TENNESSEE DEPARTMENT

OF

ENVIRONMENT AND CONSERVATION

DIVISION OF REMEDIATION

DOE OVERSIGHT OFFICE

ENVIRONMENTAL MONITORING PLAN

JANUARY through DECEMBER 2015

To reach your local
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Environmental Monitoring Plan Changes for 2015

The following notations refer to project changes from the 2014 monitoring plan.

1. **Air Quality Monitoring**

   Monitoring of Hazardous Air Pollutants (HAPs) on the Oak Ridge Reservation. With the shutdown of the TSCA incinerator at ETTP, this project was reevaluated for continuation. On a case by case basis, we retain the ability to monitor specific HAPs by splitting the fugitive air program sampling media that is used for radiological contaminants. The fugitive program continues to locate portable monitors at major demolition projects. The project is in hiatus until development of methods to monitor for mercury vapor in air are developed.

   RadNet Air Monitoring.

   No Changes.

   Fugitive Air Monitoring.

   No changes.

   RadNet Precipitation Monitoring.

   No changes.

2. **Biological Monitoring**

   Benthic Macroinvertebrate Monitoring. New for 2015, an additional set of two SQKICK samples will be collected for total mercury and methylmercury analysis of benthic macroinvertebrates at each ORR and reference site. Also, adult insects will be collected using a light trap or malaise trap at selected sites to test for total mercury and methylmercury analysis. This project will be used to analyze metals content of insects in association with bats consuming flying insects within the various watersheds that are sampled.

   White-tailed Deer Monitoring. No changes. We start immobilizing and GPS collaring deer after the last statewide deer hunts in mid-January.

   Fish Tissue Monitoring Plan. Continued from the project as described last year.

   Fungi Monitoring in East Fork Poplar Creek

   This project is expanded from last year's pilot project to further obtain 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.

   Acoustical Monitoring of Bats.

   This project is a continuation of the project started year before last. Primarily it focuses on identifying bat species and, possibly, populations by deploying acoustic identification devices on the Oak Ridge Reservation. We update the hardware and software for this innovative technique routinely and use two different hardware brands to crosscheck. Changes include the possible use of mist netting to collect bats for species identification. This year our biologist is vaccinated for rabies, and can assist investigators authorized to use mist nets for bats.

   Threatened and Endangered Species Monitoring.

   No changes.

   Aquatic Vegetation Monitoring.

   No changes.

3. **Drinking Water Monitoring**
   No Changes

4. **Groundwater Monitoring**
   Groundwater Monitoring. In 2015, the groundwater projects will broaden its sampling areas. We plan to investigate groundwater northeast and southwest of the Oak Ridge Reservation to assess water quality in relation to reference values. Quality Assurance (QA) samples will be collected during the DOE's off-site FFA sampling program scheduled for 2015. In addition the office will revisit the springs on the reservation for changes in groundwater quality.

5. **Radiological Monitoring**
   No substantive changes. The Facility Survey will not be undertaken in 2015.

6. **Surface Water Monitoring**
   We are integrating more automated equipment into this program.
   Surface Water Monitoring at the EMWM.
   No changes.
   Ambient Surface Water Monitoring. In 2015, the shortened analytic list is maintained from last year.
   Ambient Sediment Monitoring. In 2015, the ambient sediment collection will be continued.
   Surface Water Parameters. There are no substantive changes.
   Trapped Sediment Monitoring. Some trap re-positioning is done to optimize collection.
   Rain Event Surface Water Monitoring Program. No Changes to general objectives. Analyses are customized to the COC's at the station of interest. For example, Tc99 is an added analyte for ETTP.

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
EMDF	Environmental Management Disposal Facility
EMWMF	Environmental Management Waste Management Facility
EPA	Environmental Protection Agency
EPT	*Ephemeroptera, Plecoptera, Trichoptera* (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
LSS	Lab Shift Superintendent
MBK	Mill Branch Kilometer (station location)
MEK	Melton Branch Kilometer (station location)
µg	microgram
mg	milligram
MIK	Mitchell Branch Kilometer (station location)
ml	milliliter
µmho	micro mho (mho=1/ohm)
MOU	Memorandum of Understanding
mR	Microroentgen
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 http://www-oreis.bechteljacobs.org/oreis/help/oreishome.html

ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory (X-10)
ORR	Oak Ridge Reservation
pcb	polychlorinated biphenol
pCi	$1x10^{-12}$ curie (picocurie)
pH	proportion of Hydrogen Ions (acid vs. base)
ppm	parts per million
PSS	Plant Shift Superintendent
QAPP	Quality Assurance Project Plan
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
SQKICK	semi-quantitative riffle kick
TDEC	Tennessee Department of Environment and Conservation
TDH	Tennessee Department of Health
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
WNS	White Nose Syndrome disease
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), Division of Remediation, (DOR), Department of Energy Oversight (DOE-O) Office (the office), is providing an annual environmental monitoring plan for the calendar year 2015 as found in the Tennessee Oversight Agreement (TOA) Section A.7.2.1. Individual plans describing environmental monitoring and surveillance projects are compiled into the 2015 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 of the monitoring and surveillance is to assure that DOE's Oak Ridge Operations are not having adverse effects on the public health, safety, and the environment. Results from monitoring and findings of the quality and effectiveness of the DOE's environmental programs are reported in the annual Environmental Monitoring Report and the annual Status Report to the Public.

This plan is provided to the Department of Energy for the opportunity to review and consult on the office's monitoring activities and to facilitate 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.

Careful use of dedicated state funds will be used to complete our projects. The frugal 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. Project expenditures are closely tracked for efficient use of resources across all the projects.

Quality Assurance Project Plan

The sampling, monitoring and surveillance projects for 2015 will be conducted using an appropriate Quality Assurance Project Plan (QAPP). The Environmental Protection Agency's Standard Operating Procedures will be followed. The QAPP(s), coupled with detailed operating procedures to define specific project QA/QC requirements, form the basis for meeting the project objectives in making critical measurements.

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 included in the Oak Ridge Reservation RadNet system from which radiological contaminants in rain and snow are assessed. TDEC performs oversight of the ORR perimeter program. Portable samplers are 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 fungi. 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 feeds 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 may also be 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 projects provide data and information about Oak Ridge Reservation releases and potential implications on human health, safety and the environment. Contaminant transport off the Oak Ridge Reservation via groundwater will continue to be identified through groundwater pathways. This will be accomplished by joint monitoring of water supplies, wells, and springs, both on and off the ORR. 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. This year we are coordinated with DOE and the Tennessee Department of Health in a combined effort to assess offsite groundwater.

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 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 measures gamma radiation levels of truckloads of waste entering the EMWMF on a real time basis. Off normal readings are researched and may trigger audits and other investigations.

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. In 2015, monitoring and investigation will continue in close 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 or faxed to (865) 482-1835.

AIR QUALITY MONITORING

RadNet Air Monitoring on the Oak Ridge Reservation

Introduction

The Tennessee Department of Environment and Conservation's 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 2015 with EPA's 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 (HIFR), and Decontamination and Decommissioning (D&D) at the East Tennessee Technology Park (ETTP) and Y-12] and supplements 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 full calibration as needed, usually annually. The sampling results received from NAREL can 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, 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 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

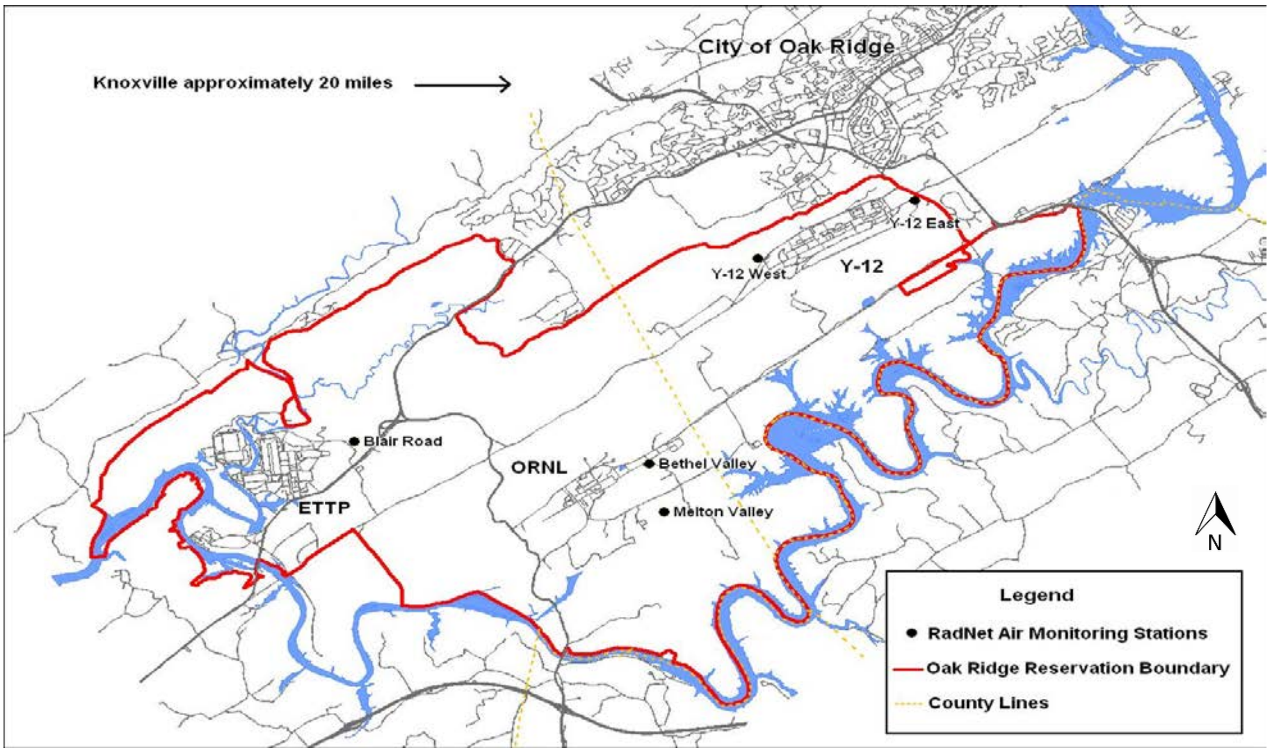

Figure 1: Locations of Air Stations Monitored in Association with EPA's RadNet Air Program on the Oak Ridge Reservation

References

National Air and Radiation Environmental Laboratory. United States Environmental Protection Agency. http://iaspub.epa.gov/enviro/erams_query_v2.simple_query (Last updated September 23, 2014).

National Air and Radiation Environmental Laboratory. United States Environmental Protection Agency. http://www.epa.gov/enviro/facts/radnet/index.html (Last updated June 24, 2014).

RadNet Standard Operating Procedure 3, RadNet/SOP-3. National Air and Radiation Environmental Laboratory, United States Environmental Protection Agency, Monitoring and Analytical Services Branch. Montgomery, Alabama. June 2006.

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, DOE Oversight Office. Oak Ridge, Tennessee. 2014.

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 2015. The program uses eight mobile high volume air samplers to supplement air monitoring performed at fixed locations in the office's RadNet 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 for determining if releases are occurring and to limits provided in the Clean Air Act (CAA) for assessing compliance with associated emission standards. Findings will be used to: identify and characterize unplanned releases; assess the dose to the public as defined in 10 CFR 835; and evaluate DOE monitoring and control measures for preventing 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, <u>Calibrating High Volume Total Suspended Particulate Sampler</u>. Maintenance on the samplers will be performed as described in DOE-O SOP 203, <u>High Volume Total Suspended Particulate System Maintenance</u>.

