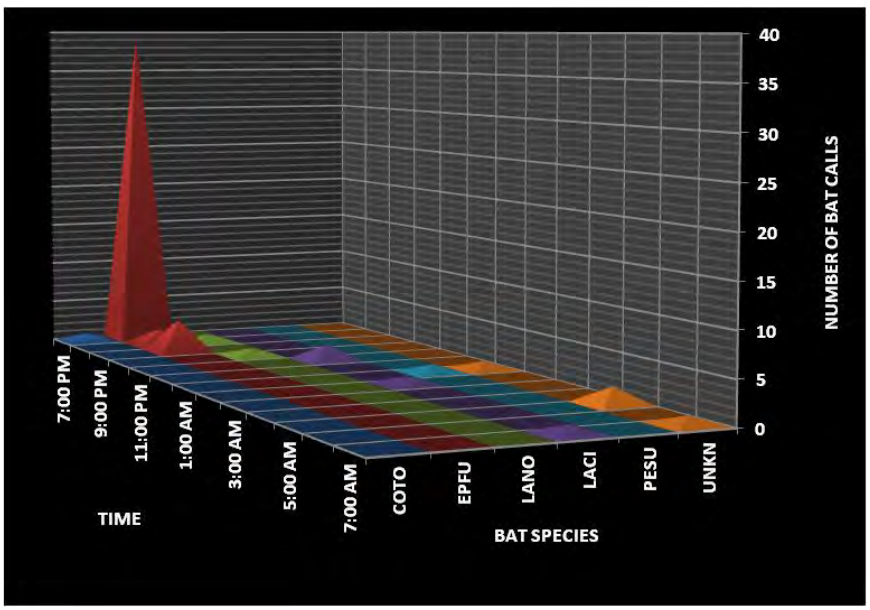
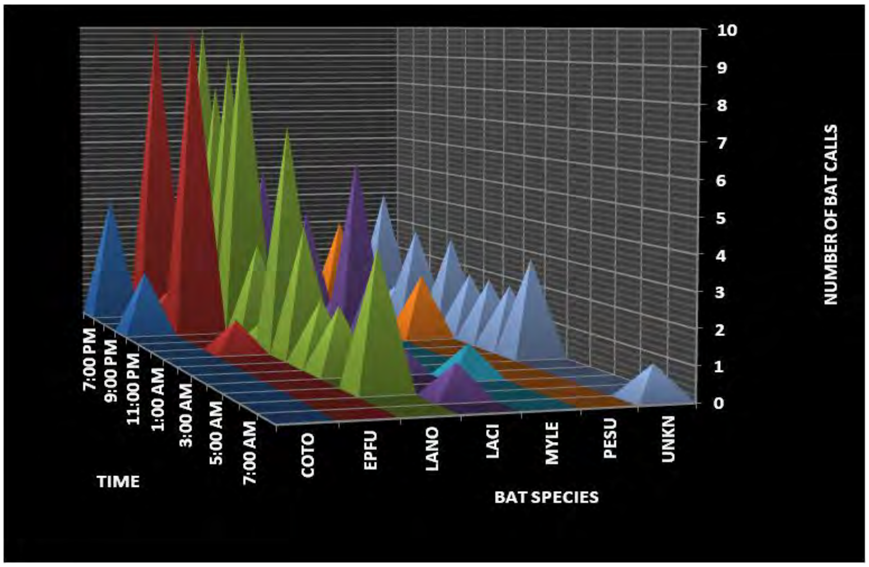


Figure 3.1.3.2.9 Freels Bend Wildlife Management Area (TWRA Three Bends)



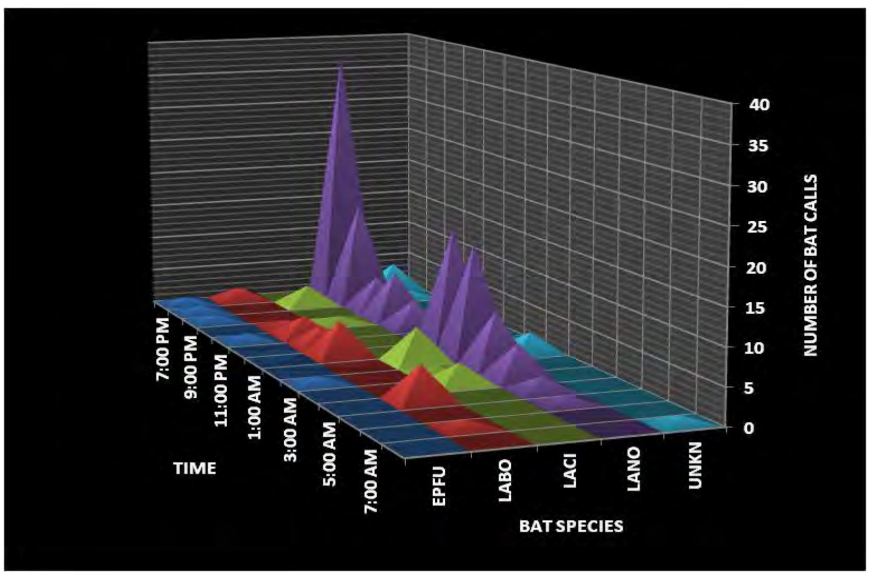
Graph ORR-46: Freels Bend Wildlife Management Area/Rainy Knob karst feature (number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name	Bat Species Code	Scientific Name	Common Name
COTO	*Corynorhinus townsendii*	Townsend's Big-eared bat	LACI	*Lasiurus cinereus*	Hoary bat
EPFU	*Eptesicus fuscus*	Big Brown bat	PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat	UNKN	Unknown species (bat detected but not identified)	



Graph ORR-47: Freels Bend Wildlife Management Area/limestone bluff (number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
COTO	*Corynorhinus townsendii*	Townsend's Big-eared bat		MYLE	*Myotis leibii*	Eastern Small-footed bat
EPFU	*Eptesicus fuscus*	Big Brown bat		PESU	*Perimyotis subflavus*	Tri-colored/Pipistrelle bat
LANO	*Lasionycteris noctivagans*	Silver-haired bat		UNKN	Unknown species (bat detected but not identified)	
LACI	*Lasiurus cinereus*	Hoary bat				



Graph ORR-48: Freels Bend Wildlife management Area/limestone karst feature (number of bat calls/hour organized by species; colors represent various species)

Bat Species Code	Scientific Name	Common Name		Bat Species Code	Scientific Name	Common Name
EPFU	*Eptesicus fuscus*	Big Brown bat		LANO	*Lasionycteris noctivagans*	Silver-haired bat
LABO	*Lasiurus borealis*	Eastern Red bat		UNKN	Unknown species (bat detected but not identified)	
LACI	*Lasiurus cinereus*	Hoary bat				

Appendix B

Fungi Monitoring in East Fork Poplar Creek

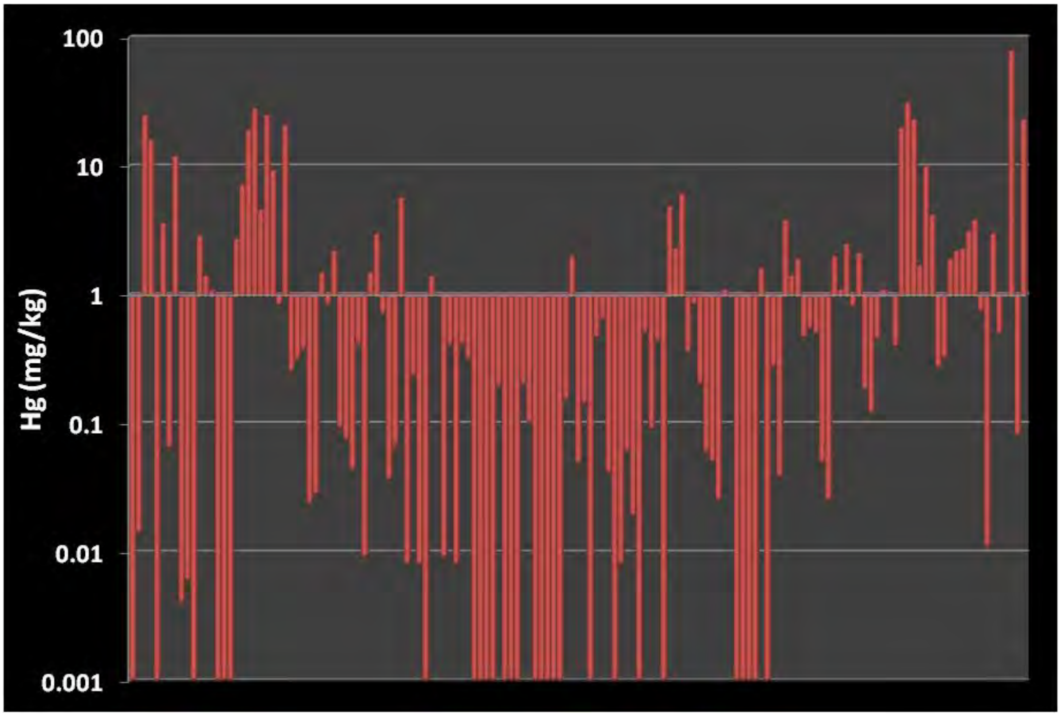


Figure 3.1.3.4.1 All Hg data plotted (mg/kg; *n*=147)

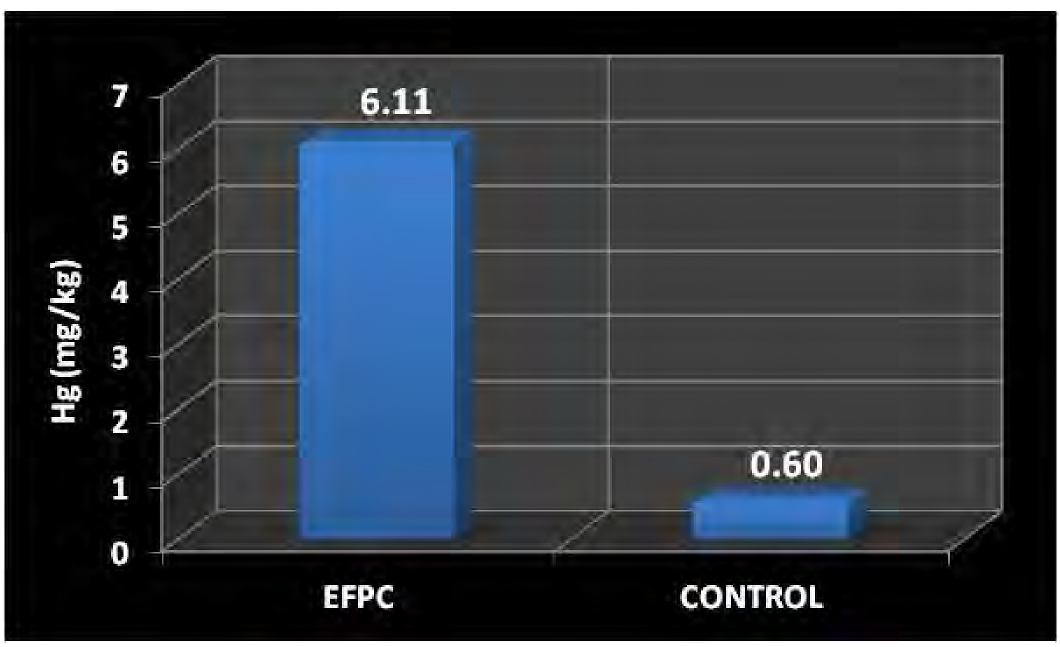


Figure 3.1.3.4.2 Combined EFPC Hg data compared to control Hg (mg/kg)

