



**TENNESSEE DEPARTMENT  
OF  
ENVIRONMENT AND CONSERVATION**

**DOE OVERSIGHT OFFICE**

**ENVIRONMENTAL MONITORING PLAN**

**JANUARY through DECEMBER 2014**

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## **TDEC DOE Oversight Office Environmental Monitoring Plan Changes for 2014**

These notations refer to changes in scope from the 2013 monitoring plan.

### **1. Air Quality Monitoring**

*Monitoring of Hazardous Air Pollutants on the Oak Ridge Reservation* With the shutdown of the TSCA incinerator at ETTP and the biggest of the diffusion buildings being gone, this program has lost most of its original purpose. We are considering ending the program or converting it to a fugitive program that monitors particular remediation projects. It is still an ambient program for now, but in 2015 it will likely be more oriented toward monitoring specific CERCLA projects, particularly ones at Y-12 that involve mercury. Comments are welcome on the long term destiny of this monitoring.

### **2. Biological Monitoring**

*Benthic Macroinvertebrate Monitoring* Invertebrates will be analyzed for mercury and methyl mercury. We hope to add to knowledge about pathways to fish and hence to humans and other receptors, particularly in Lower East Fork Poplar creek.

*White-tailed Deer Monitoring Program on the Oak Ridge Reservation* We propose to add an operational area that is currently a zone where hunters are allowed during the managed hunts. It is the area between the Bear Creek Burial Grounds and the DOE boundary next to Country Club Estates and then southwest to the White Wing Scrapyard. We will provide an updated SOP and operational map to DOE and our security contacts around the second week of December. We start immobilizing and GPS collaring deer after the last statewide deer hunts in mid-January.

*Fish Tissue Monitoring Plan* This is a new project. The objectives are to 1) identify the principal diet items of the selected fish species in EFPC, 2) identify collected fish to species and, 3) assess Hg, MeHg and PCB content of fish gut contents and in fish fillets collected from EFPC. Additionally, we aim to 4) determine potential effects on ecosystem health, specifically wildlife feeding on fish and 5) determine the magnitude of the contamination in edible portions of EFPC fish species where pollutants could be incidentally consumed by humans. The gut contents of fish will be compared to the benthic macroinvertebrate chemical analysis.

*Pilot Project: Bioaccumulation Study of Metals in Fungi from East Fork Poplar Creek Floodplain*

This is a small pilot project to get preliminary information about mercury and other contaminants in mushrooms. Some mushrooms are consumed by humans and most all of them are a food source for wild animals. DOE comments concerning this project were incorporated into the plan.

*Acoustical Monitoring of Bats on the Oak Ridge Reservation*

This project is a continuation of the project started last year. Primarily it focuses on identifying bat species and possibly populations by deploying acoustic identification devices on the Oak Ridge Reservation. Changes include the possible use of mist netting to collect bats for species identification. If mist netting is selected as a collection strategy, a federal collection permit will be required as well as appropriate training and vaccinations for those

handling the bats. The holder of the federal permit will also be present for all mist netting activities.

### **3. Drinking Water**

No Changes

### **4 Groundwater Monitoring**

*Groundwater Monitoring Plan for the Oak Ridge Reservation* In 2014, the groundwater program will focus on sampling areas not covered under the upcoming DOE's off-site sampling program. However, Quality Assurance (QA) samples will be collected during the DOE's off-site sampling program. The 2014 effort will conduct more off-site well sampling than we did for 2013. We will also continue to follow TVA's aquifer test on the breeder site.

### **5 Radiation Monitoring**

No substantive changes.

### **6 Surface Water Monitoring**

We are integrating more automated equipment into this program.

*Ambient Surface Water Monitoring* In 2014, the analyte list has been shortened by calcium, magnesium, potassium, and sodium. Also, Station #5 will be analyzed for radionuclides only; Knoxville EFO is analyzing for the inorganics and metals.

*Ambient Sediment Monitoring* In 2014, the analyte list is being shortened by the reduction of aluminum, cadmium, copper, iron, lead, magnesium, manganese selenium, uranium, zinc, <sup>89-90</sup>Sr and isotopic uranium. There will be new sites in 2014; CRM17.0, CRM10.0, CRM0.0, PCM7.0, PCM5.5, PCM3.5, PCM2.2, PCM1.0, EFM3.0, BCM2.8 and MIM0.1. There will be a second sampling event.

*Surface Water Parameters* There are no substantive changes.

*Trapped Sediment Monitoring* In 2014, the analyte list will be shortened by the loss of semi-volatile extractables, pesticides and PCBs.

*Rain Event Surface Water Monitoring Program* In 2014, this program is being restarted to measure contaminants in surface water after selected storm events.

## LIST OF COMMON ACRONYMS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials
BCK	Bear Creek Kilometer (station location)
BFK	Brushy Fork Creek Kilometer (station location)
BMAP	Biological Monitoring and Abatement Program
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
D&D	Decontamination and Decommissioning
DOE	Department of Energy
DOE-O	Department of Energy-Oversight Office (TDEC)
DOR	Division of Remediation (TDEC)
EFPC	East Fork Poplar Creek
EMWMF	Environmental Management Waste Management Facility
EPA	Environmental Protection Agency
EPT	<i>Ephemeroptera, Plecoptera, Trichoptera</i> (May flies, Stone flies, Caddis flies)
ERAMS	Formerly EPA's Environmental Radiation Ambient Monitoring System (Now RadNet)
ETTP	East Tennessee Technology Park (K-25)
g	Gram
GHK	Gum Hollow Branch Kilometer (station location)
GIS	Geographic Information Systems
GPS	Global Positioning System
GW	Ground Water
HAP	Hazardous Air Pollutant
HCK	Hinds Creek Kilometer (station location)
K-####	Facility at K-25 (ETTP)
K-25	Oak Ridge Gaseous Diffusion Plant (now called ETTP)
L	Liter
MBK	Mill Branch Kilometer (station location)
MEK	Melton Branch Kilometer (station location)
µg	Microgram
mg	Milligram
MIK	Mitchell Branch Kilometer (station location)
ml	Millilitre
µmho	micro mho (mho=1/ohm)
MOU	Memorandum of Understanding
mR	Microrentgen
mrem	1/1000 of a rem – millirem
NAREL	National Air and Radiation Environmental Laboratory (old) National Analytical Radiation Environmental Laboratory (new)
NEPA	National Environmental Policy Act
NT	Northern Tributary of Bear Creek in Bear Creek Valley
OREIS	Oak Ridge Environmental Information System <a href="http://www-oreis.bechteljacobs.org/oreis/help/oreishome.html">http://www-oreis.bechteljacobs.org/oreis/help/oreishome.html</a>
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory (X-10)

ORR	Oak Ridge Reservation
PCB	Polychlorinated Biphenol
pCi	1x10 <sup>-12</sup> curie (picocurie)
pH	Proportion of Hydrogen Ions (acid vs. base)
ppm	parts per million
QA	Quality Assurance
QC	Quality Control
R	Roentgen
RadNet	EPA's Radiation Network, formerly ERAMS
RBP	Rapid Bioassessment Program
REM (rem)	Roentgen Equivalent Man (unit)
RPM	Radiation Portal Monitor
SNS	Spallation Neutron Source
SOP	Standard Operating Procedure
TDEC	Tennessee Department of Environment and Conservation
TOA	Tennessee Oversight Agreement
TSCA	Toxic Substance Control Act
TSP	Total Suspended Particulate
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
UT-Battelle	University of Tennessee-Battelle (ORNL Prime Contractor)
WCK	White Oak Creek Kilometer (station location)
WM	Waste Management
X-####	Facility at X-10 (ORNL)
X-10	Oak Ridge National Laboratory
Y-####	Facility at Y-12
Y-12	Y-12 Plant (Area Office)

## INTRODUCTION

The Tennessee Department of Environment and Conservation (TDEC), Department of Energy (DOE) Oversight Office (the office), is providing an annual environmental monitoring plan for the calendar year 2014 under terms of the Tennessee Oversight Agreement (TOA) Section A.7.2.1. Individual work plans describing independent environmental monitoring and surveillance make up the 2014 Environmental Monitoring Plan. Monitoring of chemical and radiological emissions in the air, water, biota, and sediment on the Oak Ridge Reservation (ORR) and its environs is emphasized. A description of TDEC oversight of DOE's environmental monitoring and surveillance programs is also included. The goal is to assure that DOE's Oak Ridge Operations have no adverse impact to public health, safety, or the environment. Results from monitoring and findings of the quality and effectiveness of the 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.

This plan offers the Department of Energy the opportunity to review and consult on the office's monitoring activities and to take split-samples as needed. The office may perform short-notice or no-notice sampling for situations such as storm events, non-permitted discharges, emergencies or spills. DOE will be informed as soon as a decision is made to take short-notice or no-notice samples. Environmental monitoring is a dynamic process and will periodically change. Major changes to this plan will be made in writing to DOE.

Judicious use of cost cutting strategies will be used to complete our projects with the monies available. The strategies include the compositing of samples, use of only critical sampling stations, decreasing the frequency of sampling, and decreasing the number of analytes to only those critical for the projects. In some cases samples may be held as contingency, in case of accidental release. Project monies will be closely tracked for efficiencies.

This office or the Tennessee Department of Health's, Environmental Laboratory and Microbiological Laboratory Organization (Laboratory Services or the state lab) will process quantitative chemical samples. Laboratory Services has expertise in a broad scope of services and analyses. Certain analyses and quality assurance/quality control (QA/QC) samples are subcontracted out by the state lab to independent certified laboratories. Bench level QA/QC records and chain-of-custody records are maintained by the state for all samples collected by the office. The *Laboratory Services Standard Operating Procedures* are followed and also serve as a guide to the office's laboratory procedures. General sampling and analysis methods follow Environmental Protection Agency (EPA) guidelines.

Benthic macroinvertebrates and other biological samples are taxonomically identified at the state lab, in the office's laboratory, or by Laboratory Services subcontractors. Common water quality measurements and radiological readings are done in the field with calibrated instruments. Environmental dosimeters are analyzed by outside vendors. All work follows Environmental Protection Agency (EPA), state, and instrument manufacturer's protocols as appropriate. Data loggers are used to reduce transcription errors.

### **Air Quality Monitoring**

The office's integrated air quality monitoring is designed to verify and enhance DOE monitoring of the air quality on the Oak Ridge Reservation and in surrounding areas which may be impacted from DOE Oak Ridge Operations. The office implements EPA's ambient monitoring system, Radiation Network (RadNet). Radiological surveillance of ambient air quality in the vicinity of the ORR is provided and compared to the results of the national RadNet program. Three precipitation monitors are now included in the Oak Ridge Reservation RadNet system from which radiological contaminants in rain and snow will be assessed. TDEC performs oversight of the ORR perimeter program. This year we will not perform independent analysis of the perimeter program pre-filters. This is a change from previous years caused by budget needs and comparative value of this low volume air sampling compared with our other high volume air samplers. Portable samplers are also set up to measure hazardous and radioactive contaminants around selected DOE demolition and remediation projects. The Environmental Management Waste Management Facility (EMWMF) location was added in 2005 as an air-sampling site for fugitive emissions. Results are used to verify that DOE keeps contamination contained during cleanup and disposal activities. In the event of a large catastrophic release, any of these data could be used for consequence assessment and to guide recovery efforts, even in the community.

### **Biological Monitoring**

To determine the impact of DOE operations the office provides independent biological monitoring and oversight on and off the Oak Ridge Reservation. It also works in conjunction with the Tennessee Wildlife Resources Agency (TWRA), the Tennessee Valley Authority (TVA), and with other Tennessee Department of Environment and Conservation offices to coordinate valley-wide monitoring efforts related to fishing advisories. Specific contaminant pathways are investigated on the Oak Ridge Reservation as well. Results are used to formulate recommendations on clean up and to measure potential human and/or environmental risk. The office is currently measuring impacts to aquatic biota, contamination in geese, and effects on other indicator species such as lichens, watercress and diatoms. Invasive plants are also being mapped on a 3000-acre conservation easement. TWRA is assisting us in a deer telemetry project that will determine how far deer in Melton Valley and Bear Creek Valley range. This is important to assess the potential for contaminated deer to be harvested off the Oak Ridge Reservation, a pathway potentially as important as offsite groundwater pathways.

Bat communities will continue to be inventoried this year using acoustical recording equipment whereby the ultrasonic bat calls are identified much like a bird is identified by its singing. For bats, the recordings are analyzed by computer software that can identify bat species. Information will feed into general resource conservation efforts and into any regulatory decisions involving habitat management and/or resource injuries.

### **Drinking Water Monitoring**

Public water systems on the Clinch and Tennessee Rivers can be adversely impacted by DOE activities on the Oak Ridge Reservation. Independent drinking water monitoring supports the public water system's monitoring efforts related to releases from the Oak Ridge Reservation. The office implements EPA's RadNet Drinking Water Program. Results are compared to the national program. The office provides labor; EPA provides expendables and analysis. DOE plant water distribution systems operate at a fraction of historical capacity and

can stagnate, causing a loss of chlorine. Therefore, chlorine residuals in DOE facilities are also monitored. Sampling and analysis for possible chemical and radiological constituents may be accomplished during oversight of water main repairs and line-flushing activities. The comprehensive goal is to document trends and ensure that systems continue to be safe from radiological, chemical, and bacteriological contamination.

### **Groundwater Monitoring**

The office's groundwater monitoring program provides information about Oak Ridge Reservation releases and potential impacts on health and the environment. Given the implications of contaminant transport off the Oak Ridge Reservation via groundwater, the office will continue to emphasize the identification of groundwater pathways. This will be accomplished by monitoring water supplies, wells, and springs, both on and off the ORR and by conducting hydrogeological investigations such as aquifer evaluations and dye traces. Integration of groundwater and surface water sampling results allows concepts of groundwater behavior to be refined. Much groundwater tracing is opportunistic, as staff must take advantage of favorable weather, or discoveries made during construction or remediation, etc. Citizen reports of large springs in the ORR environs are useful and guide sample collection planning.

### **Radiological Monitoring**

The office's radiological monitoring is directed toward the development of a comprehensive radiological monitoring system as prescribed by the Tennessee Oversight Agreement, Attachment C.2 "Radiological Oversight." The primary focus of the program is the detection of radiological contamination with the potential to impact human health and the environment. Our radiological program contributes in all media areas, reviews CERCLA and NEPA documents, waste disposition, and other projects involving radionuclides. Autonomous monitoring includes facility surveys, gamma monitoring of the ORR, surplus sales surveys, and real-time gamma monitoring around active demolition and remediation sites. Automated gamma monitoring is being done at the Environmental Management Waste Management Facility (EMWMF) in Bear Creek Valley, for example. The DOE weigh scales database is compared to our gamma-monitoring data. Using time stamps to match data, the office monitors radiation readings on waste shipments delivered for disposal and assures that radioactive shipments are weighed and documented. The office has deployed its gamma radiation portal monitor at the EMWMF waste cell entrance. This instrument will measure gamma radiation levels of truckloads of waste entering the EMWMF on a real time basis. Previously used measurement instruments have only been able to display readings after manual downloads resulting in lengthy delays of relevant data. The portal monitor will allow the office to see gamma rates before waste is buried.

### **Surface Water Monitoring**

The office measures trends in the quality of water and sediments in the Clinch River and Oak Ridge Reservation tributaries. Surface water is one of Tennessee's most important economic and environmental resources, but local waterways rarely unconditionally meet all designated uses. For example, there are advisories on fish consumption from local reservoirs and streams. Legacy pollution from DOE, other industries, and non-point source origins are continuing problems. Long term monitoring can define success or failure of clean-up actions, source controls, and attenuation. Specifically, the office is analyzing water from Bear Creek to isolate legacy source inputs. It is hoped that the long-term monitoring strategy for the new

Environmental Management Waste Management Facility can be positively affected and that existing sources/pathways can be found, analytically isolated, trended, and remedied.

From another perspective, the Clinch and Tennessee Rivers are drinking water sources for several municipalities. Knowing the pollutant concentration is vital to the monitoring of those drinking water sources. In 2014, monitoring and investigation will continue in closer proximities to remediation projects and new construction.

**Invitation for Public Comment**

This plan is published to inform the public about state sampling on the ORR and environs. Any comments from the public on where or how future sampling should be done are greatly appreciated. Comments can be sent to:

Sonya Isabell  
TDEC DOE-O  
761 Emory Valley Road  
Oak Ridge TN 37830

Comments can also be sent to [sonya.isabell@tn.gov](mailto:sonya.isabell@tn.gov) or faxed to (865) 482-1835.

# AIR QUALITY MONITORING

## Monitoring of Hazardous Air Pollutants on the Oak Ridge Reservation

### Introduction

This independent monitoring project is conducted under authority of the Tennessee Oversight Agreement. The project was initiated in 1997 at the East Tennessee Technology Park (ETTP or K-25 site) in response to the heightened level of public concern regarding potential impacts to public health from the TSCA Incinerator emissions. Monitoring of hazardous metals in air expanded to include the National Security Complex (Y-12) and the Oak Ridge National Laboratory (ORNL or X-10) in the following year. Following the closure of the TSCA Incinerator at ETTP, the project continues to monitor hazardous metals in fugitive emissions associated with demolition activities or other non-point sources at the three Oak Ridge Reservation (ORR) sites. Levels of arsenic, beryllium, cadmium, chromium, lead, nickel and uranium (as a metal only) in the ambient air are monitored.

During 2014, projected demolition activities on the Oak Ridge Reservation are primarily limited to the remaining K-25 units. These units should produce similar fugitive emissions of metal to those resulting from past demolition activities at the K-25 building. Completion of K-25 demolition is anticipated early in 2014, but the date of completion is currently uncertain. At the time of completion, known potential sources of fugitive emissions on the ORR will be significantly reduced. At this point, sampling will continue and filters will be collected for radionuclide analysis, but metals analysis will be discontinued unless a new potential source of hazardous metals is identified. The possibility of doing metals analysis due to an unforeseen release in an emergency, such as a fire or building collapse in a tornado is retained, as the filters will be archived automatically for at least six months.

In the future, including 2014, metals analysis may be resumed if new potential sources of hazardous air pollutant emissions are identified. One scenario that might trigger future metals monitoring is demolition of building with significant lead or beryllium contamination, as both metals were used extensively in some ORR buildings. In addition, mercury monitoring in air should be considered when buildings with elevated levels of mercury contamination are demolished in the future. Mercury monitoring would require additional equipment and a change in sampling protocol. No buildings with high levels of mercury contamination are scheduled for demolition in the next few years, so for the 2014 year, no changes in sampling locations, sampling protocols, or analytical methods are proposed.

A high-volume total suspended particulate (TSP) ambient air sampler is deployed at each site at one of several potential sampling locations. These locations were selected based on wind rose data, availability of electrical power, and co-location with DOE and TDEC radiological air monitors. The proposed sampling sites for next year differ slightly from those used over the previous eight years. The sites are as follows:

- ORNL: X-10E, RadNet station east of the main entrance to the site  
X-10C, station at the corehole 8 remediation site  
X-10W, station No. 3 west of the site (See Figure 1)

- Y-12: Y-12E, RadNet station east of the plant entrance  
Y-12W, RadNet station west of the plant site (See Figure 2)
- ETTP: K-11, near the north end of the K-25 building  
K-42/TSCA-1, on Blair Road  
K-35/TSCA-2, on Gallaher Road (See Figure 3)

The current plan is to keep samplers located at the X-10C, Y-12E and K-11 sites throughout the coming year, and to split samples with the radiological monitoring group throughout the year at all three sites. Due to closure of the TSCA incinerator, the K-2 site was abandoned in favor of the K-11 site, which is closer to the ongoing demolition activities at the K-25 and K-27 gaseous diffusion buildings. As was the case with the K-2 site, DOE maintains an air monitor for metals and radiological emissions at the K-11 site, so monitoring results from this site may still be compared to data collected by DOE. The X-10C site is located adjacent to the Tank W1A (corehole 8) soil removal project, which is nearing completion but is located near potential sources of fugitive emissions from ORNL demolition activities. This sampler is mounted on a trailer and may be moved to either the X-10E or X-10W site if conditions at ORNL warrant a change in sample location. Power supply at the X-10E site is provided via a temperature sensitive source, making deployment at this site potentially problematic during the coldest months. The Y-12E air monitor was relocated a few hundred meters to the north of the old site to accommodate construction activities on the east end of the Y-12 plant.

#### **Methods and Materials**

On a weekly basis, sample filters will be collected from samplers. Samples will be composited and sent for analysis to the state Department of Health Environmental Laboratory in Nashville. Composite samples will be analyzed quarterly by the laboratory using inductively-coupled plasma and atomic absorption techniques. Some samples may be split for analysis by a sub-contractor of the state laboratory according to EPA Method IO-3.5, which determines if metals are in ambient air particulate using inductively coupled plasma/mass spectrometry (ICP-MS). The composite sample will be made using one quarter of each filter. This effectively gives each filter equal weight in the composite, even though the volume of air sampled may vary somewhat from filter to filter. To prevent the average quarterly concentrations in air computed for the composite from differing significantly from a true volume weighted composite, filters collecting particulate from air volumes differing from the quarterly mean sample volume by more than 20 percent will be sent to the state lab for individual analysis. Results from these filters (if any) and those obtained for the composite may then be weighted by volume of air sampled to more accurately determine the actual mean quarterly concentrations.

Methods and protocols for sampler maintenance and calibration have been developed based on high volume total suspended particulate (TSP) system maintenance manuals supplied by the manufacturer and sampling criteria tailored specifically to this project and DOE-O's mission and staffing levels (Thomasson, 2005 and Standard Operating Procedures developed for maintenance and calibration of TSP systems by the TDEC-DOE radiological monitoring program, 2010). Routine maintenance is generally limited to brush and motor changes. At intervals less than two months since the last brush change, the sampler motor will be disassembled and the motor's brushes inspected for condition and evaluated for longevity. When it is anticipated that the brushes may not last until the next site visit, they will be replaced. Based on experience with the typical lifetime of the sampler motor, it will be changed about twice annually. The sampler will also be

inspected to ensure that the sampling orifice remains level and parallel to the ground. During each site visit, the sampling cartridge will be removed and replaced with one holding a new filter. The cartridge will be covered both top and bottom for transport to the DOE Oversight laboratory. The sample will be removed at the DOE-O laboratory and placed in a zip-lock bag until the composite sample is made and sent to the Department of Health Environmental Laboratory for analysis. The 24-hour chart recording pressure differential will be removed and replaced weekly and its pen trace will be evaluated for average readings for the weekly period. Relevant information will be recorded on the reverse side of the chart. Date and time of sampling and elapsed time will be recorded, and readings of atmospheric pressure and ambient temperature may also be recorded on the chart. Proper chain of custody for samples will be maintained. DOE-O staff will maintain a quarterly calibration check that will be carried out in accordance with the manufacturer's specifications.

Reporting on the status of analytical results from each sampling location will be done annually. Comparison of mean values of air concentrations from 40 CFR 266 to sampling results from DOE monitors at the ETTP site will be made. Annually, a report will be prepared presenting conclusions regarding current levels of HAPs metals in ambient air and included in the DOE-O environmental monitoring report.

Materials required for this project include:

hi-volume sampler	filters
calibration kit	motor brushes and other replacement parts
tools and extension cords	flow charts
project data/custody forms	plastic sample bags and waterproof marking pens

#### **References**

Boiler and Industrial Furnace Regulations, Title 40 CFR Part 266 Appendix V.

Guidelines for the Control of Toxic Ambient Air Contaminants, Draft New York State Air Guide-1, Appendix B of Air Guide-1, Ambient Air Quality Impact Screening Analyses, New York State Department of Environment Control. 1994 Edition.

Operations Manual for GMW Model 2000H Total Suspended Particulate Sampling System, Graseby GMW Variable Resistance Calibration Kit # G2835. 1998.

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Yard, C.R., Health and Safety Plan. Tennessee Department of Environment and Conservation, Division of Remediation, Department of Energy Oversight Office. Oak Ridge, Tennessee. 2013.