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 on 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 it's 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	Frequency		Isotopic Uranium	Gamma	Technitium-99
	Monitor	Analysis			
Y12 B9723-28	weekly	4 Weeks Composite	X		X
Y12 B9212	weekly	4 Weeks Composite	X		X
ETTP K25 K11	weekly	4 Weeks Composite	X		X
ETTP Portal 4	weekly	4 Weeks Composite	X		X
ORNL Corehole 8	weekly	4 Weeks Composite	X	X	
ORNL B4007	weekly	4 Weeks Composite	X	X	
EMWMF	weekly	4 Weeks Composite	X	X	X
Background	weekly	4 Weeks Composite	X	X	X

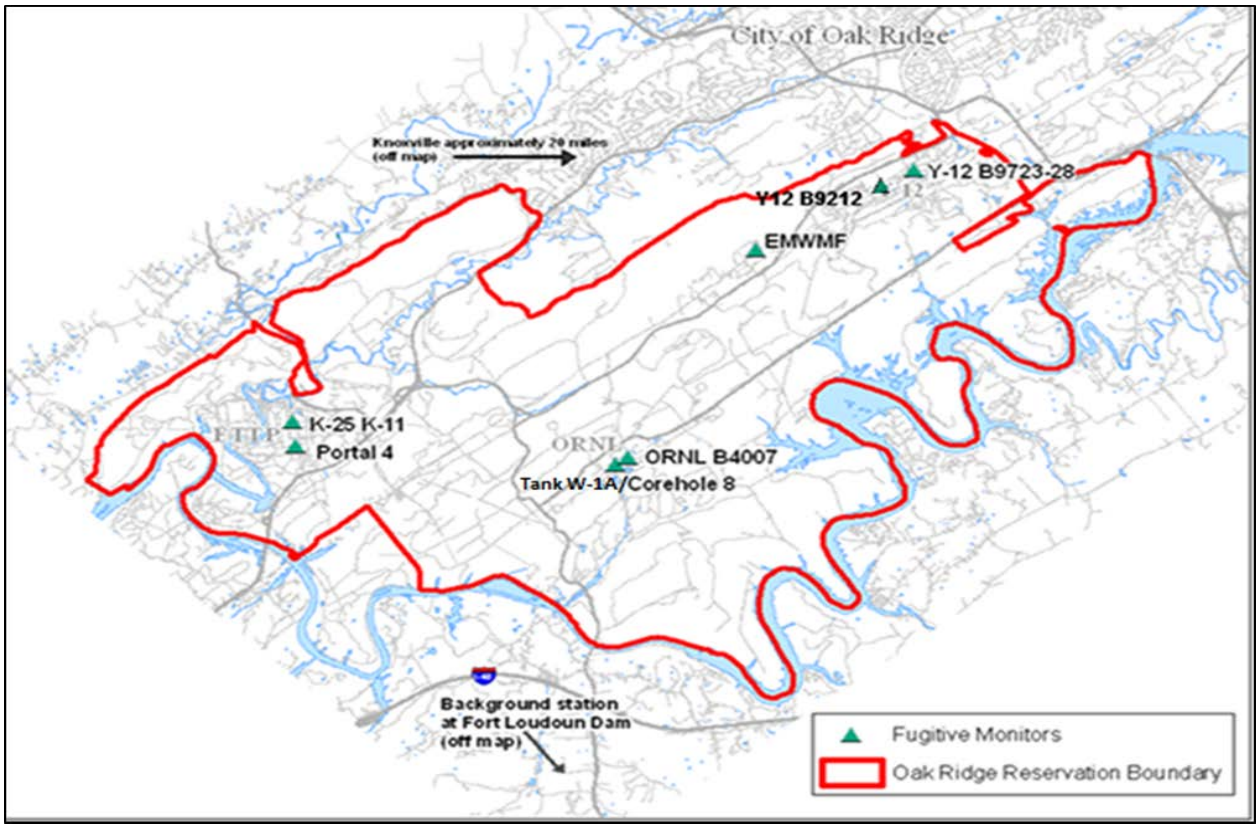

Figure 1: Locations of current monitoring stations in the Fugitive Air Monitoring Program

References

Clean Air Act. 40 CFR Part 61, Subpart H. National Emissions Standards for Hazardous Air Pollutants (NESHAPS). U.S. Environmental Protection Agency (EPA). 1994.

Conley, T.B., S.D. Schneider, T.M. Walsh, K.M. Billingsley. D&D of the Radioisotope Development Laboratory (3026 Complex) and the Quonset Huts (2000 Complex) at the Oak Ridge National Laboratory Funded by the American Recovery and Reinvestment Act-10255. WM'04 Conference. March 7-11, 2010. Phoenix, AZ.

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Yard, C.R., Health, and Safety Plan, Tennessee Department of Environment and Conservation, Division of Remediation, DOE Oversight Office. Oak Ridge, Tennessee. 2014.

RadNet Precipitation Monitoring on the Oak Ridge Reservation

Introduction

The Tennessee Department of Environment and Conservation's DOE Oversight Office, a part of the Division of Remediation, will continue to monitor the precipitation at three locations on the Oak Ridge Reservation in 2015 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. The three precipitation samplers are co-located next to three of the RadNet air monitoring locations (described in the RadNet Air Monitoring Plan) on the Oak Ridge Reservation (Figure 1).

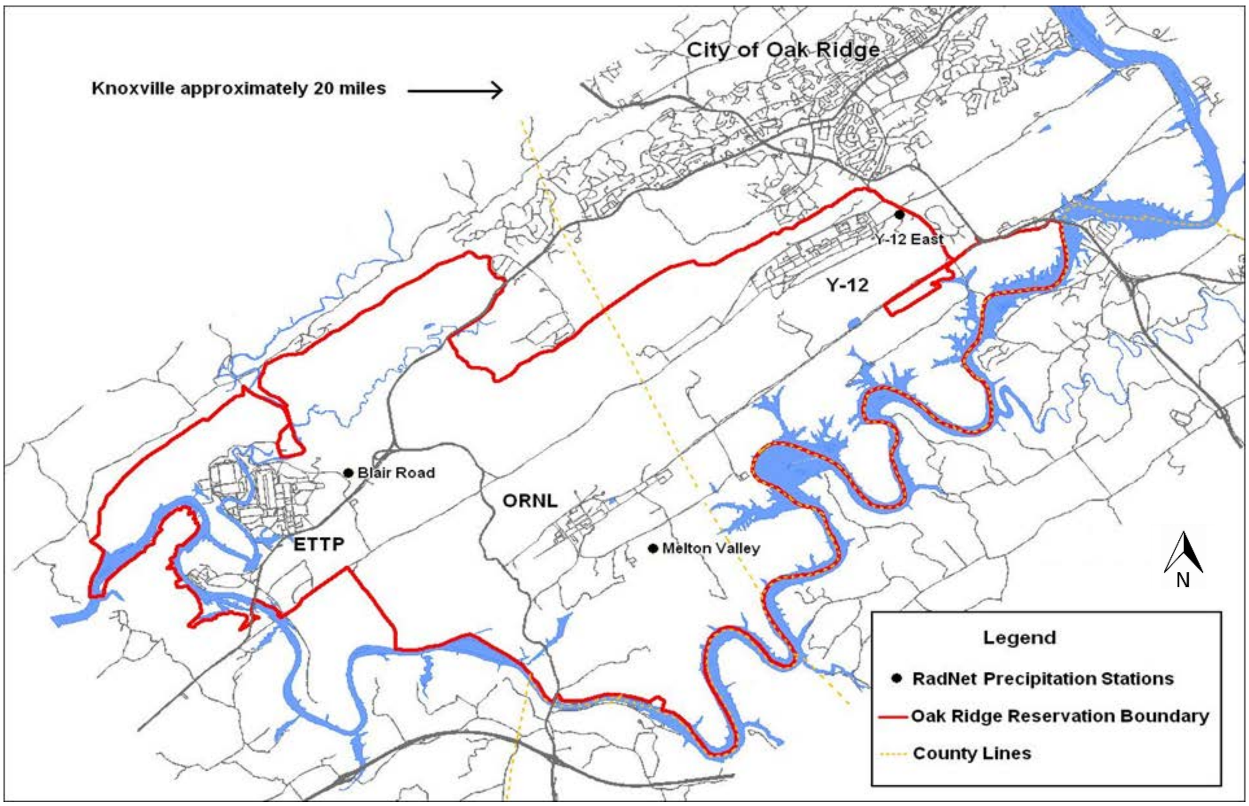

Figure 1: Locations of Precipitation Stations Monitored on the Oak Ridge Reservation

The first precipitation monitor, provided by EPA, was placed co-located with the RadNet air station near Oak Ridge National Lab's (ORNL) High Flux Isotope Reactor and the SWSA 5 (solid waste storage area) burial grounds in 2005. Another precipitation monitor was placed on the east side of East Tennessee Technology Park (ETTP) in April 2007 and is co-located with the Blair Road RadNet air station. This sampler is used to monitor decontamination and decommissioning (D&D) at ETTP. The third 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 Y-12 and to provide an indication of 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. The samples sent at the end of the month may contain less than two liters if that is all that has been collected. Samples are composited monthly by EPA for gamma analysis (Table 1). Results from the gamma analysis will be provided to the office and will be available on http://iaspub.epa.gov/enviro/erams_query_v2.simple_query, the EPA RadNet searchable Envirofacts database. 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 transport, to evaluate associated control measures, and to appraise conditions on the Oak Ridge Reservation compared to other locations in the RadNet program.

Table 1: EPA Analysis of RadNet Precipitation Samples

ANALYSIS	FREQUENCY
Gamma Scan	Monthly on composite samples

References

NAREL Standard Operating Procedure for Collecting RadNet Precipitation Samples. National Analytical Radiation Environmental Laboratory, United States Environmental Protection Agency. Montgomery, Alabama. 2013.

National Air and Radiation Environmental Laboratory. United States Environmental Protection Agency. http://iaspub.epa.gov/enviro/erams_query_v2.simple_query (Last updated September 23, 2014).

National Air and Radiation Environmental Laboratory. United States Environmental Protection Agency. http://www.epa.gov/radnet (Last updated June 24, 2014).

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Yard, C.R., Health and Safety Plan, Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2014.

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 (QS-SOP) for Macroinvertebrate Stream Surveys* (TDEC 2011) and provisions within the Clean Water Act of 1977 will drive the project. This QS-SOP is based upon ASTM method STP528-EB ("Use of Aquatic Invertebrates in the Assessment of Water Quality") and is intended to assist the Division of Water Pollution Control in maintaining their quality control and quality assurance processes and ensure compliance with government regulations. The United States' guidance for benthic macroinvertebrate sampling follows the Environmental Protection Agency's Rapid Bioassessment Protocol for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish. Chapter 7: Macroinvertebrates (USEPA 1999). These SOPs provide specific operational direction for the office's Quality Assurance Project Plan for Macroinvertebrate Stream Surveys.

Introduction

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

Accordingly, benthic macroinvertebrates are collected from various ORR streams and analyzed to measure the degree of impact from past and present DOE operations. The office 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

Semi-quantitative kick net samples (i.e., SQKICK) provide a snapshot of the benthic community population at a particular stream location and the respective taxonomic identifications and taxa counts present at this site are used to calculate the Tennessee Macroinvertebrate Index (TMI, TDEC

2011). Several quantifiable attributes of the biotic assemblage (i.e., “metrics”) that assess macroinvertebrate assemblage structure, composition, and function comprise these indices (Hilsenhoff 1982, 1987, 1988, Fore et al. 1996, Karr and Chu 1998), and metrics are used to measure and calculate an overall score to represent the ecological condition and integrity of stream health. This multimetric index approach is effective for evaluating anthropogenic disturbance and pollution, for standardizing assessment and for communicating the biotic condition of streams (Barbour et al., 1999), because susceptibility to toxic agents varies with the response of individual genera and species (Resh et al. 1988, 1996).

During 2015, benthic macroinvertebrate samples will be collected from 20 stream sites (Table 1, Figures 1-5) and processed following TDEC Water Pollution Control (WPC) standard operating procedures (SOP, TDEC 2011). The 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 2015, an additional set of two SQKICK samples will be collected for total mercury and methylmercury analysis of benthic macroinvertebrates at each ORR and reference site. Also, adult insects will be collected using a light trap, or malaise trap, at selected sites to test for total mercury and methylmercury analysis. This will be used to analyze metals content of insects consumed by bats flying within the various watersheds that are sampled.

Water quality data, surface water samples and habitat assessment data will be collected at each sampling location. These activities are addressed in a separate chapter. All work associated with this program will be in compliance with the office’s Health, Safety, and Security Plan (Yard 2014).