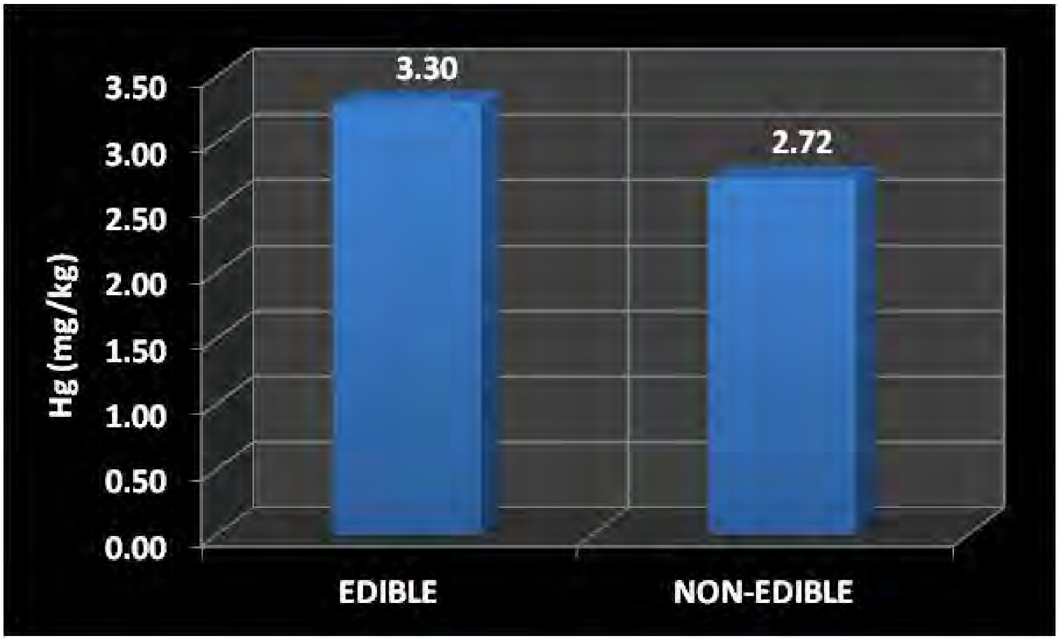


Figure 3.1.3.4.3 Combined EFPC Hg data compared to control Hg (mg/kg)

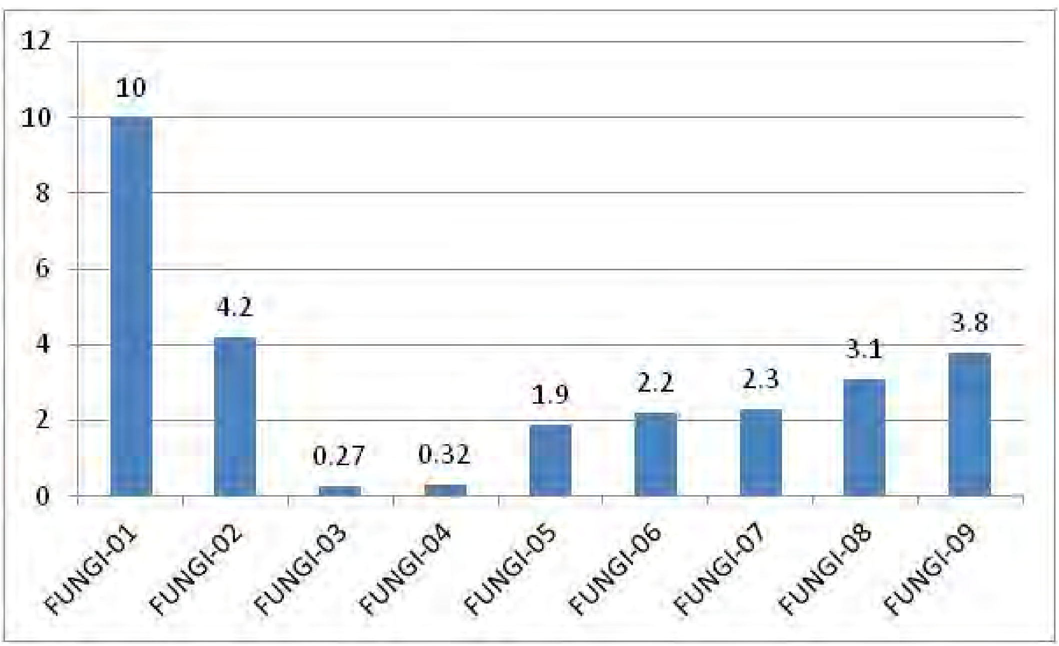


Figure 3.1.3.4.4 EFPC-01 sampling plot (*n*=9 subsamples; Hg= 3.12 mg/kg)

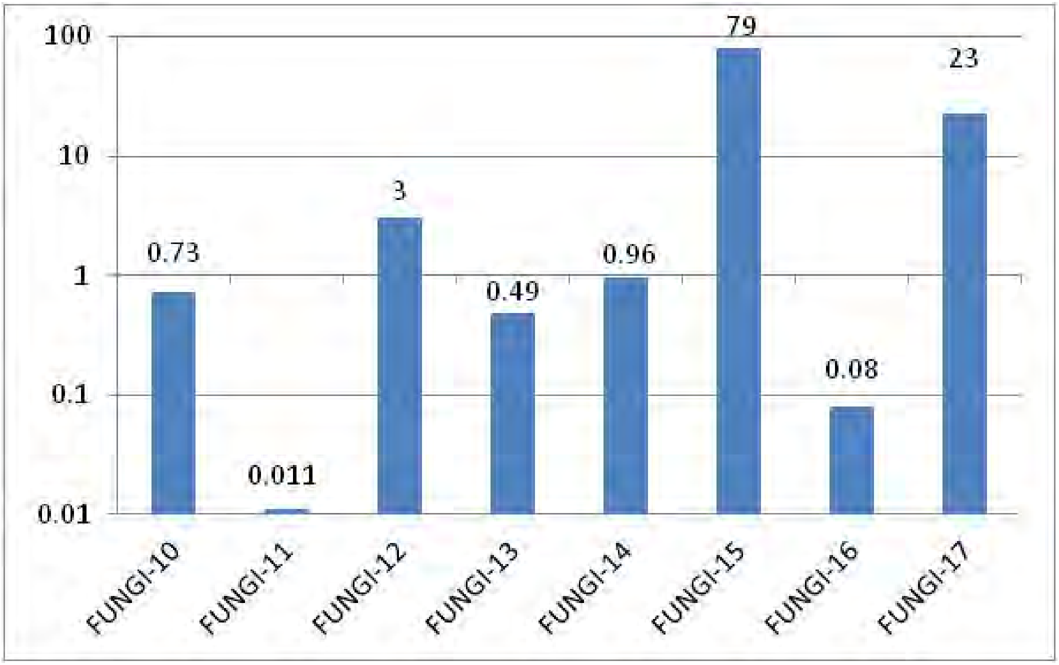


Figure 3.1.3.4.5 EFPC-02 sampling plot (*n*=8 subsamples; Hg= 13.41 mg/kg)

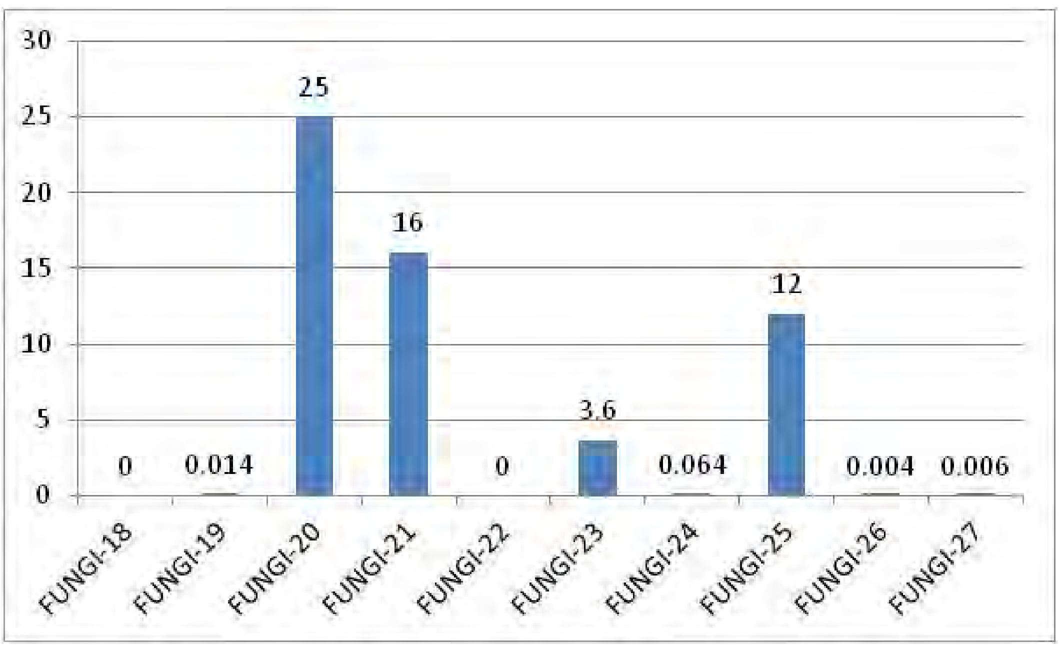


Figure 3.1.3.4.6 EFPC-03 sampling plot (*n*=10 subsamples; Hg= 5.67 mg/kg)