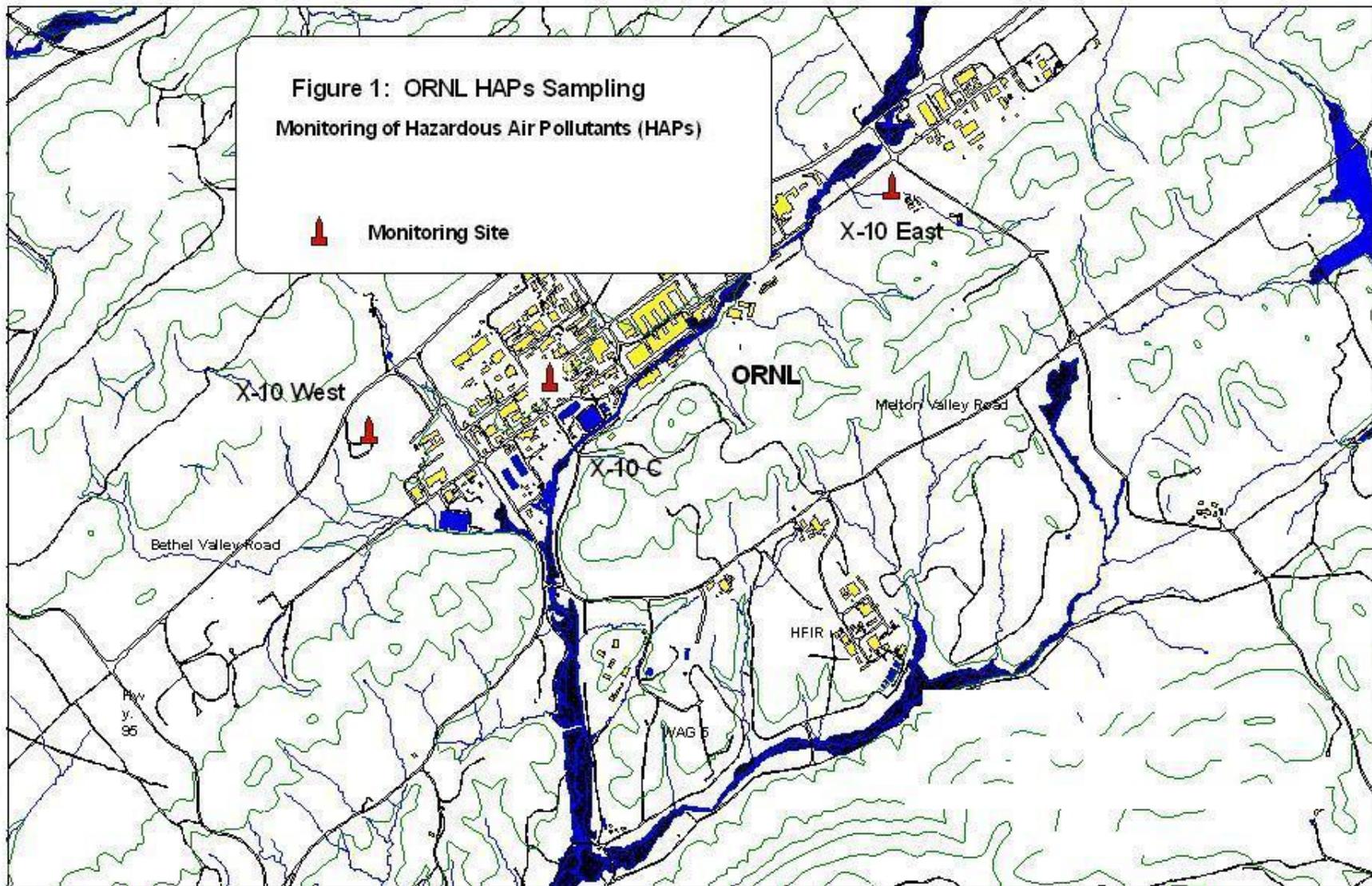


Figure 1: ORNL HAPs Sampling Locations

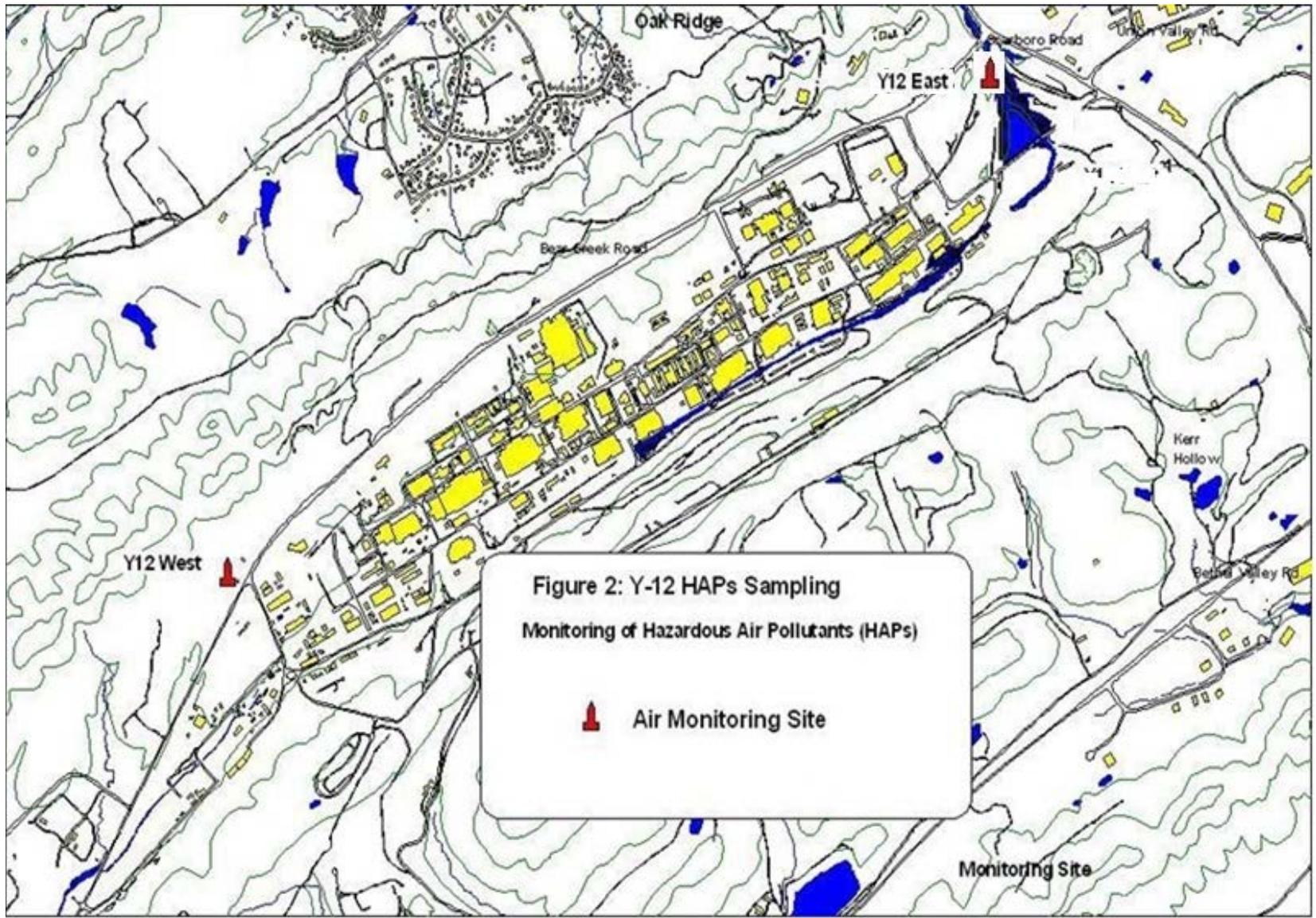


Figure 2: Y-12 HAPs Sampling Locations

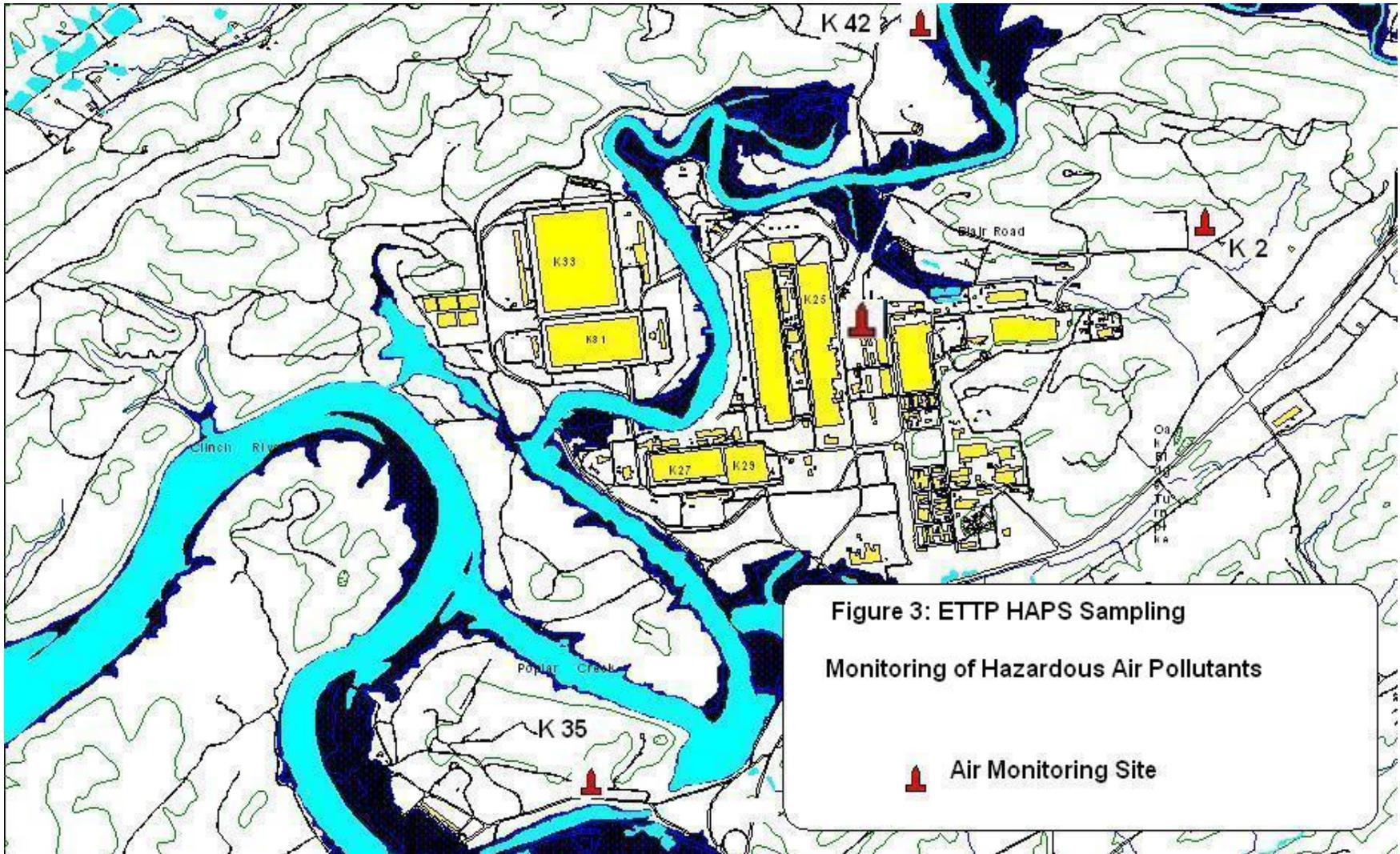


Figure 3: ETP HAPs Sampling Locations

## RadNet Air Monitoring on the Oak Ridge Reservation

### Introduction

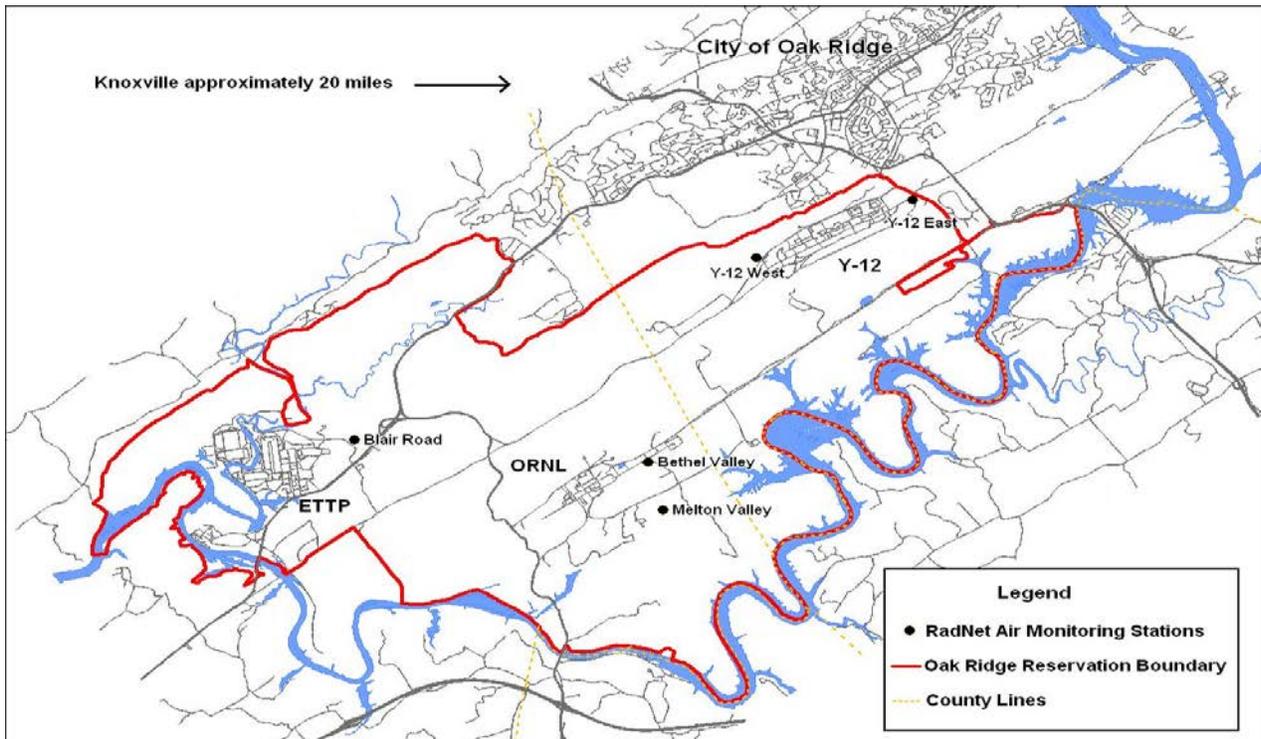
The Tennessee Department of Environment and Conservation, DOE Oversight Office, a part of the Division of Remediation, will continue to monitor the air at five locations on the Oak Ridge Reservation in 2014 with EPA's Radiation Network (RadNet) Air Monitoring Program. This is one of two main air monitoring programs used by the office to assess the potential impact of Oak Ridge Reservation air emissions on the surrounding environment. The program also assesses the effectiveness of DOE controls and monitoring systems. The other air-monitoring program, Fugitive Air Monitoring (described in an associated plan) focuses on monitoring diffuse emissions and sites of special interest (e.g., remedial sites). There is an additional air-monitoring program, which samples the air indirectly via precipitation (described in the RadNet Precipitation Monitoring Plan). The office's participation in EPA's RadNet Air Program targets specific operations (e.g., the High Flux Isotope Reactor, and D&D at ETTP and Y-12) and provides verification of state and DOE monitoring, via independent third party analysis.

### Methods and Materials

The five RadNet air monitors use synthetic fiber filters (ten centimeters in diameter) to collect particulates as air is pulled through the units at approximately 60 cubic meters per hour (about 35 cubic feet per minute). The monitors are operated continuously and the filters will be changed twice weekly (Monday and Thursday) by office staff. The quantity of radioactivity on each filter will be estimated by staff, using a radiation detector, in accordance with the RadNet Standard Operating Procedure (US EPA, 2006). The filters will then be mailed for analysis to EPA's National Air and Radiation Environmental Laboratory (NAREL) in Montgomery, Alabama. Each RadNet air monitor will undergo calibration verification quarterly and undergo full calibration at least annually. The sampling results received from NAREL will be compared to data collected in the fugitive air monitoring program (to verify the quality of state analysis) and to the Clean Air Act (to assess compliance with applicable standards). EPA's analytical parameters and frequencies for the RadNet Air Monitoring Program are provided in Table 1. Results from these analyses will be provided to the office and will be available at [http://iaspub.epa.gov/enviro/erams\\_query\\_v2.simple\\_query](http://iaspub.epa.gov/enviro/erams_query_v2.simple_query), the EPA RadNet searchable Envirofacts database. The EPA RadNet webpage provides more information on the program (<http://www.epa.gov/radnet>). The approximate locations of the five RadNet air monitoring stations are depicted in Figure 1.

**Table 1: EPA Analysis of RadNet Air Samples**

ANALYSIS	FREQUENCY
Gross Beta	Each of twice weekly samples
Gamma scan (conditional)	When samples are found to have $> 1 \text{ pCi/m}^3$ in the gross beta analysis
Plutonium-238, Plutonium-239, Plutonium-240 Uranium-234, Uranium-235, Uranium-238	Annually, on composites of the air particulate filters



**Figure 1: Approximate Locations of Air Stations Monitored in Association with EPA’s RadNet Air Program on the Oak Ridge Reservation**

**References**

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# **Fugitive Radiological Air Emissions Monitoring**

## **Introduction**

The DOE Oversight Office of the Tennessee Department of Environment and Conservation's Division of Remediation will continue monitoring fugitive air emissions on the Department of Energy (DOE) Oak Ridge Reservation (ORR) in 2014. The program uses eight mobile high-volume air samplers to supplement air monitoring performed at fixed locations in the office's RadNet air monitoring program and DOE's perimeter ambient air monitoring program. As in the past, sampling in the program will focus on locations where there is a potential for airborne releases of radioactive pollutants from non-point sources of contaminants (i.e., fugitive emissions). Candidate monitoring locations include remedial activities, waste management operations, and the decommissioning and demolition of contaminated facilities. The results from the ORR monitors will be compared to background measurements to determine if releases are occurring and limits provided in the Clean Air Act (CAA) to assess compliance with associated emission standards. The results from the ORR monitors will be compared to background measurements, to determine if releases are occurring, and to limits provided in the Clean Air Act (CAA), to assess compliance with associated emission standards. Findings will be used 1) to identify and characterize unplanned releases, 2) to assess the dose to the public as defined in 10 CFR 835 and, 3) to evaluate DOE monitoring and control measures to prevent airborne releases to the environment, as required by the Tennessee Oversight Agreement (C.2 Radiological Oversight).

## **Methods and Materials**

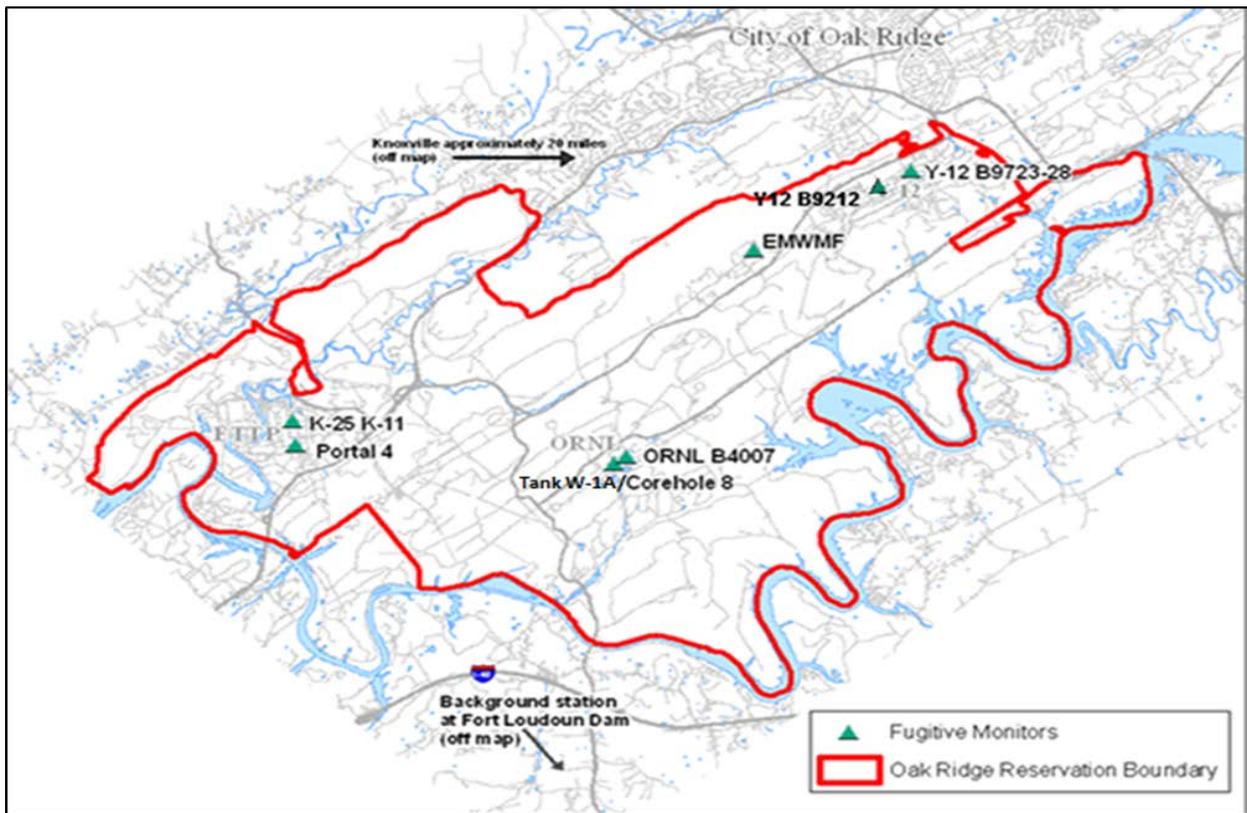
Eight high-volume air samplers will be used in the program. One sampler will be stationed at Fort Loudoun Dam in Loudon County to collect background data. The remaining units will be placed at locations on the ORR where there is a potential for the release of fugitive emissions (e.g., excavation of contaminated soils, demolition of contaminated facilities, waste disposal operations, etc.). Each of the air samplers will use an 8x10-inch glass-fiber filter to collect particulates from air as it drawn through the unit at a rate of approximately 35 cubic feet per minute. To help insure accuracy, airflow through each sampler will be calibrated quarterly, using a Graseby General Metal Works Variable Resistance Calibration Kit, in accordance with DOE-O Standard Operating Procedure (SOP) 202, Calibrating High Volume Total Suspended Particulate Sampler. Maintenance on the samplers will be performed as described in DOE-O SOP 203, High Volume Total Suspended Particulate System Maintenance.

Samples will be collected from each sampler weekly and a composite sample will be collected every four weeks for analysis at the State of Tennessee's Environmental Laboratory for analysis. Analyses will be based on the contaminants of concern for the location being monitored and previous findings. Where gross analyses are used, radionuclide specific analysis will be performed if the results exhibit significant spikes, upward trends, consistently elevated results, and/or exceed screening levels. The screening levels for gross alpha and gross beta measurements will be the Clean Air Act (CAA) limits for uranium-235 and strontium-90 respectively. To assess the concentrations of the contaminants measured for each location, results from the station will be compared with the background data and the standards provided in the CAA. Associated findings will be reported to DOE and its contractors as warranted and included in the office's annual Environmental Monitoring Report for submission to DOE and public review.

Current monitoring locations are depicted in Figure 1 and associated radiochemical analysis are provided in Table 1, along with the sampling locations and the activities being monitored. These may change during the year based on findings and as remedial activities evolve.

**Table 1: Fugitive air emission monitoring stations and associated analysis**

Station	Activity Monitored	Frequency		Analysis			
		Sampling	Analysis	Gross Alpha & Beta	Uranium Isotopes	Gamma Spectrometry	Technitium-99
Y-12 : B9723-28	Y-12 facility reduction activities	weekly	four week (composite)		X		X
Y-12 : B9212	Y-12 facility reduction activities	weekly	four week (composite)		X		X
ETTP: K-25 K-11	K-25 and K-1073-B remedial activities	weekly	four week (composite)		X		X
ETTP: Portal 4	K-25 and K-27 remedial activities	weekly	four week (composite)		X		X
ORNL: Corehole 8	ORNL Central campus remedial activities	weekly	four week (composite)	X	X	X	
ORNL: B4007	ORNL Central campus remedial activities	weekly	four week (composite)	X	X	X	
EMWMF	Disposal activities at the EMWMF	weekly	four week (composite)	X	X	X	X
Fort Loudoun Dam (Loudon County)	Background	weekly	four week (composite)	X	X	X	X



**Figure 1: Locations of current monitoring stations in the Fugitive Air Monitoring Program**

## References

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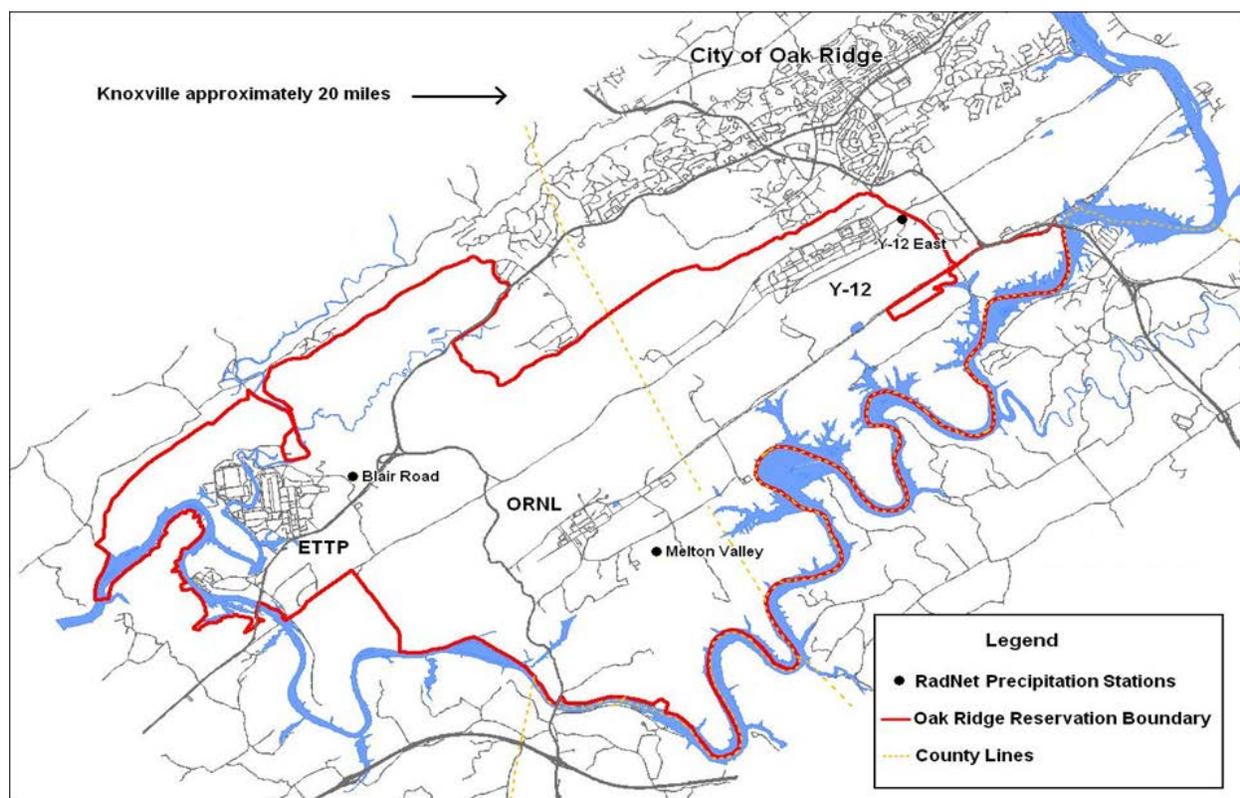
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## RadNet Precipitation Monitoring on the Oak Ridge Reservation

### Introduction

The Tennessee Department of Environment and Conservation DOE Oversight Office, a part of the Division of Remediation (the division), will continue to monitor the air at three locations on the Oak Ridge Reservation in 2014 with EPA's RadNet Precipitation Monitoring Program. The project 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, but the data provide an indication of the presence of radioactive materials that may not be evident in the particulate samples collected by the office's air monitors. All precipitation samplers are co-located next to RadNet air monitoring locations (described in the RadNet Air Monitoring Plan) on the Oak Ridge Reservation (Figure 1).



**Figure 1: Approximate Locations of Precipitation Stations Monitored on the Oak Ridge Reservation**

The first precipitation monitor provided by EPA was co-located with the RadNet air station near ORNL's High Flux Isotope Reactor and the SWSA 5 (solid waste storage area) burial grounds in 2005. Another precipitation monitor was placed near the TSCA Incinerator in April 2007, co-located with the Blair Road RadNet air monitoring station east of ETPP. This sampler is used to monitor D&D at ETPP. The third and final precipitation station is co-located with the RadNet station east of Y-12 and was deployed in March 2008. This station is used to monitor operations at the Y-12 National Security Complex and to provide an indication of potential radiation transport toward the city of Oak Ridge from ORNL's Melton and Bethel Valleys.

## Methods and Materials

The precipitation monitors provided by EPA's RadNet Program will be used to collect samples for the program. Each monitor collects precipitation that falls on a 0.5 square meter fiberglass collector which drains into a five-gallon plastic collection bucket. Each station will be checked twice a week and a sample will be collected from the bucket (using a four-liter cubitainer) when a minimum of two liters of precipitation has accumulated. The sample will then be processed as specified in the *Environmental Radiation Ambient Monitoring System (ERAMS) Manual* (U.S. EPA, 1988) and shipped to EPA's National Air and Radiation Environmental Laboratory in Montgomery, Alabama, where samples are composited monthly by EPA for gamma analysis. Tritium analysis has been discontinued. Results from the gamma analysis will be provided to the office and will be available on the EPA RadNet searchable Envirofacts database ([http://iaspub.epa.gov/enviro/erams\\_query\\_v2.simple\\_query](http://iaspub.epa.gov/enviro/erams_query_v2.simple_query)). More information on the program can be found on the EPA RadNet webpage (<http://www.epa.gov/radnet>). The data will be used to identify anomalies in radiological contaminant levels to assess the significance of precipitation in contaminant pathways, to evaluate associated control measures, and to appraise conditions on the Oak Ridge Reservation compared to other locations in the RadNet program.

## References

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- National Air and Radiation Environmental Laboratory. United States Environmental Protection Agency. <http://www.epa.gov/radnet> (Last updated June 18, 2013).
- Standard Operating Procedure for Collecting RadNet Precipitation Samples. National Analytical Radiation Environmental Laboratory (NAREL), US EPA. Montgomery, Alabama. 2013.
- Tennessee Oversight Agreement, Agreement Between the U.S. Department of Energy and the State of Tennessee., Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2011.
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# BIOLOGICAL MONITORING

## Benthic Macroinvertebrate Monitoring

### Project Description

The objective of this monitoring program is to perform biological monitoring on streams affected by the U.S. Department of Energy (DOE) activities and practices on the Oak Ridge Reservation (ORR). Methods outlined in the State of Tennessee Department of Environment and Conservation (TDEC), Division of Water Pollution Control (WPC) Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys (TDEC 2011) will drive the project.

### Introduction

Because benthic macroinvertebrates are relatively sedentary and long-lived, they are excellent indicators of the “overall health” of an aquatic system. In systems where the source of the toxicant is non-point (e.g. runoff or seeps) or where the combined effects of pollutants in a complex effluent exceed individual toxicity, benthic macroinvertebrate communities may be one of the only means of evaluation. Hence, macroinvertebrates are used by biologists as indicator organisms (i.e., habitat assessments) to determine if a stream is supporting fish and aquatic life

Benthic macroinvertebrates are collected from various ORR streams and analyzed to measure the degree of impact from past and present DOE operations. The division conducts annual semi-quantitative biomonitoring on the following ORR watersheds: Bear Creek, Mitchell Branch, White Oak Creek, Melton Branch, and East Fork Poplar Creek. Benthic samples are also collected from Clear Creek near Norris Dam which serves as an ecoregion reference site for all ORR test sites.

### Methods and Materials

During 2014, benthic macroinvertebrate samples will be collected from 20 stream sites (Figures 1-5) and processed following TDEC Water Pollution Control (WPC) standard operating procedures (SOP, TDEC 2011). The semi-quantitative Riffle Kick (SQKICK) collection technique for single habitat analysis will be used. This test method involves standing in a body of water, kicking up sediment and catching the suspended organisms in a 1-m square kick net. Two SQKICK samples will be collected at each station and combined into one sample. A riffle kick is done in relatively fast-moving water and a run kick in slower-moving water. Care will be taken to avoid losing sample material from the sides or bottom of the net. Another method is the undercut bank jab, done by sampling the sediment below water level in a bank area that may be partially obscured by brush or partially submerged tree roots.

Samples will be collected from two riffles at each site. Both samples will be combined and transferred into one sample container. The container will be labeled internally and externally with site-specific information and stored in the TDEC DOE-O laboratory for future processing. Standard methods will be altered when sampling lower White Oak Creek due to the presence of radioactive contamination in the stream sediment. The two kick samples will be combined in a five-gallon bucket, creek water will be added and the sample swirled to suspend the lighter material (invertebrates), which will then be poured through a sieve. This

process will be repeated five times, collecting the majority of organisms. Any material not used will be returned to the creek. For quality control purposes, duplicate samples will be collected at 10% of the stream sites.

New for 2014, an additional set of 2 SQKICK samples will be collected for total mercury and methylmercury analysis of benthic macroinvertebrates at each ORR and reference site. Mercury is accumulated directly by aquatic invertebrates from water and sediment, and actively through ingestion of contaminated prey or food items (Environment Canada 2002). Mercury may be bound to outer membranes or chitinous exoskeletons, absorbed within gut contents, incorporated into body tissue and excreted. Mercury bound to outer membranes/exoskeletons may also be lost through moulting (Zauke 1977). Because predaceous invertebrates belong to a higher trophic group in the aquatic ecosystem, they sometimes may bioaccumulate more MeHg than non-predaceous invertebrates (Parkman and Meili 1993).

Also, adult insects will be collected using a light trap at most sites for analysis of total mercury and methylmercury. This information will be used to evaluate metals content of insects potentially consumed by bats and birds that may use these streams as flyways.

Water quality data, surface water samples and habitat assessment data will be collected at each sampling location. These activities are addressed in a separate EMP. All work associated with this program will be in compliance with the office's Health, Safety, and Security Plan (Yard 2013).

Once collections have been made at all 20 sites, the semi-quantitative samples will be processed in-house by division staff with expertise in macroinvertebrate taxonomy. Sample analyses will include the identification and enumeration of the benthic macroinvertebrates to genus. Using the raw benthic data from the semi-quantitative sub-samples, a numerical value will be generated for seven biometrics. These metrics include (1) EPT (*Ephemeroptera*, *Plecoptera*, and *Trichoptera*) richness, (2) taxa richness, (3) percent OC (oligochaetes and chironomids), (4) percent EPT (EPT abundance), (5) NCBI (North Carolina Biotic Index), (6) percent nutrient tolerant, and (7) percent clingers (contribution of organisms that build fixed retreats or that have adapted to attach to surfaces in flowing waters). After values have been calculated for the metrics, a score of 0, 2, 4, or 6 is assigned to each metric based on comparison to the ecoregion reference database. The seven scores are totaled and the site's biological condition is determined (i.e., fully supporting, etc.). Metric equations and the biocriteria used to determine biological condition can be obtained by referring to the SOP (TDEC 2011). Office data will be compared to TDEC Protocol benthic sampling data compiled by biologists with the Oak Ridge National Laboratory Biological Monitoring and Abatement Program (ORNL BMAP).