Once collections have been made at all 20 sites, the semi-quantitative samples will be processed in-house by office 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 (Table 2). 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). In order to validate species-level taxonomy, light trapping and other collection methods may be employed to trap adult insects in ORR streams and springs during 2015 (Weinzierl et al. 2005, Nowinszky et al. 2010). Weather permitting, field sampling will be completed within a four-week time span in April and May 2015.

Table 1: Oak Ridge Reservation Benthic Monitoring Sites

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

Table 2: Description of Metrics and Expected Responses to Stressors

Category	Metric	Description	Response to Stress
Richness Metrics	Taxa Richness	Measures the overall variety of the macroinvertebrate assemblage	Number decreases
	EPT Richness	Number of taxa in the orders *Ephemeroptera* (mayflies), *Plecoptera* (stoneflies), and *Trichoptera* (caddis flies)	Number decreases
	Intolerant Taxa	Number of taxa in sample that display a tolerance rating of <3.0	Number decreases
Composition Metrics	% EPT-*Cheum*	% of EPT abundance excluding *Cheumatopsyche* taxa	% decreases
	% OC	% of oligochaetes (worms) and chironomids (midges) present in sample	% increases
Tolerance Metrics	NCBI	North Carolina Biotic Index which incorporates richness and abundance with a numerical rating of tolerance	Number increases
	% Nutrient Tolerant	% of organisms present in sample that are considered tolerant of nutrients	% increases
Habit Metric	% Clingers	% of macroinvertebrates present in sample w/ fixed retreats or attach themselves to substrates	% decreases

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

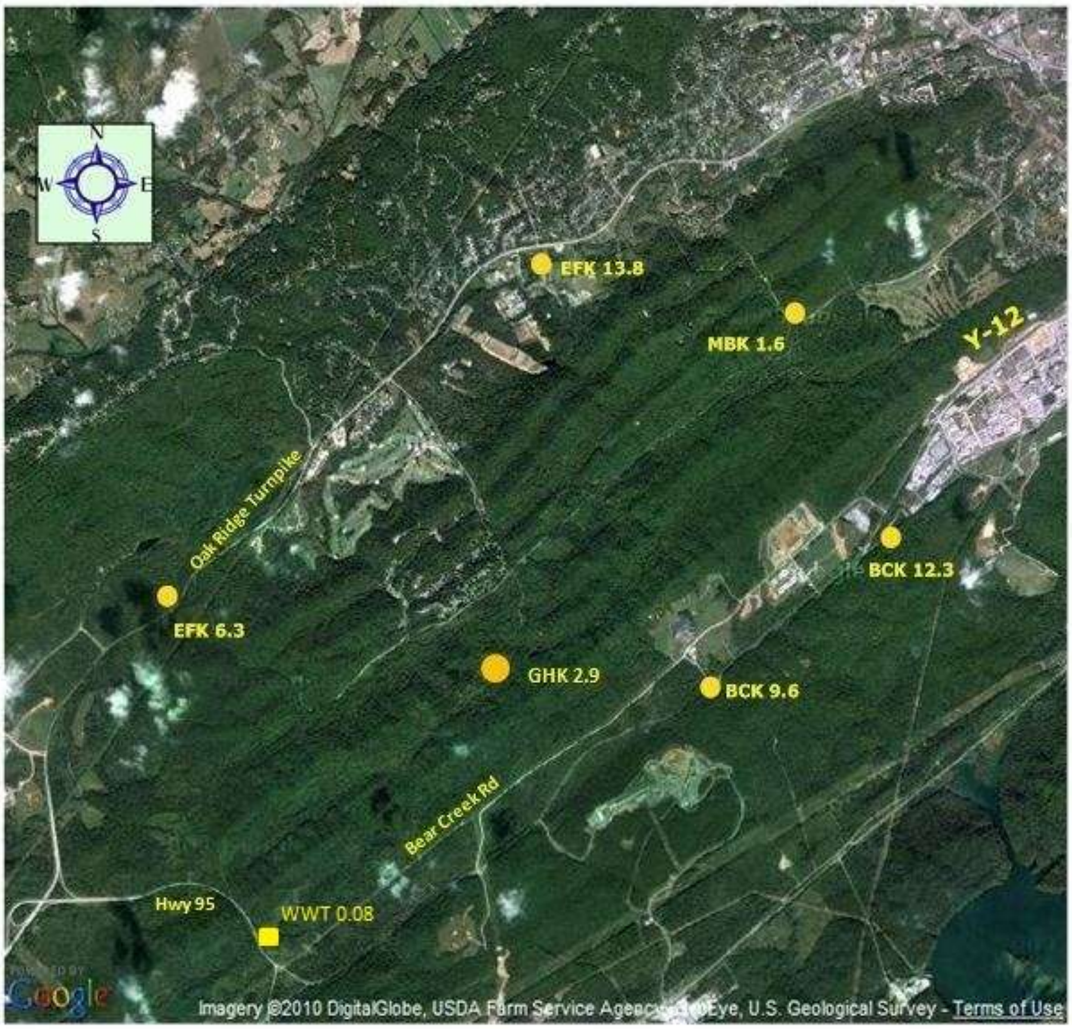

Figure 2: East Fork Poplar Creek / Bear Creek Watersheds

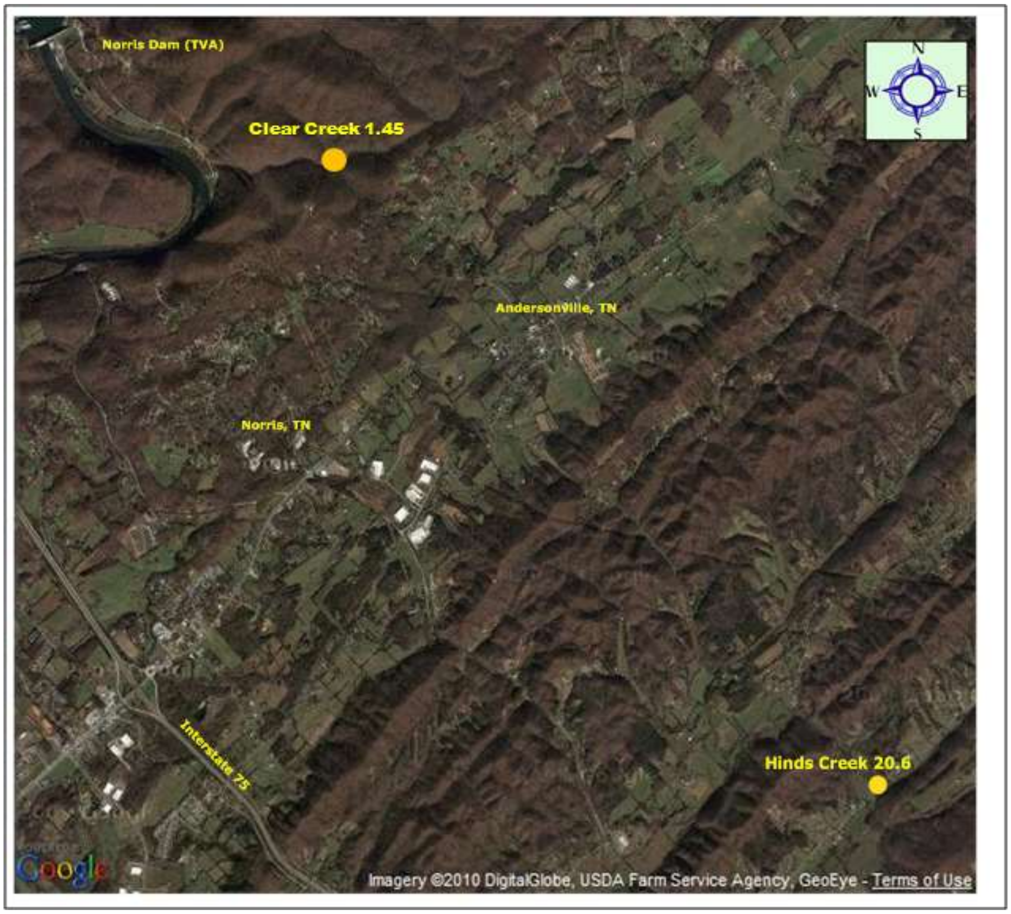

Figure 3: Clear Creek and Hinds Creek Reference Sites

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

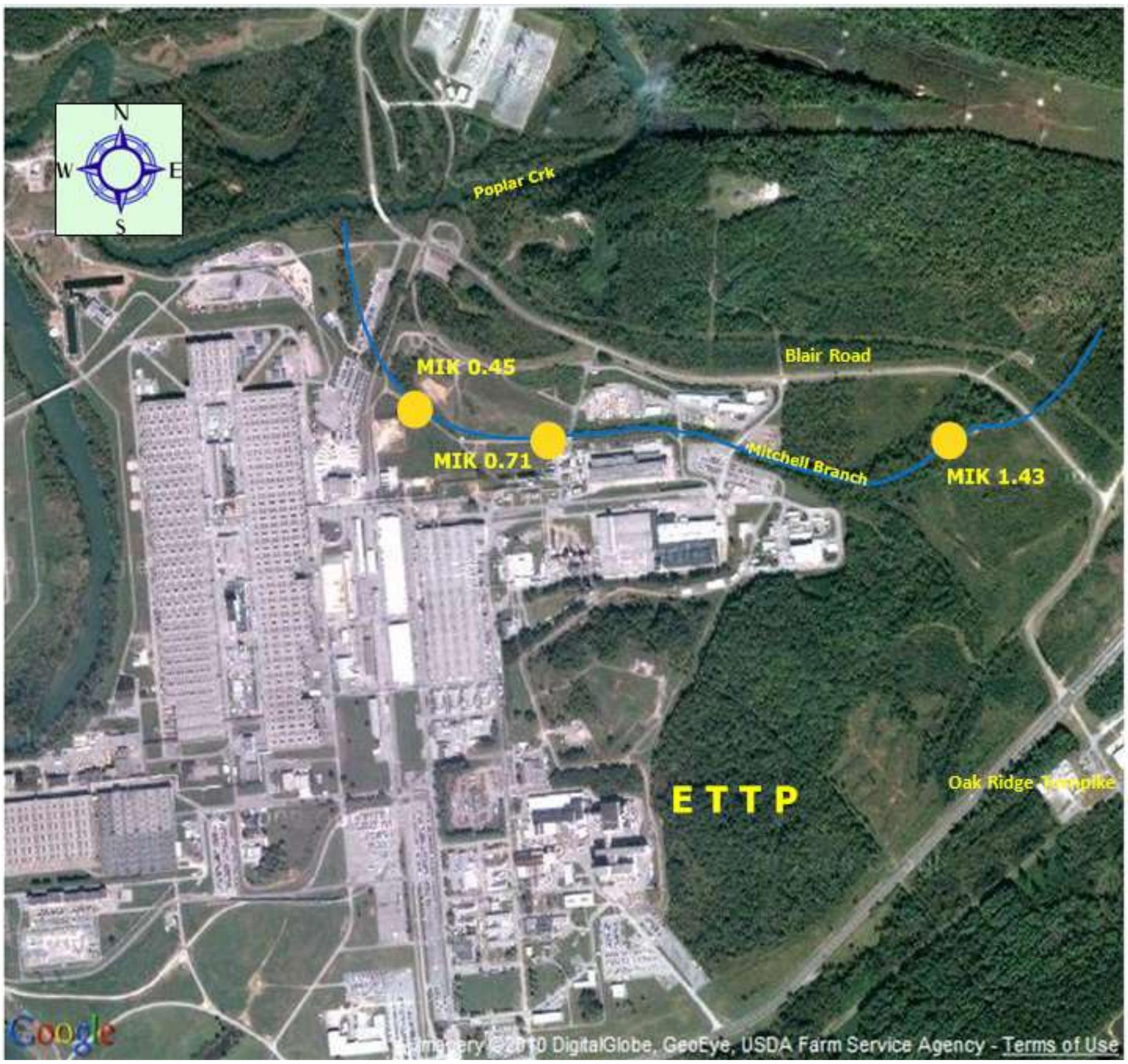

Figure 5: Mitchell Branch Watershed (ETTP)

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White-tailed Deer Monitoring on the Oak Ridge Reservation

Introduction

Whitetail deer continue to bioaccumulate and biomagnify contamination from legacy waste management areas on the Oak Ridge Reservation (ORR). During 2015, the Tennessee Department of Environment and Conservation, Department of Energy Oversight Office (DOE-O) will continue capture and GPS collaring of ORR white-tailed deer. The primary objective is to track the movements and determine the home ranges of individual deer and distances to offsite areas that they visit and potentially transport contamination. A secondary opportunistic objective will be to collect deer tissue samples for analysis to compare to geospatial data. Inferred contamination pathways to human and ecological receptors will be evaluated against DOE Orders and entered into CERCLA reviews for operable units on the ORR.