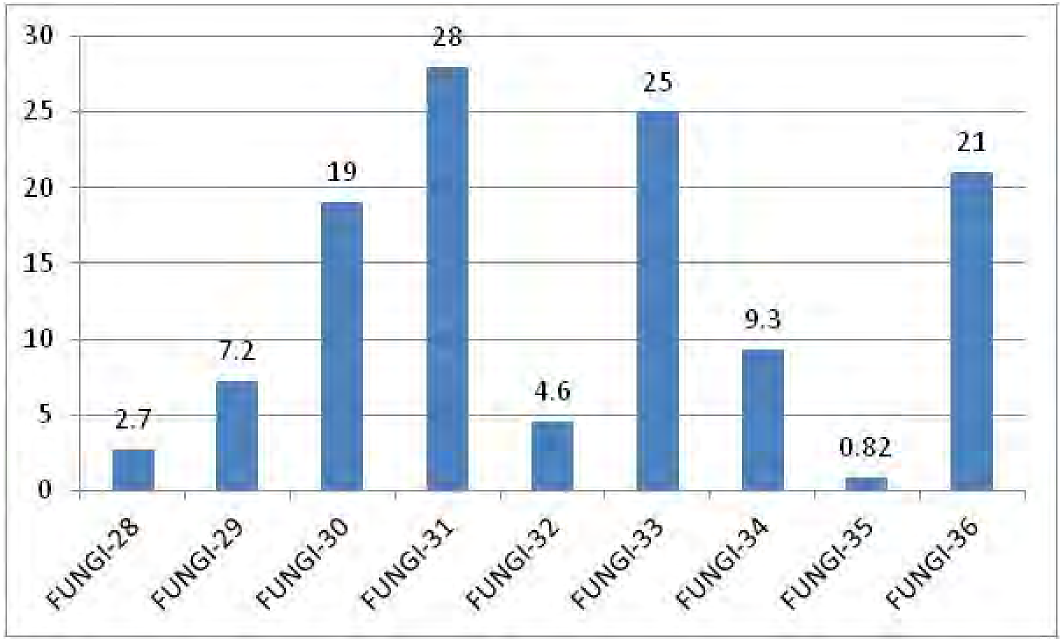


Figure 3.1.3.4.7 EFPC-04 sampling plot (*n*=9 subsamples; Hg= 13.07 mg/kg)

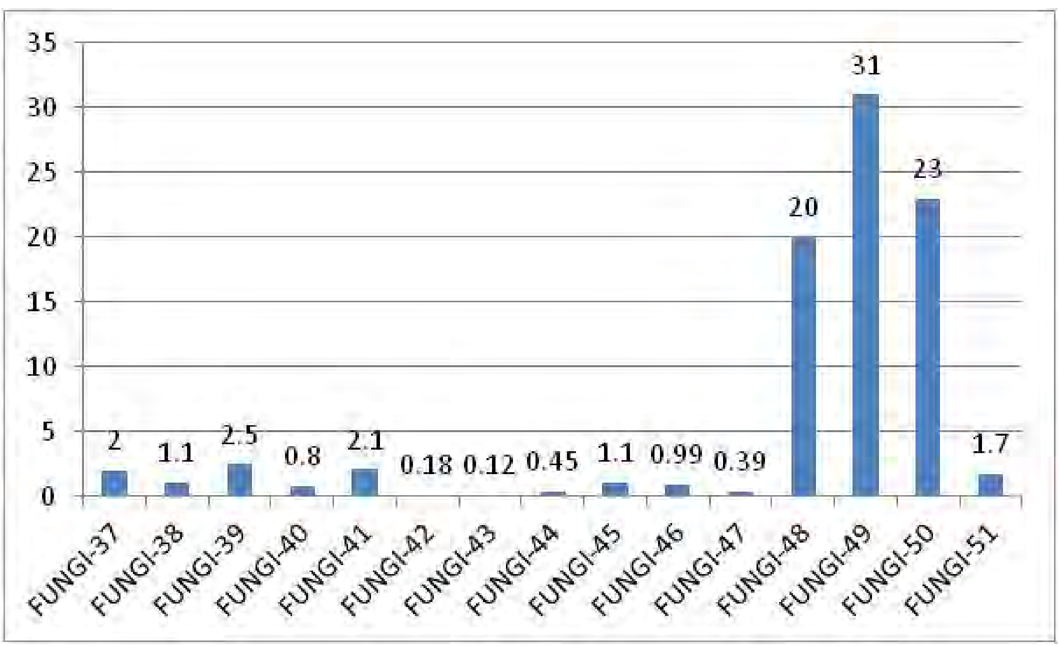


Figure 3.1.3.4.8 EFPC-05 sampling plot (*n*=15 subsamples; Hg= 5.83 mg/kg)

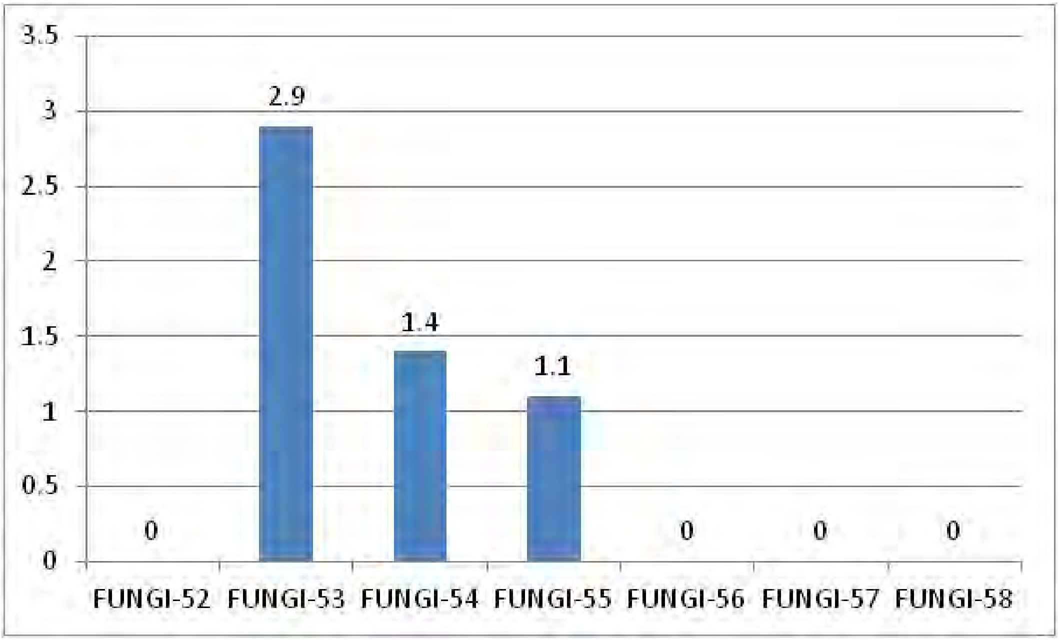


Figure 3.1.3.4.9 EFPC-06 sampling plot (*n*=7 subsamples; Hg= 0.78 mg/kg)

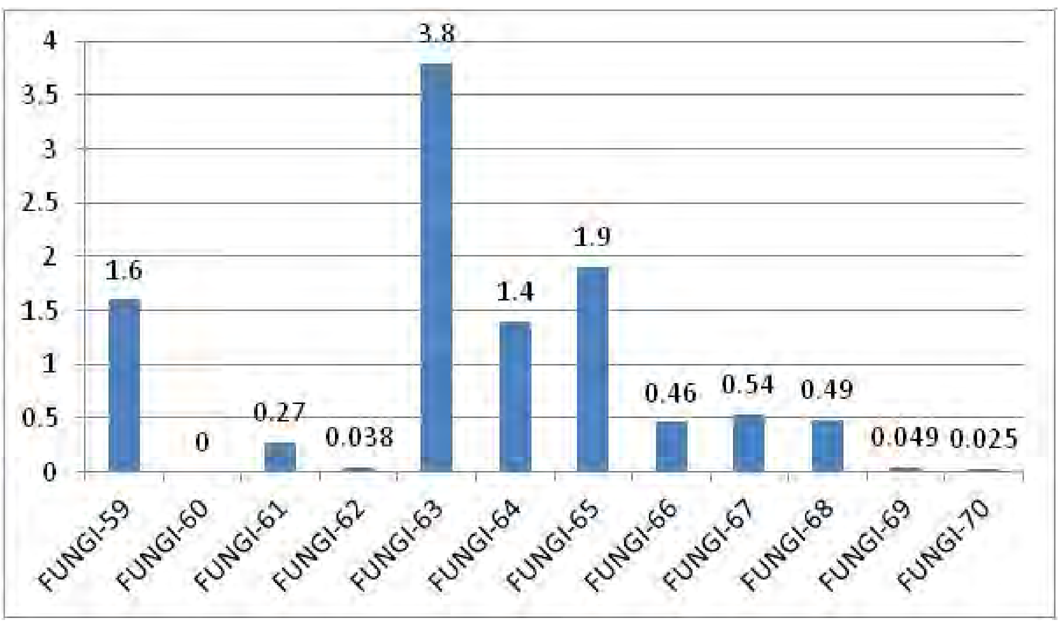


Figure 3.1.3.4.10 EFPC-07 sampling plot (*n*=12 subsamples; Hg= 0.88 mg/kg)

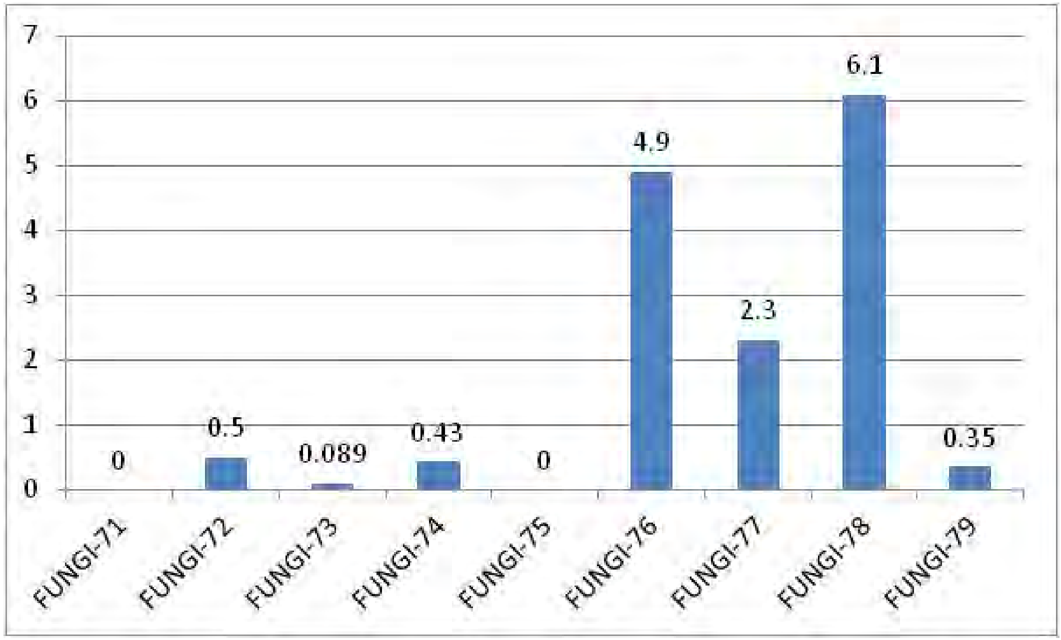


Figure 3.1.3.4.11 Control-01 sampling plot (*n*=9 subsamples; Hg= 1.63 mg/kg)