### **Sampling Locations in Kilometers (mile equivalents) for RBP III Semi-Quantitative Sites (Figures 1-5):**

*East Fork Poplar Creek*: EFK 25.1 (15.6), EFK 24.4 (15.2), EFK 23.4 (14.5), EFK 13.8 (8.6), and EFK 6.3 (3.9). Reference site: Hinds Creek HCK 20.6 (12.8).

*Bear Creek*: BCK 12.3 (7.6) and BCK 9.6 (6.0). Reference sites: Gum Hollow Branch GHK 2.9 (1.7), Mill Branch MBK 1.6 (1.0), and White Wing Tributary ET-1 [WWT 0.08 (0.05)].

*Mitchell Branch Creek*: MIK 0.71 (0.44) and MIK 0.45 (0.28). Reference sites: MIK 1.43 (0.89).

*White Oak Creek*: WCK 2.3 (1.4), WCK 3.4 (2.1), and WCK 3.9 (2.4). Reference site: WCK 6.8 (4.2).

*Melton Branch*: MEK 0.3 (0.2)

*Clear Creek*: CCK 1.45 (ecoregion reference site).

Weather permitting, field sampling will be completed within a four week time span in April and May 2014.

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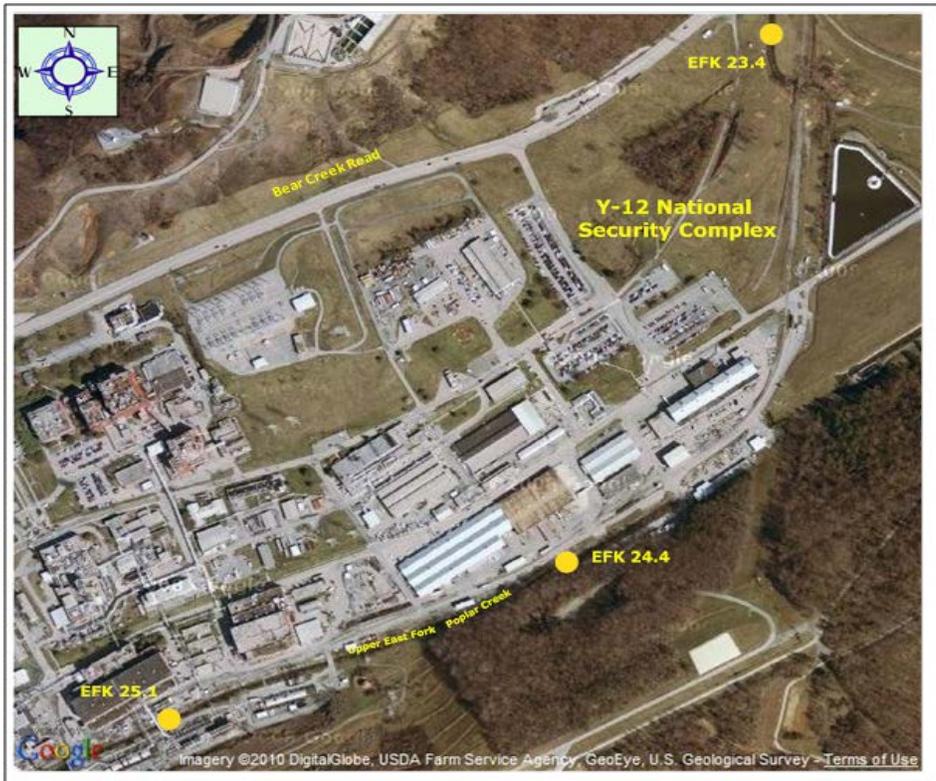
Parkman, H. and M. Meili. *Mercury in Macroinvertebrates from Sweden for Lakes: Influence of Lake Type, Habitat, Life Cycles and Food Quality*. Canadian Journal of Fisheries and Aquatic Sciences 50:521-534. 1993.

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**Figure 1: Upper East Fork Poplar Creek / Y-12 Plant**



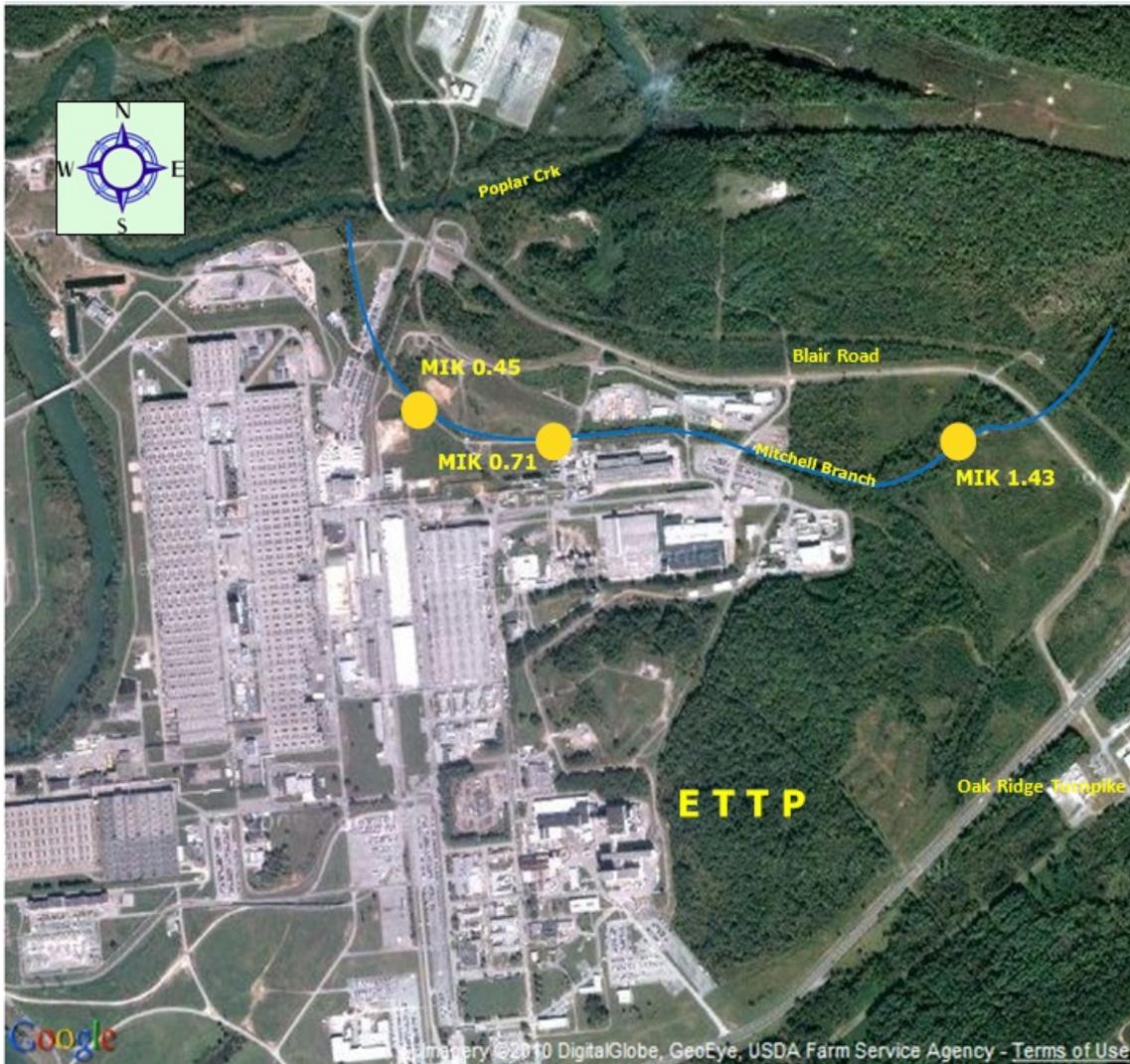
**Figure 2: East Fork Poplar Creek / Bear Creek Watersheds**



**Figure 3: Clear Creek and Hinds Creek Reference Sites**



**Figure 4: White Oak Creek / Melton Branch Watersheds (ORNL)**



**Figure 5: Mitchell Branch Watershed (ETTP)**

# White-tailed Deer Monitoring Program on the Oak Ridge Reservation

## Introduction

During 2014, the Tennessee Department of Environment and Conservation, Department of Energy Oversight Office (DOE-O) will continue chemical immobilization and collaring of Oak Ridge Reservation (ORR) white-tailed deer. The primary objectives of this monitoring program are to track the movements and determine the home range of deer both on and off the ORR. A secondary objective will be to collect ten additional deer tissue samples (i.e., road kill, hunter kill, diseased) for metals analysis.

## Methods and Materials

Three additional Telonics store-on-board global positioning system (GPS) collars will be deployed on ORR deer during 2014. Field activities will commence following the final Oak Ridge Wildlife Management Area deer hunt and State-wide deer hunts (approximately January 15<sup>th</sup>). The focus will be to collar bucks if possible. Four deer were collared during 2012-2013 (three does and one buck). Two collars will drop off in December 2013. The other two collars were scheduled to drop off on in January and March 2014. Unfortunately, we lost one deer prematurely in September 2013, so that collar is going to be refurbished for redeployment in 2014. All the collared deer are located in the Melton Valley area of the Oak Ridge National Laboratory. Once collars have been recovered, GPS data can be downloaded for analysis. Recovered collars will be returned to Telonics, Inc. (Mesa, Arizona) to be reprogrammed. Refurbished collars will be deployed on deer during 2014. The target areas to dart and collar deer during 2014 includes Melton Valley and West Bear Creek Valley.

Following the DOE Oversight Standard Operating Procedure (TDEC 2013), chemical immobilizing drugs will be delivered to the deer using the PneuDart Model 389 dart projector, and, following successful anesthesia, collars and numbered ear tags will be applied to each animal.

## Procedure for Live Deer Collar Attachment

### *Darting Protocol*

- 1) Deer will be caught using a variety of methods:
  - (a) Darting from vehicle
  - (b) Clover traps

Deer require sedation/general anesthesia with drugs administered by dart gun so that collars and ear tags can be attached to the animal. Deer are at high risk of stress, shock and capture myopathy during capture and restraint, particularly if allowed to struggle and in hot weather. Accordingly, care will be taken to dart and capture deer between December-April while East Tennessee weather conditions are, on average, relatively cool (<65° F). Deer immobilization will be done with the cooperation of a local veterinarian and the Tennessee Wildlife Resources Agency (TWRA).

General guidance for handling a sedated deer:

- Always cover the eyes as soon as possible to help calm the animal; a blanket or large towel thrown over the eyes before the deer is under control helps to reduce stress.

- Deer must be kept in sternal recumbency (on the chest) at all times during general anesthesia and recovery.
- Do not allow the animal to roll on its side or back at any time as this may lead to regurgitation and death through asphyxiation or inhalation.
- Keep the head elevated during anesthesia to reduce the risk of regurgitation.
- Intubation may be required in some cases, together with passing a stomach tube to prevent bloat (gas accumulation).
- Constant monitoring for bloat is recommended.
- Monitor body temperature (rectal thermometer), heart rate (stethoscope), respiration (observed through thoracic movements) and hemoglobin saturation (i.e., SpO<sub>2</sub> pulse oximeter) throughout any general anesthetic procedure .

### *Darting from Vehicle Protocol*

A sampling team typically consists of three trained staff members: one driver and two designated marksmen. Once the deer has been darted and is under anesthesia, one staff member fills out the capture record sheet while the other two handle the downed deer. Upon capture, the deer will be immediately blindfolded and the dart will be removed with a sterile scalpel, and antibiotic is to be administered on the wound (Walter et al. 2005). The deer is placed in sternal recumbency, and the mouth checked for obstructions and that the tongue is not rolled back. Staff members have been trained to handle the drugs and dart projector and how to monitor the deer while under anesthesia and recovery (i.e., Safe-Capture International certified training). Deer will be darted primarily using a mixture of 500 mg of telazol (250 mg of tiletamine and 250 mg of zolazepam) reconstituted with 5 ml of 100 mg/ml xylazine HCl (Rompun® dry substance, Bayer). Xylazine is a CNS (central nervous system) depressant that sedates but does not cause loss of consciousness. Telazol (tiletamine + zolazepam) produces rapid immobilization with altered consciousness. Whenever secondary dosages are necessary, ketamine (cyclohexamine) will be administered to enhance anesthesia and to avoid a zolazepam accumulation and to enable a quicker recovery (Fahlman 2005). Cyclohexamines provide partial analgesia with minimal circulatory and respiratory depression.

Once under complete anesthesia, the deer collar (Telonics, Mesa, Arizona) will be fitted and trimmed if necessary to custom fit the neck, allowing enough slack such that three fingers can fit between the neck and collar. It may be necessary to allow additional slack in the collar to compensate for neck swelling in bucks (rut season). Once fitting is determined, the bolts holding the collar are tightened and the collar installation is complete. Next, numbered ear tags are affixed to each ear, and lastly a hair sample is collected using a curry comb (for laboratory analysis of contaminants).

Prior to field excursions, the telazol-xylazine drug mixture will be loaded into darts under a laboratory hood for safety. Care will be taken in the field handling the darts and dart projector to prevent accidental exposures to staff. Drugs will be kept under lock and key both in the laboratory and in the field. We will use Pseudart 1.5 cc, barbed and 1 inch long needled darts (Pseudart®, Williamsport, Pennsylvania, USA). Darts will be delivered to the animal via the Pseudart model 389 projector at a distance ranging from 10 to 20m from the vehicle. The secondary ketamine dosage, if necessary, will be administered with syringe. While under anesthesia, deer vital signs will be monitored every ten minutes (heartbeat, respiration, rectal temperature) and the animal will be kept in sterna recumbency at all times. Additionally,

hemoglobin saturation (SpO<sub>2</sub>) and heart rate will be monitored by a pulse oximeter with a transmission probe placed on the tongue (Morandi and Nicoloso 2009). The reversal drug tolazoline will be administered 90 minutes following initial immobilization. Tolazoline should antagonize the effects of xylazine 3-5 minutes after intramuscular injection. At least one staff member will remain with the recovering animal until it is standing and walking away, observing from a distance so as not to excite the deer. This is a precaution to prevent predators from feeding on the immobilized deer.

### *Clover Trap Protocol*

#### Trap Set-up:

Clover trap installation and set-up will be demonstrated in the field using hands-on techniques during the set-up process and before actual trapping. At a minimum, nitrile gloves should be worn to minimize human scent while handling the trap. Coordinates should be recorded at each site with a hand-held GPS unit.

#### Trap Placement:

Clover traps will be strategically placed as to allow for “element of surprise” to the animal during the approach to trap by biologists and is accomplished using any available brush or woodland debris available. Trap site setups should be secluded to prevent human interference (i.e., “out-of-sight and out-of-mind”). The goal is to avoid as much stress to the animal as possible prior to and during handling.

#### Checking Traps:

A clover trap team consists of at least two biologists plus a qualified wildlife biologist who is certified to handle tranquilizing drugs and a dart gun (i.e., TWRA). One person is designated as the restrainer or handler (especially if tranquilizing drugs do not take effect on the deer). The second person is designated data collector and equipment manager. The restrainer is responsible for subduing and controlling the deer as needed. The equipment person is responsible for carrying the capture kit, blindfolding the deer, checking age and sex, administering ear tags, making photographs and recording the data.

Bait should be placed past the trip wire, but also within the bounds of the trap walls to prevent feeding from outside the trap. “Chumming” the trap at the door with some corn is encouraged. After setting and before leaving the trap site, verify that no vegetation will interfere with the operation of the door closing or movement of the “trip” wire. It is also recommended to remove larger branches and rocks from within the trap to reduce injury to animals or team members. Otherwise the trap should be adjusted as to avoid having objects/debris on the trap floor.

Typically, biologists drive a trap line in the early morning. Each trap is checked for animals, then re-baited and repaired as necessary. If the trap is sprung but has nothing in it, inspect the trip wires and replace them if necessary, inspect netting for holes, check to make sure the trap is still properly staked, and reset the door making sure all the cable sleeves are aligned and pointing away from the trap door. If there is a deer in the trap, then TWRA must be notified immediately such that they can arrive at the field site in a timely manner and dart the animal.

#### Capture Procedure<sup>a,b</sup>:

1. During deployment, the clover trap must be checked at least once per day (ideally early AM) for presence of deer or other animals in the trap.

2. Check for presence of deer from a good distance with binoculars if necessary to avoid distressing the animal.
3. If a deer is present in the clover trap, contact TWRA immediately to come out and sedate the animal with the dart gun.
4. After administration of tranquilizing drugs to the deer (i.e., xylazine-telazol mixture), allow time for the drug to take effect and for the deer to calm down. Everyone must remain at a good distance from the trap during this time to minimize stress to the deer.
5. Double glove with nitrile and heavy leather or cotton gloves to avoid cuts from deer hooves and self- and cross-contamination during animal handling.
6. One biologist with protective gear (gloves, helmet and shin protection) will enter the trap, with the immediate goal of quickly subduing the deer by restraining the body and legs (if necessary). If the drug has not brought the deer down, approach it from the side and wrap your arms around the front of the body. Grip the front legs below the “elbow” and tuck them into the chest of the deer. Then straddle the animal and slowly put your weight on its back. In doing this, the restrainer can use his/her body weight to gain control of and safely but slowly allow the animal’s legs to fold as the biologist body weight is applied. However, if the tranquilizing drug has taken full effect on the deer, restraint may not be necessary. If the deer is down but still aroused, administer ketamine to enhance immobilization.
7. Once the animal is subdued by the restrainer, the assisting person can enter the trap closing the door behind them to prevent escape. The assistant places the facemask (hood) over the animal’s head/eyes and processing can begin. The eyes of the animal must be covered to reduce stress. Also, make sure the animal’s breathing is not restricted in any way.
8. Fit the collar to the deer’s neck and trim excess collar material if necessary, attach the holding plate and tighten the nuts with 11/32 nut driver thus securing the collar around the deer’s neck. The second biologist will then affix the numbered ear tags to each ear per prescribed method, record field notes and vital data about the animal (i.e., age, sex, weight estimate, etc.), and also photograph events.
9. While under anesthesia, the deer will be monitored every ten minutes for body temperature, heartbeat and respiration, and continue doing this until the animal recovers.
10. During processing of the animal, the capture data sheet must be filled out completely by the assistant or assigned data collector.
11. Using a curry comb, a 5-10g sample of deer hair (i.e., softball-size wad) will be collected from the mid-dorsal region of the deer’s back. Place the hair sample in a labeled Ziploc® baggie and then store in an ice chest for transport.
12. The clover trap door will be left open while the deer recovers from the drug. At least one biologist must remain within sight of the deer while it recovers from the drug and leaves the trap on its own power. After 90 minutes, the reversal drug Tolazoline will be administered by syringe such that the animal should be on its feet within 5-10 minutes. These measures are designed to provide protection from predators while the deer is down.

<sup>a</sup>Handling of live animals will follow the recommendations and guidelines of the Animal Care and Use Committee of the American Society of Mammalogists (Gannon et al. 2007, Sikes et al. 2011).

<sup>b</sup>Methods modified from James and Stickle (2010).

**Tissue Sampling of Deceased Deer** (*modified from Mills et al. 1995, Wobeser 1996, Munson 2006*)

1. Double glove with nitrile gloves to avoid self- and cross-contamination during sampling.
2. Before and after each dissection, stainless-steel cutting tools will be sanitized.
3. Using a bone-cutting tool, extract approximately a 3-4 inch section of shin bone from the lower front leg of the deer.
4. Using stainless-steel forceps place the bone sample into a labeled Ziploc® baggie or Whirl-Pak® and seal. Store in ice chest at for transport to lab 4° C by using ice or freezer packs.
5. Using a stainless scalpel or knife, cut approximately 50-75g of muscle from the rump and place into a labeled plastic vial and close cap. Store in ice chest for transport to lab.
6. With one person holding the deer on its back, the second person makes a 6-8 inch incision near the sternum, finds the liver and extracts approximately 50-75g of liver tissue. Place the liver sample in a labeled Ziploc® baggie or Whirl-Pak® and seal. Store in ice chest for transport.
7. Using a clean curry comb, brush approximately 5-10g of hair (wad of hair about the size of a softball) from the mid-dorsal area of the deer. Place hair sample into a labeled Ziploc® baggie or Whirl-Pak® and seal. Pack in ice chest for transport to the lab.
8. Upon returning to the TDEC DOE-O lab, place all samples in the deep freezer until time to deliver samples to the Tennessee Department of Health Environmental Laboratory for analysis.
9. Record all pertinent information on lab sheets, sample labels, and make necessary entries into field notebook.
10. Deliver tissue samples to state lab within appropriate holding time frames, and sign chain of custody forms.

**Required Equipment (Deer Immobilization & Tissue Sampling)**

Clover trap	Aluminum foil
Heavy gloves	Ziploc® bags / Whirl-Pak® (24-oz & 69-oz)
Hockey-type helmet & shin-guards	Sample labels
Telonics GPS collars	Cooler/ice packs
Field notebook	Stainless-steel scalpels (knives)
Latex gloves (purple nitrile)	Stainless-steel saw
Deionized water	Stainless-steel scissors
Rubber gloves	Hand sanitizer
Stainless-steel forceps	Curry comb
Magic Marker (Sharpie®)	Bone-cutting tool (stainless)
Hand-held GPS unit	Plastic vials (tissue samples)
Deer eye cover (mask/hood)	11/32 nut driver (to affix collar)
Antibiotic ointment	Ear tags (yellow numbered)
Flagging tape	Zip-ties
Extra nuts/plates for collars	Hole punch ear tagger
Wire cutters/nippers	Needle nose pliers
Pneu Dart 389 Projector	Super shears (leather cutter)
Stakes / small sledge hammer	Toolbox
Blankets (to cover deer)	Pneu Dart 1.5 cc Type C Darts

Immobilization Drugs (Xylazine/Telazol)	Reversal Drugs (Tolazoline)
Backpack with deer supplies & gear	Syringes
Bushnell Range Finder	Stethoscope/anal temperature probe
Telonics TR-4 VHF receiver	Pulse oximeter

### **Laboratory Procedures**

The Tennessee Department of Health, Environmental Laboratory and Microbiological Laboratory Organization (Laboratory Services) has expertise in a broad scope of services and analysis available to the Tennessee Department of Environment and Conservation (TDEC) Department of Energy Oversight (DOE-O) and other TDEC divisions statewide. General sampling and analysis methods are to follow Environmental Protection Agency (EPA) guidelines as listed in appropriate parts of 40 Code of Federal Regulations (CFR). Laboratory Services may subcontract certain analyses and QC samples out to independent laboratories. Bench level Quality Assurance/Quality Control (QA/QC) records and chain-of-custody records are maintained at the Tennessee Environmental Laboratory, as are QA records on subcontracted samples.

DOE-O will primarily use the Knoxville branch of Laboratory Services. Wet chemistry and metals samples will generally be analyzed in Knoxville while organics samples will be sent on to the Central Laboratory in Nashville. Methylmercury (MeHg) samples are analyzed at Brooks-Rand Laboratory in Seattle, Washington. All laboratory analysis will follow appropriate methods as documented in the Laboratory Services Inorganic Chemistry SOP and Organic Chemistry SOP. Specific analytical methods are covered in the Standard Operating Procedures (SOP) manuals for the Tennessee Laboratory Services Division. The SOPs direct analysts to the proper EPA or other methodology.

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## **Fish Tissue Monitoring Plan**

### **Introduction**

In 2014, the Tennessee Department of Environment and Conservation (TDEC) will initiate a pilot fish bioaccumulation monitoring project on the Oak Ridge Reservation (ORR), specifically the East Fork Poplar Creek (EFPC) watershed. Fish will be collected twice/year at five EFPC and Bear Creek locations and at two-to-three reference streams. Electro-shocking of fish for the purpose of obtaining fish tissue and gut content samples for contaminant analysis will be the capture method. TDEC fish sampling will be conducted in collaboration with DOE researchers to offset potential disturbances to fish monitoring projects and to avoid unnecessary population losses. Previous ORR fish monitoring programs have focused on tissue analysis (i.e., fish fillets), but few studies have investigated tissue and gut content contaminants in individual species. Fish tissue will be evaluated for Hg content; gut contents will be evaluated for Hg and PCBs.

Historically, contaminant stressors from the Y-12 Plant to EFPC have been chlorine, mercury (Hg), PCBs (polychlorinated biphenyls), nutrient loading, hydrological regime alteration, miscellaneous spills, and habitat-related factors (Peterson et al. 2011). Previous investigations in EFPC identified mercury and PCBs as the primary substances that have accumulated to elevated levels in fish and pose health concerns to human consumers as well as terrestrial wildlife (Loar et al. 1992, Hinzman et al. 1993, Sample et al. 1996, Southworth et al. 2011). Redbreast sunfish may provide a good sentinel species for toxicity assessments of EFPC because they are ubiquitously distributed throughout the creek, bioaccumulate Hg and PCBs, are relatively short-lived, and found to have restricted home ranges such that contaminant burdens reflect exposure at the site of collection (Southworth 2011). However, since the mid-2000s, the Oak Ridge National Laboratory's (ORNL) BMAP biologists have found that redbreast sunfish have been increasingly difficult to collect throughout EFPC. Therefore rock bass, which typically have higher mercury concentrations in their tissues, have been collected instead. Accordingly, non-destructive sampling for mercury (i.e., biopsy plug samples) and reducing PCB sampling (which requires sacrificing fish) may alleviate some of the pressure on the redbreast population in EFPC (Peterson et al. 2013).

Although mercury bioaccumulation was found to decrease in EFPC fish in the headwater reach, it has paradoxically increased in the lower reaches of EFPC (Southworth et al. 2000). Both fish and aquatic macroinvertebrate communities in Upper East Fork Poplar Creek (UEFPC) lack key species indicative of unimpaired aquatic systems and are numerically dominated by pollution-tolerant organisms (Peterson et al. 2013). Mercury concentrations in fish in lower EFPC, in contrast to uppermost EFPC, have increased nearly 40% since the mid-1980s (Southworth et al. 2011). Indeed, the fish community at the downstream kilometer 13.8 EFPC site has species richness and abundance that approximately equals background, but average Hg concentrations in redbreast sunfish (i.e., body burdens) at this site have been in the range of 0.6 to 1 mg/kg (ppm) since 1984 (Suter II et al. 1999). In contrast, PCB concentrations in fish generally decreased downstream (Southworth et al. 2011). Thus, the target contaminants to be examined for this study are Hg and PCBs.

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. Mercury bioaccumulates in aquatic plants,

invertebrates, fish, and mammals, and the concentration tends to increase with increasing trophic level (Hg biomagnifies). Mercury accumulation in fish results from the complex interactions of a series of environmental components, including supply, methylation rates, trophic interactions, and fish bioenergetics (Rodgers 1996). Methylmercury has been reported to constitute from 70% to 99% of the total-Hg in skeletal muscle in fish (Huckabee et al. 1979; EPA 1985; Riisgård and Famme 1986; Greib et al. 1990; Saroff 1990, Spry and Wiener 1991, Bloom 1987, 1992, Southworth et al. 1995, Environment Canada 2002).

In fish, the accumulation of mercury from water occurs via the gill membranes. Gills take up aqueous MeHg more readily than inorganic mercury (Huckabee et al. 1979; Boudou et al. 1991). Methylmercury is eventually transferred from the gills to muscle and other tissues where it is retained for long periods of time (Julshamn et al. 1982; Riisgård and Hansen 1990). However, biomagnifications of MeHg through dietary pathways, rather than gill uptake from water alone, is considered the dominant mechanism for elevated MeHg concentrations in fish (Jernelöv and Lann 1971, Phillips and Buhler 1978, Rodgers and Beamish 1981, Harris and Snodgrass 1993, Rodgers 1994, 1996, Hall et al. 1997).

Elemental Hg, bivalent inorganic Hg, and MeHg are the three most important forms of Hg occurring in natural aquatic environments (Battelle 1987). The process of methylation of inorganic Hg to MeHg, which is highly bioavailable, is thus an important key to the fate of mercury in the environment (Beckvar et al. 1996). Research has demonstrated that MeHg generation may be exclusive to the in-situ Hg methylation by anaerobic, sulfate-reducing bacteria (microbial organisms) such as *Verrocumicrobia*, *ε-Proteobacteria*, and the *δ-Proteobacteria* within the EFPC community (Vishnivetskaya et al. 2011). However, Sellers et al. (1996) suggest that photodegradation of Hg to MeHg may be another important process where light penetration of the water column is significant in aquatic systems. Further detailed information and reviews are available in the scientific literature regarding Hg methylation in aquatic systems (Robinson and Tuovinen 1984, Compeau and Bartha 1985, Craig and Moreton 1983, Berman and Bartha 1986, Callister and Winfrey 1986, Jackson 1986, Weis et al. 1986, Korthals and Winfrey 1987, Foster 1987, Parks et al. 1989, D'Itri 1991, Gilmour and Henry 1991, Kelly et al. 1995, Leermakers et al. 1995, Southworth et al. 1995, 2000, 2011), although chemical methylation also occurs (Weber 1993). Lastly, dissolved organic carbon (DOC) in aquatic systems significantly increases Hg solubility (St. Louis et al. 1994), thus abundant Hg methylation occurs in wetlands where microbial activity and DOC are high (Environment Canada 2002). Indeed, Hurley et al. (1995) demonstrated a positive correlation between % wetland in a watershed (i.e., high DOC) and increased MeHg yield to rivers.

The Food and Drug Administration and EPA now agree that 0.3 ppm is the appropriately protective level for mercury in locally-consumed freshwater fish. Thus, TDEC considers the evidence compelling that fish tissue MeHg levels >0.3 parts per million have a potentially detrimental effect on the health of Tennesseans, particularly children (Denton 2007). Table 1 shows current criteria used for issuing fish consumption advisories in Tennessee.