Figure 1: TDEC staff observe a deer swimming across the Clinch River. (TDEC Photo)

Methods and Materials

Field activities will commence following the final Oak Ridge Wildlife Management Area deer hunt and state-wide deer hunts (approximately January 15th). This prevents human consumption of the immobilizing chemicals from legally harvested deer. Five does (Nicole #14, Ophelia #15, Penelope #16, Quey #17, Renee' #18) were collared and tagged during 2014. Penelope (#16) lost her collar but it was recovered with data prior to the programmed release date. Another collar (Nicole's, #14) is scheduled to drop off in January 2015 to be retrieved. Three existing deployments (Ophelia #15, Quey #17, Renee'#18) are programmed to detach in 2016. One deer (Elizabeth #6) still has a deployed collar from 2012 that did not detach. Four deer will remain collared after this year's retrievals. An additional five Telonics store-on-board global positioning system (GPS) collars will be deployed during 2015 and programmed to make a total of nine collars to be retrieved for 2016. All the collared deer are located in the Melton Valley area of the Oak Ridge National Laboratory. When collars are recovered, GPS data are downloaded for analysis. This project will be evaluated in its entirety for data robustness to meet objectives and potentially finish with a 2016 summary report for the multiyear project. Recovered collars will be returned to Telonics, Inc. (Mesa, Arizona) to be refurbished for redeployment if the project continues in Melton Valley or other areas as determined.

Figure 2: Elizabeth, a whitetail doe with ear tag #6 and GPS collar as recorded on a game camera, 07/09/2014. (TDEC photo)

Following the DOE Oversight Standard Operating Procedure (TDEC 2013), chemical immobilizing drugs will be delivered to the deer using the Pneu-dart 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

Transporting Dart Projector:

- *The projector looks like a firearm.*
- *When not in use the projector must be transported in a case.*
- *The projector must be under control of a person certified in its use and immobilization of animals,*
- *Call ORNL LSS upon ingress and egress to Melton Valley.*
- *Call ETTP PSS upon ingress and egress to other ORR areas under ETTP jurisdiction.*
- *Call Y-12 PSS before transporting projector on the ORR near Y-12 boundaries; do not transport the projector through Y-12 checkpoints.*
- *Detailed documentation of equipment, SOPs, and current operational area is forwarded to DOE two weeks before field operations with the dart projector. This is to assure that security staff are aware of our project and related equipment and supplies.*

Darting Protocol, Abbreviated

1) Deer will be caught using a variety of methods:
    (a) Darting from vehicle or blind
    (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_2 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). A 2:1 mixture of 5.0 mg/kg Telazol® (i.e., Cyclohexamine immobilization agent, Fort Dodge Animal Health, Fort Dodge, IA, USA; Safe-Capture 2012) and 2.5 mg/kg Xylazine (i.e., neuroleptic tranquilizer drug, Fort Dodge Animal Health, Fort Dodge, IA, USA; Safe-Capture 2012). This solution is administered at one milliliter (ml) per 85 pounds (lbs.). A typical dose for a 120 lb. deer is 1.5 ml of this mixture. 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.

Figure 3: 1.5 cc dart type C, (top) for remotely dispensing immobilizing chemicals to whitetail deer with the Pneu-dart Model 389 Projector (bottom). This project uses the barbed version of the dart. Equipment details are sent to DOE security prior to field work. (Pneu-dart photos.)

Once the deer is 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 Pneu-dart 1.5 cc, barbed and 1 inch long needled darts (Pneudart®, Williamsport, Pennsylvania, USA). Darts will be delivered to the animal via the Pneu-dart model 389 projector at a distance ranging from 10 to 40m 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 sternal recumbency at all times. Additionally, hemoglobin saturation (SpO_2) and heart rate will be monitored by a pulse oximeter with a transmission probe placed on the tongue (Morandi and Nicoloso 2009) or by stethoscope and capillary recovery from pressing the gum. The reversal drug tolazoline will be administered 80 minutes following the initial telazol dose. Tolazoline should antagonize the effects of xylazine within 30 to 40 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. It is best if the deer continues to lie down as long as it wants until the recovery is complete and the deer is not apt to injure itself. This attendance is a precaution to prevent predators from feeding on the immobilized deer.

Clover Trap Protocol

Approaching deer in the trap causes immediate panic and therefore should be accomplished as fast as possible. Catching more than one deer at a time is a complication as the animals jump every which way bouncing off each other and the inside of the trap. It is difficult to control a multiple capture. If a situation arises where risk exceeds gain, it is better to turn the animal(s) loose. Antlerless deer can be restrained without immobilizing chemicals and released without a recovery period, a compensating benefit of trapping.

Figure 4: North Dakota biologists restraining a trapped whitetail deer. (Photo, North Dakota Game and Fish)

Trap Set-up:

Clover trap installation and set-up will be carried out 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 by biologists. This 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 projector. One person is designated as the restrainer or handler (especially if tranquilizing drugs are not used or 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 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.

Capture Procedure[a,b]:

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, sedate the animal with the dart projector set to 1 yard range configuration. Stick the muzzle end just through the netting to dispense the dart into the hindquarter, shoulder, or neck/shoulder area of the deer.
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 (six to ten minutes). 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 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.

[a] 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).

[b] Methods modified from James and Stickles (2010).

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. Eighty minutes after the initial Telazol injection, the reversal drug Tolazoline will be administered by syringe such that the animal should be on its feet within 30 to 40 minutes. These measures are designed to provide protection from predators while the deer is down.

Figure 5: Ophelia, tag #15, adorned with new GPS collar and ear tag. Space blankets maintain body temperature during immobilization. The blindfold calms the deer and protects the eyes from direct sun. (TDEC Photo)

Procedure for 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.

<u>Required Equipment (Deer Immobilization & Tissue Sampling)</u>

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
PneuDart 389 Projector	Super shears (leather cutter)
Stakes / small sledge hammer	Toolbox
Blankets (to cover deer)	PneuDart 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.

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 Environmental Monitoring Plan

Introduction

Mercury is one of the most prevalent contaminants of concern at contaminated sites in the United States (ATSDR 2007). The primary source of mercury exposure for wildlife and humans is eating fish (Rice et al. 2000). In aquatic ecosystems, methylating bacteria convert inorganic mercury to highly toxic methylmercury (Morel et al. 1998; Ullrich et al. 2001). Organisms at the base of the food web, such as phytoplankton and periphyton, absorb methylmercury directly from the water (Miles et al. 2001), whereas consumers, including fish, are primarily exposed to methylmercury through their diet (Hall et al. 1997; Tsui and Wang 2004).

Mercury has been found to possess high toxicity to aquatic organisms (Mason et al., 1996) and in its organic form, methylmercury (MeHg), has a large capacity for biomagnification along food webs either through uptake from water or diet (Rodgers and Beamish 1983, Wiener et al. 2003). Even though most of the Hg in freshwater environments consists of inorganic Hg, almost all of the Hg bioaccumulated in fish is MeHg (Choi et al., 1990). Methylmercury differs from the inorganic form in that it is more toxic, more mobile, more readily taken-up by aquatic organisms and it accounts for 95 – 99% of the total mercury that bioaccumulates in the muscle tissue of higher trophic level freshwater fish (Choi et al., 1990, Grieb et al., 1990; Bloom 1992, Munthe et al. 2007). Interestingly, some research suggests that Hg methylation can occur within the bacteria-laden fish gut and intestines (Rudd et al. 1980, Craig 1986, Winfrey and Rudd 1990, Boening 2000).

Absorption of MeHg through gills is a potential route of entry (Xun et al., 1987, Brezonik et al., 1991), although ingestion of food does seem to be the primary route. 85% to 90% of MeHg in fish and benthic invertebrates comes from food sources (Lawrence and Mason, 2001; Rodgers, 1994; Mason, 2001). Once MeHg has been taken up by organisms low in the food chain (such as phytoplankton and zooplankton), it is efficiently accumulated and transferred to organisms higher in the food chain (Gilmour et al., 1992, Benoit et al., 1998, Gnamus et al. 2000, Mason, 2001). Accumulation of MeHg by fish is of concern since consumption of MeHg-contaminated fish is the major route for transfer of mercury from the aquatic environment to fish-eating birds and mammals, including humans (Rodgers, 1994, Stewart et al. 2008).

Benthic macroinvertebrates play vital roles in lotic food webs by forming a major link between primary producers and higher trophic levels and in lotic ecosystems by regulating organic matter decomposition and nutrient cycling (Wallace and Webster 1996). Benthic insects are one group of organisms used to monitor metal exposures and assess biological contaminants in freshwaters (Cain et al. 1992; Hare 1992; Rosenberg and Resh 1993). Consumption of metal-contaminated benthic macroinvertebrates, such as *Hydropsyche*, can be a significant cause of chronic metal contamination in resident trout (Farag et al. 1995; Woodward et al. 1995). For example, Murphy (2004) demonstrated that algae, aquatic insects, crayfish, detritus, and fish accounted for 75-97% of the diet in fish (*Catostomus commersoni*, *Ictalurus punctatus*, *Lepomis auritus*, and *Micropterus dolomieu*) collected in the mercury-contaminated South River and South Fork of the Shenandoah River and in the uncontaminated North River, located in the Shenandoah River Basin, Virginia.

Statement of the Problem

Metal contamination can reduce benthic macroinvertebrate species richness, as well as density, growth and production (Maret et al., 2003; Gray and Delaney, 2008). Heavy metals can be accumulated which can affect predator-prey interactions in macroinvertebrate (Clements, 1999) and fish communities (Freund and Petty, 2007) through the food web. Accordingly, a shift in community composition from sensitive to tolerant taxa can occur when aquatic ecosystems are contaminated by heavy metals, thereby affecting the whole food web (Beltman et al., 1999).

In May 1985, a National Pollutant Discharge Elimination System (NPDES) permit was issued for the Y-12 Complex. As a condition of the permit, biological monitoring of aquatic life was developed (i.e., biological monitoring and abatement program, BMAP) to demonstrate that the effluent limitations established for the Y-12 Complex protect the receiving stream, East Fork Poplar Creek (EFPC), and in particular, the growth and propagation of fish and aquatic life (Loar et al. 1989). Thus, annual sampling of fish and macroinvertebrates continues to the present day.

Historic contaminant releases from the Y-12 Complex into East Fork Poplar Creek (EFPC) has resulted in exposure and impacts to higher trophic levels because fish and benthic macroinvertebrates are missing key species indicative of unimpaired streams and are numerically dominated by pollution-tolerant organisms (Peterson et al. 2013). Since 1985, the BMAP stream monitoring efforts collected annual macroinvertebrate and fish samples (i.e., redbreast sunfish, rock bass, bluegill, and stonerollers) and identified mercury and PCBs at elevated levels in fish fillets that pose human health and terrestrial wildlife concerns (see Table 1; Loar et al. 1992, Hinzman et al. 1993, Sample et al. 1996, Southworth et al. 2000, 2011). It was determined that Hg bioaccumulation in fish did respond to decreased Hg inputs in the Y-12 headwater reach, but paradoxically increased in the lower reaches of EFPC; PCB concentrations in fish generally decreased downstream (Southworth et al. 2000, 2011).

When fish tissue samples show levels of a contaminant higher than established criteria, the water body is posted and the public is advised of the danger. Table 1 shows current criteria used for issuing fish consumption advisories in Tennessee.