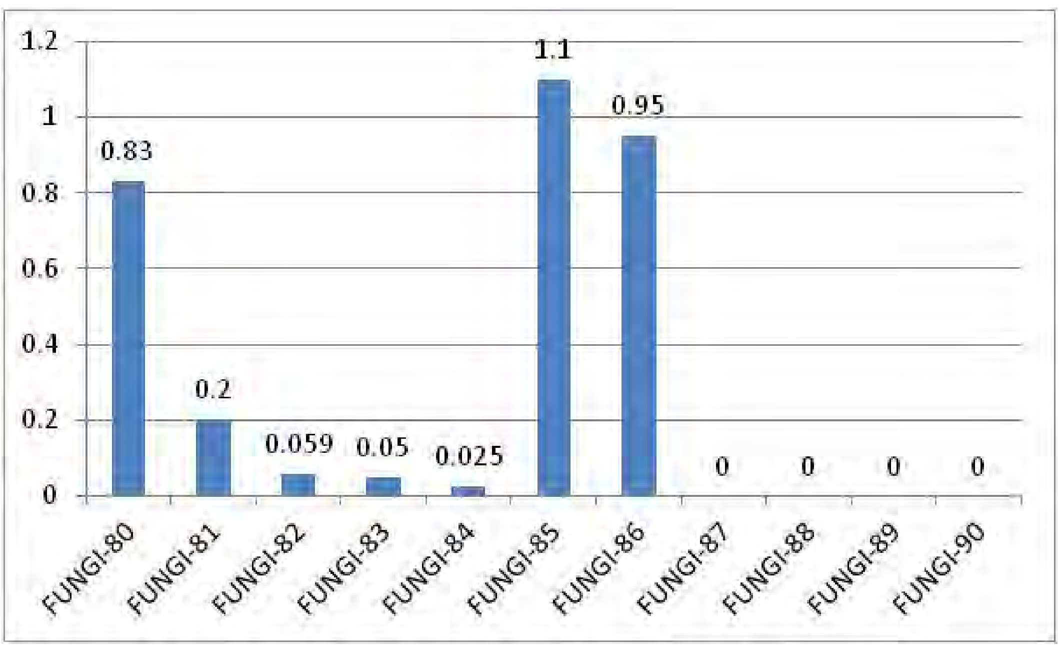


Figure 3.1.3.4.12 Control-02 sampling plot (*n*=11 subsamples; Hg= 0.29 mg/kg)

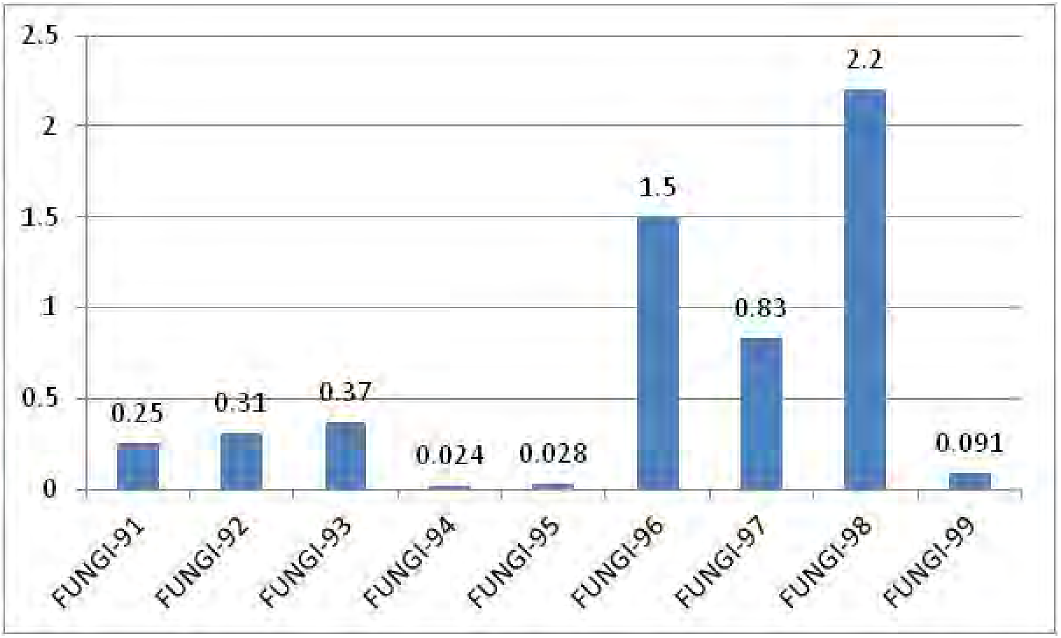


Figure 3.1.3.4.13 Control-03 sampling plot (*n*=9 subsamples; Hg= 0.62 mg/kg)

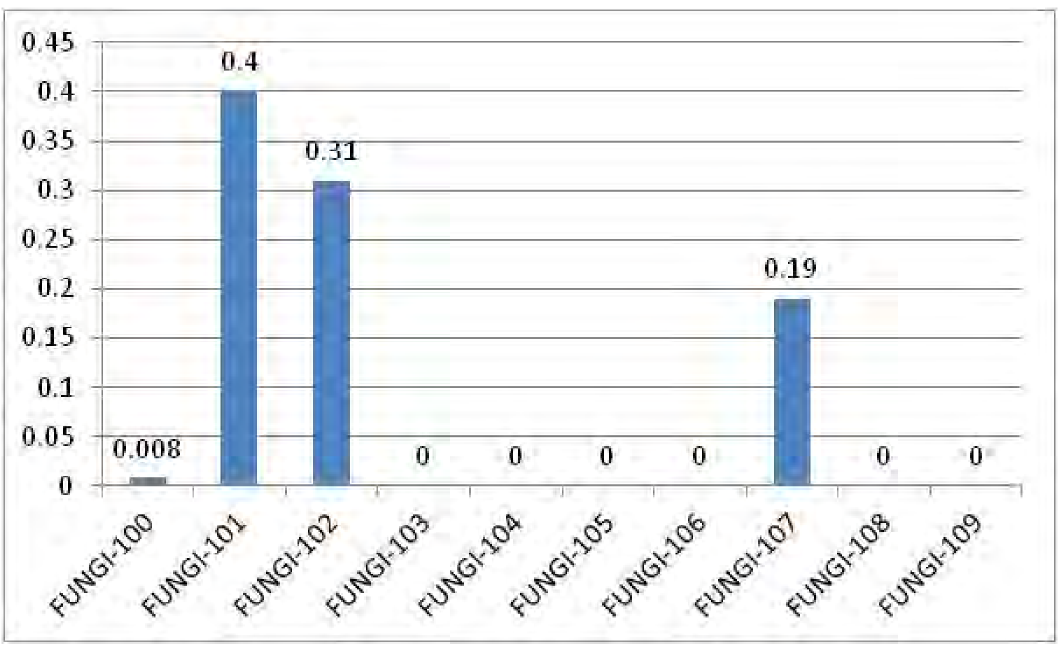


Figure 3.1.3.4.14 Control-04 sampling plot (*n*=10 subsamples; Hg= 0.09 mg/kg)

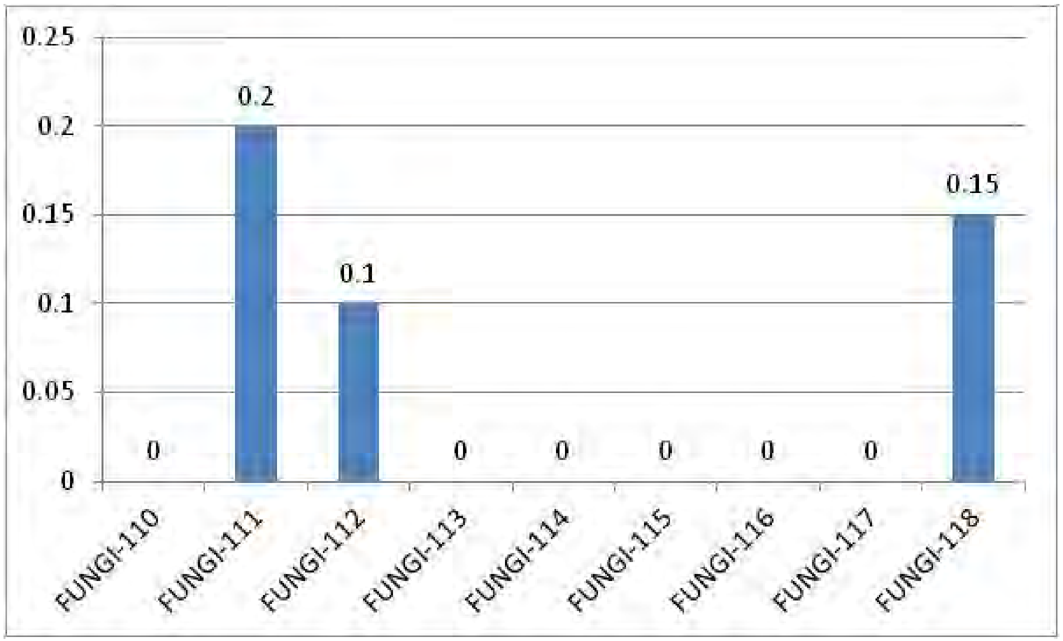


Figure 3.1.3.4.15 Control-05 sampling plot (*n*=9 subsamples; Hg= 0.05 mg/kg)

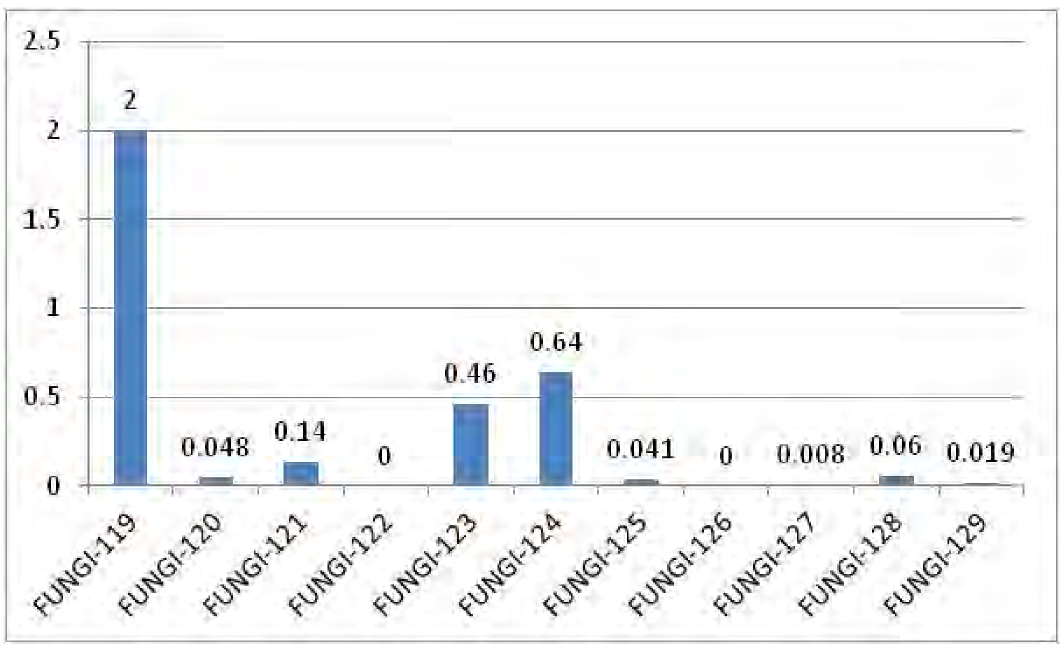


Figure 3.1.3.4.16 Control-06 sampling plot (*n*=11 subsamples; Hg= 0.31 mg/kg)