**Table 1. State of Tennessee fish tissue advisory criteria**

<b>Contaminant</b>	<b>Level (ppm)</b>
PCBs	1.00
Hg	0.30

## Objectives:

1. Identify the principal diet items of the selected fish species in EFPC and selected Bear Creek sites. (see Table 2).
2. Identify collected fish to species.
3. Assess Hg, MeHg and PCB content of fish gut contents and in fillets from fish collected from EFPC.
4. Determine potential effects on ecosystem health, specifically wildlife feeding on fish.
5. Determine the magnitude of the contamination in edible portions of EFPC fish species where pollutants could be incidentally consumed by humans.

## Methods

### *Study area*

The focus of the monitoring effort is the EFPC watershed and comparable reference streams, including Clear Creek, Whites Creek, Hinds Creek and selected sites in Bear Creek. The study area is located in the Valley and Ridge physiographic province of the Southern Appalachians, with EFPC headwaters originating within the confines of the Y-12 National Security Complex, and extends generally southwest for approximately 25 km to its mouth at Poplar Creek. Parallel northeast-trending ridges constitute the northern (Black Oak Ridge) and southern (Chestnut Ridge) boundaries of the watershed (Peterson et al. 2013). The ridges are composed primarily of sandstones and dolostones and the valleys are underlain by shales, limy shales, and limestones (Geraghty and Miller, Inc. 1985).

### *Fish sampling*

All fish collected will be counted and identified to species, weighed, measured, and age estimated (i.e., young-of-the-year, juvenile, adult) in collaboration with DOE. Fish sampling protocols recommend at least six fish per sample for laboratory analysis of metals and PCBs. Fish captured that are large enough for human consumption will be evaluated for risk to human health and smaller fish will be evaluated for risk to the ecosystem. A fish community analysis may also be conducted if sampling efforts are deemed to provide a representative sample of species present at each sampling station. All work associated with this project will be conducted in compliance with DOE's sampling procedures and the office's Health, Safety, and Security Plan (Yard 2013).

### Target fish species:

1. Redbreast sunfish
2. Rock bass
3. Bluegill
4. Stonerollers
5. Other species as collected (i.e., largemouth bass, carp, etc.)

### Methods may include:

1. Observe/assist DOE fish shocking in spring and fall
2. Collect fish gut contents (non-lethal methods)
3. Collect fish fillets (or preferably biopsy plugs) when fish are available
4. Fish cage study (redbreast sunfish)

### *Laboratory analyses*

The Tennessee Department of Health Laboratory Services has expertise in a broad scope of services and analyses. This expertise is available to the Tennessee Department of Environment and Conservation, Department of Energy Oversight Office and other TDEC divisions statewide. General sampling and analysis methods will follow Environmental Protection Agency (EPA) guidelines as listed in appropriate parts of Title 40 Code of Federal Regulations (CFR). Laboratory Services may subcontract certain analyses and QC samples out to independent laboratories. Bench level quality assurance/quality control (QA/QC) records and chain-of-custody records are maintained at Laboratory Services, as are QA records on subcontracted samples.

DOE-O will primarily use the Knoxville branch of Laboratory Services. Wet chemistry and metals samples will generally be analyzed in Knoxville, while organics samples will be sent on to the Central Laboratory in Nashville. Methylmercury (MeHg) samples are farmed-out and analyzed at Brooks-Rand Laboratory in Seattle, Washington. All Laboratory Services analyses will follow appropriate methods as documented in the Laboratory Services Inorganic Chemistry SOP and Organic Chemistry SOP. Specific analytical methods are covered in the Standard Operating Procedures (SOP) manuals for Laboratory Services. The SOPs direct analysts to the proper EPA or other methodology.

Because MeHg is known to constitute essentially 99% of the total mercury in fish tissue (Environment Canada 2002), then for QA/QC purposes, only 10% of fish samples will be analyzed for both total-Hg and MeHg. That is, 90% of fish samples collected for the project will only be analyzed for total-Hg (plus PCBs). Accordingly, the assumption is made that all analytical results (concentration) of total-Hg determined for fish muscle samples will equal the same concentration of MeHg.

**Table 2: Fish monitoring sites and respective laboratory analyses**

	<b>Stream km</b>	<b>Analytes</b>	<b>Expected Species</b>
EFPC	21.5, 18, 14, 6, 1.5	PCBs Hg/ MeHg	Redbreast sunfish, rock bass, bluegill, stonerollers, carp, largemouth bass, other species
Hinds Creek	20.6 (reference)	PCBs Hg/ MeHg	Redbreast sunfish, rock bass, bluegill, stonerollers, carp, largemouth bass, other species
Whites Creek	2.3 (reference)	PCBs Hg/ MeHg	Redbreast sunfish, rock bass, bluegill, stonerollers, carp, largemouth bass, other species
Clear Creek	1.45 (reference)	PCBs Hg/ MeHg	Redbreast sunfish, rock bass, bluegill, stonerollers, carp, largemouth bass, other species

### *Fish electro-shocking*

A collaborative effort with DOE during their BMAP sampling in EFPC and Bear Creek will be used to obtain fish for analysis. Applicable state (and federal) collection permits will be secured in advance of sampling activity. Fish will be collected from EFPC and reference streams (Figures 1-3) twice a year (i.e., spring, fall) using a backpack electro-shocker to obtain fish muscle (fillets) and gut content samples. Obviously, taking fillet samples requires sacrificing the fish, thus, the less invasive and preferred sampling method is collection of

biopsy plug samples for Hg analysis. Every attempt will be made to obtain at least six fish (of the same species) for analysis. Field procedures will generally follow the guidance and standard methods of Adams et al. (1999), Barbour et al. (1999), EPA (2000), and Peterson et al. (2013) for sampling in wadeable streams to assess fish assemblages.

#### *Fish gut contents sampling (non-lethal)*

Several nonlethal methods have been developed to sample the stomach contents of fish, including gastroscopes, tubes, stomach suction, stomach flushing, emetics, forceps, and chronic fistulas (Strange and Kennedy 1981, Kamler and Pope 2001, Waters et al. 2004). Techniques have been devised which enable removal of stomach contents without harming the fish and among the simplest of these is removing stomach contents with forceps (Wales 1962). Because this is a new pilot project, the preferred TDEC method for non-lethal fish-gut content removal is to-be-determined. Fish gut contents will be analyzed for Hg and PCBs.

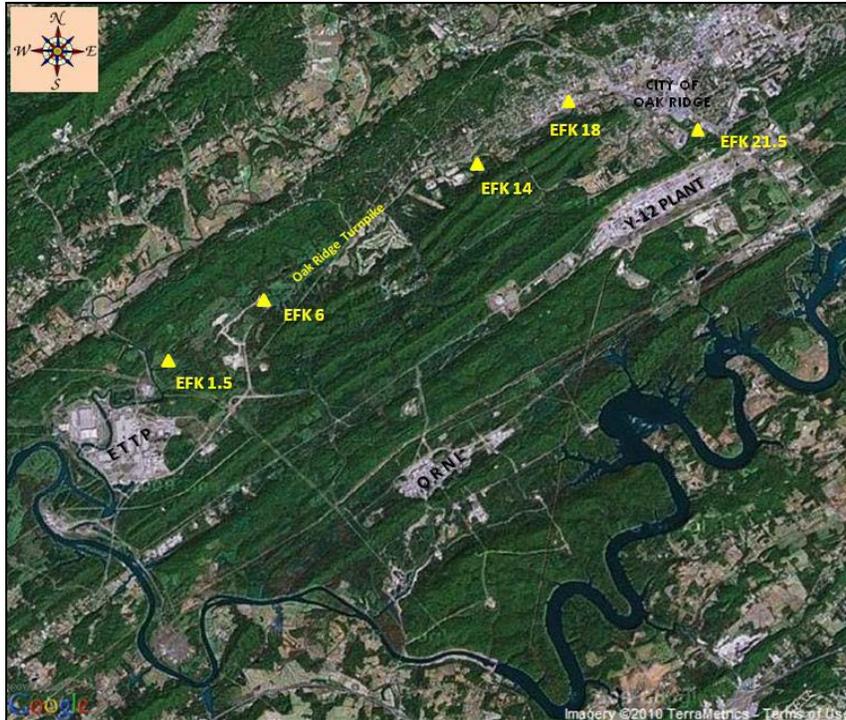
#### *Fish tissue*

DOE-collected fish samples will be prepared in the field and/or at either the ORNL or the TDEC DOE-O labs for later delivery to either the State or the DOE laboratories for analysis. Samples will consist of fish fillets (or preferably biopsy plugs) and fish gut contents for individual species (ideally, a six-fish composite). Redbreast sunfish (*Lepomis auritus*) will be a primary species for contaminant analysis (i.e., body burden of Hg and PCBs), but rock bass (*Ambloplites rupestris*), bluegill (*Lepomis macrochirus*) or other species may also be sampled if redbreast sunfish are unavailable. Sunfish species are ideal fish to monitor changes in bioaccumulation over time or space; they are short-lived and sedentary and thus represent recent exposure to contaminants at the site of collection (Peterson et al. 2013). Muscle tissue from six individual fish from each site will be analyzed for mercury and/or PCBs. At sites where PCB analyses are conducted, muscle fillets of fish will be taken as a sample size of at least 3 grams is needed for PCB analysis. However, for fish that only need mercury analysis, a nondestructive technique known as a biopsy sample is taken from the live fish (i.e., only 100 mg of tissue required for Hg analysis), and then the fish are tagged using a Passive Integrated Transponder (PIT) and re-released at the site of capture (Figures 4 and 5, Peterson et al. 2013). This method provides the additional advantage where the same individual fish may be re-captured in the future and re-analyzed for mercury again allowing for an assessment of bioaccumulation and growth rates. This is particularly important for redbreast sunfish (*Lepomis auritus*) because this species has been increasingly difficult to collect throughout EFPC and rock bass, which typically have higher mercury concentrations in their tissues, have been collected by other researchers as a surrogate species for contaminant analysis (Peterson et al. 2013). In short, non-destructive sampling for mercury and reduced PCB sampling (which requires sacrificing fish) may alleviate some of the pressure on the redbreast population in EFPC (Peterson et al. 2013). Fish sampling and sample preparation techniques will follow the guidance of the Environmental Protection Agency's standardized practices for sampling and analyzing fish (EPA 2000), and fish sample preparation techniques from Southworth et al. (2011). Also see techniques in Peterson et al (2013) for biopsy plug sampling.

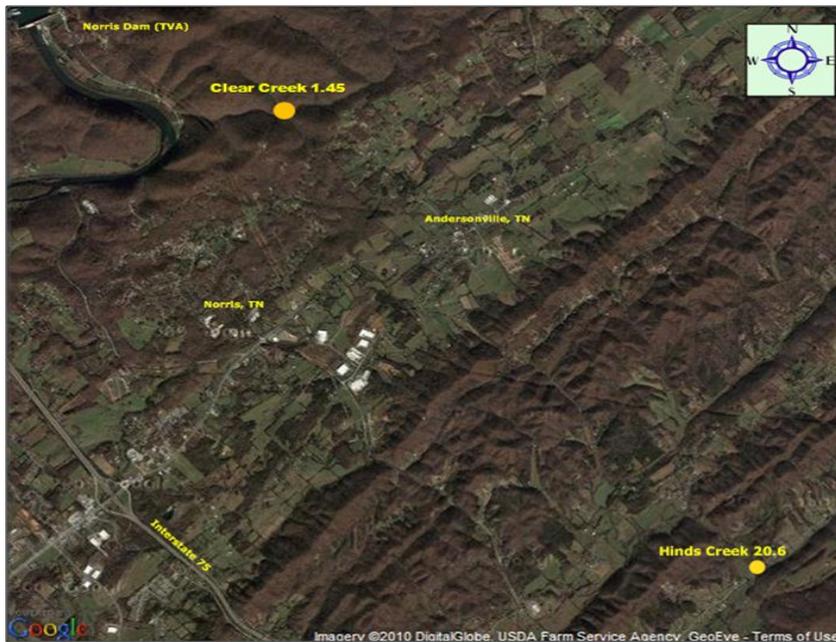
#### *Introduced redbreast sunfish study*

Additionally, tagged naïve redbreast sunfish may be released in Lower East Fork Poplar Creek to examine Hg bioaccumulation in fish tissue. Because this method could potentially create unknown exacerbations to the existing EFPC fish population, additional research and planning is required prior to initiating this phase of the project. A to-be-determined number

of tagged fish would be released at three to four upstream-to-downstream sites along EFPC (and at locations other than the standard BMAP fish and macroinvertebrate monitoring stations). Redbreast sunfish reared in a fish hatchery or fish captured at a reference stream will likely be used for this study. This phase of the project remains in the planning and developmental stages. Methods for this study will generally follow the field and laboratory protocols of Spruill et al. (1998), Ebinghaus et al. (1999), EPA (2000), and Murphy (2004).



**Figure 1: Fish monitoring sites in East Fork Poplar Creek**



**Figure 2: Fish monitoring sites at Clear Creek and Hinds Creek reference streams**



**Figure 3: Fish monitoring site at Whites Creek reference stream**



**Figure 4: Fish biopsy plug sample.  
(Photo credit: Peterson et al. 2013)**



**Figure 5: Passive Integrated Transponder (PIT) tag equipment for identification of fish recaptures. (Photo credit: Peterson et al. 2013)**

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## **Pilot Project: Bioaccumulation Study of Metals in Fungi from East Fork Poplar Creek Floodplain**

### **Introduction**

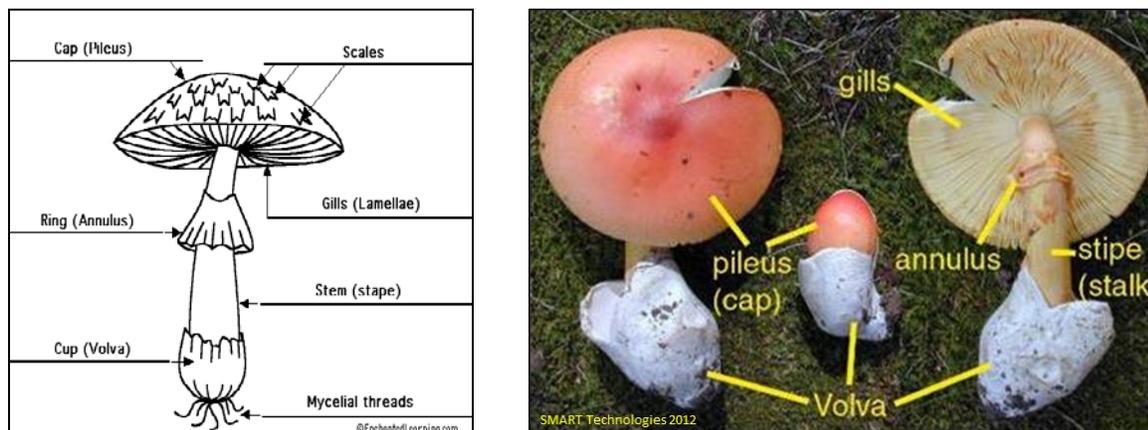
Vascular plants accumulate both inorganic and methylmercury from sediment and water in root, stem, and leaf sections (Alberts et al. 1990; Boudou et al. 1991). In contrast, heavy metal concentrations in cryptogams (i.e., lower plants that reproduce by spores), such as mushrooms, are considerably greater than those in agricultural crop plants, such as vegetables, and fruit (Zhu et al. 2010). The main parts of the mushroom fruiting body consists of the cap, ring, stem, cup and mycelium threads (Figures 1-a and 1-b). Many wild edible mushroom species (e.g., chanterelles, morels) have been demonstrated to accumulate concentrations of heavy metals such as lead, cadmium, iron, copper, manganese, zinc, chromium, nickel, aluminum, and mercury (Svoboda et al. 2000; Falandysz et al. 2003; Dursun 2006; Cocchi et al. 2006; Chen et al. 2009, Elekes et al. 2010). In particular, mercury is found with high abundance in the fruiting bodies of some edible and inedible mushroom species (Falandysz and Brzostowski 2007). Svoboda et al. (2006) observed mercury concentrations of 2.6 mg/kg in *Clitocybe nebularis* (clouded agaric). Also, *Clitocybe nuda* (wood blewit), *Lycoperdon perlatum* (common puffball), *Boletus edulis* (king bolete), and *Agaricus* spp. are also known to bioconcentrate mercury in their fruiting bodies as well (Stegnar et al. 1973, Brunnert and Zadragil 1981, Falandysz et al. 2002, Svoboda et al. 2006). Other mushroom species mainly from the genera *Macrolepiota*, *Lepista* and *Calocybe* accumulate high levels of cadmium and mercury even in unpolluted and mildly polluted areas (Kalač and Svoboda 2000). Methylmercury, a highly toxic form of mercury, was found to be effectively absorbed by *Boletus* spp. under field conditions (Falandysz et al. 2004).

Due to the toxicity of mercury, the World Health Organization (WHO) established intake guidelines for humans, and set the maximum weekly intake by humans of total mercury and methylmercury to 300 and 200 µg, respectively (Melgar et al. 2009). Some species of higher mushrooms, however, accumulate in their fruiting bodies levels of mercury that are higher than these limits (Stijve and Roschnik 1974, Falandysz et al. 2002, Tüzen and Soylak 2005, Falandysz et al. 2007).

Since heavy metals may enter the food chain through the consumption of mushrooms, it is necessary to assess the levels of heavy metal found and to report possible contamination that would represent a health hazard. To our knowledge, metals content of mushrooms, specifically mercury concentrations, has seldom been investigated on the Oak Ridge Reservation (ORR).

Mushroom samples will be collected seasonally (i.e., spring, summer, fall) at sites on the East Fork Poplar Creek (EFPC) floodplain and perhaps some of its tributaries (Table 1, Figures 2-5). Reference samples will be collected in to-be-determined locations off the ORR. The objective of this pilot monitoring program is to collect and analyze mushroom samples for mercury (total Hg and methylmercury) and report possible contamination and health hazards for the protection of human health and the environment. Due to the nature and extent of ORR contamination issues, radiological analyses may also be conducted. Because there are >10,000 described species of mushrooms in North America (>75,000 species worldwide), we additionally seek to enhance our ecological and botanical knowledge of mushroom species

present on the ORR. One goal will be to analyze as many mushroom species as possible collected from each sampling location, especially edible mushrooms.



**Figure 1-a and 1-b: Mushroom morphology**

Tentative Sites	Location / nearest facility or business
Mush-1	EFPC / Staybridge Suites
Mush-2	EFPC / Kmart/Kroger
Mush-3	EFPC / Holiday Inn Express
Mush-4	EFPC / Robertsville Middle School
Mush-5	EFPC / Bruner Site (Magnolia Tree Restaurant)
Mush-6	EFPC / TVA substation
Mush-7	EFPC / Turtle Park
Mush-8	EFPC / O-R Country Club Golf Course
Mush-9	EFPC / Lambert Quarry
Mush-10	EFPC / Renovare Blvd. bridge (Horizon Center)
Mush-11	EFPC / Novus Drive bridge (Horizon Center)
Mush-12	EFPC / Confluence with Poplar Creek
Mush-13*	Clear Creek / Norris Watershed
Mush-14*	Whites Creek / Chuck Swan WMA

**Table 1: Tentative sampling sites at East Fork Poplar Creek and reference areas\* (off the map)**

### Methods and Materials

Parameters to be analyzed:

*Inorganics:* mercury, methyl mercury

*Organics:* PCBs

### Schedule

Mushroom sampling will be conducted in the spring (March-May) and late summer/fall (July-October). The timing of sampling will be carefully selected to optimize the greatest probability for the presence of a variety of species and coordinated based upon recent precipitation events.

### *Procedure*

In the field, entire fungal sporocarps (i.e., fruiting body) will be hand collected from to-be-selected EFPC sampling plots and reference plots during 2014. Sampling sites were partially selected based upon high concentrations of Hg present in EFPC floodplain soil samples (OREIS Database; Figures 6 and 7). The literature suggests that each plot will be approximately ten square meters. Additional subplots may be added if mushrooms are sparse and additional sampling is necessary to bolster fungal biomass for laboratory analyses. However, because this is a pilot project with a steep learning curve, a broad survey of each site will be conducted to determine the quantity of available mushrooms at sampling time. The goal is to collect enough sporocarps of each species to provide a 5-10 gram dry weight sample for laboratory analysis (Eckl et al. 1986). Care will be taken to extract the entire fruiting body from the forest substrate with clean plastic gardening tools (if needed). Mushrooms will be photographed before extraction as an aid to taxonomic identification of each sporocarp. Mushrooms will be sampled, cut and/or divided with plastic, glass or pottery instruments to avoid any metal contacts that can influence the results (Elekes et al. 2010). Processed samples will be stored in plastic bags at 4°C until analysis at the Tennessee Department of Health Environmental Laboratory can be undertaken.

Freshly collected fruiting bodies of mushrooms will be washed with deionised water to remove extraneous material (i.e., plant and substrate debris) and cut with a clean plastic knife into small pieces (Falandysz et al. 2004). Next, the samples will be dried at 60°C between 12 and 15 h in an oven and finally weighed (Radulescu et al. 2010). Alternatively, the samples may also be placed in a dehydrator and dried, then weighed and placed into storage at 4°C until delivery to the Tennessee Department of Health Environmental Laboratory. These methods follow the sampling and processing protocols of Eckl et al. 1986, Falandysz et al. 2004, Elekes et al. (2010), Radulescu et al. (2010), and Vinichuk (2012). Species determined to be edible will be examined to consider how mercury and PCBs may impact human health and those deemed inedible will be examined to determine if there are risks to wildlife and the ecosystem. For example, box turtles are known to consume mushrooms.

Although researchers have determined that methylmercury (MeHg) constitutes 50-99% (mean 75%) of total mercury (THg) present in fish tissue samples (Kannan et al. 1998, Sun et al. 2006, Hajeb et al. 2010, Carrasco et al. 2011, Salaramoli et al. 2012), mushrooms have been shown to have low levels of (5%) of MeHg (Rieder et al. (2011)). Accordingly, the assumption is made that MeHg may contribute  $\geq 75\%$  of THg that may be present in mushroom samples and, hence, for QA/QC purposes, only 10% of fungi samples collected will be analyzed for MeHg.

### *Laboratory Procedures*

The Tennessee Department of Health, Environmental Laboratory and Microbiological Laboratory Organization (the state lab) has expertise in a broad scope of services and analyses available to the Tennessee Department of Environment and Conservation (TDEC) Department of Energy Oversight (DOE-O) and to other TDEC divisions statewide. General sampling and analysis methods are to follow Environmental Protection Agency (EPA) guidelines as listed in appropriate parts of 40 Code of Federal Regulations (CFR) and TDEC sampling procedures and health and safety guidelines (TDEC 1996, Yard 2013). Laboratory Services may subcontract certain analyses and QC samples out to independent laboratories. For example, methylmercury samples are typically farmed-out to Brooks-Rand Laboratory, Seattle, Washington for analysis. Bench level Quality Assurance/Quality Control (QA/QC) records

and chain-of-custody records are maintained at the Tennessee Environmental Laboratory, as are QA records on subcontracted samples.

DOE-O will primarily use the Knoxville branch of Laboratory Services. Wet chemistry and metals samples will generally be analyzed in Knoxville while organic samples will be sent on to the state lab in Nashville. All laboratory analysis will follow appropriate methods as documented in the Laboratory Services Inorganic Chemistry SOP and Organic Chemistry SOP. Specific analytical methods are covered in these manuals. They also direct analysts to the proper EPA or other methodology.



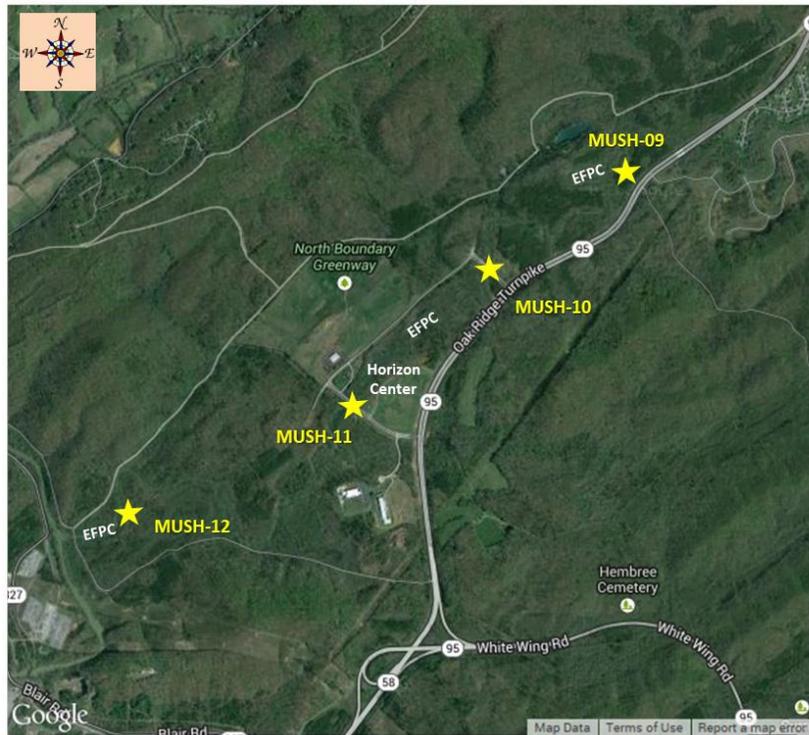
**Figure 2: Tentative mushroom sampling locations**



**Figure 3: Tentative mushroom sampling locations**



**Figure 4: Tentative mushroom sampling locations**



**Figure 5: Tentative mushroom sampling locations**



**Figure 6: OREIS Database Pre-Remediation Hg Samples in EFPC (Yellow Circles = >100 ppm Hg; Purple Circles = <100 ppm Hg)**



**Figure 7: OREIS Database Pre-Remediation Hg Samples in EFPC  
(Yellow Circles = >100 ppm Hg; Purple Circles = <100 ppm Hg)**

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# Acoustical Monitoring of Bats on the Oak Ridge Reservation

## Introduction

There is a paucity of available information regarding the distribution and occurrence of bats in the southeastern United States, including the occurrence of bat species on the Oak Ridge Reservation (ORR). Although the presence of the federally endangered gray bat (*Myotis grisescens*) has been documented on the ORR, the status of the federally endangered Indiana bat (*Myotis sodalis*) and knowledge of the overall bat community is not well known. However, it should be noted that a male Indiana bat was captured during a mist net survey on the Oak Ridge Reservation in the summer of 2013 which is the first documented Indiana bat recorded since 1950. Of special interest to bat ecologists is that the northern long-eared bat (*Myotis septentrionalis*) is currently under consideration for listing as a federally endangered species by the U.S. Fish and Wildlife Service.

Bats of the genus *Myotis* (i.e., mouse-eared bats) consume a variety of insects, including *Coleoptera*, *Diptera*, *Ephemeroptera*, *Lepidoptera*, *Neuroptera* and *Trichoptera* (Best et al. 1997). The gray bat is highly migratory, establishes nursery colonies in warm caves during summer, hibernates in different cold caves during the winter (Gardner and Hofmann 1986, Gore 1992, Decher and Choate 1995), and typically forages almost exclusively over rivers, streams and lakes where insects are abundant, usually within two km of their cave or abandoned mine (Tuttle 1976, LaVal et al. 1977, LaVal and LaVal 1980, Mitchell and Martin 2002). They migrate between summer and winter caves and will use transient or stopover caves along the way. One-way migrating distance between winter and summer caves may vary from as little as ten miles to well over 200 miles. An important hibernaculum for gray bats in Tennessee is Hubbards Cave which has been gated since the early 1970s to prevent human disturbances of the bat colony (Tuttle 1985, 1986). Near Oak Ridge another gray bat hibernaculum is located in a cave above Norris Dam in Anderson/Campbell County. Gray bats may roost at man-made sites that simulate summer caves, such as abandoned barns (Gunter and Elder 1971) and storm drains (Hayes and Bingham 1964, Timmerman and McDaniel 1992). In contrast, the Indiana bat is a highly migratory species, forms maternity roosts in snags and trees with exfoliating bark that are partially exposed to sunlight during summer, but are more concentrated in caves during winter hibernation (Gardner and Hofmann 1986). The sunlight is thought to speed the development of the young pups (French 2009). However, Salyers et al. (1996) discovered two male Indiana bats roosting in a bat box in Indiana, and elsewhere, immature males were captured beneath a concrete bridge (Mumford and Cope 1958). Indiana bats forage in and around the tree canopy of floodplain (i.e., forest edge of floodplains), riparian and upland forest (USDOE 2007). Factors contributing to the decline of bat species include stream channelization, cattle farming, deforestation, insecticide poisoning, urban expansion, and more recently, white nose syndrome disease (Gardner and Hofmann 1986).

Previous ORR bat investigations have been limited by short term, two- to four-night surveys of mist-netting and acoustic surveys at project sites (i.e., to meet the requirements of section 7 of the Endangered Species Act of 1973 for threatened and endangered species), and thus no long term, intensive monitoring data is available.

Bats (order Chiroptera) are fundamental ecosystem components for insect suppression, pollination and seed dispersal. Bats in the eastern United States use ultrasonic echolocation to locate prey and navigate in their surroundings. Echolocation calls of most bats are species

specific. Ultrasonic detectors are widely used to record and analyze bat echolocation calls and have improved conservation efforts by providing increased knowledge of bat ecology and to efficiently characterize and inventory bat communities at study sites.

The TDEC (Tennessee Department of Environment and Conservation) Division of Remediation's DOE-Oversight Office plans to continue investigating the bat community present on the Oak Ridge Reservation during 2014. Following emergence from winter hibernation, the ORR bat community will be monitored using nonintrusive methods such as the Anabat™ system to record calls to enable acoustic identification of species. Recorded bat calls will be analyzed and species determined using specialized software. We will use a combination of active and passive ultrasonic field surveys beginning after April 15, 2014, and continuing through October 31, 2014.