Table 1: State of Tennessee fish tissue advisory criteria

Contaminant	Level (ppm)
PCBs	1.00
Hg	0.50

The rigorous BMAP fish and macroinvertebrate sampling program has provided robust annual diversity and analytical data (e.g., fish fillets) for the evaluation of ORR stream recovery. However, little or no baseline data exist regarding fish gut (stomach) contents such as: (1) taxonomic identification of ingested prey items, and (2) Hg and PCB analytical data of gut contents (for comparison to fish fillet data). This new information will likely enhance our understanding of the ecology and trophic relationships associated with the ongoing abatement and recovery of impaired ORR streams.

Objectives

1. Determine the taxonomic identification of principal diet items found in each fish stomach
2. Assess Hg, MeHg and PCB content of fish gut contents from ORR and control streams
3. Compare Hg, MeHg and PCB fish gut analytical data with fish fillet analytical data

Methods and Materials

The US Environmental Protection Agency quality assurance project plan (USEPA QAPP) for this project is based upon: (1) Rapid Bioassessment Protocol for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish. Chapter 8: Fish (USEPA 1999), and (2) Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1: Fish Sampling and Analysis, 3rd edition (USEPA 2000). Recent studies have shown that analysis of stomach contents of benthophagous fishes can be an important strategy in taxonomic surveys (Russo et al., 2002; Tupinambás et al., 2007; Santos et al., 2009) and contaminant bioaccumulation studies (Peterson et al. 2013) because fish exploit a wide variety of microhabitats. To evaluate the importance of fish gut analyses for taxonomic inventories of benthic macroinvertebrate communities, stomach contents of fish species will be investigated (Maroneze et al. 2011). In cooperation with the Oak Ridge National Laboratory Natural Resources Management Team (ORNL NRMT), obtain gut samples from ORR stream fish (electro-shocked) collected specifically for the purpose of diversity analysis and fish fillet bioaccumulation studies. Table 2 lists the anticipated 2015 fish sampling locations, expected analytes and fish species. Figure 1 shows locations of EFPC and associated control streams.

Staff biologists will receive fish stomach samples collected by the ORNL NRMT during their spring and fall fish-shocking in ORR and control streams. Sacrificed fish may also be available as additional samples. After fish gut samples have been secured from the ORNL NRMT, samples will be kept frozen until time for post-processing. If the number of fish gut samples per species is adequate, and for example, assume 10 rockbass gut samples are collected, then 5 would be used for diversity analysis of ingested prey items and the remaining 5 rockbass gut contents would be used for Hg, MeHg and PCB laboratory analysis.

Table 2: Potential fish monitoring sites and respective laboratory analyses

	Stream km	***Analytes***	***Expected Species***
EFPC	24.4, 23.4, 18.7, 13.8, 13.0, 6.3, 0.0	PCBs Hg/ MeHg	Redbreast sunfish, rockbass, bluegill, stonerollers, other species if collected
Hinds Creek	20.6 (control)	PCBs Hg/ MeHg	Redbreast sunfish, rockbass, bluegill, stonerollers, other species if collected
Brushy Fork	7.6 (control)	PCBs Hg/ MeHg	Redbreast sunfish, rockbass, bluegill, stonerollers, other species if collected
McCoy Branch	1.9, 1.6, 1.4	PCBs Hg/ MeHg	Redbreast sunfish, rockbass, bluegill, stonerollers, other species if collected
Bear Creek	12.4, 9.9, 3.3, NT-3	PCBs Hg/ MeHg	Redbreast sunfish, rockbass, bluegill, stonerollers, other species if collected

Laboratory Procedures: Fish Gut Contents Extraction

Field and laboratory methods for fish gut extraction will follow several methods which have been developed to investigate the stomach contents of fish, including gastroscopes, tubes, stomach suction, stomach flushing, emetics, and chronic fistulas (Strange and Kennedy 1981, Light et al.

1983, Wasowicz and Valdez 1994, Hartleb and Moring 1995, Kamler and Pope 2001, Waters et al. 2004). Techniques have also been devised which enable removal of fish stomach contents with forceps (Wales 1962). 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). Fish mainly accumulate mercury through dietary pathways (Jernelöv and Lann 1971; Phillips and Buhler 1978; Rodgers and Beamish 1982; Harris and Snodgrass 1993; Hall et al. 1997). Given that most of our samples will be fish guts, then the only tools necessary will likely be forceps and scalpels for dissection and extraction of gut contents. Each stomach content sample will be frozen separately in individual plastic bags, sealed, and labeled. All field and laboratory work associated with this program will be in compliance with the office's Health, Safety, and Security Plan (Yard 2014).

Laboratory Analyses

Preparation of samples for analysis will be conducted in the TDEC DOE-O lab for later delivery to the State laboratory for analysis. Samples will consist of fish gut contents for individual species or for a homogenized fish composite (ideally five fish) for each site. Analyses for PCBs and mercury will be conducted on each sample. In situations where five fish cannot be collected from a location, a minimum of a three fish composite will be used if possible.

Gut content samples for Hg and PCB laboratory analyses will be kept frozen until shipment to the analytical laboratory (samples will be shipped overnight packed in dry ice). Gut content samples for diversity analysis will be preserved in alcohol until taxonomic analyses are conducted. Standard entomological, periphyton, zoological and botanical literature will be used to process and key out taxa to the lowest taxonomic level possible. Microscope slides of *Chironomidae* specimens (if found) will be prepared to enable taxonomic identification of midges.

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 Tennessee Department of Health's Laboratory Service in Nashville. Wet chemistry and metals samples and organics samples will be sent to the laboratory for analysis. 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 manuals for the Tennessee Laboratory Services Division. The SOPs direct analysts to the proper EPA or other methodology. The cornerstone QAPP for laboratory procedures will generally follow Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1: Fish Sampling and Analysis, 3rd edition (USEPA 2000).

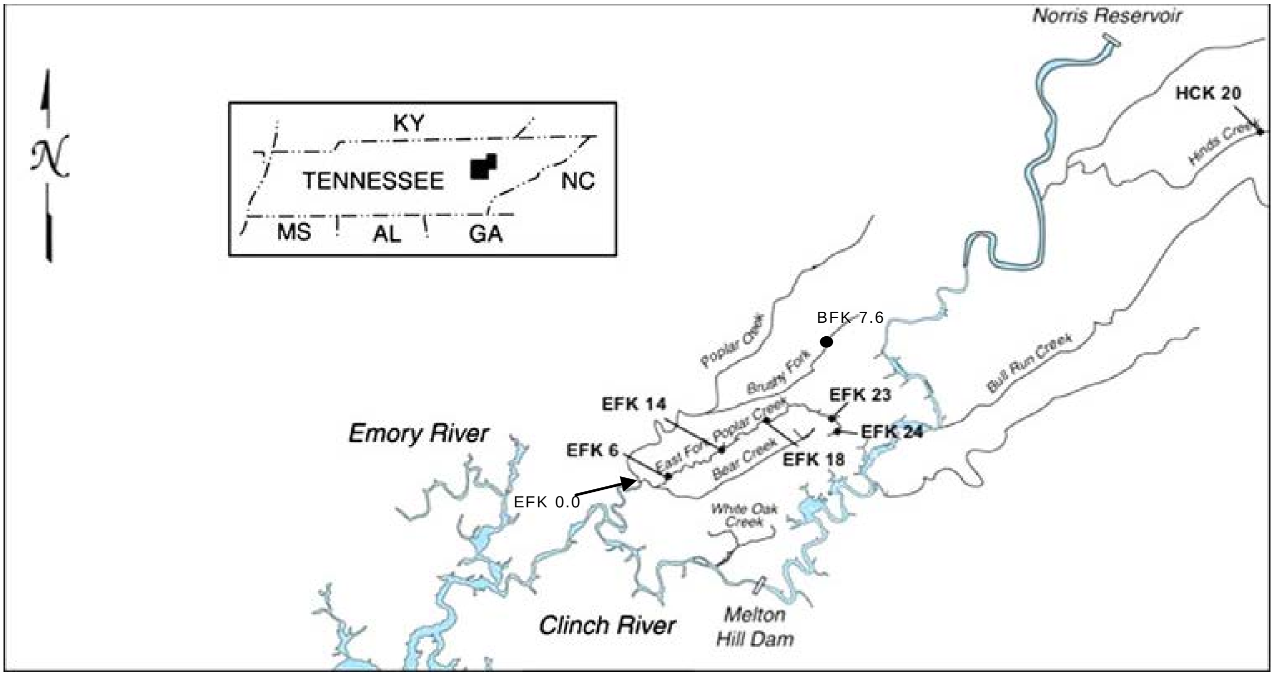

Figure 1: Fish monitoring sites in East Fork Poplar Creek

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Fungi Monitoring in East Fork Poplar Creek

Introduction

Heavy metal concentrations in fungi (mushrooms) are considerably higher than those in agricultural crop plants, vegetables, and fruit (Zhu et al. 2011). The main parts of the mushroom fruiting body consists of the cap, ring, stem, and the cup (Figures 1-a and 1-b). The mycelium is the underground vegetative part of the fungus, consisting of a mass of branching, thread-like hyphae, which allows the fungus to absorb nutrients, metals and minerals (Stijve and Besson 1976). 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; Kalaˇc and Svoboda 2000; Falandysz et al. 2003; Dursun et al. 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 Bielawski 2001, Falandysz and Brzostowski 2007). Svoboda et al. (2006) observed mercury concentrations of 2.6 mgkg 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, 2007, 2011, 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, Soylak et al. 2005, Falandysz et al. 2007).

To the best of our knowledge, metals content of fungi (e.g., mercury), has seldom been investigated on the Oak Ridge Reservation (ORR). Specifically, some questions to be answered: Is there a statistically significant difference between Hg concentrations in ORR fungi (i.e., fruiting bodies) compared to control fungi? Can we determine if atmospheric Hg is playing a role? That is to say, is there a statistically significant difference between atmospheric Hg-uptake in control site fungi samples compared to Hg-uptake in EFPC floodplain fungi samples? Lastly, assume Hg-laden edible mushrooms (e.g., morels) are collected and consumed by recreational users of the EFPC floodplain, does this scenario pose a human health risk due to Hg ingestion?

Mushroom samples will be collected seasonally (i.e., spring, summer and 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. Because there are >10,000 described species of mushrooms in North America (>75,000 species worldwide), we seek to enhance our ecological and botanical knowledge of mushroom and fungi species present on the ORR. To that end, we may also collect fresh mushroom specimens to process fungal tissue for DNA analysis using the latest genetics technology for both documenting biodiversity and molecular systematic studies (Dentinger et al. 2010).