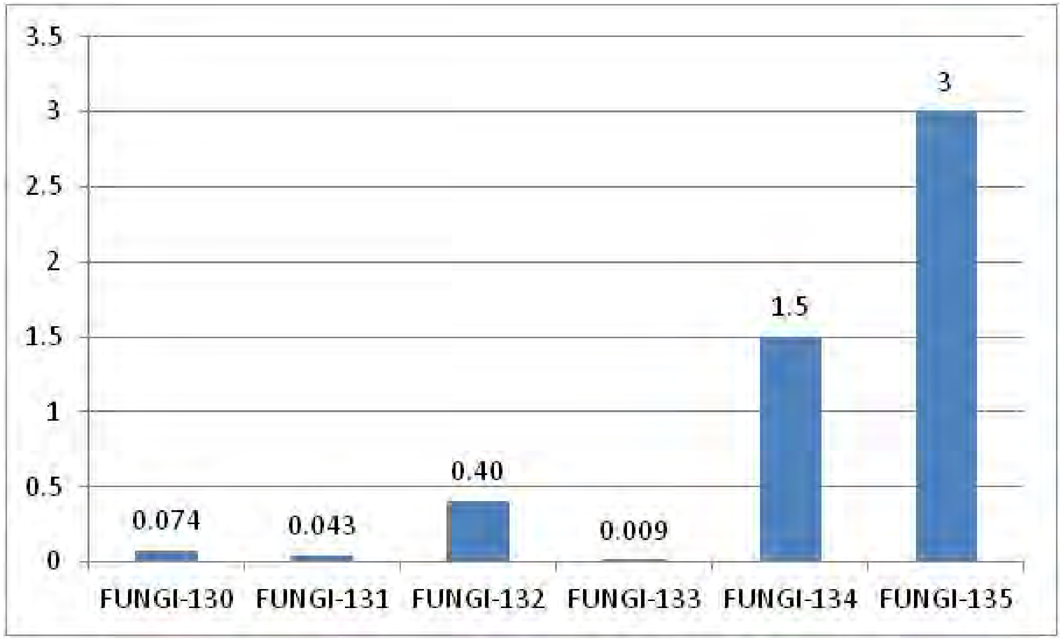


Figure 3.1.3.4.17 Control-07 sampling plot (*n*=6 subsamples; Hg= 0.84 mg/kg)

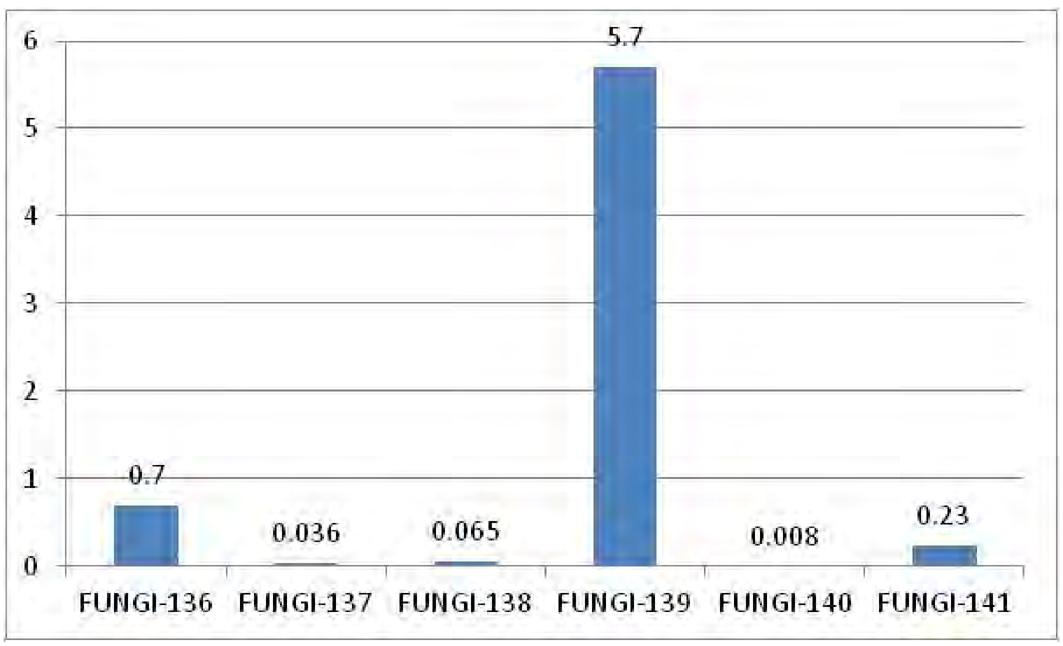


Figure 3.1.3.4.18 Control-08 sampling plot (*n*=6 subsamples; Hg= 1.12 mg/kg)

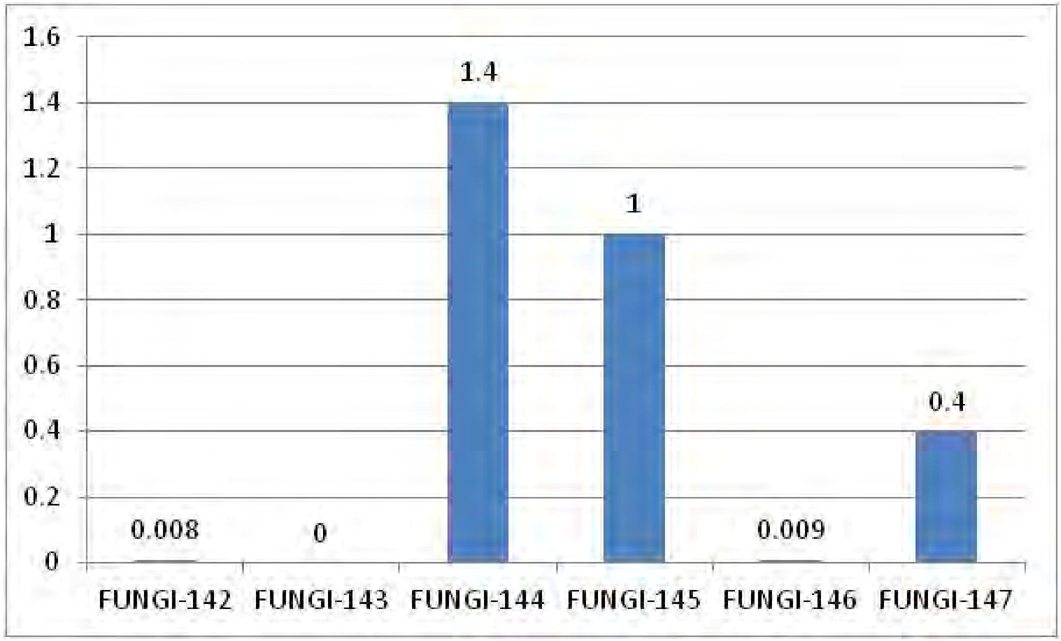


Figure 3.1.3.4.19 Control-09 sampling plot (*n*=6 subsamples; Hg= 0.47 mg/kg)

Appendix C

2014 Groundwater Sampling Results

2014 Groundwater Sampling Results

Groundwater samples were collected by TDEC between October 2013 and July 2014, before, during, and after the planned TVA aquifer pumping test. Samples were analyzed for radiochemicals, inorganics, and VOCs. At selected locations, samples were collected for stable nitrogen and oxygen isotopes. Samples were analyzed either by the TDH environmental laboratory or in the case of uranium isotopes and transuranic by a contract laboratory. The resulting data were evaluated against Environmental Protection Agency (EPA) National Public Drinking Water Regulations (NPDWR), EPA National Secondary Drinking Water Standards (NSDWR), EPA Health Advisories, EPA Maximum Contaminant Level Goal (MCLG) (EPA, 2011), and the 90^{th} percentile results for the National Water Quality Assessment (NAWQA) United States Geological Survey (USGS) groundwater study (DeSimone 2009).

EPA established NPDWRs that set mandatory water quality standards for drinking water contaminants. These are enforceable standards, which are established to protect the public against consumption of drinking water contaminants that present a risk to human health. An NPDWR is the maximum allowable amount of a contaminant in drinking water that can be delivered to the consumer.

In addition, EPA has established NSDWRs that set non-mandatory water quality standards for 15 contaminants. EPA does not enforce these NSDWRs. They are established only as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor. These contaminants are not considered to present a risk to human health at the NSDWR . (EPA website 3/3/16).

TDEC sampling of residential wells in the area between ORNL and the proposed reactor site before, during, and after the planned TVA pumping test was intended to address the following questions:

- Are contaminants present in the Hood Ridge Area groundwater samples?
- Do detected contaminants approach or exceed relevant drinking water standards?
- Are residential wells and TVA wells potentially connected hydrologically to DOE legacy waste sites on the ORR?
- Does the water quality respond to the TVA aquifer test?

The study area consists of a residential / agricultural area known as Hood Ridge. Situated within Roane County, Tennessee (Figure C.1) southwest, and across the Clinch River from the ORR, the area is approximately six kilometers from ORNL located in Bethel Valley. The study area was expanded to include two wells of the proposed site of the TVA modular reactors, formerly the site of the never constructed Clinch River Breeder Reactor (CRBR) (Figure C.1). The sample locations selected for this study area are listed in Table C.1 along with the rationale for sampling.