Bats in the eastern United States use echolocation to locate prey and navigate in their surroundings (Britzke 2003). During summer nights, bat roost-emergence and feeding activity commonly peaks immediately after sunset and can continue for several hours (Kunz 1973, Barclay 1982). Typically, a lesser activity peak occurs before sunrise as bats return to their diurnal roosts after foraging (Kunz 1973). They usually roost in tree cavities or under exfoliating bark of snags or live trees, where they form maternity colonies of < 100 individuals during summer (May–July) (Caceres and Barclay 2000).

The Tennessee Oversight Agreement mandates a comprehensive and integrated monitoring and surveillance program for all media (i.e., 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. Accordingly, monitoring the ecological recovery progress of wildlife and environmental restoration of habitat are important aspects of remedial activities on the ORR. Additionally, the Environmental Monitoring Section has responsibility for the lead on threatened and endangered species issues within the TDEC DOE-Oversight Office.

Bat detectors enable bats to be studied in greater detail and are now employed by most researchers in censuses of bat faunas (Barataud 1998, Pauza and Pauziene 1998) and in the analysis of habitat use (Vaughan et al. 1997, Avila-Flores and Fenton 2005). Acoustic surveys of bat echolocation calls are often used to model a species' occurrence at a site (i.e., occupancy model, French 2009), and improve conservation efforts by increased knowledge of bat ecology (Britzke et al. 2011). The application of bat ultrasonic monitoring devices such as the Anabat SD-2 detector has allowed ecologists to quickly and efficiently characterize and inventory bat communities at multiple areas (O'Farrell and Gannon 1999, Owen et al. 2004), and transform those calls into frequencies which are audible to humans (Parsons et al. 2000).

### **Study Site**

The study will be conducted on the Oak Ridge Reservation, Oak Ridge, Tennessee, which consists of approximately 34,500 acres (14,000 ha) within Anderson and Roane counties. The reservation is bound on the north and east by residential areas of the City of Oak Ridge and on the south and west by the Clinch River.

More than 20 caves have been identified on the ORR. Mitchell et al. (1996) surveyed seven of the caves (Copper Ridge, Flashlight Heaven, Walker Branch, Big Turtle, Little Turtle, Pinnacle, and Bull Bluff), but no gray bats were found. There is an unverified report of ten

gray bats roosting in Little Turtle Cave in September 1996 (Webb 2000). Therefore, Anabat surveys of ORR cave entrances will also be conducted on multiple nights to determine species, if present. We should note that ORR caves will not be entered by office staff at any time due to the current issues with the white nose disease.

### **Objectives**

- Conduct passive fixed-point Anabat surveys at multiple ORR sites
- Conduct Anabat mobile transect surveys on ORR access roads
- Focus on identifying the presence of federally endangered bats on the ORR
- Identify roost trees and other roosting habitats (i.e., bridges, rock crevices, etc.)
- Compare bat communities in different forest stands (e.g., mixed hardwoods vs. pines)
- Using bat houses, guano samples may be collected for DNA and metals toxicology analyses

### **Methods**

For this project, we will deploy at least two Anabat SD-2 detectors (Titley Electronics, Ballina, NSW, Australia) to record bat echolocation calls at each study site. New detectors may also be deployed during 2014 (i.e., Wildlife Acoustics SongMeter SM2BAT2+ detector). It is recommended by the U.S. Fish and Wildlife Service (USFWS 2011) that a project area of suitable bat habitat would require the deployment of at least two detectors for two nights for a total of four detector nights. It is important to note that Anabat detectors are the currently accepted technology for most government bat surveys as recommended and approved by the U.S. Fish and Wildlife Service. This project will generally following the bat monitoring guidance and protocols of Kuenzi and Morrison (1998), Murray et al. (1999), Jones et al. (2004), Szewczak 2004, Manley et al. (2006), Britzke et al. (2011), and the U.S. Fish and Wildlife Service (USFWS 2011). This research will be in cooperation with the Division of Natural Areas (TDEC Bureau of Parks and Conservation), Tennessee Wildlife Resources Agency, the Forestry, Wildlife and Fisheries Department of the University of Tennessee, the US Fish and Wildlife Service, and the Oak Ridge National Laboratory. Accordingly, we propose the following Anabat survey methods:

- Fixed-point survey with Anabat on station for 30 minutes and surveying multiple sites per work session. Surveys will begin 30 minutes past sunset and continue for approximately 2-3 hours (Wear 2004, Ford et al. 2005, Schirmacher et al. 2007);
- Passive survey at fixed-point location recording bat echolocation calls overnight (program Anabat to begin recording 30 minutes past sunset and continue until dawn, Martin and Britzke 2010). Detector systems placed into the field for remote, passive sampling are often housed in waterproof containers with an aperture through which the microphone can be fitted (Britzke et al. 2010). Detectors will be placed a few feet off the ground on camera tripods to reduce recording ultrasonic insect clutter (Weller and Zabel 2002). Hobo Pendant® light/temperature meters will also be deployed with Anabats left in the field for overnight recording sessions;
- Mobile Anabat transect monitoring will begin 30 minutes past sunset and the route will be driven at 20 mph along approximately 20-30 miles of gravel access roads. This activity will be conducted every two weeks from mid-April

through mid-November 2013. The Anabat microphone will be mounted on the roof of the car during the survey;

- Cave surveys: Duchamp et al. (2006) determined that using a second detector at a site increased the probability of detecting different species of bats at a site (i.e., double observer method). We will likely deploy two Anabat detectors at some overnight sites, such as caves, with each detector oriented five m apart with microphones facing opposite each other, yet pointed towards the most open area of the habitat to allow sampling of an area distinct from the other detector. Note that detectors will be deployed outside of the cave entrance and that the cave will not be entered.
- The ORR contains many acres of high quality Indiana bat habitat with upland forest and dead pine snags adjacent to large bodies of water. Summer colonies of Indiana bats are more dispersed in forests and more difficult to detect and monitor in annual surveys than gray bats. The nearest known hibernation cave to the ORR is in the Great Smoky Mountains National Park (Blount County). Although no maternity roosting colonies of Indiana bats are known on the ORR, a male Indiana bat was documented on the ORR during the summer of 2013 for the first time since 1950. High quality Indiana bat roosting habitat on the ORR should be identified and monitored periodically (Mitchell and Martin 2002). Hence, one of the objectives of the project is to conduct daylight roost and tree habitat surveys on the ORR
- Mist net surveys: If a federal permit is secured to handle and trap bats, then mist net surveys may be conducted during 2014. Appropriate training and medical vaccinations will be required for those individuals handling bats during the mist netting process. If another's permit (USFWS) is used for collection, that person must be present for all mist netting activities.

Anabat data files will be analyzed with several software programs to produce preliminary bat identification output: Analook-W, BCID-East, Kaleidoscope Pro, EchoClass. For the new SM2BAT+ detectors, the SonoBat™ software will be required for bat file analysis. Bat species shall be assumed to have a likely probability of presence at a study site if two or more of the software program outputs agree on the species reported.

Potential bat habitats to be monitored include water resources (streams, ponds, riparian zones, springs, rivers, wetlands), travel corridors (e.g., linear landscape features, rocky outcrops and bluffs, forested roads, trails, dry creek beds) and karst features such as caves (LaVal et al. 1977, Racey 1998, Grindal and Brigham 1999, Menzel et al. 2005). For example, *Myotis sodalis* (Indiana bat) may forage in forests with intact canopies, near headwater streams (Menzel et al. 2005, Schirmacher et al. 2007), and within riparian zones (Webb 2000, Ford et al. 2005). The Indiana bat may form maternity roosts in shaggy-barked trees and snags with exfoliating bark during summer and then hibernate in caves during winter (Menzel et al. 2001, Timpone et al. 2010).

### **Timetable**

Mid-April: Commence field monitoring

Weekly: Anabat fixed-point survey\*\*

Weekly: Overnight Anabat survey

Every two weeks: Roost and habitat (tree) survey

Once per month: Mobile transect survey\*\*

Every two weeks: Collect guano samples from bat houses

Last of October: Suspend operations until following April

\*\*Conduct surveys the first 2-3 hours following sunset

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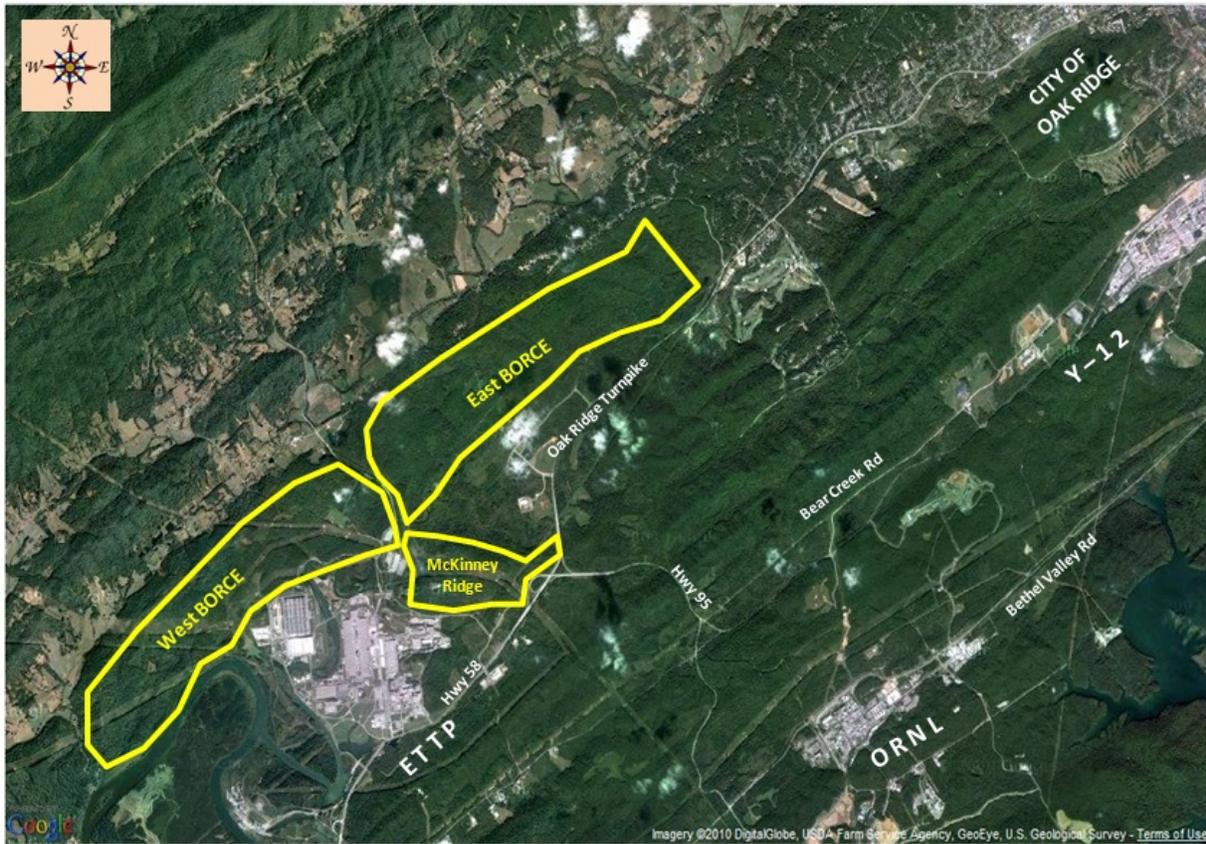
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## **Threatened & Endangered Species Monitoring**

### **Introduction**

More than 30 rare animal species and twenty-one state-listed and federal-candidate plant species are known to be present on the ORR. More than 1000 different species of plants grow on the reservation, reflecting its diversity. The reservation supports a wide variety of wildlife species including 60 reptilian and amphibian species; 63 fish species; more than 120 species of terrestrial birds; 32 species of waterfowl, wading birds, and shorebirds; and about 40 mammal species (Salk 2004). Habitats supporting the greatest number of species are those dominated by hardwood forests and wetlands. The ORR's plant and animal life is situated in a relatively intact ecosystem that is highly diverse when compared with surrounding areas in the same physiographic province (Mann et al. 1996). All areas of the ORR are relatively pristine when compared with the surrounding region, especially in the ridge and valley province. The ORR, consisting of the Oak Ridge National Environmental Research Park and associated lands surrounding DOE facilities at Oak Ridge, Tennessee, is about 15,000 ha of mostly contiguous native forest in the valley and ridge province (Mann et al. 1996). Approximately 20 miles of greenway trails are available for hiking and bicycling on the Black Oak Ridge Conservation Easement (BORCE, Figure 1) which consists of about 3000 acres of mainly forested uplands including the Dyllis Orchard greenway trail (opened to the public in October 2007). About half of the BORCE has been surveyed for rare vascular plant species by TDEC personnel. Additional ORR geomorphic and topographic features supporting rare plant communities include wetlands, karst features (caves), rocky bluffs, limestone cedar barrens, and an area of old growth forest. About 70% of the ORR is in forest cover and less than 2% remains as open agricultural fields. The forests are mostly oak-hickory, pine-hardwood, or pine. Communities are generally characteristic of the intermountain regions of Appalachia (Mann et al. 1996). Oak-hickory forest, which is most widely distributed on ridges and dry slopes, is the dominant association. Minor areas of other hardwood forest cover types are found throughout the ORR; these include northern hardwoods, a few small natural stands of hemlock or white pine, and floodplain forests (Mann et al. 1996). Among these are numerous TDEC-designated natural areas on the ORR. Currently, most of the ORR is a wildlife management area (WMA), thus the BORCE site and the WMA is managed by the Tennessee Wildlife Resources Agency (TWRA).

This project will incorporate the office's oversight role of environmental surveillance and monitoring (TDEC 2006). Additionally, several federal and state laws support this effort. The Federal Endangered Species Act of 1973 (ESA), as amended, provides for the inventory, listing, and protection of species in danger of becoming extinct and/or extirpated, and for conservation of the habitats on which such species thrive. The National Environmental Policy Act (NEPA) requires that federally-funded projects avoid or mitigate impacts to listed species. 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. The National Resource Damage Assessments (NRDA), as directed by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, and as amended by SARA (Superfund Amendments and Reauthorization Act of 1986), relates to damages to natural resources on the ORR.



**Figure 1: Black Oak Ridge Conservation Easement (BORCE)**

For 2014, major functions and focus of the threatened and endangered species (T&E species) project planned for the ORR include: (1) provide botanical oversight and field support to the TDEC Division of Natural Areas as needed relating to ORR T&E species, (2) inventory and map the botanical diversity that exists on the ORR, (3) independently monitor and verify biological survey information provided by DOE, and comply with T&E species requirements per CERCLA and NEPA regulations, (4) identify and protect T&E species and TDEC-designated natural areas that represent biological diversity on the ORR, (5) provide field oversight during DOE subcontractor vascular plant surveys on ORR projects (i.e., road construction projects, land transfers, etc.), and (6) identify areas of the ORR infested with exotic pest plants (Drake et al. 2002, TEPPC 2002).

### **Methods and Materials**

During 2014, monitoring of vascular plants on the ORR by office staff will follow a modified version of the methods and guidance outlined in Washington-Allen et al. (1995) and Ayl et al. (1996). Additionally, field methods for documentation of pteridophytes (ferns and fern allies) will follow the field protocols of the All Taxa Biodiversity Inventory fern forays project in the Great Smoky Mountains National Park (ATBI 2007). Field mapping of native and invasive plant species will utilize field stations (50-foot diameter mini-plots) at pre-selected intervals (i.e., grid patterns, traverses, etc.) based on specific reconnaissance projects. Unusual or rare plants will be located and mapped, if found, between these intervals. Generally, field biodiversity inventories will begin with existing roads and trails, then transects will be walked cross-country (similar to a “timber cruise”) in generally north-south, east-west traverses to complete a grid pattern of coverage over the parcel. Habitats such as

small drainage ravines, floodplains, wetlands, watersheds, sub-watersheds, sinkholes, cedar barrens, rock outcroppings, cliffs, springs, caves, etc. will be field surveyed for plant taxa. Field surveys are designed to locate and identify T & E plant species, invasive plant species, aquatic and wetland taxa.

Each field station (mini-plot) will be mapped and located using a Global Positioning System (GPS) hand-held field unit (Garmin® Etrex). Each field station will be defined as a 50-foot circle from center point or circumference. Plant taxa will be organized and compartmentalized as: canopy, subcanopy, shrub, herbaceous, and groundcover layers. Digital camera images will be made at most field sites to record and document plant taxa. Additionally, the boundaries of the pine deadfall areas (pine-beetle devastated areas) will be mapped whenever possible in the field. These sites may become important ecological study areas to determine if native climax species or exotic pest species will re-establish here.

Terrestrial plant species may be collected for preservation as herbarium specimens (vouchers). The samples will be collected as much as possible with either flower or fruit, then pressed and dried, and mounted on herbarium paper with appropriate identification labels. These are quite useful for training purposes but more importantly to properly document and confirm plant species (especially rare species) encountered in the field. Care will be taken while collecting plant specimens so as not to destroy or damage a rare plant colony.

Vascular plant identifications will require the use of the following sources and taxonomic keys: Radford et al. (1968), Prescott (1980), Cobb (1984), Lellinger (1985), Wofford (1989), Gleason & Cronquist (1991), Chester et al. (1993), Chester et al. (1997), Carman (2001), Wofford & Chester (2002), University of Tennessee Herbarium (2007), and Weakley (2007).

Field data sheets (survey logs) will be recorded for each survey station and later placed in a database for inclusion in the environmental monitoring report. Maps will be prepared with available GIS software to illustrate locations of all field stations with plant data, geologic features and other pertinent biological habitat and field data.

Field monitoring methods and health and safety procedures will follow the guidelines in the office's Health, Safety, and Security Plan (Yard 2013).

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# **Aquatic Vegetation Monitoring on the Oak Ridge Reservation**

## **Introduction**

The Tennessee Oversight Agreement (TOA) requires the state to perform monitoring to assess the effectiveness of DOE contaminant control systems on the Oak Ridge Reservation (ORR). If surface water bodies (e.g., springs and ponds) have been impacted by radiological contamination, certain aquatic organisms in the immediate vicinity may uptake radionuclides. This program will focus on the detection and characterization of radiological constituents that may be bioaccumulated by aquatic vegetation on and in the vicinity of the Oak Ridge Reservation.

Target vegetation for sampling includes, but will not be limited to: watercress (*Nasturtium officinale*), common cattail (*Typha latifolia*), willow (*Salix sp.*), and box elder (*Acer negundo*).

Locations considered as potential monitoring sites include springs, seeps, streams, creeks, wetlands, and ponds. Watersheds such as Bear Creek and its tributaries, White Oak Creek/Lake and its tributaries, Mitchell Branch, and East Fork Poplar Creek are all probable target locations for sampling.

In 2014, the monitoring will focus on areas likely to have radiological contamination, either from past or current DOE activities. Current activities may include areas downstream of the demolition of buildings with radiological contamination from past activities to determine if radiological constituents are migrating into the environment. Previous sampling locations that exhibited elevated results in past years may be resampled. Metals analysis may also be conducted. Metals analysis for 2014 would most likely focus on mercury along East Fork Poplar Creek in box elder trees as they are readily available at most locations.

## **Methods and Materials**

Aquatic vegetation samples will be collected at sites both on and off the ORR, the latter for background data. At least one gallon of vegetation, including roots but minimal other debris, will be sent to the State of Tennessee Environmental Laboratory in Nashville, Tennessee, for analysis. Samples are analyzed for gross alpha, gross beta, and gamma radionuclides. Additional radiological analysis may be performed if merited. Metals analysis may also be conducted on the vegetation from sites if needed and samples may be collected along East Fork Poplar Creek for mercury analysis.

## **References**

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# DRINKING WATER MONITORING

## Sampling of Oak Ridge Reservation Potable Water Distribution Systems

### Introduction

The water distribution systems at each of the Department of Energy (DOE) Oak Ridge Reservation (ORR) sites are regulated by the *Tennessee Safe Drinking Water Act*, (T. C. A. 68-13-701), and by the *Regulations for Public Water Systems and Drinking Water Quality* (Chapter 1200-5-1). The Tennessee Department of Environment and Conservation (TDEC), Division of Remediation (DOR) Office of DOE Oversight (the office) may conduct oversight of sampling for total coliform bacteria and free chlorine residuals at various sites throughout the potable water distribution systems on the ORR. In addition, the office will oversee ORR line-flushing practices, water main repairs, cross-connection control programs, and water-loss/leak detection activities in order to identify potential threats to the potable water supply. If potential threats are identified or requests are made by ORR personnel, then additional chemical and radiological sampling may be conducted during 2014 to insure that the quality of the potable water is maintained.

Because of the potential for contamination from sites and backflow into the system during leaks, the office, through a memorandum of understanding (MOU) with the TDEC Division of Water Resources (DWR), reviews chemical, radiological, and bacteriological sampling results from the drinking water distribution systems on the ORR. Each site has agreed to provide us the same monthly documentation that is sent to the DWR.

### Methods and Materials

The following sections provide information regarding the sample processing and analytical laboratory procedures.

#### *Free Chlorine Residual Test*

This test is performed at several sites on the ORR pursuant to the TOA requirements and as a courtesy when requested. Samples will be collected in two small sample containers provided with the Hach® Pocket Colorimeter Kit. One of the sample containers will be designated as the blank and the other will be the actual sample to be analyzed. The blank is filled with 10 ml of water placed into the pocket colorimeter and the “zero” button is depressed. The blank is removed from the pocket colorimeter after the instrument has been zeroed. The actual sample is filled with 10 ml of water and a n,n-diethyl-p-phenylene diamine (DPD) powder pillow (test reagent) is added to the sample container and gently shaken. It is then placed in the pocket colorimeter. The “read” button is depressed and the free chlorine residual is analyzed (read directly from the pocket colorimeter display) within one minute.

Independent chlorine sampling will be conducted quarterly at either the Y-12 National Nuclear Security Administration (NNSA) facility or at the Oak Ridge National Laboratory (ORNL). Reasonable attempts will be made to rotate sampling between these two facilities each quarter. Specific sampling sites and number of samples to be taken will be determined based on water usage patterns, distribution system layouts, and other factors, such as construction activities and line breaks.

Independent chlorine sampling at the East Tennessee Technical Park (ETTP) will only be conducted upon request or in case of line breaks/repairs. This is due to the City of Oak Ridge's acceptance of ownership of the system at ETTP. DOE does not regulate this system; TDEC's Division of Water Services is the regulator.

As stated previously, if sampling shows evidence that shallow subsurface plume infiltration, cross connections, low chlorine residuals, line breaks/leaks, or other upset conditions have occurred which could cause a possible threat to the quality of the drinking water at Y-12, ORNL, and/or ETTP, then independent sampling of organic, inorganic, and radiological constituents will be conducted. The following methods will be used for sampling those organic, inorganic, and radiological constituents.

#### Bacteriological Testing

The U.S. Environmental Protection Agency (EPA)-approved method for testing coliforms (Colilert® in the pass/fail mode) will be the methodology utilized by Laboratory Services. The lab has expertise in a broad scope of services and analyses available to the office and other TDEC divisions statewide. For bacteriological testing on raw water sources, the counting application of the Colilert kits would be identified and utilized.

Sample collection will be completed by filling an appropriate sample container with 100 ml of water. All chain-of-custody procedures for conducting bacteriological sampling will be followed.

#### Organic, Inorganic and Radiological Testing

Analytical methods are provided in the Standard Operating Procedures (SOP) manuals for Laboratory Services. The SOPs refer to proper EPA and/or other methods. In order to assess methods used, office staff should communicate with their sampling and analytical counterparts within the ORR on a basis that facilitates technical exchange and openness. General sampling and analysis methods will follow EPA guidelines as listed in the appropriate section of Title 40 of the Code of Federal Regulations (CFR).

#### *Quality Control/Quality Assurance*

If independent sampling activities are conducted, care will be taken to include quality control samples. The level of quality control methodology implemented will be commensurate with the level of independent sampling conducted. Forms of control sampling to be considered will be blanks, duplicate analysis, division-split samples, or even-split samples with site DOE contractor. Information pertaining to the quality control samples will be included in program files and spreadsheets.

Equipment that will be required to accomplish this oversight and sampling project include:

- latex or vinyl exam gloves
- Hach Pocket Colorimeter Kit,
- Hach free chlorine DPD powder pillows
- bound field book
- state vehicle
- *Health, Safety, and Security Plan*
- sample bottles

- sampling cooler
- disinfectant (full strength) spray bottle
- ice
- chain-of-custody forms
- sample labels

Table 1 displays sampling sites, constituents, and anticipated frequency.

**Table 1: Anticipated Sampling**

SITE	CONSTITUENTS	FREQUENCY	NUMBER OF SAMPLES
Y-12	Free Chlorine	Every other Quarter	1 per every other Quarter
	Bacteriological	As Needed	As Needed
	VOCs <sup>1</sup>	As Needed	As Needed
	Radiological <sup>2</sup>	As Needed	As Needed
	Mercury	As Needed	As Needed
ORNL	Free Chlorine	Every other Quarter	1 per every other Quarter
	Bacteriological	As Needed	As Needed
	VOCs <sup>1</sup>	As Needed	As Needed
	Radiological <sup>2</sup>	As Needed	As Needed
	Metals including Mercury	As Needed	As Needed
ETTP	Free Chlorine	As Needed	As Needed
	Bacteriological	As Needed	As Needed
	VOCs <sup>1</sup>	As Needed	As Needed
	Radiological <sup>2</sup>	As Needed	As Needed
	Metals including Mercury	As Needed	As Needed

Note<sup>1</sup> = volatile organic compounds

Note<sup>2</sup> = gross alpha/beta and gamma will be collected.

## References

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## RadNet Drinking Water on the Oak Ridge Reservation

### Introduction

In 2014, the Tennessee Department of Environment and Conservation, DOE Oversight Office, a part of the Division of Remediation, will continue to monitor drinking water quarterly at five area water treatment plants in association with EPA's RadNet Drinking Water Monitoring Program. This program is important because it conducts radiological analysis of public drinking water processed from waters near the Oak Ridge Reservation (ORR). Since any radiological contaminants released on the ORR can enter local streams and be transported to the Clinch River, the possibility that ORR pollutants could impact area water supplies remains. To date, the monitoring of the river via local water treatment facilities has indicated that concentrations of radioactive contaminants are below regulatory criteria. The program provides a mechanism to evaluate the impact of DOE activities on water systems located in the vicinity of the ORR and to verify DOE monitoring in accordance with the Tennessee Oversight Agreement (TDEC, 2011).

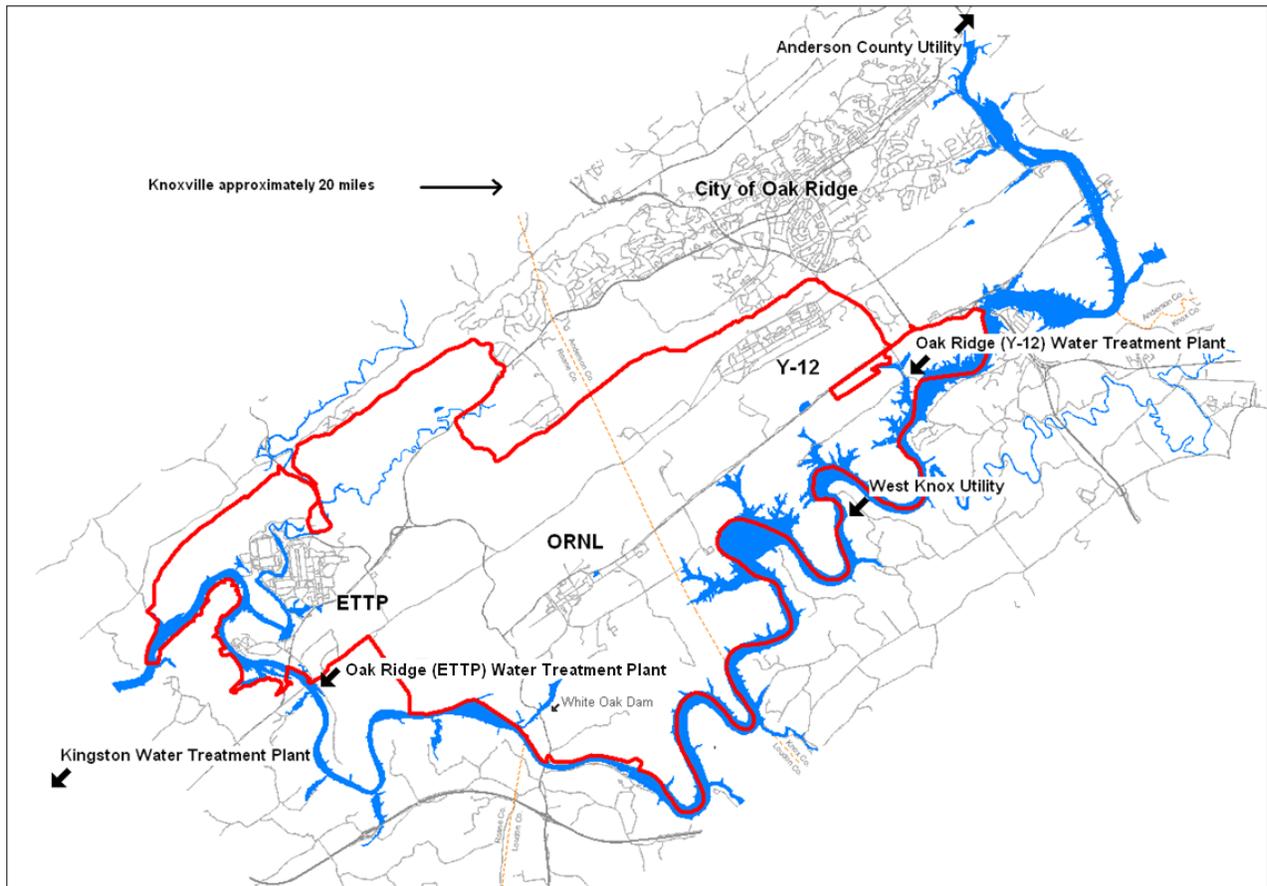
### Methods and Materials

As in the past, EPA will provide radiochemical analysis of finished drinking water samples collected quarterly by office staff at five public water supplies located on and in the vicinity of the ORR. This analysis will be performed at EPA's National Air and Radiation Environmental Laboratory in Montgomery, Alabama. When received, the results will be compared to each other (to identify anomalies) and to drinking water standards (to assess DOE compliance, adequacy of contaminant controls, and any associated hazards). Analytical parameters and the frequencies of RadNet analysis are provided in Table 1. Results from these analyses will be provided to the office and will be available on the EPA RadNet searchable Envirofacts database ([http://iaspub.epa.gov/enviro/erams\\_query\\_v2.simple\\_query](http://iaspub.epa.gov/enviro/erams_query_v2.simple_query)). More information on the program can be found on the EPA RadNet webpage (<http://www.epa.gov/radnet>).