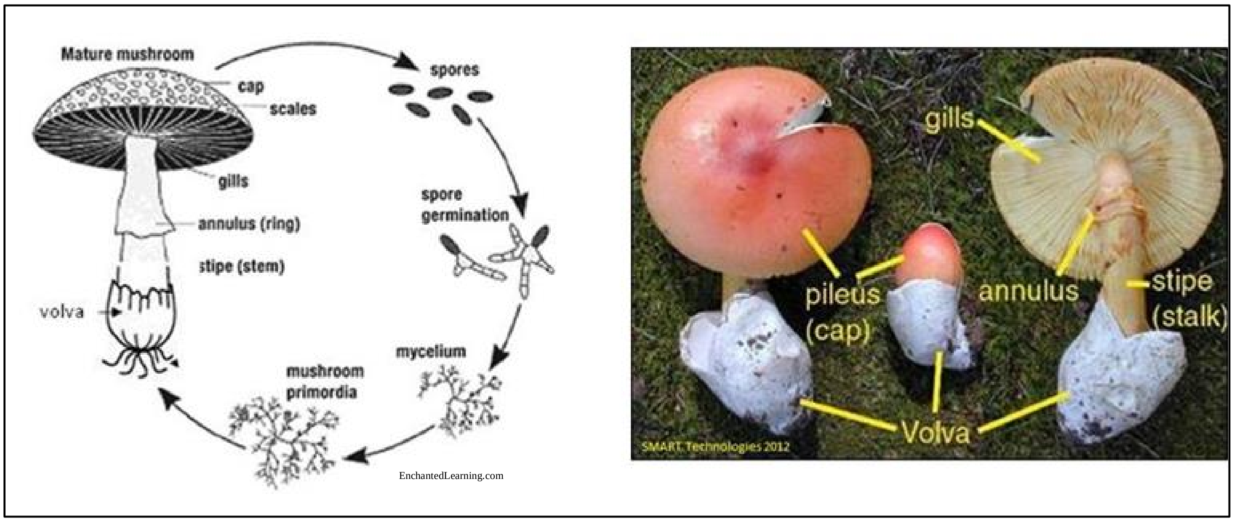

Figure 1-a and 1-b: Mushroom morphology and reproduction

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

Table 1: Tentative sampling sites at East Fork Poplar Creek and their descriptions

Methods and Materials

Parameters to be analyzed:

Inorganics: mercury, methyl mercury

DNA Method: Methods for identifying species by using short orthologous DNA sequences, known as DNA barcodes, have been proposed and initiated to facilitate biodiversity studies, identify juveniles, associate sexes, and enhance forensic analyses (Kress et al. 2005). The nuclear internal transcribed spacer (ITS) is one of the main DNA regions for applying barcoding in plant phylogenetic investigations at the species level and shows high levels of interspecific divergence (Kress et al. 2005). DNA-fingerprinting has been successfully used to detect hypervariable, repetitive DNA sequences (minisatellites and microsatellites) in fungi (Meyer et al. 1993). Combined with methods used to identify random amplified polymorphic DNA (RAPD), conventional DNA-fingerprinting hybridization probes can also be used as single primers to detect DNA polymorphisms and enables the differentiation and clarification of taxonomic relationships among fungal species and strains (Meyer et al. 1993). DNA extraction will follow one of two methods. One is to extract DNA from fresh mushrooms using Whatman FTA® cards (DNA-absorbing filter paper) which combines with a commercial DNA extraction kit (Sigma Extract-N-Amp™ Plant PCR Kit) that reliably provides PCR-ready DNA in ten minutes from fresh mushrooms. This method enables processing of newly collected tissues prior to specimen preservation, thereby maximizing the quality of isolated DNA (Dentinger et al. 2010). The second method relies on enzymatic extraction of dried samples without requiring extensive grinding of the material beforehand, simplifying the extraction process and making it adaptable to a 96-well DNA plate format (Dentinger et al. 2010).

These two high-throughput protocols for DNA extraction from mushrooms can provide rapid and reliable methods for generating ITS (internal transcribed spacer) barcodes and for systematic studies. Because mushrooms are filamentous fungi, these methods will enable rapid processing of most fungi for studies using DNA (Dentinger et al. 2010). We will likely use the second method because it will be much more practical to use dried specimens that can be shipped to a laboratory that specializes in DNA analysis.

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. 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), Yard (2011), and Vinichuk (2012).

Mushroom Standard Operating Procedures

In the field, entire fungal sporocarps (i.e., fruiting body, mushrooms) will be hand collected from 12 EFPC sampling plots and four reference plots during 2015. Sampling sites were partially selected based upon elevated concentrations of Hg (>400 ppm) present in EFPC floodplain soil samples (OREIS Database; Figures 6 and 7). The literature suggests that each plot will be approximately ten square meters and additional subplots may be added if mushrooms are sparse and additional sampling is necessary to bolster fungal biomass for laboratory analyses. During field sampling events, a broad survey of each site will be conducted to determine the quantity and quality of available fungi material. The goal is to collect enough fungi material to provide an approximate five 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 carefully extracted from the soil (or cut at the soil surface) with plastic, glass or pottery instruments to avoid any metal contacts that can influence the results (Elekes et al. 2010).

Freshly collected fruiting bodies will be washed with deionised water to remove extraneous material (i.e., plant and substrate debris) and cut with a clean plastic knife in small pieces (Falandysz et al. 2004). Next, the samples will be dried at 60°C between 12 and 15 hours 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. All samples will be analyzed for total mercury. If enough sample material is available, then methylmercury and DNA analyses will also be conducted. 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). DNA processing of fungi samples will follow the suggested protocols of Meyer et al. (1993), Kress et al. (2005), and Dentinger et al. (2010).

Figure 2: Tentative mushroom sampling locations (Map 1)

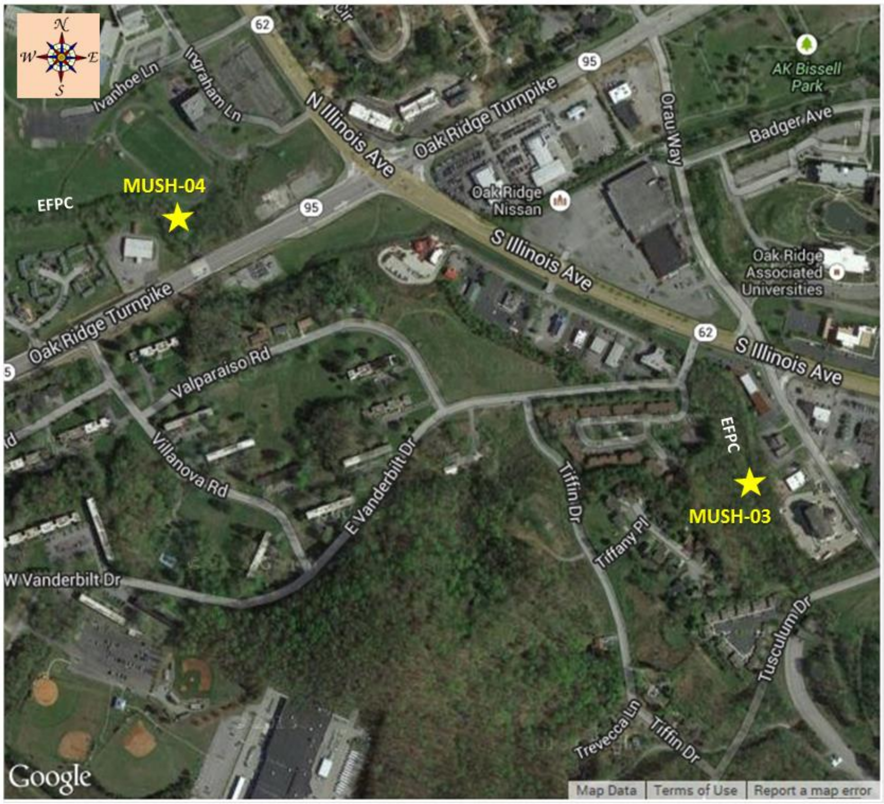

Figure 3: Tentative mushroom sampling locations (Map 2)

Figure 4: Tentative mushroom sampling locations (Map 3)

Figure 5: Tentative mushroom sampling locations (Map 4)

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

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

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). 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 Tennessee Department of Health's Laboratory 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. Methylmercury samples are typically farmed-out and analyzed by Brooks-Rand Laboratory, Seattle, Washington.

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Acoustic Monitoring of Bats on the Oak Ridge Reservation

Problem Statement

There is a paucity of available information regarding the distribution and occurrence of bats in the southeastern United States, including bat species that may be present on the Oak Ridge Reservation (ORR). Although the presence of the federally endangered gray bat (*Myotis grisescens*, MYGR) has been documented on the ORR, the status of the federally endangered Indiana bat (*Myotis sodalis*, MYSO) and knowledge of the overall bat community is less well known. Previous ORR bat investigations have been limited by short term (3-4 nights) surveys of mist-netting and acoustic surveys at the U.S. Department of Energy's (DOE) ORR project sites (to meet the requirements of section 7 of the Endangered Species Act of 1973), and thus no sustained, extensive monitoring data is available. Further, the Northern Long-eared bat (*Myotis septentrionalis,* MYSE), of special interest to bat ecologists, is currently under consideration for listing as a federally endangered species by the U.S. Fish and Wildlife Service. Information gained from this study will not only address the missing data gaps but also provide critical occurrence information for the endangered species and for the MYSE listing process.

Introduction

Bat populations are in decline globally. Factors contributing to the decline of bat species include stream channelization, cattle farming, deforestation, cave vandalism, insecticide poisoning, urban expansion (Gardner and Hofmann 1986), and, more recently, cave bat populations have been decimated by white nose syndrome disease (WNS).

Bats in the southeastern United States use ultrasonic echolocation to locate prey and navigate in their surroundings (Britzke 2003), often in complete darkness. During summer nights, bat roost-emergence and feeding activity commonly peaks immediately after sunset and can continue for several hours (Kunz 1973, Barclay 1982). Ultrasonic (acoustic) 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).

Populations of bats are commonly monitored acoustically because many species echolocate while foraging at night. Identifying bat species from their echolocation calls is desirable for management of biodiversity and compliance with environmental regulations (Agranat 2012). Further, this technology has improved conservation efforts by providing increased knowledge of bat ecology and efficiently-characterized bat occurrence at study sites. Data downloaded from bat detectors is analyzed with automated software programs that compare the recorded data to built-in call libraries of bat species to enable likely species identifications. Echolocation calls of most southeastern bats can generally be considered as species specific based upon call characteristics. However, it is often challenging to obtain accurate species identifications with the automated software programs because variation of calls within species (i.e., intraspecific variation; also geographic variation), often resulting in overlap among species, sometimes makes them indistinguishable from others (Barclay 1999). O'Farrell et al. (2000) demonstrated that statistically significant differences were found between hoary bats recorded in different locations, however they concluded that whatever variation exists does not affect the ability to identify these bats acoustically.

Study Site

The study will be conducted on the ORR which is a 34,000-acre site owned and operated by DOE. The site is nestled in the ridge and valley physiographic province of east Tennessee (Anderson and Roane counties). Geologically, the ORR bedrock consists of thrust faulted and folded limestone, siliceous dolomite, siltstone, shale, and sandy shale. Given that much of the ORR consists of carbonate bedrock, there are well developed karst features such as caves and sinkholes. Approximately 60 caves have been documented on the ORR (McCracken et al. 2013). Therefore, acoustic surveys of some ORR cave entrances will be conducted on multiple nights to determine species. It is important to note that ORR caves will not be entered at any time due to the current issues with the white nose syndrome.

Objectives

1. Conduct field habitat assessments on the ORR and identify likely Indiana bat (MYSO) roosting habitat for acoustic monitoring. Specifically, MYSO may form maternity roosts in sunlit trees and standing snags with exfoliating or loose bark during summer and then hibernate in caves during winter (Menzel et al. 2001, Timpone et al. 2010). Bat habitats for other species will also be identified for acoustic monitoring such as:
    a) Caves & abandoned mine works
    b) Rock bluffs and outcroppings
    c) Bridges & tunnels
    d) Field/forest edge
    e) Culverts/storm sewers
    f) Forest corridors (linear features: fence lines, access roads, trails)
    g) Waterways (wetlands, ponds, streams, rivers)
    h) Abandoned buildings

    (LaVal et al. 1977, Racey 1998, Grindal and Brigham 1999, Menzel et al. 2005)
2. Monitor field stations identified in #1 above utilizing acoustic bat detector equipment and determine species present on the ORR.
3. Determine the occupancy and location of endangered species on the ORR.
4. Collect bat echolocation calls 24/7 at pre-selected ORR caves (with known bat populations) for one full year in an attempt to detect potential erratic behavior which could be an indication of WNS-infected bats.

Information gained from this study will fill the missing data gaps but also provide critical occurrence information for the endangered species and for the MYSE listing process.

Methods

This project will generally follow 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, USFWS 2014). 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's Natural Resources Management Team (ORNL NRMT). Accordingly, we propose the following bat survey methods:

- Bat roost 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. This activity will involve field walk-downs especially of forested sections of the ORR with known karst features.
- Active acoustic surveys (attended) with detectors on station for 3-5 hours following sunset (Wear 2004, Ford et al. 2005, Schirmacher et al. 2007). Extend detachable microphones on tripods or painter poles wherever possible to reduce ground clutter and ultrasonic insect noise.
- Passive survey at fixed-point locations (unattended) recording bat echolocation calls overnight (program detectors to record bat calls from dusk 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 deployed several feet off the ground on tripods or painter poles to reduce recording ultrasonic insect clutter (Weller and Zabel 2002).
- Co-monitor 10% of ORR field sites in cooperation with the ORNL NRMT.
- Hobo Pendant® data loggers (Onset Computer Corporation, Bourne, MA) will also be deployed during unattended active surveys for overnight recording of light and temperature data.
- 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). Thus, we will likely deploy two detectors at some overnight sites, such as caves, with each detector oriented five meters 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.