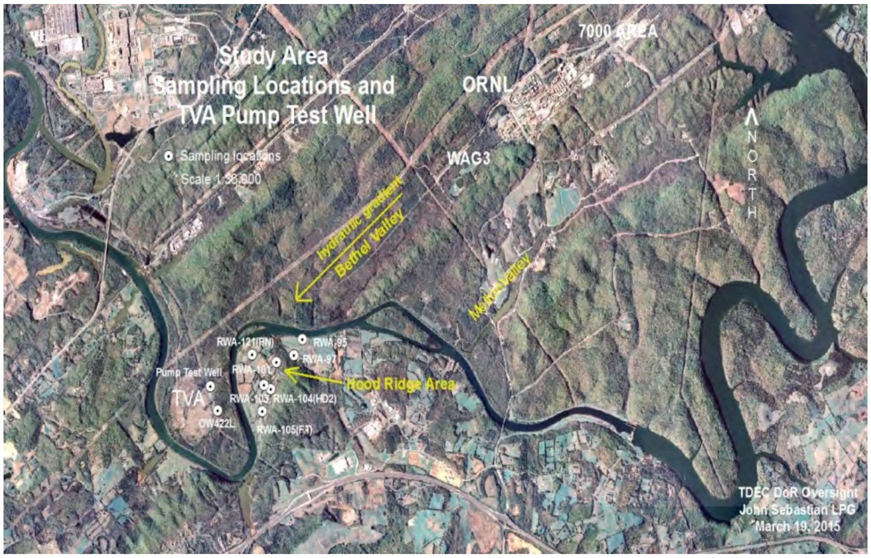


Figure C.1 2014 Study area sampling locations and TVA test well

Due to access problems and sampling complications with two wells (RWA-103, RWA-106), sampling was abandoned after one sampling event. Two TVA wells were subsequently added to the program [TVA well (OW422L) and TVA pumping well (designated TVAPT well)], which was sampled near the end of the aquifer test. Groundwater analysis parameters are found in Table C.2.

Table C.1 2014 TDEC Sampling Locations

Location	Depth (from owners report)	Estimated Lithology at Completion	Rationale for sampling
RWA-74	107 m (350 ft)	Fleanor Shale	Tritium reported in past results
RWA-97	122 m (400 ft)	Witten/Bowen/Benbolt Formation	Well in use
RWA-101	61 m (200 ft)	Benbolt Formation	Target formation
RWA-103	61 m (200 ft)	Witten Formation	^{90}Sr detected in past results
RWA-104	186 m (610 ft)	Benbolt Formation [bottom 6 m (20 feet)]	Logging of the well shows it penetrates the Big and Little Limestones near the base of the Witten Fm., known to be in waste trenches and contaminated at ORNL in Bethel Valley
RWA-106	52 m (170 ft)	Witten Formation	Well in use
RWA-121	~123m (400 ft)	Benbolt Formation	Well in use, target formation
OW422L (TVA)	~55m (180 ft)	Benbolt Formation	Target formation, transuranics detected, BTEX contamination
Pump Test Well (TVAPT)	~122 m (~400 ft)	Fleanor Shale	Extraction well

Groundwater from the TVA, and residential wells was analyzed for the following:
VOCs: Volatile organic compounds
Rad: Radionuclides (includes gross alpha, gross beta by liquid scintillation, gamma)
Metals: aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium
Inorganic: alkalinity, as $CaCO_3$, chloride, fluoride, hardness as total $CaCO_3$, nitrate/nitrite, ammonia
Fm.: Formation
m: meter
ft: feet
~: approximately
BTEX: benzene, ethyl benzene, toluene, and xylenes

Table C.2 2014 Groundwater Analysis Parameters

VOCs	Radionuclides	Metals			Inorganic
Volatile Organic Compounds	Gross Alpha	aluminum	antimony	arsenic	alkalinity as $CaCO_3$
	Gross Beta	barium	beryllium	boron	chloride
	Gamma radionuclides	cadmium	calcium	chromium	fluoride
	Strontium 89/90	copper	iron	lead	total hardness as $CaCO_3$
	Tritium	lithium	potassium	magnesium	nitrate/nitrite
	Technetium 99	manganese	nickel	selenium	ammonia
	Uranium Isotopes	silver	sodium	strontium	pH
		thallium	uranium	vanadium	total dissolved solids
		zinc	Mercury		sulfate
		hexavalent chromium			

2014 Sampling

Waste Areas with Potential Impact to Study Area

ORNL is approximately six kilometers to the northeast of the Hood Ridge area along geologic strike and regionally upgradient. Waste Area Groups (WAGs) associated with ORNL and underlain by the same geologic (Chickamauga Group) carbonates as the Hood Ridge area are WAG 1, WAG 2, WAG 3, and the 7000 Area (Figure C.3). The closest, WAG 3, is approximately 6 kilometers to the northeast of the Hood Ridge area along geologic strike and regionally upgradient, with the South Campus site being the furthest away at approximately 18 kilometers northeast along geologic strike. The distances are within the dimensions of groundwater basins in carbonate rocks worldwide (Worthington 1991).

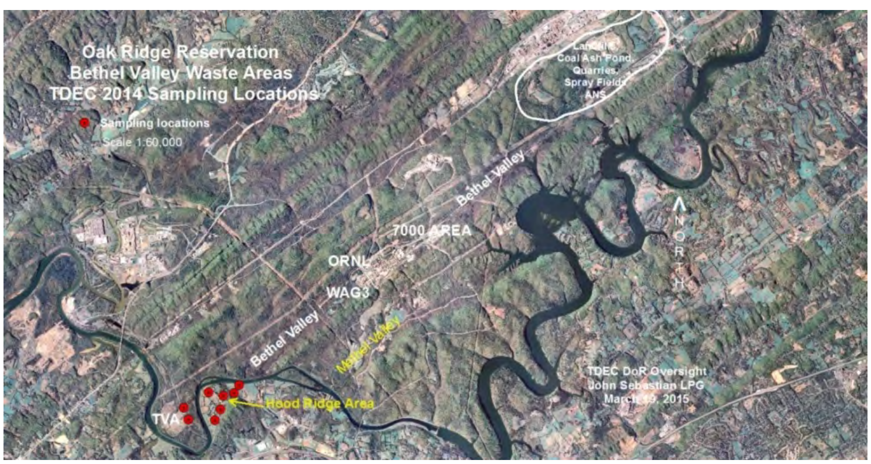


Figure C.3 Oak Ridge Reservation, Bethel Valley Waste Areas, TDEC 2014 Sampling Locations

Inorganic Results

Three of the wells analyzed (RWA-121, RWA-104, and OW422L) had results during 2014 exceeding EPA drinking water standards at least once during the study period. The majority of contaminants exceeding primary drinking water standards were from TVA well OW422L and from an unused residential well, RWA-104. Analysis of water from the kitchen sink faucet, supplied by residential well RWA-121, reported the presence of lead above drinking water limits (0.4 mg/L; the primary limit is 0.015 mg/L, Table C.4). The highest concentration of lead reported from water collected at the well was approximately 0.010 mg/L. There is a filtration system for the whole house that is serviced yearly. TDEC and TDH contacted well owners regarding any health risks of the exceeded NPDWR criteria.

Table C.4 Residential Well NPDWR Exceedances

Well	Date Collected	Lead mg/L	Selenium mg/L	Fluoride mg/L	Benzene mg/L	Toluene mg/L
NPDWR		**0.01 mg/L**	**0.05 mg/L**	**4 mg/L**	**0.005 mg/L**	**1.0 mg/L**
NSDWR				**2 mg/L**		
RWA-104	3/25/2014	U	0.005	4.0	0.0776	0.0032
RWA-104	7/22/2014	U	0.034J	4.8	0.0246	0.00251
RWA-121	3/24/2014	0.00097J	U	0.043J	U	U
RWA-121	6/24/2014	0.011	U	NT	U	U
RWA-121 FDW[1]	8/6/2014	U	U	NT	NT	NT
RWA-121 SSHW[2]	8/6/2014	0.4	U	NT	NT	NT
RWA-121 UDW[3]	8/6/2014	U	U	NT	NT	NT
RWA-121 UW[4]	8/6/2014	0.00084J	U	NT	NT	NT
OW422L	4/3/2014	0.00088J	0.056	9.5 J	0.524	1.84

NPDWR: EPA National Primary Drinking Water Regulations
NSDWR: EPA Secondary Drinking Water Regulation Standards
mg/L: milligrams per liter
[1]Filtered Drinking Water
[2]Sink Shower House Filtration Water
[3]Unfiltered Drinking Water
[4]Unfiltered Well Water

Other contaminants reported in TDEC's data from the study-area wells that were below primary drinking water standards include cyclohexane, disinfection byproducts, fission products, transuranic radionuclides, chlorinated solvents, benzene, toluene, ethyl benzene and xylene compounds, chromium, and antimony.

Various inorganics (metallic and non-metallic) were common in the study area wells, and when compared to data from the NAWQA (DeSimone 2009) could be considered elevated. Aluminum and iron were commonly elevated and may have been attributable to suspended sediments. Concentrations of potassium, sodium, chloride, phosphorus, and ammonia were elevated at times.

RWA-104's data indicates a response to the extraction of groundwater by TVA during the pump test. This response is illustrated by VOC results reported from analysis of three samples collected on October 29, 2013, March 25, 2014, and July 22, 2014. A total of 26 different VOCs were detected from this well; 12 were detected in the October 29, 2013 sample; 18 in the March 25, 2014 sample; and 15 in the July 22, 2014 sample.

Fourteen of the 26 VOCs detected changed concentrations from low concentration prior to the aquifer test, increased concentration during the aquifer test, to subsequently decreased concentration after the aquifer test ceased (rise and fall). Three VOCs declined from one event to the next, eight were indeterminate, and one VOC declined during the pump test and recovered afterwards (U shaped). Table C.5 illustrates these observations. The last column describes the general response of the VOC concentrations if plotted as a line chart.

Also of interest are concentrations for metals and non-metallic inorganics reported from analysis of groundwater from TVA well OW422L and RWA-104 indicates correlation of the two wells during the aquifer test. Table C.6 provides a comparison of the two wells for metals and non-metallic inorganics.

Table C.7 shows general inorganic and water parameters of interest from the TVA well OW422L. Table C.8 displays VOCs from OW422L.