**Table 1: EPA Analysis for RadNet Drinking Water Samples**

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

The five Oak Ridge area locations monitored in the program are the Kingston Water Treatment Plant, the City of Oak Ridge Water Treatment Facility at ETTP, West Knox Utility District, the City of Oak Ridge Water Treatment Facility at Y-12, and the Anderson County Utility Board Water Plant. Figure 1 depicts the approximate locations of raw water intakes associated with these facilities.



**Figure 1: Approximate locations of the intakes for public water systems monitored in association with EPA’s RadNet drinking water program**

**References**

National Air and Radiation Environmental Laboratory (NAREL). United States Environmental Protection Agency. [http://iaspub.epa.gov/enviro/erams\\_query\\_v2.simple\\_query](http://iaspub.epa.gov/enviro/erams_query_v2.simple_query) (Last updated September 25, 2013).

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# GROUNDWATER MONITORING

## Groundwater Monitoring Plan for the Oak Ridge Reservation

### Introduction

The Tennessee Department of Environment and Conservation, Division of Remediation, Department of Energy – Oversight Office (referred to as DOR/DOE-O or the office), as established under the Tennessee Oversight Agreement (TOA) and the Federal Facilities Agreement (FFA), will conduct monitoring of the groundwaters offsite the Oak Ridge Reservation (ORR).

In 2014, the groundwater program will focus on sampling areas not covered under the upcoming DOE off-site sampling program. However, Quality Assurance (QA) samples will be collected. The QA samples will be selected in sensitive areas of interest to determine if the analytical results are comparable. The groundwater program has a budget to support the collection of up to forty samples. The plan is to sample up to thirty locations not being supported under the DOE off-site sampling program and take the remaining ten samples as QA for DOE's off-site program. The sampling locations will be determined after DOE's Data Quality Objectives for the groundwater strategy have been completed.

Tracers are widely used to determine the direction and movement of the groundwater system. Two types of tracers may be used to identify flow and transport. Tracers may include using existing contaminants or injectable fluorescent dyes.

Sampling plan addendums will be written prior to any field work to include the rationale and parameters for each sampling location. In addition to the sampling program, the groundwater staff will be available to introduce and promote the upcoming DOE off-site sampling strategy to the residential well owners while following the attached communications plan.

### Methods and Materials

#### *Sampling*

Residential or water-supply wells will be sampled by collecting water as close to the wellhead as possible, while following the Health and Safety Plan (Yard, 2013). Residential or water-supply wells will be sampled after being purged for at least 20 minutes or after field parameters stabilize. Monitoring wells will be co-sampled by facility personnel with contractor sampling equipment or by office personnel using either disposable bailers or a portable pump. New or properly decontaminated tubing and standard or plan-specific purging methods will be used. Parameters, such as, pH, temperature, dissolved oxygen, oxidation-reduction potential, and conductivity will be collected prior to sampling and recorded in the field notebook and transferred on to a trip report documenting the sample collection.

Springs will be sampled based on location, measured field-parameters, and the nature of discharge. Where possible, sampling will be conducted at a variety of stage levels (i.e., dry season, wet season, (low stage and high stage)) for all sampling locations. Water-quality data loggers (In-Situ Troll™ and Hobo™ temperature and conductivity meters) will be utilized where practicable to provide continuous monitoring of water quality parameters. This will determine optimum sample-collection frequency and timing of sampling events, in order to better understand the response time and variability of the system.

Samples will be analyzed based on known or suspected DOE site-related contamination, and for the acquisition and compilation of hydrogeological and hydrogeochemical data. The list of analyses in Table 1 is preliminary and could change as the results, their interpretation, and information of the system increases.

Specific radiochemical analyses will be determined prior to sampling and will be included in the sampling plan addendums. If the results of domestic water supply sampling show an alpha activity greater than five picoCuries/liter or beta activity greater than fifteen picoCuries/liter then radionuclide isotope-specific analysis for potential alpha or beta emitters may be performed on the laboratory-archived sample. Appropriate QA/QC samples will be utilized.

<b>Table 1 Preliminary Lists of Analyses</b>
Volatile Organic Compounds
Radionuclides - Includes alpha/beta by liquid scintillation, gamma radionuclides, strontium 89/90, tritium, technetium 99, and uranium isotopes
Metals - Includes aluminum, antimony, arsenic, barium, beryllium, boron (a metalloid) cadmium, calcium, chromium, copper, iron, lead, lithium, potassium, magnesium, manganese, nickel, selenium, silver, sodium, strontium, thallium, uranium, vanadium, zinc, mercury and/or hexavalent chromium depending on site.
Inorganics - Includes alkalinity as CaCO <sub>3</sub> , chloride, fluoride, hardness as total as CaCO <sub>3</sub> , nitrate/nitrite, ammonia, pH, total dissolved solids, and sulfate

### *Tracing*

Monitoring wells implicitly assume a porous medium and have a low probability of intersecting primary conduits (Smart, 1999). The only reliable way to design a monitoring system in these settings is by the use of groundwater tracing. Tracing does not assume anything about how the system functions, only that tracers and other fingerprints can be reliably identified when they are discharging. The majority of the tracing will use contaminants, (e.g., <sup>90</sup>Sr, <sup>99</sup>Tc, <sup>3</sup>H etc.), natural isotopes (uranium-series nuclides, <sup>15</sup>N, <sup>18</sup>O and <sup>13</sup>C) and geochemical fingerprints (the Schoeller plot patterns of fundamental chemical constituents: Ca, Mg, Na, K, Cl, SO<sub>4</sub>, HCO<sub>3</sub> and CO<sub>3</sub>, or plots relating Mg, SO<sub>4</sub>, Cl, and total dissolved solids).

However, these tracers will not yield complete flow and transport information. For old facilities with contaminants that have been in the ground for decades, the only reliable way to obtain flow and transport data is by injected tracing. The least expensive, most reliable and easily detectable injectable tracers are fluorescent dyes (ASTM 1995). Such fluorescent tracers can also serve as surrogates for contaminants.

### *Reconnaissance*

Since this groundwater investigation will focus on areas not being investigated, additional reconnaissance may be needed. The groundwater program, will locate springs, seeps, and wells that are potential discharge locations and/or could be impacted by DOE activities. If feasible, detailed geologic maps and/or hydrogeological cross sections may be generated with the cooperation of the Division of Geology.

### **References**

Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPQAM). U.S. Environmental Protection Agency. Enforcement and Investigations Branch, Region IV. Athens, Georgia. 1997.

Smart, C.C., *Subsidiary Conduit Systems: A Hiatus in Aquifer Monitoring and Modeling*, In: Palmer, A.N., Palmer, M.V., and Sasowski, I.D., (eds.) Karst Waters Institute Special Publication No. 5, Proceedings of the Symposium: Karst Modeling, Charlottesville, Virginia, February 24-27, 1999, p. 146-157. 1999,

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# RADIOLOGICAL MONITORING

## Facility Survey Program and Infrastructure Reduction Work Plan

### Introduction

The Tennessee Department of Environment and Conservation's Department of Energy Oversight Office (DOE-O), in cooperation with the U.S. Department of Energy and its contractors, operates a facility survey program on the Oak Ridge Reservation (ORR). The DOE-O survey program provides a comprehensive, independent characterization of facilities on the ORR based on their operational history, present mission, physical condition, inventories of radiological and/or hazardous materials, degree of contamination, contaminant release history, and potential for release of contaminants to the environment.

The goal of the program is to fulfill part of the commitments agreed to by the State of Tennessee and the Department of Energy in Section 1.2.3 of the Tennessee Oversight Agreement, which states that "*Tennessee will pursue the initiatives in attachments A, C, E, F, and G. The general intent of these action items is to continue Tennessee's: (1) environmental monitoring, oversight and environmental restoration programs; (2) emergency preparedness programs; and (3) delivery of a better understanding to the local governments and the public of past and present operations on the ORR and potential impacts on the human health and/or environment by the Oak Ridge Reservation.*" As part of this larger endeavor, the facility survey program is designed to provide a detailed assessment of all potential hazards affecting or in any way associated with facilities on the Oak Ridge Reservation. To meet this objective, survey team members walk through each facility and gather information that is recorded in a database that allows the team to characterize facilities and evaluate their potential for release of contaminants to the environment (PER). The conditions of facilities are considered within a variety of environmental conditions ranging from catastrophic (i.e. tornado, earthquake) to normal everyday working situations. From an emergency preparedness perspective such information is essential.

In 2002, the Department of Energy instituted a formal, accelerated D&D program aimed at facility reduction through demolition. Facility survey staff responded to this activity by making facility visits and conducting external inspections of each facility prior to and during demolition. This activity will continue in 2014.

### Methods and Materials

The criteria used in the selection of facilities to be surveyed include 1) position of facility in S&M/D&D programs; 2) physical condition of facility; 3) perceived levels of contamination; 4) types or quantities of inventories (hazardous or radiological); and 5) special circumstances (incidents, public or other agency request, or other unforeseen situations).

Using standard radiation survey instruments, inventory data, and historical documentation, staff members walk through each facility and record information in a questionnaire format. Based on these results and professional judgment, staff then rank the potential for release of contaminants to the environment (PER) for each facility by scoring 0 (least potential) to 5 (greatest potential) for each of 10 "categories." Tables 1 and 2 illustrate the scoring guidelines for potential environmental release, and the categories to be scored.

**Table 1: Potential for Environmental Release Scoring Guidelines**

<b>Score</b>	Score is based on observations in the field and the historic and present-day threat of contaminant release to the environment/building and/or ecological receptors.
<b>0</b>	No potential: no quantities of radiological or hazardous substances present.
<b>1</b>	Low potential: minimal quantities present, possibility of an insignificant release, very small probability of significant release, modern maintained containment.
<b>2</b>	Medium potential: radiological or hazardous substances present, structures stable in the near to long term, structures have integrity but are not state-of-the-art, adequate maintenance.
<b>3</b>	Medium potential: structures unstable, in disrepair, containment failure clearly dependent on time, integrity bad, maintenance lacking, containment exists for the short term only.
<b>4</b>	High potential: radiological or hazardous substances present. Containment for any period of time is questionable; migration to environment has not started.
<b>5</b>	Radiological or hazardous substance containment definitely breached, environmental/interior pollution from structures detected, radiological and/or hazardous substances in inappropriate places like sumps/drains/floors, release in progress, or radiological exposure rates above Nuclear Regulatory Commission (NRC) guidance.
Note: A score of 0 or 1 designates a low Potential Environmental Release rank; a score of 2 or 3 designates a moderate rank; a score of 4 or 5 designates a high rank.	

**Table 2: Ten Categories Scored**

<b>1.</b>	Sanitary lines, drains, septic systems
<b>2.</b>	Process tanks, lines, and pumps
<b>3.</b>	Liquid Low-level Waste tanks, lines, sumps, and pumps
<b>4.</b>	Floor drains and sumps
<b>5.</b>	Transferable radiological contamination
<b>6.</b>	Transferable hazardous materials contamination or waste
<b>7.</b>	Ventilation ducts and exit pathways to create outdoor air pollution
<b>8.</b>	Ventilation ducts and indoor air/building contamination threat
<b>9.</b>	Elevated radiation exposure rates inside the facility
<b>10.</b>	Elevated radiation exposure rates outside the facility

Individual facility survey reports are delivered to DOE where they can be used to help prioritize D&D activities and corrective actions.

As facilities are surveyed, scored, and compared with each other, a relative “potential for environmental release” will emerge. The facilities that show a high potential for release of contaminants will be noted in the program’s annual environmental monitoring report. Staff will revisit these facilities at their discretion to evaluate changing conditions. Table 3 provides a list of target facilities to be surveyed during 2014.

**Table 3: Target Schedule of Facilities to be Surveyed 2014**  
**ORNL** **Y-12**

Facility	Completion Date	Facility	Completion Date
X-3017	Feb. 15	Y-9720-18	Feb. 15
X-2026	April 30	Y-9720-12	Mar. 15
X-2523	June 29	Y-9201-3	May 15
X-2525	Aug. 30	Y-9720-13	July 15
		Y-9401-2	Aug 30
		Y-9723-31	Sept. 30

- X-3017 Second Isotek Building
- X-2026 Isotek Downblending Building
- X-2523 Rad Waste Treatment
- X-2525 Laboratory Fabrication Services
- Y-9720-12 Storage Facility
- Y-9720-13 Storage Facility
- Y-9201-3 Alpha 3
- Y-9720-18 Storage Facility
- Y-9723-31 Change House
- Y-9401-2 Plating Shop and Maintenance

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## Haul Road Surveys

### Introduction

The Tennessee Department of Environment and Conservation's Division of Remediation, DOE Oversight Office, with the cooperation of the U.S. Department of Energy (DOE) and its contractors, will continue to perform weekly surveys of the Haul Road in 2014. The Haul Road was constructed for and is dedicated to trucks transporting Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) radioactive and hazardous waste from remedial activities on the Oak Ridge Reservation (ORR) to the Environmental Management Waste Management Facility (EMWMF) in Bear Creek Valley for disposal. To account for wastes that may fall or be blown from the trucks in transit, DOE Oversight personnel perform walk over inspections of the road and associated access roads weekly. Anomalous items noted along the roads are scanned for radiation, logged, and their description and location submitted to DOE for disposition. If anomalous items remain from previous inspections, they will be included in subsequent reports, until removed or DOE advises the items have found to be free of radioactive or hazardous contamination.

### Methods and Materials

For safety and by agreement with DOE and its contractors, staff members performing the weekly inspections will log onto the Haul Road at the ETTP (northeast) check-in station and advise site personnel they intend to enter onto the road to perform the survey. The DOE contractor responsible for the road will brief staff members on any known conditions that could present a safety hazard. The contractor will also provide a two-way radio to office staff in order to maintain communication should unforeseen conditions arise that could present a safety hazard while on the road. Should excessive traffic present a safety concern, the survey will be postponed to a later date. Alternate entrances may be used to access the road with DOE approval, but the basic requirements remain in effect.

When staff arrive at the location to be surveyed, they will park their vehicle completely off the road (as far away from vehicular traffic as possible). No less than two people will perform the surveys, each walking in a serpentine pattern along opposite sides of the road to be surveyed. Typically, a Ludlum Model 2221 Scaler Ratemeter with a Model 44-10 2"X2" NaI Gamma Scintillator probe held approximately six inches above the ground surface will be used to scan for radioactive contaminants as the walk over proceeds. Anomalous items found during the survey will be 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. Each anomalous item will be surveyed for radiological contamination and the findings included in the above report. The radiological contamination will be documented in disintegrations per minute per 100 cm<sup>2</sup> (dpm/100cm<sup>2</sup>) and compared to the limits set forth in Regulatory Guide 1.86. Instrumentation and procedures used in the radiological assessments will also be recorded. Table 1 provides the current inventory of equipment available to staff for such assessments.

When staff members return to the road for the next weekly inspection, they will perform a follow-up inspection of anomalous items found in previous weeks. If any anomalous items remain, they will be included in subsequent reports, until removed or staff are advised the item(s) have been determined to be free of radioactive and hazardous constituents.

**Table 1: Office of DOE Oversight Portable Radiation Detection Equipment**

<b>Radiological Detection Instruments</b>	<b>Radiological Detection Probes</b>	<b>Radioactivity Measured</b>
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 cm <sup>2</sup> Alpha Scintillator	Alpha (cpm)
Bicron Micro-Rem	Internal 1x1 inch 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 <sup>2</sup> active.	Alpha, Beta
Identifinder-NGH	Isotopic Identifier and Ratemeter	Gamma Spectroscopy and Dose Rate Meter

**References**

Federal Facility Agreement for the Oak Ridge Reservation. Tennessee Department of Environment and Conservation, Department of Energy Oversight Office. January 1992.

Regulatory Guide 1.86, Termination of Operating License for Nuclear Reactors. U.S. Atomic Energy Commission. June 1974.

Tennessee Oversight Agreement, Agreement Between the U.S. Department of Energy and the State of Tennessee, Tennessee Department of Environment and Conservation, DOE Oversight Office, Oak Ridge, Tennessee. 2011.

Yard, C.R., Health, Safety, and Security Plan, Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2013.

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

## **Introduction**

Gamma radiation is emitted by various radionuclides that have been produced, stored, and disposed of on the Oak Ridge Reservation (ORR). Associated radionuclides are evident in ORR facilities and the surrounding soils, sediments, and waters. In order to assess the risk posed by these contaminants, the Tennessee Department of Environment and Conservation (TDEC) began monitoring ambient gamma radiation levels on and in the vicinity the ORR in 1995. In this effort, 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, and
- information relative to the unplanned release of radioactive contaminants on the ORR.

## **Methods and Materials**

Dosimeters used in the program will be obtained from Landauer, Inc., Glenwood, Illinois. Each of the dosimeters use an aluminum oxide photon detector to measure the dose from gamma radiation (minimum reporting value = 1 mrem). At locations where there is a potential for the release of neutron radiation, the dosimeters will also contain an allyl diglycol carbonate-based neutron detector (minimum reporting value = 10 mrem for thermal neutrons and 20 mrem for fast neutrons). Dosimeters will be collected from the monitoring locations quarterly and sent to vender for processing. To account for exposures that may be received in transit or storage, control dosimeters will be included in each batch of dosimeters received from the Landauer Company. The control dosimeters will be stored in a lead container during the monitoring period and returned to Landauer with the associated field-deployed dosimeters for processing. Any dose reported for the control dosimeters will be subtracted from the dose reported for the field-deployed dosimeters by the processor. The results will be reviewed as received and a quarterly report prepared and submitted to DOE and other interested parties. At the end of the year, the results will be summed for each location and the resultant annual doses compared to background values and the state/DOE primary dose limits for members of the public (100 mrem/year).

Monitoring locations are chosen to identify sources of external radiation on the ORR, develop conservative estimates of the dose to the public from DOE operations/facilities, and to collect information relative to the need and/or effectiveness of remediation. Associated monitoring sites include:

- |   |                                   |
|---|-----------------------------------|
| 1) Oak Ridge National Laboratory                      | 5) Off site areas of interest     |
| 2) Y-12 National Security Complex                     | 6) Tower Shielding Facility       |
| 3) Spallation Neutron Source Site                     | 7) East Tennessee Technology Park |
| 4) Environmental Management Waste Management Facility | 8) ORAU/ORISE Neutron Source      |

## **References**

Federal Facility Agreement, Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. January 1992.

Occupational Radiation Protection. 10CFR835. United States Nuclear Regulatory Commission. Source: 56 FR 23398, May 21, 1991.

Radiation Dose Limits for Individual Members of the Public, 10CFR20.1301 Subpart D. United States Nuclear Regulatory Commission. Source: 56 FR 23398, May 21, 1991.

Tennessee Oversight Agreement, Agreement Between the U.S. Department of Energy and the State of Tennessee, Tennessee Department of Environment and Conservation, DOE Oversight Office, Oak Ridge, Tennessee. 2011.

Yard, C.R., Health and Safety Plan. Tennessee Department of Environment and Conservation, Division of Remediation, Department of Energy Oversight Office. Oak Ridge, Tennessee. 2013.

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

## Introduction

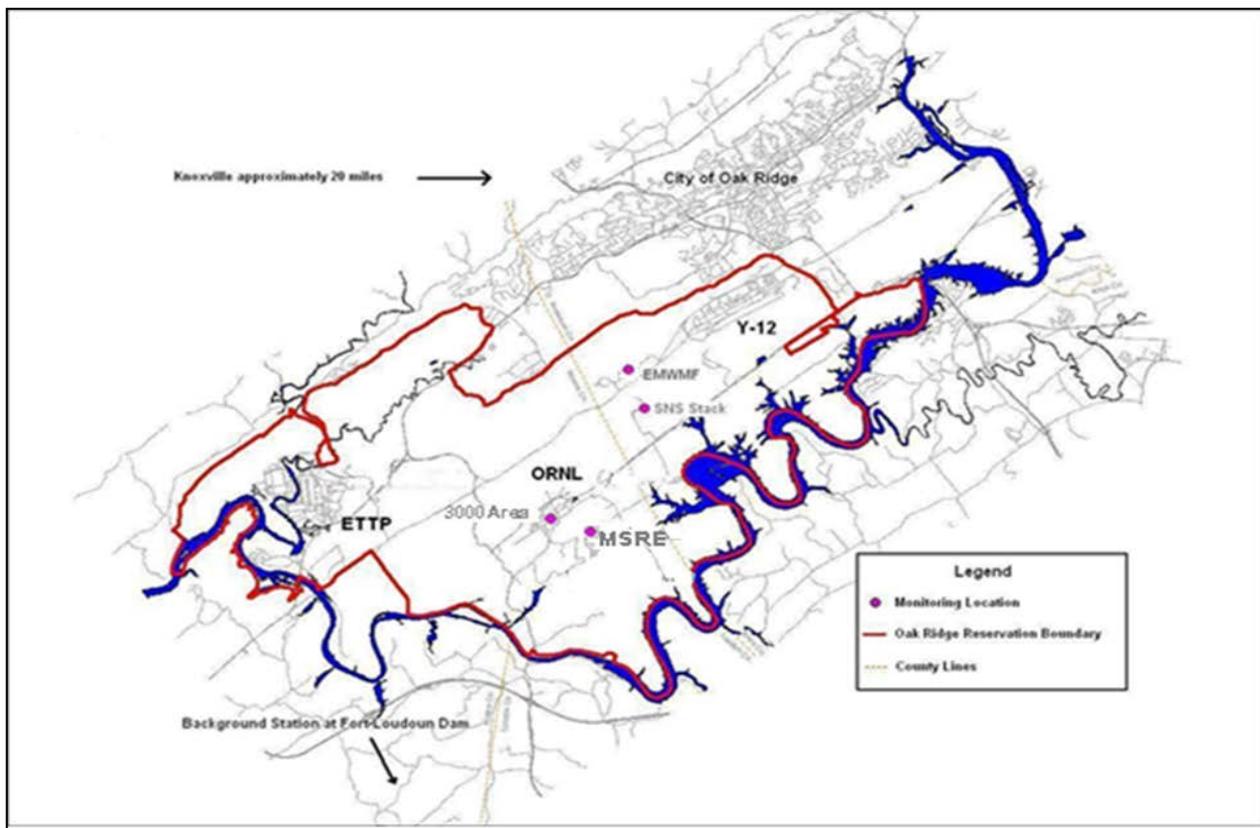
The DOE Oversight Office of the Tennessee Department of Environment and Conservation's Division of Remediation (the division) has deployed gamma radiation exposure rate monitors equipped with microprocessor controlled data loggers on the Oak Ridge Reservation (ORR) since 1996. The instruments are primarily used to record exposure rates at locations where the radiation levels are expected to fluctuate significantly over relatively short periods of time (e.g., remedial and waste management activities) and to supplement the integrated dose rates provided by the office's environmental dosimetry program. While the environmental dosimeters provide the cumulative dose over the time period monitored (months), 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), providing an exposure rate profile that can be correlated with activities and/or changing conditions. This allows the source of anomalous results to be tracked and appropriate actions taken. The results are compared to background levels and dose limits provided in state regulations. Findings are used to 1) identify unplanned releases of radioactivity, 2) assess compliance with state regulations and DOE Orders, and 3) evaluate DOE control measures, as required by the Tennessee Oversight Agreement (C.2 Radiological Oversight).

## Methods and Materials

The exposure rate monitors deployed in the program are manufactured by Genitron Instruments and are marketed under the trade name GammaTRACER<sup>®</sup>. 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 1  $\mu$ rem/hour to 1 rem/hour at predetermined intervals from one minute to two hours. The results reported are the average of the measurements recorded by the two Geiger Mueller detectors. Data from each detector can be accessed if needed. The results recorded by the data loggers are downloaded to a computer by office personnel using an infrared transceiver and associated software.

Monitoring in the program focuses on the measurement of exposure rates under conditions where 1) gamma emissions can be expected to fluctuate substantially over relatively short periods, 2) there is a potential for an unplanned release of gamma emitting radionuclides to the environment, and/or 3) anomalous results from the office's environmental dosimetry program warrant. Candidate monitoring locations include remedial activities, waste disposal operations, pre and post operational investigations, and emergency response activities. Data recorded by the monitors are evaluated by comparing the results to background data, the state limit for the maximum dose to an unrestricted area (2 mrem in any one hour period), and the state and DOE primary dose limits for members of the public (100 mrem/year). The locations of sites currently monitored in the program are depicted in Figure 1. These sites include:

- Fort Loudoun Dam in Loudon County (background location)
- the 3000 area remediation at Oak Ridge National Laboratory (ORNL)
- the Spallation Neutron Source (SNS) exhaust stack
- the Molten Salt Reactor Experiment (MSRE) in Melton Valley
- the Environmental Management Waste Management Facility in Bear Creek Valley



**Figure 1: Gamma exposure rate monitoring locations in 2013.**

Monitoring stations can be expected to vary as the sites subject to remediation change and findings warrant. Additional candidates for monitoring in 2014 include the demolition of buildings in the 2000 and 3026 complexes at ORNL. Centrally located on the ORNL campus, these facilities are considered to be some of the highest risk facilities at ORNL, due to the condition of the structures, the presence of loose radioactive contamination, and their proximity to active ORNL facilities.

## References

Site Characterization Summary Report for Waste Area Grouping 1 at the Oak Ridge National Laboratory, DOE/OR-1043/V1&D1. Oak Ridge, Tennessee. Bechtel Jacobs Company. September 1992.

Tennessee Oversight Agreement: Agreement between the U.S. Department of Energy and the State of Tennessee, Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2011.

Yard, C.R. Health, Safety and Security Plan. Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2013.

# Surplus Material Verification

## Introduction

Since 2002, the Tennessee Department of Environment and Conservation, Department of Energy Oversight Office (DOE-O), in cooperation with the U.S. Department of Energy and its contractors, has conducted random radiological surveys of surplus materials that are destined for sale to the public on the Oak Ridge Reservation (ORR). Standard radiological survey protocols and instrumentation are used for these surveys. In addition to performing the surveys, DOE-O 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. DOE-O, 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, DOE-O will immediately report to the responsible supervisory personnel of the surplus sales program. DOE-O will follow their response to the notification, ensuring that appropriate steps (removal of items from sale, resurveys, etc.) are taken to protect the public. DOE-O reviews any occurrence reports, procedural changes and removal of items from sales inventories.

## Methods and Materials

Staff members make random surveys of items that are arranged in sales lots by using standard survey instruments and standard survey protocols. Instrumentation used is the Ludlum Model 2221 Scaler/Ratemeter with a Ludlum Model 44-10 NaI/Tl gamma radiation scintillation detector and the Ludlum Model 2224 Scaler/Ratemeter with a Ludlum Model 43-93 Alpha/Beta Scintillator. Potential items range from furniture and computer equipment to vehicles and construction materials. Particular survey attention is paid to smaller equipment and parts. Where radiological release information is attached, radiation clearance information is compared to procedural requirements. If any contamination that exceeds twice the background reading is detected during the on-site survey, staff takes a one-minute count for alpha and beta (note elevated gamma levels at the auctions are exceedingly rare) and converts the readings to dpm. If levels found are over twice the background levels, the surplus materials manager for the facility will be notified immediately. In addition to radioactivity, any chemical concerns will be immediately brought to the attention of the manager.

## References

Tennessee Oversight Agreement, Agreement Between the U.S. Department of Energy and the State of Tennessee, Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2011.

Yard, C.R., Health and Safety Plan. Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee, 2013.

# **Monitoring of Waste at the Environmental Management Waste Management Facility (EMWWMF) using a Radiation Portal Monitor**

## **Introduction**

The Environmental Management Waste Management Facility (EMWWMF) was constructed for, and is dedicated to, the disposal of low level radioactive waste (LLW) and hazardous waste generated by remedial activities on the Department of Energy's (DOE) Oak Ridge Reservation (ORR). Operated under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the facility is required to comply with regulations contained in the Record of Decision 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) agreed to be FFA parties is approved for disposal in the EMWWMF. DOE is accountable for compliance with the WAC and has delegated responsibility to make WAC attainment decisions to its prime contractor, which it oversees. This includes waste characterization and approval for disposal in the EMWWMF (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, the DOE Oversight Office of the Tennessee Department of Environment and Conservation's Division of Remediation has emplaced a Radiation Portal Monitor (RPM) at the check-in station for trucks transporting waste into the EMWWMF for disposal. As the trucks pass through the portal, gamma radiation levels are measured and transmitted to a secure website monitored by office personnel and available to DOE and its authorized contractors for review. When anomalous measurements are noted, DOE is notified and basic information as to the nature and source of the waste passing through the portal at the time of the measurements is obtained from EMWWMF personnel. If preliminary information indicates the facility's WAC may have been violated, the information is submitted to DOE Oversight's Audit Team for review and disposition.