Field Equipment
- Anabat SD-2 bat detector (Titley Scientific, Columbia, MO)
- Anabat Roost Logger (Titley Scientific, Columbia, MO)
- AnaBat Express detector (Titley Scientific, Columbia, MO)
- SongMeter SM2BAT+ detector (Wildlife Acoustics, Maynard, MA)
- SongMeter SM3BAT detector (Wildlife Acoustics, Maynard, MA)
- EchoMeter EM3+ detector (Wildlife Acoustics, Maynard, MA)
- Waterproof lockable boxes for Anabat equipment
- Tripods & painter poles for microphone extension
- Headlamps, high candlepower flashlights, extra batteries
- Security locks & cables to protect detectors from theft or damage
- GPS, insect repellant, field notebook, etc.

Laboratory Equipment (software analysis)
Anabat data files will be analyzed with several software programs to produce preliminary bat identification output: BCID-East (Bat Call Identification, Inc., Kansas City, MO), Kaleidoscope PRO (Wildlife Acoustics, Maynard, MA), and EchoClass v.2 (U.S. Army Engineer Research and

Development Center, Vicksburg, MS). All these programs have been sanctioned by the USFWS as candidate automated software programs which have passed the standardized test/validation process. A fourth program (Analook-W v. 4.1j, Titley Scientific, Colombia, MO) will be used to validate endangered species identifications such as MYSO and MYGR. 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.

Timetable
Mid-April: Commence roost and habitat surveys
Weekly: Conduct active & passive acoustic monitoring as time allows
October: Suspend main operations until following April

Cave Monitoring Timetable
January (1st week): deploy detectors at ORR caves
Fortnightly: check detectors (change batteries, download data)
December (last week): retrieve detectors

Health and Safety
Per the TDEC Health & Safety Plan, all field work will be conducted in teams of two or more biologists (Yard 2014). Appropriate training and pre-exposure rabies vaccinations will be required for those individuals that may handle bats while assisting with mist-netting surveys under another researcher's federal collection permit (USFWS 2011).

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Threatened & Endangered Species Monitoring

Problem Statement

The Endangered Species Act of 1973 (ESA) provides for the conservation of species (fauna and flora) that are endangered or threatened throughout all or a significant portion of their range, and the conservation of the ecosystems on which they depend. In the United States, there are 675 fauna federally-listed as threatened and endangered species (T&E species), and 886 flora federally-listed as T&E species.

Various species of fish, wildlife, and plants in the United States have been rendered extinct as a consequence of economic growth and development un-tempered by adequate concern and conservation. Of the approximately 1,561 species protected by the ESA, nine have been declared extinct within the past 30 years. However, 14 U.S. species have been declared recovered and removed from the ESA's T&E species list. The official list is in a near constant state of flux due to new listings and de-listings.

There are numerous federal- and state-listed T&E species on the U. S. Department of Energy's Oak Ridge Reservation (DOE; ORR) for which distribution, occurrence and habitat information is sorely lacking. For example, information is scarce regarding the distribution of two species of federally endangered bats (Indiana bat, Gray bat) which are known to be at risk due to white nose disease and habitat loss to development. Much less is known about the status of 17 species of federally endangered mollusks known to occur in the Clinch River. Additional information is also needed for the status of three species of ORR stream fish (spotfin chub, slender chub, and yellowfin madtom) listed as federally threatened.

Lastly, information regarding the occurrence and distribution of threatened and endangered wetland plants is scarce. This information is important not only for the conservation and protection of species, but also for the listing and delisting of species. For example, two vascular plants were recently delisted by TDEC: the pink lady slipper and goldenseal plants were formerly listed as special concern-commercially exploited. We know that the federal- and state-listed white fringeless orchid prefers an area with black, mucky, acidic, organic soil found most frequently in bogs (wetlands) at the head of streams or seepage slopes. Additional wetland species that are state-listed as endangered include the yellow fringeless orchid, small purple fringed orchid, large purple fringed orchid, snowy orchid, and state-listed as threatened, the tubercled rein orchid. Field data is sorely lacking for the occurrence of the federally-threatened (state-listed endangered) Hart's-tongue Fern, which prefers limestone karst features. The TDEC Division of Natural Areas has requested assistance with monitoring the valley flame crayfish on the ORR which is Tennessee-listed as threatened. There are many more state-listed T&E species that require further monitoring including mammals, salamanders, birds, fish, reptiles, and plants.

<u>Regulatory Drivers</u>

Endangered Species Act of 1976
National Environmental Policy Act of 1969 (EAs, EISs)
Clean Water Act 1977 (Section 404: Wetlands)
Tennessee Water Quality Control Act 1977
North American Wetlands Conservation Act 1989
Tennessee Natural Areas Preservation Act of 1971

Tennessee Nongame & Endangered Or Threatened
Wildlife Species Conservation Act of 1974
Rare Plant Protection & Conservation Act of 1985
Tennessee Wild & Scenic Rivers Act 1968
National Resource Damage Assessment (Black Oak Ridge Conservation Easement)

Introduction

Tennessee is one of the most biodiverse states in the nation, boasting over 300 species of fish, ≥80 mammal and 60 reptile species, ~70 amphibian taxa (including over 40 salamander species), >340 species of birds, 225 land snail taxa, 100 aquatic snail species, ≥120 mussel and 70 crayfish species, and thousands of insect taxa (Withers 2009). Endemism is high (i.e., the ecological state of a species being unique to a defined geographic location, other defined zone, or habitat type) with at least 74 animal species known only from Tennessee. Many other species exist on the periphery of their range in Tennessee (where evolutionary processes may act most quickly) or may range little outside of Tennessee (Withers 2009).

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). More than 1000 different species of plants grow on the reservation, reflecting its diversity (Mann et al. 1996). 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. According to the TDEC Division of Natural Heritage's species inventory for Anderson and Roane counties (location of the ORR), there are 93 state and/or federal listed species. Of these, 48 are fauna and 45 are flora.

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 30 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. Currently, most of the ORR is a wildlife management area (WMA), thus the BORCE site is co-managed by the Tennessee Wildlife Resources Agency (TWRA) and TDEC.

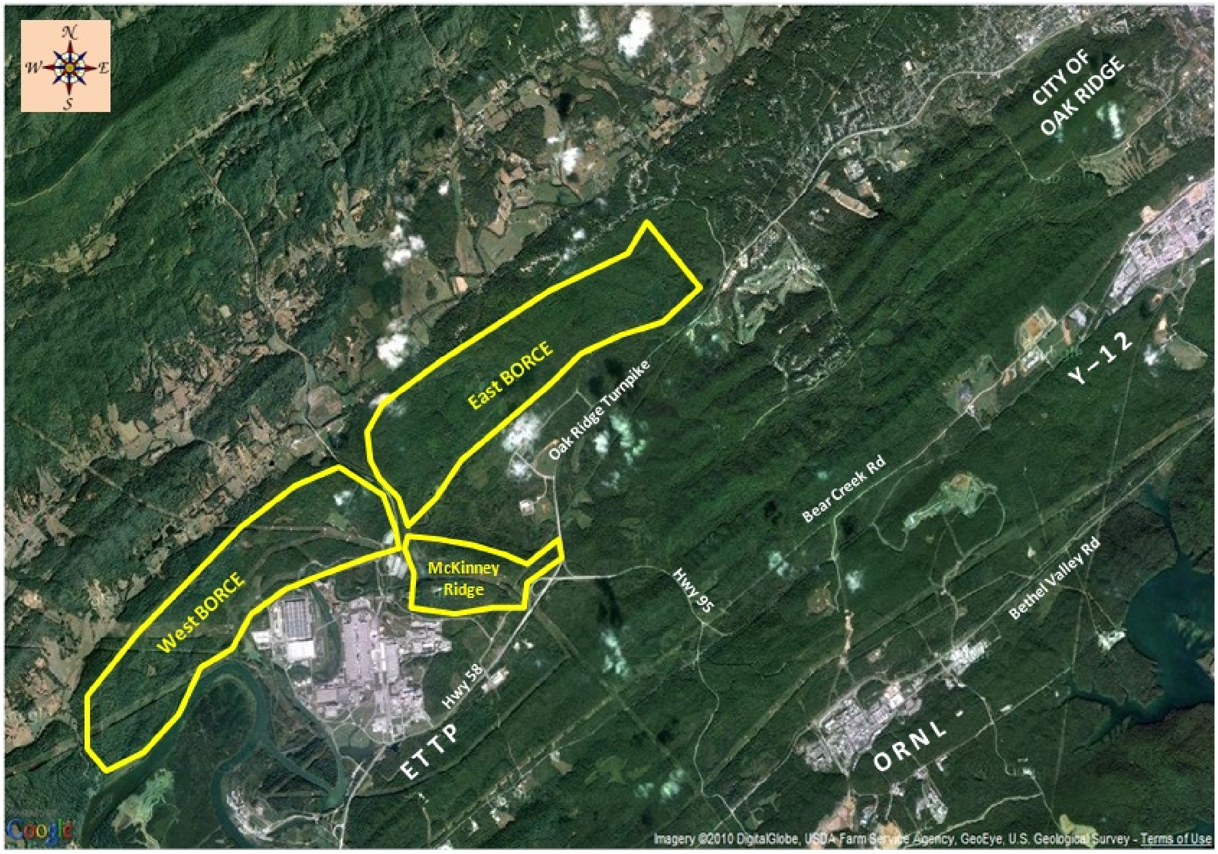

Figure 1: Black Oak Ridge Conservation Easement (BORCE)

Objectives

For 2015, project objectives 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 mapping of the botanical diversity that exists on the ORR, (3) independently monitor and verify biological survey information provided by DOE, and compliance with T&E species requirements per ESA and NEPA regulations, (4) identify and protect T&E species, wetlands 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.), (6) collect field specimens for the TDEC herbarium collection as necessary, and (7) identify areas of the ORR infested with exotic pest plants (Drake et al. 2002, TEPPC 2002).

Methods and Materials

During 2015, 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 Awl 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 sample 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 field methods and taxonomic identifications will follow methods per 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. Findings of T&E species will be reported to the TDEC Division of Natural Areas and TWRA.

Field monitoring methods and health and safety procedures will follow the guidelines in the office's Health, Safety, and Security Plan (Yard 2014).

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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 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*) and common cattail (*Typha latifolia*). 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 2015, 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. Further analysis may be conducted if warranted.

Methods and Materials

Aquatic vegetation samples will be collected at sites both on and off the ORR, the latter for background data for comparison. At least one gallon of vegetation 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 warranted.

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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 2015 to insure that the quality of the potable water is maintained.

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, due to the potential for contamination from the site to backflow into the system during leaks. Each site has agreed to provide 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

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-phenylenediamine (DPD) powder pillow (test reagent) is added to the sample container and gently shaken, 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 monthly at the Y-12 National Nuclear Security Administration (NNSA) facility, (Y-12) and the Oak Ridge National Laboratory (ORNL). If additional sampling is determined to be needed, 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 be conducted upon request or in case of line breaks/repairs. This is because the city of Oak Ridge accepted ownership of the system at ETTP.

As stated previously, if it is determined that cross connections, low chlorine residuals, line breaks/leaks, or other upset conditions have occurred that 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 organic, inorganic, and radiological constituents.