Table C.5 Comparison of Organic Analyses in RWA-104 Before, During, and After the Aquifer Test (µg/L)

Analyte	10/29/2013	3/25/2014	7/22/2014	Line Type
Benzene	104	77.6	24.6	Declined
Ethylbenzene	2.93	0.67	U	Declined
o-Xylene	3.28	0.83	U	Declined
1,2,4-Trimethylbenzene	0.84	U	U	Indeterminate
1,2-Dichloroethane	U	U	0.26j	Indeterminate
1,3,5-Trimethylbenzene	0.31j	U	U	Indeterminate
Acetone	U	NA	9.58j	Indeterminate
Carbon Disulfide	U	NA	0.22j	Indeterminate
Cyclohexane	0.18j	NA	U	Indeterminate
Isopropylbenzene	0.33j	U	U	Indeterminate
n-Propylbenzene	0.36j	U	U	Indeterminate
1,1,2-Trichloroethane	U	0.83	U	Rise and fall
1,1-Dichloroethane	U	7.5	1.52	Rise and fall
1,2-Dichloropropane	U	1.6	0.20j	Rise and fall
1,3-Dichloropropane	U	0.52	U	Rise and fall
Bromochloromethane	U	3.9	U	Rise and fall
Bromodichloromethane	U	80.5	8.52	Rise and fall
Bromoform	U	14.9	3.9	Rise and fall
Chloroethane	U	14.9	2.28	Rise and fall
Chloroform	11.1	4000	774	Rise and fall
Chloromethane	0.49j	1.1	U	Rise and fall
Dibromochloromethane	U	24.9	4.76	Rise and fall
Dibromomethane	U	4.8	0.71j	Rise and fall
Methylene chloride	U	39.9	10.3	Rise and fall
Toluene	0.99	3.2	2.51	Rise and fall
m&p-Xylene	3.3	0.85	3	U-Shaped

µg/L: micrograms per Liter
U: undetected
j: estimated result value

Table C.6 Comparison of Metal and Inorganic Analyses from RWA-104 and OW422L

Analyte	RWA-104 (mg/L) 03/25/2014	OW422L (mg/L) 04/03/2014	NPDWR(mg/L)	NPDWRS (mg/L)	NWQA 90th Percentile (mg/L)
Alkalinity	370	230	NA	NA	325
Ammonia	1.8	2.4	NA	NA	0.33
Chloride	5300	4800	NA	250	62.8
Fluoride	4	9.5J	4	2	1.1
Nitrate and Nitrite	U	U	10	NA	2.4
Total Dissolved solids	9500	8300	NA	500	590
Sulfate	260	970J	NA	250	94

Analyte	RWA-104 (mg/L) 03/25/2014	OW422L (mg/L) 04/03/2014	NPDWR(mg/L)	NPDWRS (mg/L)	NWQA 90th Percentile (mg/L)
Boron	1.5	0.71	NA	NA	0.218
Calcium	100	36	NA	NA	95.3
Iron	1800	2700	NA	0.3	1.1
Magnesium	48	12	NA	NA	36
Potassium	39	93	NA	NA	6.6
Sodium	3000	1700	NA	NA	78.7
Aluminum	0.11	2.1	NA	0.05 to 0.2	0.00528
Antimony	0.00071J	1.2	0.006	NA	<0.001
Arsenic	U	U	0.01	NA	0.00753
Barium	0.059	0.1	2	NA	0.219
Beryllium	U	U	0.004	NA	<0.001
Cadmium	U	U	0.005	NA	<0.001
Chromium	U	U	100	NA	0.004
Cobalt	0.00040J	U	NA	NA	0.00052
Copper	0.13	0.029	1.3	1	0.0123
Lead	U	0.00088J	0.015	NA	0.00109
Lithium	0.57	0.6	NA	NA	0.0438
Manganese	0.031	0.0494	NA	0.05	0.172
Mercury	U	0.000042J	0.002	NA	NA
Nickel	0.0044	0.01	NA	NA	0.003
Selenium	0.005	0.056	0.05	NA	0.00302
Silver	U	U	NA	NA	<0.001
Strontium	8.9	2.4	NA	NA	2.24
Thallium	U	U	0.002	NA	<0.001
Uranium	0.0014	0.0015	0.03	NA	0.00803
Vanadium	U	U	NA	NA	20.4
Zinc	0.03	0.027J	NA	5	0.0999
Total Hardness	460	140	NA	NA	NA

NAWQA: National Water Quality Assessment Program of the US Geological Survey
NA: not applicable
U: undetected, non-detects are not compared to NPDWRs or NWQA 90th percentiles
j: estimated result value

Table C.7 TDEC Analysis of TVA Well OW422L General Inorganics and Water Parameters of Interest (mg/L)

Analyte	OW422L (mg/L) 11/7/2013	OW422L (mg/L) 04/03/2014	NPDWR (mg/L)	NPDWRS (mg/L)	NWQA 90th Percentile (mg/L)
Ammonia	6.5	2.4			0.33
Chloride	1500	4800		250	62.8
Fluoride	3.6	9.5J	4	2	1.1
TDS	3349	8300		500	590
Sulfate	300	970J		250	94
pH Field	12-13			8.5	7.9

J: estimated result value
mg/L: milligrams per Liter

Table C.8 Selected TDEC Organic Analyses of Well OW422L

Contaminant	OW422L µg/L) 11/7/2013	OW422L (µg/L) 04/03/2014	NPDWR (µg/L)
1,2,4-Trimethylbenzene	126	92.8	
1,3,5-Trimethylbenzene	48	32.8	
4-Isopropyltoluene	13	4.5	
Benzene	315	524	5
Carbon Disulfide	4.60J	NR	
Cyclohexane	488	NR	
Ethylbenzene	136	155	700
Isopropylbenzene	27.8	22.4	
Methylcyclohexane	409	NR	
Naphthalene	5.6J	8.5	
n-Butylbenzene	13	3	
n-Propylbenzene	36	24.1	
m&p xylene	541	619	
o-xylene	266	255	10,000 total xylenes
Toluene	1007	1840	1000

µg/L: micrograms per Liter
NR: not reported
j: estimated result value

Radionuclide Results

2014 groundwater samples were analyzed for gross alpha activity, gross beta activity, gamma-emitting radioisotopes (such as ^{137}Cs), ^{99}Tc, ^{89}Sr/^{90}Sr, tritium, alpha-emitting transuranic elements, and uranium isotopes. Fission products (^{99}Tc, ^{90}Sr), transuranic, and uranium isotopes were reported in groundwater samples collected from one or more of the wells in the study area. All reported concentrations are below EPA primary drinking water standards.

Concentrations of ^{99}Tc reported from analysis of groundwater from well RWA-97 increased during the aquifer test and declined afterward. Results for ^{99}Tc in RWA-97 are shown in Table C.9 below.

The fission product ^{90}Sr was present in one well at 2.54 pCi/L, which is below the 8 pCi/L EPA primary drinking water standard. Table 3.1.5.3.1.6 displays the reported data for fission products. In Table 3.1.5.3.1.6, orange shading indicates positive results. Analytical problems were associated with two positive results for ^{90}Sr (marked with an *) and are noted with the results.

Table 3.1.5.3.1.6 Fission Products Identified in Study Area Wells

Analyte/Site	Date Collected	Strontium-90	CSU	ssMDC	Technetium-99	CSU	ssMDC	Units
RWA-95	02/06/14	0.18	NA	0.2	0.54	0.34	0.69	pCi/L
RWA-95	03/27/14	-0.14	NA	0.15	0.57	0.34	0.72	pCi/L
RWA-97	06/04/13	2.86*	0.789	1.19	0	0.56	0.69	pCi/L
RWA-97	11/04/13	0.28	0.19	0.22	0	0.31	0.72	pCi/L
RWA-97	03/24/14	0.28	0.17	0.2	1.77	0.37	0.74	pCi/L
RWA-97	06/17/14	0.86	0.26	0.28	10.19	0.53	0.81	pCi/L
RWA-104	10/29/13	0.4	0.24	0.23	0	0.31	0.71	pCi/L
RWA-104	03/24/14	0.12	NA	0.18	0.55	0.33	0.69	pCi/L
RWA-104	07/22/14	0.21	0.12	0.19	-0.47	0.29	0.6	pCi/L
RWA-103	05/28/13	2.24	0.78	1.41	0	0.57	0.69	pCi/L
RWA-106	12/17/13	-0.15	NA	0.24	-0.54	0.29	0.69	pCi/L
TVA PTW	03/24/14	0.27	0.18	0.21	0.54	0.33	0.68	pCi/L
RWA-101	06/04/13	3.81*	0.91	1.19	0.55	0.58	0.7	pCi/L
RWA-101	11/18/13	-0.21	NA	0.23	2.26	0.32	0.72	pCi/L
RWA-101	03/24/14	0.21	0.08	0.16	0	0.32	0.68	pCi/L
RWA-121	11/01/13	0.24	0.14	0.23	0.58	0.32	0.74	pCi/L
RWA-121	03/24/14	0.21	0.08	0.16	0	0.32	0.68	pCi/L
RWA-121	06/24/14	2.54	0.94	0.28	0.56	0.34	0.71	pCi/L

^{90}Sr: Strontium-90 (fission product)
^{99}Tc: Technectium-99 (fission product)
CSU: Combined Standard Uncertainty (one sigma)
ssMDC: sample specific Minimum Detectable Concentration
MDA: Minimum Detectable Activity
NA: not available
pCi/L: picoCuries per Liter

Transuranic isotopes 241Am, 243/244Cm, 237Np, 238Pu, and 239/240Pu were reported in the results for the following wells: RWA-97, RWA-101, and RWA-104. Concentrations can be described as being low, generally ranging from hundredths (1/100th) of a pCi/L to tenths (1/10th) of a pCi/L, which is below the EPA primary drinking water standard for alpha-emitting radionuclides of (15 pCi/L).

All radioactive substances reported were below levels of concern for human health (NPDWRs).

2014 Conclusions

In conjunction with the TVA aquifer test, this project collected groundwater from wells in an area adjacent to Bethel Valley. Pumping wells can influence the migration of contaminants through existing groundwater pathways in bedrock. This has been documented (DOE Groundwater Strategy 2014) for two geographic locations (Melton Valley and Union Valley). DOE has made efforts to curtail pumping beyond the exit pathway monitoring points due to the potential of enhanced migration of plumes (DOE Groundwater Strategy 2014). Results obtained from this study suggest that water quality in this area is similar to that found in Melton Valley across the Clinch River from the ORR. There are enough similarities between Bethel Valley and Melton Valley that the potential exists in the Hood Ridge area for migration of DOE plumes to occur.

Low levels of anthropogenic radionuclides, such as fission products technetium-99, Strontium-90, and transuranic elements were reported in the results of TDEC analyses of area groundwater. The reported detection of anthropogenic radionuclides down gradient and along geologic strike suggests that groundwater in this area could be affected by waste disposals. Concentrations of some of the 26 VOCs detected changed during the TVA aquifer test. Analyses of the Hood Ridge area groundwater reported the presence of radioactive, metallic, non-metallic inorganic, and VOC contaminants. Several metals, fluoride, and VOC contaminants were reported above their EPA primary drinking water regulations. While it is possible these results could be influenced by naturally occurring elements or radioactive fallout, given the significant sources at the ORR, more investigation is warranted. TDEC and TDH contacted well owners regarding possible health risks of the exceeded NPDWR criteria.