## **Methods and Materials**

A Canberra RadSentry Model S585 portal monitor is used in the program. 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 1). Measurements (one per 200 milliseconds) are initiated by the occupancy sensor when a truck enters the portal. The results are transmitted from the RSPs to the control box, where it is stored, analyzed, and uploaded to a secure website, along with associated information (e.g., date, time, and background measurements), which is monitored by office staff and available for review by DOE and its authorized contractors. If radiation levels exceed a predetermined level, the RPM sends an alert notification to staff members by email. When an alert notification is received or anomalies are noted in the review of the results, DOE and EMWWMF personnel will be contacted and the source of the waste passing through the portal monitor at the time of the measurements determined. If review of the information suggests WAC may have been violated, the preliminary information will be submitted to DOE Oversight's Audit Team for review and disposition.



**Figure 1: TDEC Portal Monitor at the Environmental Management Waste Management Facility**

### **References**

Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee. U.S. Department of Energy Office of Environmental Management. Oak Ridge, Tennessee. 2001.

Model S585 RadSentry Operations/Maintenance/Troubleshooting Manual9237096D V1.3  
Canberra Industries, Inc.800 Research Parkway, Meriden, CT 06450

Record of Decision for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste. DOE/OR/01-1791&D3. United States Department of Energy. Oak Ridge, Tennessee. November 1999.

Tennessee Oversight Agreement. Agreement Between the U.S. Department of Energy and the State of Tennessee. Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2011.

Yard, C.R., Health and Safety Plan. Tennessee Department of Environment and Conservation. DOE Oversight Office. Oak Ridge, Tennessee. 2013.

# **SURFACE WATER MONITORING**

## **Monitoring of Liquid Effluents, Surface Water, Groundwater, and Sediments at the Environmental Management Waste Management Facility**

### **Introduction**

The Tennessee Oversight Agreement (TOA) requires the state to conduct radiological monitoring on the Oak Ridge Reservation (ORR), as necessary, to evaluate Department of Energy (DOE) monitoring programs and to assess the effectiveness of DOE contaminant control measures to prevent releases to the environment. During 2014, the Tennessee Department of Environment and Conservation's Division of Remediation will monitor liquid effluents, surface waters, groundwater, and sediments at DOE's Environmental Management Waste Management Facility (EMWMF). The EMWMF was constructed to dispose of low level radioactive waste and hazardous waste generated by remedial activities on the ORR and is operated under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). While the facility holds no permit from any state agency, it is required to comply with substantive portions of relevant and appropriate legislation contained in the CERCLA Record of Decision (DOE, 1999) and DOE directives developed to address responsibilities delegated to the agency by the Atomic Energy Act of 1946.

While the availability of the EMWMF has presented the opportunity to expedite remedial activities on the ORR, the abundant rainfall of the region, complex hydrogeology of the location, and the proximity of the facility to local population centers present challenges to the landfill that would not be expected in more arid or remote locations. It is the intent of the project to assess the performance of the facility, evaluate EMWMF monitoring programs, and verify that contaminant control measures at the facility are consistent with criteria agreed upon by the state, EPA, and DOE.

The ORR was established in 1942, as part of the federal government's World War II effort to develop and produce the first nuclear weapons. Four major installations were constructed at that time: the X-10 facility, now known as the Oak Ridge National Laboratory (ORNL); the Y-12 plant, now known as the Y-12 National Security Complex (Y-12); the K-25 plant, now known as the East Tennessee Technology Park (ETTP); and S-50, a liquid thermal diffusion uranium enrichment plant that was shut down after less than a year of operation. The initial objectives of ORR operations were the production of plutonium and enriched uranium for use in the first nuclear weapons. In the seventy years since, a variety of production and research activities have generated numerous radioactive and hazardous wastes, most of which are eligible for disposal at the EMWMF. Contaminants include a long list of radionuclides including activation and fission products from isotope production facilities, reactor operations, and nuclear research at the ORNL facility, as well as uranium and related radionuclides associated with uranium enrichment operations and the manufacturing of nuclear weapons components at the K-25 and Y-12 plants.

The ORR encompasses approximately 35,000 acres located within the corporate boundaries of the City of Oak Ridge, Tennessee. It is bound on the north and east by the population center of the City Oak Ridge and on the south and west by the Clinch River. The climate of the region can be broadly classified as humid subtropical, with rainfall averaging approximately

55 inches/year. The site is underlain by an assemblage of sedimentary rocks (carbonates, sandstone, shales) that have undergone intense deformation during the formation of the Appalachian Mountains. This resulted in a series of folded, tilted, and faulted strata containing highly developed fracture systems that extend both laterally and at depth (ORSSAB, 2012). As a result of the fracture systems, abundant rainfall, and solution development in the carbonates (karst), the hydrology of the ORR is extremely complex. Most groundwater flow is controlled by the fracture systems, making contaminant flow paths difficult to predict, using conventional modeling techniques. In addition, substantial groundwater flow can occur in preferential pathways in fractures and solution cavities, which evidence suggests can transport contaminants rapidly for relatively long distances. Typically, contaminants in groundwater on the ORR are discharged to local streams that drain to the Clinch River, which flows southwest into the Tennessee River.

The EMWWMF was constructed in eastern Bear Creek Valley, approximately one mile west of the Y-12 National Security Complex. The valley is formed by Pine Ridge on the north and Chestnut Ridge to the south with the major drainage, Bear Creek, flowing parallel to the ridges southwest down the axis of the valley. Flow in the stream is dominated by a mature karst network developed in the Maynardville Limestone formation underlying the channel, with gaining and losing reaches common. The stream is fed by the discharge from numerous springs located primarily on the south side of the channel and small tributaries on the north. The EMWWMF is located on the southern slope of Pine Ridge approximately 1,500 feet to the north of Bear Creek, between Northern Tributary (NT) 3 on the east and the NT 5 tributary on the west. To accommodate construction of the EMWWMF, flow from a third tributary, NT-4, was diverted upslope of the facility to the NT-5 tributary and the channel filled. Shortly after the facility became operational, groundwater levels above the filled channel were found to have risen to levels near the basal liner of the facility and the drainage provided by the NT-4 channel subsequently restored by the construction of a rock filled drain running north to south beneath the facility. The underdrain discharges to the old NT 4 channel south of the facility. Construction of the underdrain lowered the water table, but groundwater levels have remained near a ten-foot geologic buffer required between the water table and the facility's liner with more recent data indicating incursions into the buffer and potentially into the liner.

Currently, the only authorized releases of contaminants from the EMWWMF are contaminated storm water (contact water) that tends to pond in the disposal cells above the leachate collection system. The contact water is routinely pumped from the disposal cells to holding ponds and tanks, sampled, and based on the results either sent off-site for treatment or released to a storm water sedimentation basin. The sedimentation basin discharges to the NT 5 tributary of Bear Creek, an intermittent stream that then drains to a losing reach of Bear Creek. The EMWWMF was designed with a 5% slope along the centerline of each disposal cell to direct storm water and leachate to the southern (lower) end of the cells (Williams, 2004). This design feature, along with the abundant rainfall of the region and low porosity native soils used as a protective layer over the leachate collections system, have resulted in excessive pooling of the contact water at the lower end of the cells (Williams, 2004). Heavy rainfall the first year of operations resulted in the storm water and associated leachate overflowing the cell berms, releasing contaminants to adjacent land and into the NT 5 tributary. To avoid similar incidents, the allowable release limits at the contact water ponds were relaxed and the compliance point moved from the ponds to the discharge from the storm water sedimentation basin. The limits on releases from the holding ponds/tanks to the sedimentation basin are based on requirements contained in DOE Order 5400.5 which restricts the release of liquid

wastes containing radionuclides to an average concentration equivalent to 100 mrem/year. The limit for discharges from the sedimentation basin to NT-5 are based on state regulations (TDEC 0400-20-11-.16{2}) that restrict concentrations of radioactive material released to the general environment in groundwater, surface water, air, soil, plants or animals to an annual dose equivalent of 25 mrem. In addition, DOE Order 458.1 limits gross alpha and gross beta activity of settleable solids in liquid effluents to 5.0 pCi/g and 50 pCi/g, respectively.

### **Methods and Materials**

As previously noted, the intent of the project is to assess the performance of the facility (does it leak?), to evaluate EMWMF monitoring programs, and to verify that contaminant control measures at the facility are consistent with criteria agreed upon by the state, EPA, and DOE. In that effort, samples will be collected of liquid effluents, surface water, groundwater, and sediments, using standard EPA protocol. Analyses will vary based on the media being sampled, findings, and the particular wastes being disposed during the period. Since monitoring for all radionuclides disposed in the facility would be cost prohibitive, analysis will focus on the more mobile species (e.g. tritium and technetium-99), contaminants that have contributed the most historically to the annual dose limits (uranium & strontium-90), and radionuclides exhibiting anomalous results in data generated by the facility. Gross analysis will be used to screen for alpha and beta emitting radionuclides, with more specific analyses performed in response to elevated results. Gamma spectrometry will be used to identify gamma emitters (e.g. cesium-137) in effluents and as otherwise merited. Analysis for selected metals will be performed semiannually at effluent-monitoring locations. Basic water quality parameters (pH, dissolved oxygen, turbidity, temperature, and flow rate of the discharge) will be monitored continuously at the sedimentation basin outfall and at the discharge from the underdrain, using an In-Situ® Troll 9500 multi-parameter water quality probe. In addition, staff will perform routine monitoring of these locations using a YSI Pro-2 water quality meter. To assess EMWMF monitoring, office results will be compared with those generated by EMWMF monitoring at the same location and anomalies will be investigated.

Current monitoring stations at the EMWMF are depicted in Figure 1, with the exception of sediment sampling locations in the NT-5 channel, which are yet to be determined. Table 1 provides the frequency of sampling and the planned analysis, followed by a description of each station and rationale for sampling the location. Figure 2 provides the location of the monitoring wells at the site that will be used, along with eight piezometers (not pictured), to assess the height of the groundwater table. A portion of the wells will also be sampled in the program to assess the performance of the facility. Well GW-918/Cattywampus Spring in both figures is the background location. Cattywampus Spring was at the headwaters of NT-4, which was filled to accommodate construction of the EMWMF and Well GW-918 placed at the location. The well/spring currently serves as the background location for both surface water and groundwater monitoring. Samples are collected quarterly and analyzed for gross alpha, gross beta, uranium isotopes, strontium-90, technetium-99, tritium, and gamma spectrometry.

Contact water that collects in the cells is periodically pumped to holding ponds and tanks, sampled, and based on the results and the judgment of EMWMF personnel, either sent for treatment or released to a drainage ditch that discharges into the storm water sedimentation basin. In the sedimentation basin, the contact water mixes with uncontaminated storm water, and then discharges through a v-weir to NT-5, which flows into Bear Creek approximately 1,500 feet to the south.



Base map reproduced from Google Maps (Google Maps (Digital Globe, et al., 2012)

**Figure 1: Sampling locations at the Environmental Management Waste Management Facility**

**Table 1: Planned Sampling Frequency and Analysis at the Environmental Management Waste Management Facility**

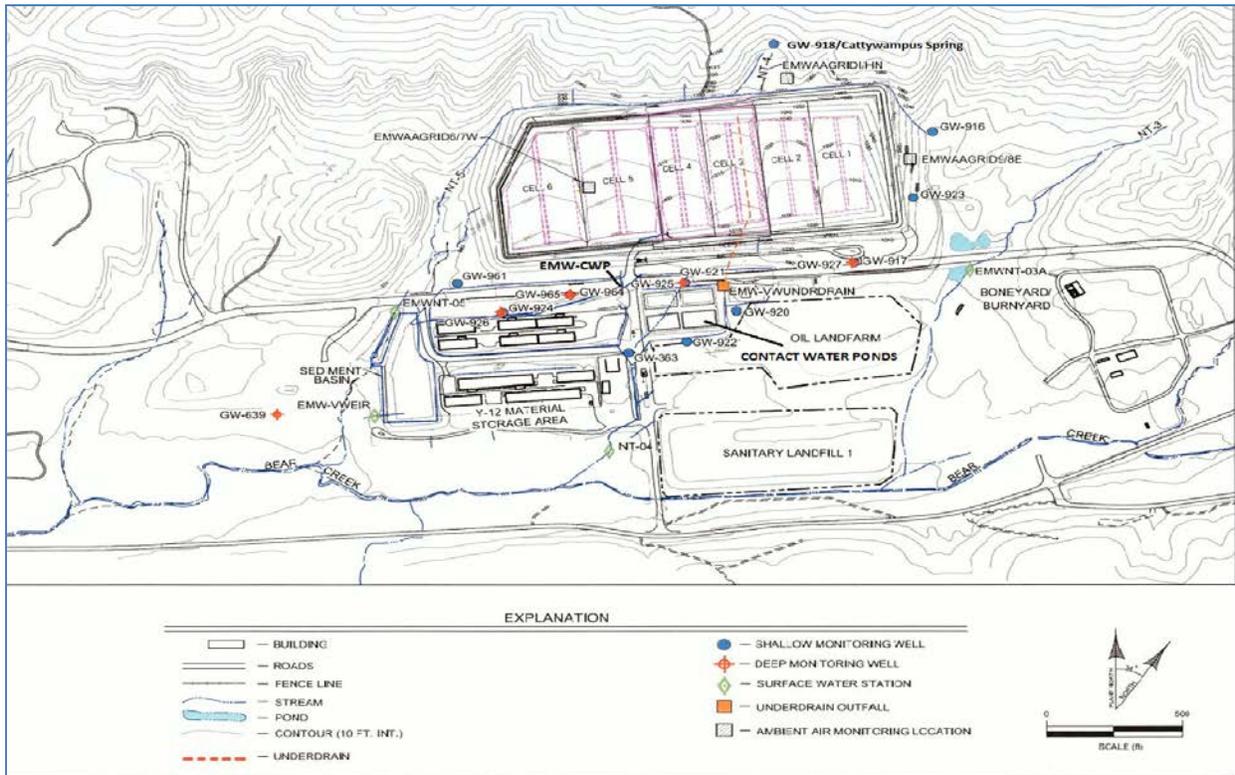
Station	Frequency	Alpha & Beta	Uranium Isotopes	Gamma Spec.	Strontium-90	Tritium	Technitium-99	Selected Metals
GW-918/Catawampus Spring (Background for surface/ground waters)	Quarterly	X	X	X	X	X	X	
Contact Water Ponds/Tanks (EMW-CWP) effluents	Monthly		X	X	X	X	X	
Sediment Basin (EMW-VWEIR) effluents	Monthly		X	X	X	X	X	
Contact Water Ponds/Tanks settleable solids in effluent	Biannually	X						
Sediment Basin Weir (EMW-VWEIR) settleable solids in effluents	Biannually	X						
NT-5 Tributary sediments upstream of EMWMF (sediment background)	Annually	X		X				
Sedimentation Basin sediments	Annually	X		X				
NT-5 Tributary sediments downstream of Sedimentation Basin	Annually	X		X				
EMWMF Underdrain (EMW-VWUNDERDRAIN) groundwater	Bimonthly		X		X	X	X	
NT-5 above Sedimentation Basin (ENWNT-05) surface Water	Biannually		X		X	X	X	
NT-3 Tributary ( EMWNT-3a) surface water	Biannually		X		X	X	X	
Wells GW-922, GW-923, & other wells with anomalous results (Groundwater)	Quarterly		X		X	X	X	
Contact Water Ponds/Tanks & Sediment. Basin effluents selected metals	Biannually							X
Other	As Warranted							

To assess compliance with the DOE limit placed on radionuclides released from the contact water ponds and tanks (100 mrem/yr.), samples will be collected of the discharge of contact water as it is pumped to a drainage ditch at EMW-CWP in Figure 1. To assess compliance

with the TDEC limit placed at the outfall of the sedimentation basin, samples will be taken of the discharge from the v-weir at the basin (EMW-VWEIR) at the estimated time of the peak flow of the released contact water. Analysis will focus on those radionuclides that have historically contributed the most to the annual dose limits for each location (uranium isotopes and strontium-90) and the more mobile radionuclides (tritium and technetium-99). Gamma spectrometry will be used to identify gamma emitting radionuclides (e.g., cesium-137) with additional analysis performed as warranted. Gross alpha and gross beta analysis will be performed intermittently on settleable solids to evaluate EMWMF compliance with limits in DOE Order 458.1 and to assess the transport of radionuclides associated with suspended solids in the effluents. Samples from both locations will be analyzed for selected metals biannually. Basic water quality parameters (pH, dissolved oxygen, turbidity, temperature, and flow rate of the discharge) will be monitored continually at the sedimentation basin outfall, using an In-Situ® Troll 9500 multi-parameter water quality probe. Gross analysis and gamma spectrometry will be performed on sediments collected in NT-5 upstream of the EMWMF (background), the sedimentation basin, and the channel of NT-5 downstream of the basin annually. To assess EMWMF monitoring, the results will be compared with those taken at the same locations and anomalies will be investigated.

To evaluate the performance of the liner and associated EMWMF monitoring, samples will be collected from the underdrain (EMW-VWUNDERDRAIN) bimonthly. Selected wells will be co-sampled with EMWMF personnel quarterly, targeting those wells that have had anomalous results reported by the EMWMF historically. To capture contaminants that could be migrating from the cells laterally in shallow groundwater, the NT-3 and NT-5 tributaries will be sampled down gradient of the waste cells under base flow and high flow conditions, at the locations currently monitored under the EMWMF surface water program (EMWNT-03a & EMWNT-05 in Figure 1). Analysis will include the uranium isotopes, strontium-90, technetium-99, and tritium, all of which are mobile in groundwater and abundant in wastes disposed in the EMWMF. An In-Situ® Troll 9500 multi-parameter water quality probe will also be used at the underdrain, to monitor the specific conductivity, pH, dissolved oxygen (DO), turbidity, temperature, and the flow rate of the discharge.

Due to state and EPA concerns with shallow groundwater at the 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)) 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 in an attempt to reestablishing the drainage previously provided by the filled NT 4 channel. Currently, the EMWMF takes 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. It will be used to model the potentiometric surface of the water table beneath the facility relative to the bottom of the geologic buffer.



Base map reproduced from *Annual Report for FY 2011 Detection Monitoring at the Environmental Management Waste Management Facility, Oak Ridge Tennessee* (DOE, 2012)

**Figure 2: Environmental Management Waste Management Facility Monitoring Well Locations**

## References

Annual Report for FY 2011 Detection Monitoring at the Environmental Management Waste Management Facility, Oak Ridge Tennessee. Elvado Environmental LLC. Knoxville, Tennessee. March 2012.

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DigitalGlobe, GeoEye, US Geological Survey, USDA Farm Service Agency (2010) Google Maps [online]. [Accessed 30 November 2012]. Available at <http://maps.google.com/>.

Record of Decision for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste. DOE/OR/01-1791&D3. U. S. Department of Energy. Oak Ridge, Tennessee. November 1999.

Tennessee Oversight Agreement, Agreement Between the U.S. Department of Energy and the State of Tennessee. Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2011.

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Yard, C.R., Health, Safety, and Security Plan, Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2013.

# Ambient Sediment Monitoring Program

## Introduction

In order to assess the degree of contamination at the benthic level attributable to the activities of the DOE, the office is collecting sediment samples for chemical analysis from the Clinch River and some local streams. Sediment samples are to be collected at two sites on the Clinch River and eight tributary sites (Poplar Creek, East Fork Poplar Creek, Bear Creek, and Mitchell Branch). The sediment samples are analyzed for certain metals and radiological contamination in order to assess the sediment quality for public health and ecological considerations.

## Workplan Outline

Objective: To determine the degree of sediment contamination at the benthic level resulting from activities of the Department of Energy. The sediment samples will be collected annually in the spring and analyzed for selected metals and radiological activity.

## Methods and Materials

Parameters to be analyzed:

*Inorganics:* arsenic, barium, beryllium, boron, chromium, mercury, nickel,

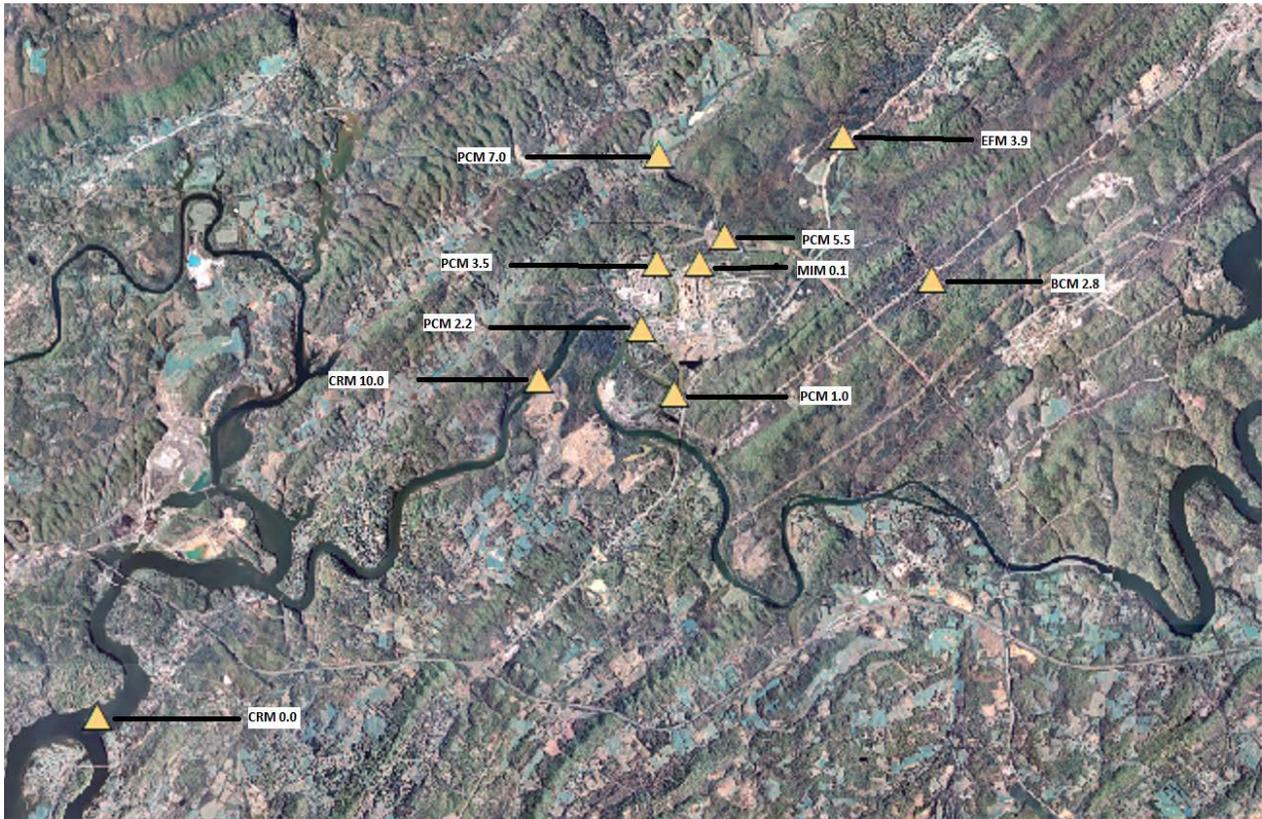
*Radiological:* gross alpha (total), gross beta (total), gross gamma (total), *gamma radionuclides:*  $^{137}\text{Cs}$ ,  $^{40}\text{K}$ ,  $^{214}\text{Pb}$ ,  $^{214}\text{Bi}$ ,  $^{212}\text{Pb}$ ,  $^{228}\text{Ac}$ ,  $^{208}\text{Tl}$ ,  $^{212}\text{Bi}$  and others as detected.

## Schedule

The ambient sediment monitoring will be conducted in the second quarter of 2014.

**Table 1: Sample Locations**

<b>Monitoring Location</b>	<b>ID</b>	<b>Alternate ID</b>
Clinch River Mile 10.0	CLINC010.0RO	CRM 10.0
Clinch River Mile 0.0	CLINC000.0RO	CRM 0.0
Poplar Creek Mile 7.0	POPLA007.0RO	PCM 7.0
Poplar Creek Mile 5.5	POPLA005.5RO	PCM 5.5
Poplar Creek Mile 3.5	POPLA003.5RO	PCM 3.5
Poplar Creek Mile 2.2	POPLA002.2RO	PCM 2.2
Poplar Creek Mile 1.0	POPLA001.0RO	PCM 1.0
East Fork Poplar Creek Mile ~3.0	EFPOP003.0RO	EFM 3.0
Bear Creek Mile ~2.8	BEAR002.8RO	BCM 2.8
Mitchell Branch Mile ~0.1	MITCH000.1RO	MIM 0.1



**Figure 1: Ambient Sediment sampling locations**

### *Sediment Standard Operating Procedures*

Sediment analysis is a key component of environmental quality and impact assessment for rivers, streams, lakes, and impoundments. Samples can be collected for a variety of chemical, physical, toxicological and biological investigations. This procedure is to be used to obtain quality assured sediment sampling. The resulting data may be qualitative or quantitative in nature and is appropriate for use in preliminary surveys and in confirmatory sampling.

### *Field Equipment for Sediment Sampling*

- Waders
- Sample Tags
- Maps
- Cell phone
- Flashlight
- Waterproof pens, ballpoint pens
- Watch
- Nitrile gloves
- Camera
- Large and small stainless steel spoons
- Rope for Petite Ponar grab samplers
- Sprayer filled with D.I. water
- Life preservers
- Paper towels
- TDEC radio
- Knife
- Chain of custody forms
- Sample request forms
- Field Book
- GPS Unit
- Calibrated water quality meter
- Spare batteries
- First Aid Kit
- Sample bottles, sediment containers
- Coolers and ice
- Stainless steel bowls
- Petite Ponar grab samplers
- Rubber pads for grab samplers
- Cable cutters for sediment traps
- Electrical tape
- Marine band radio
- Trash bags
- Boat

### *Procedure*

If the water is wadeable, one can collect a sediment sample by scooping the sediment using a stainless steel spoon or scoop. This can be accomplished by wading into the stream, and while facing upstream, scooping the sample along the stream bottom in the upstream direction. If one is sampling a deep lake or impoundment, one can use the Petite Ponar dredge to obtain a sample. Step-by-step directions are as follows:

#### Sampling Surface Sediments with a Spoon or Scoop from Beneath a Shallow Aqueous Layer

If the surface water body is wadeable, the easiest way to collect a sediment sample is by using a stainless steel spoon or scoop. The sampling method is accomplished by wading into the surface water body and while facing upstream (into the current), scooping the sample along the bottom of the surface water body in the upstream direction. Excess water may be removed from the spoon or scoop. However, this may result in the loss of some fine particle size material associated with the bottom of the surface water body. This method can be used to collect consolidated sediments but is limited somewhat by the depth of the aqueous layer. Accurate, representative samples can be collected with this procedure depending on the care and precision demonstrated by the sample team member. In surface water bodies that are too deep to wade, but are less than eight feet deep, a stainless steel spoon or scoop attached to a piece of conduit can be used either from the banks if the surface water body is narrow or from a boat. The sediment is placed into a stainless steel bowl and homogenized. A stainless steel or plastic scoop or lab spoon will suffice in most applications. Care should be exercised to avoid the use of devices plated with chrome or other materials. Plating is particularly common with garden trowels.

Follow these procedures to collect sediment samples with a scoop or trowel:

1. Using a pre-cleaned stainless steel scoop or trowel, remove the desired thickness of sediment from the sampling area.
2. Transfer the sample into an appropriate sample or homogenization container.

#### Sampling Surface Sediments From Beneath a Deep Aqueous Layer with a Ponar Dredge

The Ponar dredge has a modification yet it is similar in size and weight to the Eckman dredge. It has been modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends thus reducing turbulence around the dredge. Lower it slowly as it approaches bottom, since it can displace and miss fine particle size sediment if allowed to drop freely. The Ponar dredge is one of the most effective samplers for general use on all types of substrates.

The "petite" Ponar dredge is a smaller, much lighter version of the Ponar dredge. It is used to collect smaller sample volumes when working in industrial tanks, lagoons, ponds, and shallow water bodies. It is a good device use when collecting sludge and sediment containing hazardous constituents because the size of the dredge makes it more amenable to field cleaning.

Follow these procedures for collecting sediment with a Ponar dredge:

1. Attach a sturdy nylon or steel cable to the hook provided on top of the dredge.

2. Arrange the Ponar dredge sampler in the open position and place the spring-loaded pin into the aligned holes so the sampler remains open when lifted from the top.
3. Slowly lower the sampler to a point a few inches above the sediment surface.
4. Drop the sampler sharply into the sediment, then pull sharply up on the line, thus releasing the spring-loaded pin and closing the dredge.
5. Raise the sampler to the surface and slowly decant any free liquid through the screens on top of the dredge. While doing this be careful to retain the fine sediment fraction.

Open the dredge and transfer the sediment to a stainless steel or plastic bowl. Continue to collect additional sediment until sufficient material has been gained. Thoroughly mix sediment to obtain a homogeneous sample, and then transfer to the appropriate sample containers. Samples for volatile organic analysis must be collected directly from the bowl before mixing the sample to minimize volatilization of contaminants.

### *Laboratory Procedures*

The Tennessee Department of Health, Environmental Laboratory and Microbiological Laboratory Organization (the state lab) has expertise in a broad scope of services and analyses available to the Tennessee Department of Environment and Conservation (TDEC) Department of Energy Oversight (DOE-O) and to other TDEC offices statewide. General sampling and analysis methods are to follow Environmental Protection Agency (EPA) guidelines as listed in appropriate parts of 40 Code of Federal Regulations (CFR). Laboratory Services may subcontract certain analyses and QC samples out to independent laboratories. Bench level Quality Assurance/Quality Control (QA/QC) records and chain-of-custody records are maintained at the Tennessee Environmental Laboratory, as are QA records on subcontracted samples.