Springs Parameter Data

Table 3.1.5.1.3 Spring Parameter Measurements

Station Name	Spring	Date	Time	Temp-erature degrees Celsius	Dissolved Oxygen mg/L	Specific Conductivity µS/cm	pH	Oxidation Reduction Potential milliVolts
2015SPGEMP-02	Turnpike Spring	07/08/15	1252	14.4	12.68	260.2	7.21	241.4
2015SPGEMP-02	Turnpike Spring	07/08/15	1255	14.4	12.56	259.8	7.15	252
2015SPGEMP-03	CCC Spring	06/10/15	1210	16.1	1.17	413.4	6.88	88.3
2015SPGEMP-03	CCC Spring	06/10/15	1225	16.1	1.1	412.4	6.93	87.8
2015SPGEMP-03	CCC Spring	06/10/15	1244	16.2	1.31	413.6	7.07	54.7
2015SPGEMP-04	Poplar Spring	06/10/15	1112	14.4	3.82	264.4	6.77	245.4
2015SPGEMP-04	Poplar Spring	06/10/15	1119	14.3	3.82	264.2	6.71	240.3
2015SPGEMP-04	Poplar Spring	06/10/15	1125	14.3	3.81	264.2	6.72	228.2
2015SPGEMP-04	Poplar Spring	06/10/15	1130	14.3	3.79	264.2	6.74	214.5
2015SPGEMP-04	Poplar Spring	06/10/15	1139	14.4	3.81	264.1	6.75	212.6
2015SPGEMP-05	Jack's Spring	05/20/15	843	14.7	6.18	308.5	7.09	179.12
2015SPGEMP-06	NWTRIB Spring	05/27/15	1228	14.5	7.22	484.2	3.69	228.1
2015SPGEMP-06	NWTRIB Spring	05/27/15	1257	15.9	7.22	481.9	3.15	175.6
2015SPGEMP-07	Gaston Spring	05/20/15	921	13.5	6.41	346.2	7.14	175.4
2015SPGEMP-08	Green Barn Spring	05/20/15	1100	13.1	7.21	320.1	7.04	294.4
2015SPGEMP-09	Edwards Spring	07/08/15	857	15.1	7.72	221.0	6.91	216.4
2015SPGEMP-09	Edwards Spring	07/08/15	903	15.0	8.05	219.9	6.81	272.4
2015SPGEMP-09	Edwards Spring	07/08/15	911	15.0	8.05	219.7	6.86	294.4
2015SPGEMP-09	Edwards Spring	07/08/15	917	15.0	7.96	219.6	6.87	303
2015SPGEMP-09	Edwards Spring	07/08/15	926	15.0	7.41	219.6	6.86	310.1
2015SPGEMP-11	Horizon Spring	07/08/15	1216	13.3	3.9	477	6.79	186.7
2015SPGEMP-11	Horizon Spring	07/08/15	1222	13.3	3.02	477.2	6.76	169.6
2015SPGEMP-11	Horizon Spring	07/08/15	1232	13.3	2.75	477.6	6.78	161.8
2015SPGEMP-11	Horizon Spring	07/08/15	1239	13.3	2.72	477.6	6.79	159.2
2015SPGEMP-14	Outfall 2 Spring	06/03/15	1135	17	8.13	301.8	7.85	238.9
2015SPGEMP-14	Outfall 2 Spring	06/03/15	1139	17	8.28	301.4	7.87	244.9
2015SPGEMP-16	JA Jones Spring	09/02/15	1018	19.9	1.22	555	7.02	64.1
2015SPGEMP-16	JA Jones Spring	09/02/15	1028	19.9	0.79*	551.4	6.87	70
2015SPGEMP-16	JA Jones Spring	09/02/15	1043	19.7	0.65	554	6.86	101.7
2015SPGEMP-17	0956/Rifle Range Spring	05/27/15	1129	14.2	7.06	257.7	7.87	NR
2015SPGEMP-17	0956/Rifle Range Spring	05/27/15	1131	14.2	6.98	257.5	7.91	263.2
2015SPGEMP-18	Crooked Tree Spring	05/27/15	1042	17.6	7.51	299.7	7.41	239.1
2015SPGEMP-18	Crooked Tree Spring	05/27/15	1044	17.5	7.77	300.9	7.37	247.2
2015SPGEMP-18	Crooked Tree Spring	05/27/15	1108	17.6	7.57	307.1	7.22	NR
2015SPGEMP-20	Love Spring	06/10/15	900	15.2	1.98	312.3	7.17	248.1

Station Name	Spring	Date	Time	Temp-erature degrees Celsius	Dissolved Oxygen mg/L	Specific Conductivity µS/cm	pH	Oxidation Reduction Potential milliVolts
2015SPGEMP-20	Love Spring	06/10/15	910	14.9	1.82	307.4	6.96	210.5
2015SPGEMP-20	Love Spring	06/10/15	920	14.8	1.91	306.9	6.96	188.4
2015SPGEMP-20	Love Spring	06/10/15	930	14.8	1.87	306.7	6.93	181.4
2015SPGEMP-20	Love Spring	06/10/15	940	14.8	1.88	306.8	6.95	171.0
2015SPGEMP-22	MVMR Spring	05/20/15	1005	13.8	7.73	292.4	7.37	178.8
2015SPGEMP-24	Tomsseep Spring	09/02/15	831	18.0	1.62	613	6.78	152.6
2015SPGEMP-24	Tomsseep Spring	09/02/15	841	18.0	1.43	613	6.67	104
2015SPGEMP-24	Tomsseep Spring	09/02/15	847	18.0	1.37	613	6.67	95.5
2015SPGEMP-24	Tomsseep Spring	09/02/15	855	18.0	1.36	613	6.68	88.7
2015SPGEMP-24	Tomsseep Spring	09/02/15	859	18.0	1.47	612	6.7	91.5
2015SPGEMP-27	ReginaLovesBobby Spring	07/08/15	952	15.1	9.18	243.6	6.95	296.6
2015SPGEMP-27	ReginaLovesBobby Spring	07/08/15	1002	15.1	9.29	243.4	6.95	306.1
2015SPGEMP-27	ReginaLovesBobby Spring	07/08/15	1009	15.1	9.38	243.4	6.95	310.9
2015SPGEMP-27	ReginaLovesBobby Spring	07/08/15	1016	15.1	9.36	243.3	6.95	313.9
2015SPGEMP-27	ReginaLovesBobby Spring	07/08/15	1026	15.5	8.67	243.3	6.95	316.3
2015SPGEMP-28	SS-5 Spring	06/22/15	941	13.9	3.65	539.6	7.14	306.7
2015SPGEMP-28	SS-5 Spring	06/22/15	951	13.8	3.07	538.3	7.11	309.6
2015SPGEMP-28	SS-5 Spring	06/22/15	957	13.8	3.10	538	7.11	311.4
2015SPGEMP-28	SS-5 Spring	06/22/15	1004	13.8	2.67	538.1	7.11	312.5
2015SPGEMP-28	SS-5 Spring	06/22/15	1010	13.8	2.66	538.1	7.09	313.6
2015SPGEMP-29	SS-7 Spring	06/22/15	853	13.2	5.7	370.4	6.95	324.9
2015SPGEMP-29	SS-7 Spring	06/22/15	900	13.2	5.68	370.3	7.00	326.7
2015SPGEMP-29	SS-7 Spring	06/22/15	907	13.2	5.64	370.6	7.01	326.2
2015SPGEMP-29	SS-7 Spring	06/22/15	912	13.2	5.67	370.7	7.03	329.6
2015SPGEMP-29	SS-7 Spring	06/22/15	919	13.2	5.61	370.0	7.06	318.9
2015SPGEMP-31	SS-4 Spring	06/22/15	1037	16.4	1.01	694	6.99	298.3
2015SPGEMP-31	SS-4 Spring	06/22/15	1044	16.4	0.97	694	6.86	296.2
2015SPGEMP-31	SS-4 Spring	06/22/15	1055	16.4	1.16	695	6.85	290.8
2015SPGEMP-31	SS-4 Spring	06/22/15	1106	16.4	2.61	695	6.83	288.6
2015SPGEMP-32	21-002 Spring	09/02/15	1235	14.3	9.32	209.1	7.34	215.3
2015SPGEMP-32	21-002 Spring	09/02/15	1241	14.3	9.16	209.7	7.3	223.3
2015SPGEMP-32	21-002 Spring	09/02/15	1250	14.3	8.93	208.4	7.31	220.2
2015SPGEMP-32	21-002 Spring	09/02/15	1301	14.3	9.05	208.8	7.36	209.6
2015SPGEMP-37	USGS 10-895 Spring	07/08/15	1050	15.1	6.28	244.1	6.77	153.3
2015SPGEMP-37	USGS 10-895 Spring	07/08/15	1103	14.0	8.29	186.6	6.63	214.9
2015SPGEMP-37	USGS 10-895 Spring	07/08/15	1114	14.2	8.34	187.6	6.67	232.4
2015SPGEMP-37	USGS 10-895 Spring	07/08/15	1122	14.0	9.7	234.5	6.61	235.7
2015SPGEMP-37	USGS 10-895 Spring	07/08/15	1137	14.0	9.62	234.6	6.6	244.3

Station Name	Spring	Date	Time	Temp-erature degrees Celsius	Dissolved Oxygen mg/L	Specific Conductivity µS/cm	pH	Oxidation Reduction Potential milliVolts
2015SPGEMP-37	USGS 10-895 Spring	07/08/15	1149	14.0	9.63	234.4	6.6	231.2
2015SPGEMP-38	Bootlegger Sp	06/03/15	1250	14.6	8.31	390.1	7.17	257.0
2015SPGEMP-38	Bootlegger Sp	06/03/15	1300	14.6	8.28	399.7	7.06	273.2
2015SPGEMP-38	Bootlegger Sp	06/03/15	1310	14.6	8.16	389.4	7.03	284.8
2015SPGEMP-38	Bootlegger Sp	06/03/15	1316	14.6	7.78	382.3	7.01	263.8
2015SPGEMP-39	Cattail Spring	06/03/15	1210	15.6	3.66	468.2	7.11	169.9
2015SPGEMP-39	Cattail Spring	06/03/15	1213	15.7	3.65	468.1	7.08	170.9
2015SPGEMP-39	Cattail Spring	06/03/15	1223	15.6	3.59	468.5	7.07	172.4
2015SPGEMP-39	Cattail Spring	06/03/15	1235	15.7	3.64	468.0	7.13	167.9
2015SPGEMP-40	Mtn. Dew/ Overhang Spring	06/10/15	1005	14.1	5.58	309.3	6.92	230.5
2015SPGEMP-40	Mtn. Dew/ Overhang Spring	06/10/15	1015	14.1	6.4	309.6	6.87	244.8
2015SPGEMP-40	Mtn. Dew/ Overhang Spring	06/10/15	1030	14.1	5.35	309.2	6.85	250.4
2015SPGEMP-40	Mtn. Dew/ Overhang Spring	06/10/15	1040	14.2	5.92	309.4	6.83	255.8
2015SPGEMP-40	Mtn. Dew/ Overhang Spring	06/10/15	1103	141	6.04	309.9	6.84	234.6