DOE-O will primarily use the Knoxville branch of Laboratory Services. Wet chemistry and metals samples will generally be analyzed in Knoxville while organics samples will be sent on to the state lab in Nashville. All laboratory analysis will follow appropriate methods as documented in the Laboratory Services Inorganic Chemistry SOP and Organic Chemistry SOP. Specific analytical methods are covered in these manuals. They also direct analysts to the proper EPA or other methodology.

### **References**

Environmental Compliance Standard Operating Procedures and Quality Assurance Manual. United States Environmental Protection Agency. Region IV, Environmental Services Division. Atlanta, Georgia. 1991.

Field Branches Quality System and Technical Procedures: Field Sampling Procedures – Sediment Sampling United States Environmental Protection Agency. Region IV, Athens, GA. 2010.

Methods for Collection, Storage, and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual. Doc: EPA 823-B-01-002. United States Environmental Protection Agency. Office of Water. Washington: GPO. 2001.

Standard Operating Procedures – Sediment Sampling. Tennessee Department of Environment and Conservation. DOE Oversight Office. Oak Ridge, Tennessee 2012.

Standard Operating Procedures. Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee 1996.

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Yard, C.R. Health and Safety Plan. Tennessee Department of Environment and Conservation, Division of Remediation, Department of Energy Oversight Office. Oak Ridge, Tennessee. 2013.

# Surface Water Physical Parameters Monitoring

## Introduction

Due to the presence of areas of extensive point and non-point source contamination on the Oak Ridge Reservation (ORR), there exists the potential for contamination to impact surface waters on the ORR. During 2014, to assess the degree of surface water impact relative to this potential contamination displacement, stream monitoring data will be collected monthly to establish a database of physical stream parameters (conductivity, pH, temperature, and dissolved oxygen).

The primary objective of this monitoring project is to provide supplementary water quality data for office programs and organizations outside of TDEC. Furthermore, this monitoring task is directed toward determining long-term water quality trends, assessing attainment of water quality standards and providing additional baseline data for evaluating stream recovery. Table 1 lists the locations that have been selected for monitoring.

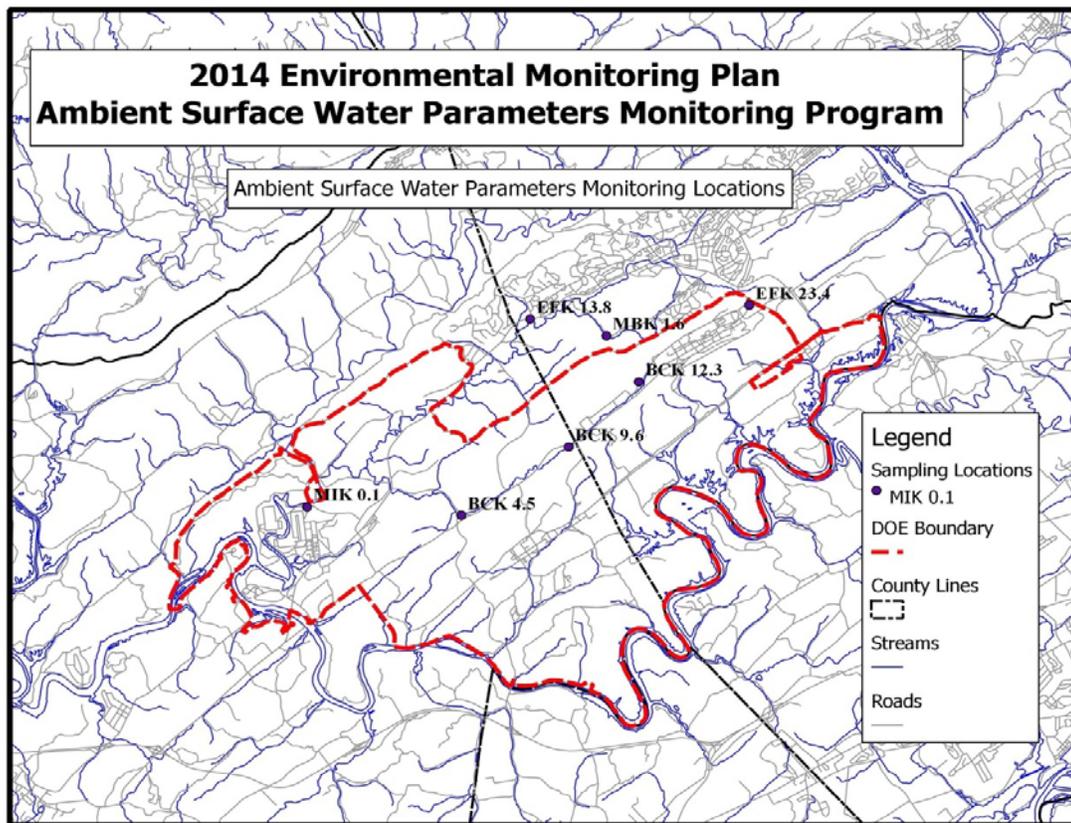


Figure1: Sampling Locations

**Table 1: Sample Locations**

Stream Location	TDEC-DOE-O Project Site	DWR Site
East Fork Poplar Crk	EFK 23.4	EFPOP014.5AN
East Fork Poplar Crk	EFK 13.8	EFPOP008.6AN
Bear Creek	BCK 12.3	BEAR007.6AN
Bear Creek	BCK 9.6	BEAR006.0AN
Bear Creek	BCK 4.5	BEAR002.8RO
Mitchell Branch	MIK 0.1	MITCH000.1RO
Mill Branch	MBK 1.6	FECO67I12
Stream Location = ORR Stream/Watershed		
TDEC-DOE-O Project Site Activities = measure temperature, pH, conductivity, D.O.		
DWR Site = Division of Water Resources site designation		

**Methods and Materials**

The surface water physical parameters of temperature, pH, conductivity, and dissolved oxygen will be measured. Field monitoring will follow the 2011 TDEC WPC Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water.

**Schedule**

Once per month, surface water monitoring will be conducted.

**References**

Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water. Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, Tennessee. 2011.

The Status of Water Quality in Tennessee: Technical Report. Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, Tennessee. 1998.

Yard, C.R. Health, Safety, and Security Plan. Tennessee Department of Environment and Conservation, Department of Energy Oversight Office. Oak Ridge, Tennessee. 2013.

## Ambient Trapped Sediment Monitoring

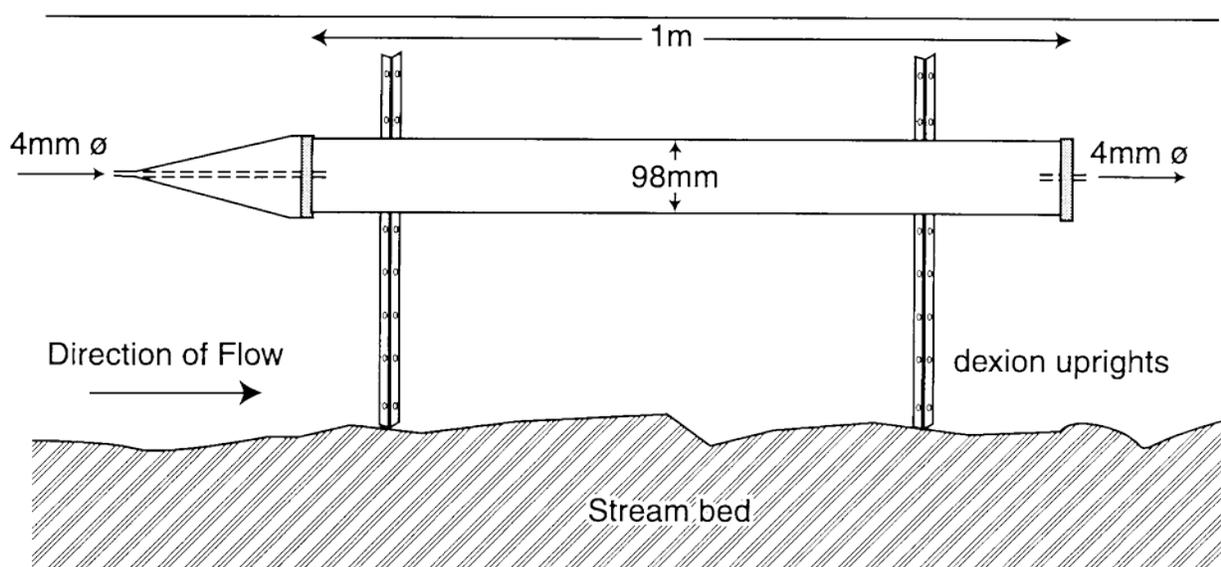
### Introduction

Sediment analysis is a key component of environmental quality and impact assessment for rivers, streams, lakes, and impoundments. Samples can be collected for a variety of chemical, physical, toxicological and biological investigations. The objective of this monitoring program is to assess the sediment that is being currently transported and deposited in Mitchell Branch, East Fork Poplar Creek, and Bear Creek. Sediment traps will be deployed at the following approximate stream locations: Mitchell Branch mile 0.1, East Fork Poplar Creek mile 4.0, Bear Creek 6.0. The exact location of deployment will depend on stream conditions at the time of deployment.

### Methods and Materials

#### Sediment Sampler Design

The passive sediment samplers will be modeled after a design described by Phillips *et al.* (2000).



Phillips *et al.* (2000)

The following parameters will be analyzed utilizing TDH Laboratory services:

*Inorganics:* arsenic, barium, beryllium, boron, chromium, mercury, and nickel

*Radiological:* gross alpha (total), gross beta (total),  $^{89-90}\text{Sr}$ , gross gamma (total), *gamma radionuclides:*  $^{137}\text{Cs}$ ,  $^{40}\text{K}$ ,  $^{214}\text{Pb}$ ,  $^{214}\text{Bi}$ ,  $^{212}\text{Pb}$ ,  $^{228}\text{Ac}$ ,  $^{208}\text{Tl}$ ,  $^{212}\text{Bi}$  and others as detected.

### Schedule

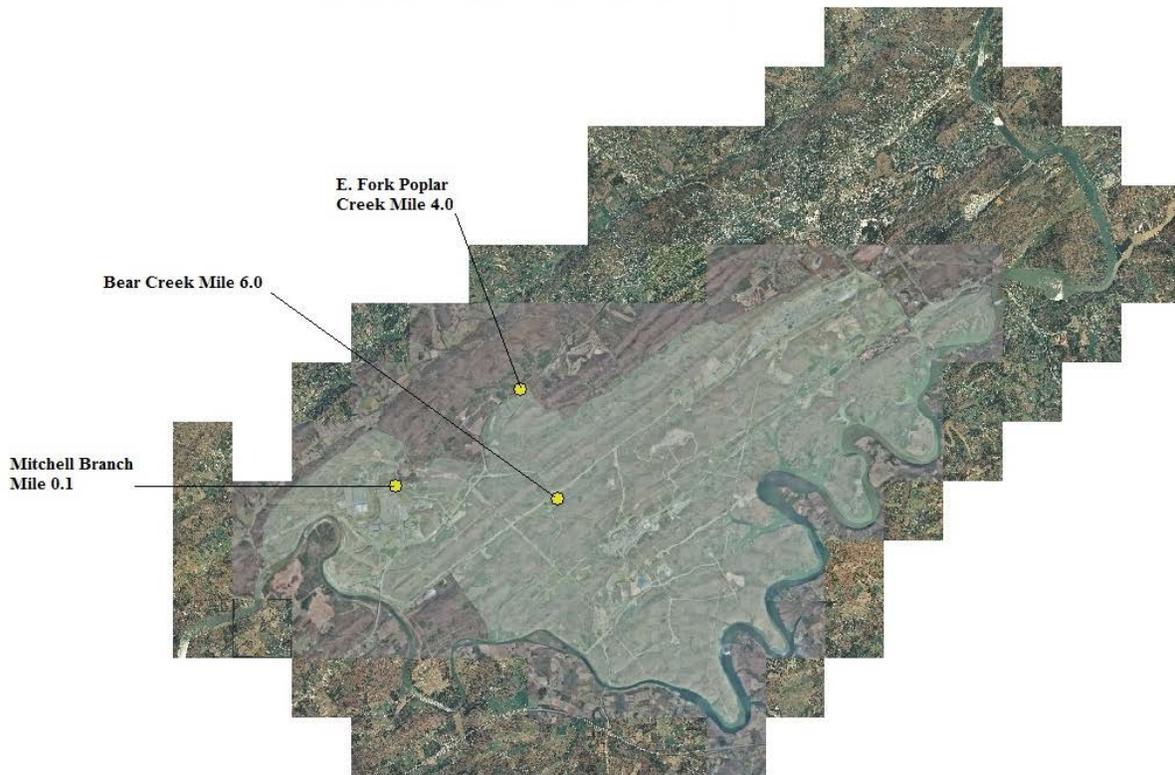
Passive sediment samplers will be deployed in the second quarter of 2014. They will be checked at six months and at one year.

### *Sediment Standard Operating Procedures*

This procedure is to be used to obtain quality assured sediment sampling. The resulting data may be qualitative or quantitative in nature and is appropriate for use in preliminary surveys and in confirmatory sampling.

#### *Required Equipment*

aluminum foil	sample labels
sample jars	cooler with ice
sediment traps	cable ties
stainless steel mixing bowls	stainless steel spoons
lab analysis request sheets	chain of custody forms
chain-of-custody forms	field book
GPS unit	nitrile gloves



**Figure 1: Trapped Sediment Site Locations**

#### *Procedure*

The passive sediment trap samplers will be installed in the stream horizontally with steel stakes driven into the stream bed. Step by step directions are as follows:

1. Locate a sampling site that is suitable for sediment collection (moderate current).

2. Don nitrile gloves to avoid self-contamination and cross-contamination during sampling.
3. Drive two steel stakes into the stream bed in the location selected. Position the stakes with the proper distance to match the mounting rings on the passive sediment sampler.
4. Check the trap approximately three months after deployment; collect the accumulated sediment when a sufficient quantity is obtained (>50 g). Carefully transfer sample into the appropriate containers using a stainless steel spoon.
5. Record all pertinent information on lab sheets, sample labels, and make necessary entries into field notebook.
6. Place all samples into cooler as soon as possible. Temperature within the cooler should be maintained at 4° C by using wet ice.
7. Deliver sediment samples to state lab within appropriate holding time frames, and sign chain-of-custody forms.

### *Laboratory Procedures*

Laboratory Services has expertise in a broad scope of services and analyses available to DOE-O and to other TDEC divisions statewide. General sampling and analysis methods are to follow Environmental Protection Agency (EPA) guidelines as listed in appropriate parts of 40 Code of Federal Regulations (CFR). Certain analyses and QC samples may be subcontracted out by Laboratory Services to independent laboratories. Bench level Quality Assurance/Quality Control (QA/QC) records and chain-of-custody records are maintained at the state lab as are QA records on subcontracted samples.

DOE-O will primarily use the Knoxville branch of Laboratory Services. Wet chemistry and metals samples will be analyzed in Knoxville. All laboratory analysis will follow appropriate methods as documented in the Laboratory Services Inorganic Chemistry SOP and Organic Chemistry SOP. Specific analytical methods are covered in these manuals. They also direct analysts to the proper EPA or other methodology.

### **References**

Field Branches Quality System and Technical Procedures: Field Sampling Procedures – Sediment Sampling. United States Environmental Protection Agency. Region IV, Athens, GA. 2010.

Methods for Collection, Storage, and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual. Doc: EPA 823-B-01-002. United States Environmental Protection Agency. Office of Water. Washington: GPO. 2001.

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# Ambient Surface Water Monitoring Program

## Project Description

The objective of this monitoring program is to conduct surface water sampling relative to the Clinch River and to some of its tributaries which have been impacted by the Department of Energy (DOE) operations on the Oak Ridge Reservation (ORR).

## Introduction

The ORR Clinch River tributaries of McCoy Branch, Raccoon Creek, Grassy Creek, and Poplar Creek drain into the Clinch River. The public municipalities and ORR nuclear processing industrial plants which are located in this area of the Clinch River are the City of Norris, the City of Clinton, Knox County, the City of Oak Ridge, the Y-12 complex, the Oak Ridge National Laboratory (ORNL) (old X-10 complex), the East Tennessee Technology Park (ETTP) (old K-25 complex), and the City of Kingston. Relative to obtaining public drinking water, and obtaining industrial plant processing water, all of these areas utilize the surface waters of the Clinch River. It's possible that the environment, ecology, and aquatic life of the Clinch River and its adjacent tributaries have been negatively impacted by ORR areas of extensive anthropogenic point and non-point source contamination which would possibly endanger the public.

The office conducts semi-annual surface water monitoring and sampling relative to six sites located on the Clinch River and to four Clinch River tributaries (McCoy Branch, Raccoon Creek, Grassy Creek, and Poplar Creek). Two of the Clinch River sites, CRM 78.7 and CRM 52.6, serve as reference sites. Table 1 provides specifics relative to the ten sampling sites.

## Methods and Materials

Relative to all the sampling sites, the following activities will be conducted. Surface water samples will be collected and, utilizing YSI Professional Plus and YSI 556 MPS multi-parameter field instruments, the parameters of pH, temperature, dissolved oxygen, and conductivity will be measured.

The surface water sampling program will follow 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 will be conducted in compliance with the office's *2013 Health, Safety, and Security Plan*. The ambient surface water monitoring and sampling will be conducted in the second and fourth quarters of 2014. Figure 1 provides a topographical map of the sampling sites.

The surface water samples will be transported to the TDH Laboratory Services in Knoxville and analyzed for the following parameters. To reduce analytical costs, the TDEC Knoxville EFO and our office share sampling of site #5, CLINC010.0RO. The Knoxville EFO #5 surface water sample is only analyzed for the below inorganic and metals parameters. Our #5 surface water sample is only analyzed for the below radionuclide parameters.

*Inorganics:* chemical oxygen demand, hardness (total as CaCO<sub>3</sub>), nitrogen (ammonia), nitrogen (NO<sub>3</sub> & NO<sub>2</sub>), nitrogen (total Kjeldahl), phosphorus (total), residue (dissolved), and residue (suspended).

*Metals:* arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, selenium (*McCoy Branch only*), and zinc.

*Radionuclides:* gamma radionuclides, gross alpha, gross beta, strontium-90 & technetium-99 (*Raccoon Creek only*).

The Tennessee Department of Health Laboratory Services has expertise in a broad scope of services and analyses. This expertise is available to the Tennessee Department of Environment and Conservation, Department of Energy Oversight Office and other TDEC divisions statewide. General sampling and analysis methods will follow Environmental Protection Agency (EPA) guidelines as listed in appropriate parts of Title 40 Code of Federal Regulations (CFR). Laboratory Services may subcontract certain analyses and QC samples out to independent laboratories. Bench level quality assurance/quality control (QA/QC) records and chain-of-custody records are maintained at Laboratory Services, as are QA records on subcontracted samples.

## **References**

Environmental Compliance Standard Operating Procedures and Quality Assurance Manual, U.S. Environmental Protection Agency, Region IV, Environmental Services Division, Atlanta, Georgia. 1991.

Environmental Investigations Standard Operating Procedures and Quality Assurance Manual, U.S. Environmental Protection Agency, Region IV, 960 College Station Road, Athens, Georgia. 1996.

Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water, Tennessee Department of Environment and Conservation, Division of Water Pollution Control, August 2011.

Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys, Tennessee Department of Environment and Conservation, Division of Water Pollution Control, July 2011.

Standard Guide for Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing, E 1391-90, American Society for Testing and Materials, Philadelphia, PA, 1990.

Standard Operating Procedures, Tennessee Department of Health Laboratory Services Services, Nashville, Tennessee, 1999.

Tennessee Oversight Agreement, Agreement Between the U.S. Department of Energy and the State of Tennessee, Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2011.

The Status of Water Quality in Tennessee: Technical Report, Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, Tennessee. 1998.

**Table 1: Stream Locations**

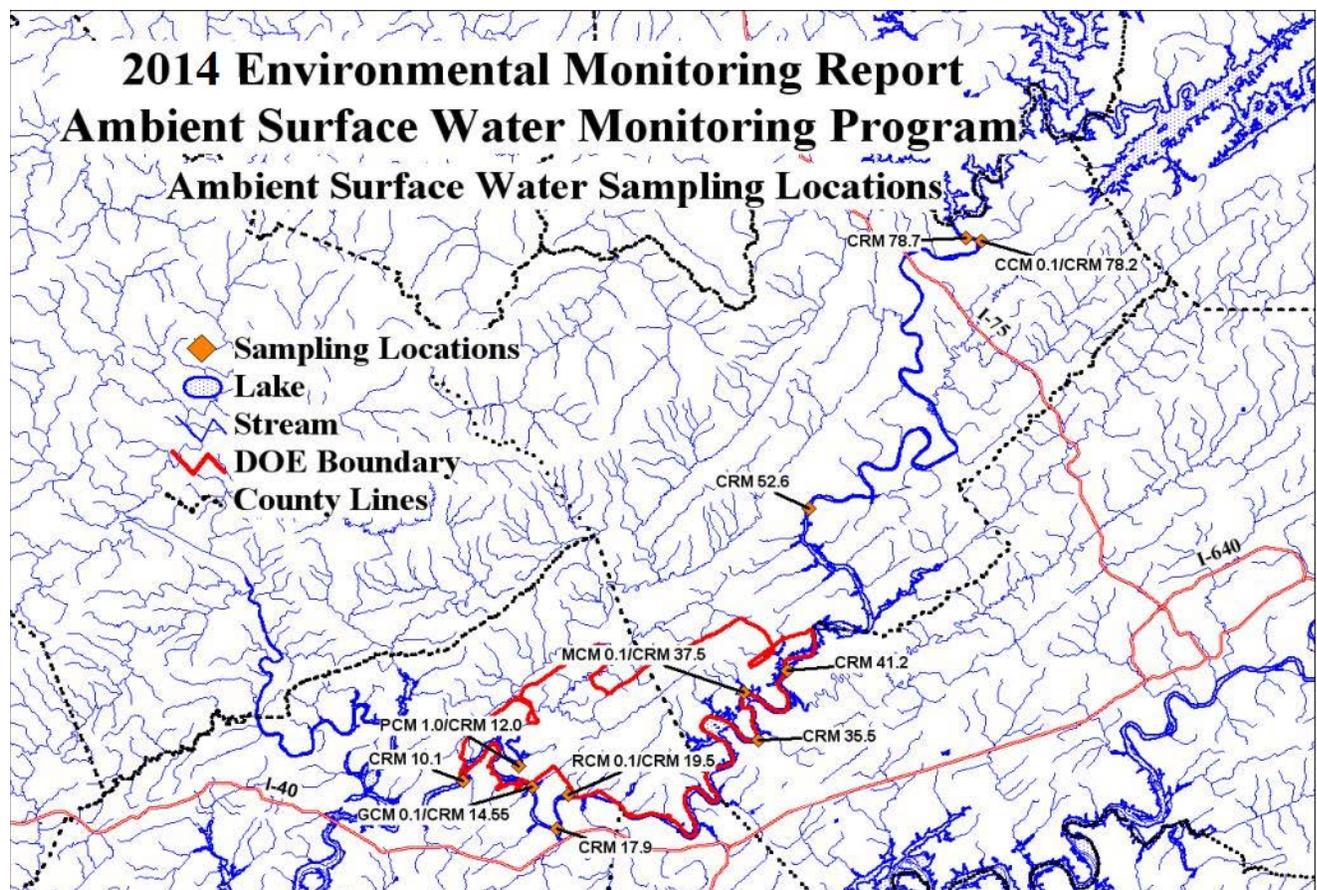
Stream Location	TDEC-DOE-O Project Site	DWR Site	Stream Mile	Clinch River Mile
#Clinch River	1	CLINC078.7AN	CRM 78.7	78.7
#Clinch River	2	CLINC052.6AN	CRM 52.6	52.6
Clinch River	7	CLINC041.2AN	CRM 41.2	41.2
Clinch River	3	CLINC035.5AN	CRM 35.5	35.5
Clinch River	4	CLINC017.9RO	CRM 17.9	17.9
Clinch River	5	CLINC010.0RO	CRM 10.0	10.0
*McCoy Branch	10	MCCOY000.9AN	MCM 0.9	37.5
*Raccoon Creek	18	RACCO000.4RO	RCM 0.4	19.5
*Grassy Creek	20	GRASS000.7RO	GCM 0.7	14.6
*Poplar Creek	33	POPLA001.0RO	PCM 1.0	12.0

Stream Location = Clinch River/Tributary, # = reference, \* = tributary.

DWR Site = Division of Water Resources site designation.

Stream Mile = Specific streams' mile.

Clinch River Mile = distance (miles) of stream location from the Clinch River/Tennessee River confluence.



**Figure 1: Sample Locations**

# Rain Event Surface Water Monitoring Program

## Introduction

Heavy rainfall events have the capability of transporting significant quantities of contaminants, which would normally remain in place, into nearby bodies of water. This mass transport can, in turn, impact the quality of the receiving waters. Due to the presence of areas of extensive point and non-point source contamination on the Oak Ridge Reservation (ORR), there exists the potential for contamination to impact surface waters on the ORR during excessive rainfall events. These events could cause the displacement of contamination that would not normally impact streams around the ORR.

During 2014, to assess the degree of surface water impacts caused by these rainfall events, a sampling of streams will be conducted following heavy rainfall events to determine the presence or absence of contaminants of concern. Table 1 and Figure 1 show locations that have been selected for sampling.

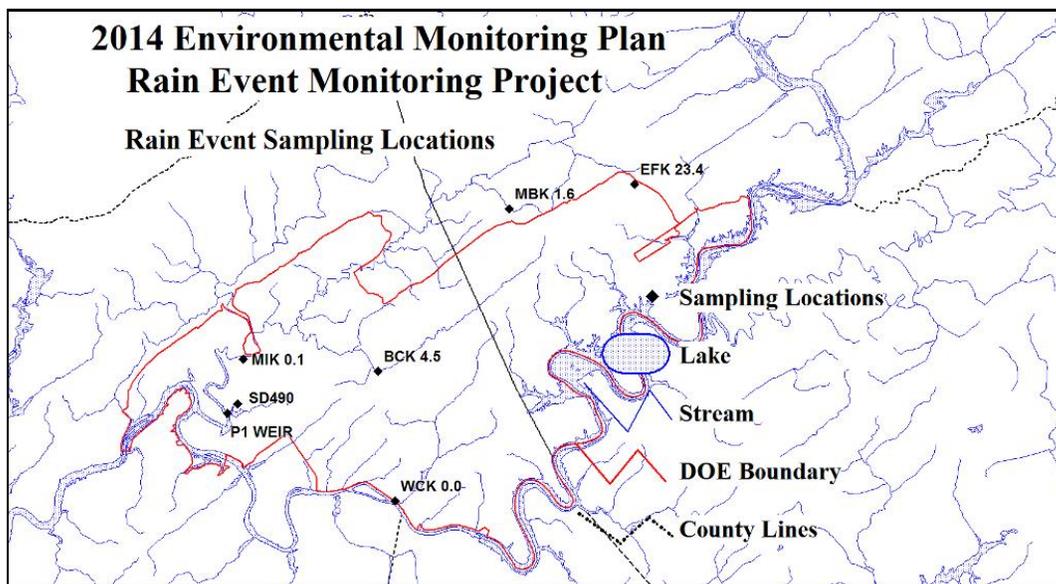


Figure 1 : Sample Locations

Table 1: Sample Locations in kilometers (mile equivalents)

Site	Location
EFK 23.4 (14.5)	East Fork Poplar Creek (Station 17)
WCK 0.0 (0.0)	White Oak Creek (Weir at Clinch River)
BCK 4.5 (2.8)	Bear Creek (Weir at Hwy. 95)
MIK 0.1 (0.06)	Mitchell Branch (Weir at ETP)
Storm Drain 490 (SD490)	P1 Pond at ETP
P1 Pond Weir	P1 Pond at ETP
MBK 1.6 (1.0)	Mill Branch (Reference)

## **Methods and Materials**

The physical parameters of temperature, pH, conductivity, and dissolved oxygen will be measured in the field. However, the following analytes will be analyzed utilizing TDH Laboratory services:

*Metals:* arsenic, cadmium, chromium, copper, hexavalent chromium (*Mitchell Branch, P1 Weir and SD490 only*), iron, lead, manganese, mercury, uranium metal (*P1 Weir and SD490 only*) and zinc.

*Radionuclides:* gamma radionuclides, gross alpha, gross beta, and strontium-90 (*White Oak Creek only*), Tc-99 (*P1 Weir and SD490 only*).

## **Schedule**

Sampling and monitoring will be conducted no more than once per quarter following either a one-inch rain event in a 24-hour period or a two-inch rain event over a 72-hour period.

## **Standard Operating Procedures**

Field sampling protocols will follow the TDEC DOE-O standard operating procedures for sampling surface water.

## **Laboratory Services Procedures**

The Tennessee Department of Health Laboratory Services has expertise in a broad scope of services and analyses. This expertise is available to the Tennessee Department of Environment and Conservation, Department of Energy Oversight Office (the office) and other TDEC divisions statewide. General sampling and analysis methods will follow Environmental Protection Agency (EPA) guidelines as listed in appropriate parts of Title 40 Code of Federal Regulations (CFR). Laboratory Services may subcontract certain analyses and QC samples out to independent laboratories. Bench level quality assurance/quality control (QA/QC) records and chain-of-custody records are maintained at Laboratory Services, as are QA records on subcontracted samples.

The office will primarily use the Knoxville branch of Laboratory Services. Wet chemistry and metals samples will be analyzed in Knoxville, while organics samples will be sent to Laboratory Services in Nashville. All Laboratory Services analyses will follow appropriate methods as documented in the Laboratory Services Inorganic Chemistry SOP and Organic Chemistry SOP. Specific analytical methods are covered in the Standard Operating Procedures (SOP) manuals for Laboratory Services. The SOPs direct analysts to the proper EPA or other methodology.

## **References**

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Tennessee Oversight Agreement, Agreement Between the U.S. Department of Energy and the State of Tennessee, Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2011.

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