Bacteriological
The U.S. Environmental Protection Agency (EPA)-approved method for 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
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 nitrile exam gloves
- Hach Pocket Colorimeter Kit,
- Hach free chlorine DPD powder pillows
- bound field book
- state vehicle
- <u>Health, Safety, and Security Plan</u>
- sample bottles
- sampling cooler
- disinfectant (full strength) spray bottle

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

Table 1: Anticipated Sampling

SITE	CONSTITUENTS	FREQUENCY	NUMBER OF SAMPLES
Y-12	Free Chlorine	Monthly	1 per Month
	Bacteriological	As Needed	As Needed
	VOCs[1]	As Needed	As Needed
	Radiological[2]	As Needed	As Needed
	Mercury	As Needed	As Needed
ORNL	Free Chlorine	Monthly	1 per Month
	Bacteriological	As Needed	As Needed
	VOCs[1]	As Needed	As Needed
	Radiological[2]	As Needed	As Needed
	Metals including Mercury	As Needed	As Needed
ETTP	Free Chlorine	As Needed	As Needed
	Bacteriological	As Needed	As Needed
	VOCs[1]	As Needed	As Needed
	Radiological[2]	As Needed	As Needed
	Metals including Mercury	As Needed	As Needed

Note[1] = volatile organic compounds
Note[2] = gross alpha/beta and gamma will be collected.

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RadNet Drinking Water on the Oak Ridge Reservation

Introduction

In 2015, the Tennessee Department of Environment and Conservation's DOE Oversight Office, part of the Division of Remediation, will continue to monitor drinking water quarterly at four area water treatment plants through 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

EPA will provide radiochemical analysis of finished drinking water samples collected quarterly by office staff at four 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). 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 four Oak Ridge area locations monitored in the program are the Kingston Water Treatment Plant, West Knox Utility District, the City of Oak Ridge Water Treatment Facility at Y-12, and the Anderson County Utility Board Water Plant. The City of Oak Ridge Water Treatment Facility at East Tennessee Technology Park (ETTP) was shut down on September 30, 2014, and will no longer be a part of this program. Figure 1 depicts the approximate locations of raw water intakes associated with these facilities.

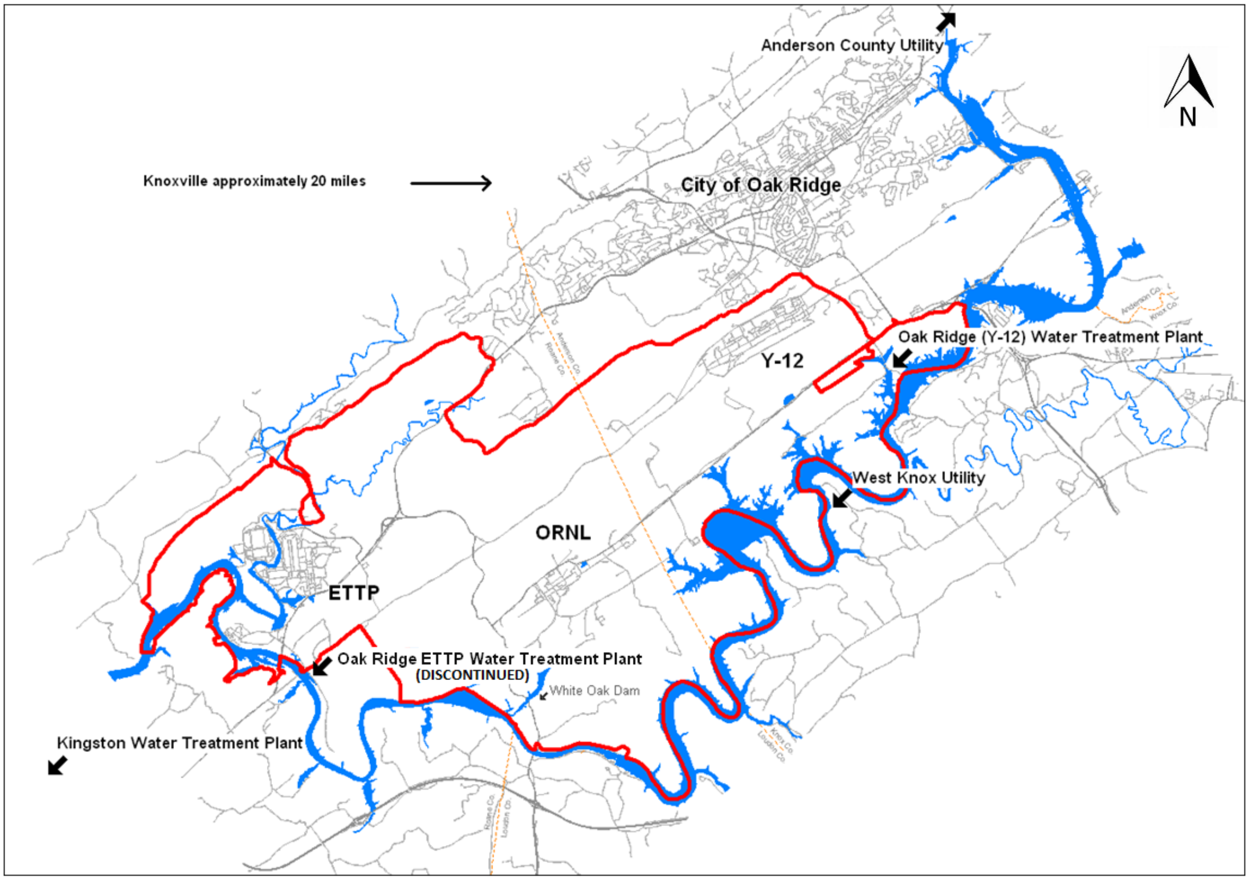

Figure 1: Approximate locations of the intakes for public water systems monitored in association with EPA's RadNet drinking water program

References

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GROUNDWATER MONITORING

Background Groundwater Determination for the Oak Ridge Reservation

Introduction

The Division of Remediation's Department of Energy Oversight Office (DOE-O), as established under the Tennessee Oversight Agreement (TOA) and the Federal Facilities Agreement (FFA), will conduct a background monitoring study of groundwater offsite of the Oak Ridge Reservation (ORR). This plan outlines the goals and parameters for DOE-O's first wide-scale background evaluation of groundwater.

Overview

The goal of this program is to evaluate chemical data, hydrogeologic characteristics, and geochemical parameters in order to estimate the upper bounds of background chemical concentration ranges and to identify and/or acquire datasets that adequately represent background conditions. In order to meet this goal, several tasks need to be performed. The first task is to identify upgradient residential wells that are from the same aquifers and that exhibit the same type of geochemical environments that exist at and downgradient of the Oak Ridge Reservation. Once the potential background groundwater locations have been identified, the second task is to sample enough times to collect sufficient data to determine the spatial (between wells) and temporal (over time) trends.

The sampling of background groundwater locations will aid in identifying both natural and anthropogenic processes that could result in elevated concentrations of various chemicals in otherwise unaffected groundwater. Sampling background wells might identify some compounds (radionuclides) may have been associated with previous airborne releases and therefore may not be associated with specific groundwater plumes. The airborne compound would be sparsely detected at low concentrations even in the upgradient wells.

One of the first and most critical requirements, when defining background water quality or making comparison against a compliance threshold is a clear and hydrogeologically defensible conceptual model of the site's subsurface architecture.

Site Conceptual Model

The Valley and Ridge Physiographic Province is characterized by a sequence of folded and faulted, northeast-trending Paleozoic sedimentary rocks that form a series of alternating valleys and ridges that extend from Alabama and Georgia to New York (USGS, 2014). Figure 1 shows the geologic map of the Oak Ridge Area (Lemiszki et al, 2013).

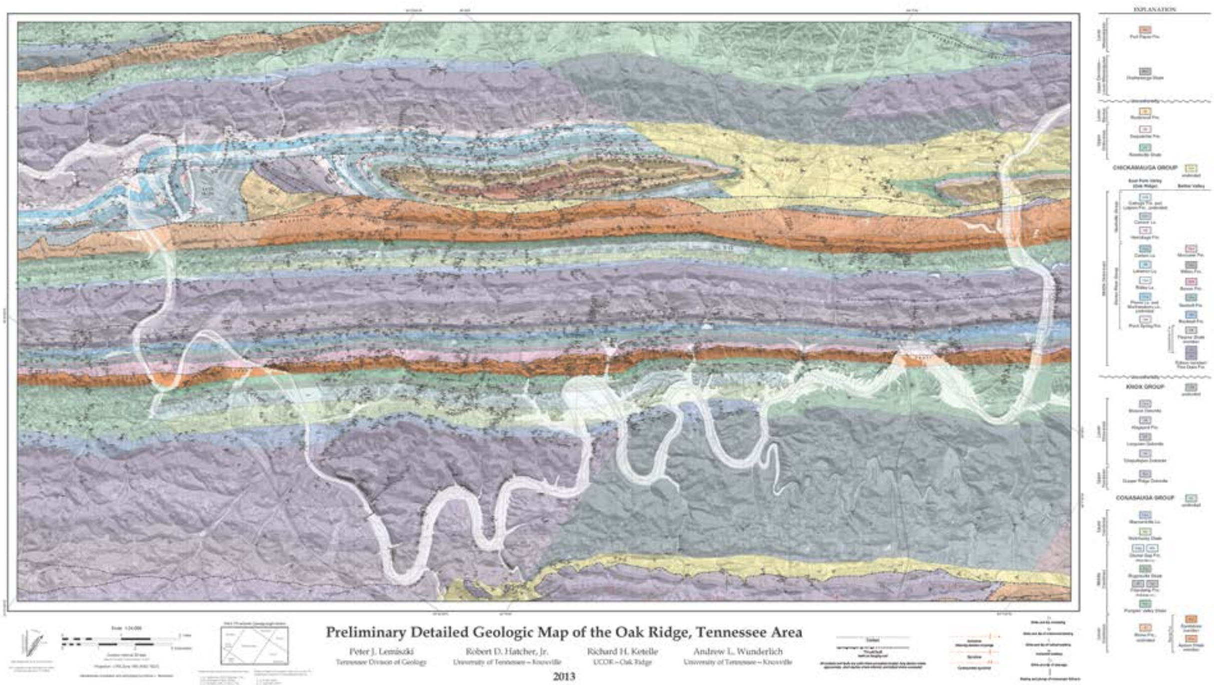

Figure 1: Preliminary Detailed Geologic Map of the Oak Ridge, Tennessee Area (Lemiszki et al, 2013)

The arrangement of the northeast-trending valleys and ridges and the broad expanse of the Cambrian and the Ordovician rocks in eastern Tennessee are the result of a combination of folding, thrust faulting, and erosion. The result of the faulting is that geologic formations can be repeated several times across the faults. For example, the carbonate-rock aquifers in the Chickamauga, the Knox, and the Conasauga Groups are repeated across the thrust faults. In eastern Tennessee, the thrust faults are closely spaced and are more responsible than the folds for the present distribution of the rocks. Following the folding and thrusting, erosion produced the sequence of ridges and valleys on the present land surface (USGS, 2014).

Ground-water movement in the Valley and Ridge Province in eastern Tennessee is localized, in part, by the repeating lithology created by thrust faulting and, in part, by streams. Major streams are parallel to the northeast-trending valleys and ridges, and tributary streams are perpendicular to the valleys and ridges. Older rocks (primarily the Conasauga Group and the Rome Formation) have been displaced upward over the top of younger rocks (the Chickamauga and the Knox Groups) along thrust fault planes thus forming a repeating sequence of permeable and less permeable hydrogeologic units. The repeating sequence, coupled with the stream network, divides the area into a series of adjacent, isolated, shallow ground-water flow systems. Within these local flow systems, most of the ground-water movement takes place within 300 feet of land surface. In recharge areas, most of the ground water flows across the strike of the rocks. The water moves from the ridges where the water levels are high toward lower water levels adjacent to major streams that flow parallel to the long axes of the valleys. Most of the ground water is discharged directly to local springs or streams, but some of it moves along the strike of the rocks, following highly permeable fractures, bedding planes, and solution zones to finally discharge at more distant springs or streams. Although fracture zones locally are present in the clastic rocks, the highly permeable zones, which are primarily present in the carbonate rocks, act as collectors and conduits for the water (USGS, 2014).

Several distinct flow intervals have been identified that occur within the water table aquifer on the ORR. These are the uppermost water table interval; the intermediate interval; the deep interval; and a transition to saline water or brine (DOE, 2014.) Figures 2 through 5 provide the conceptual/block models of Bethel Valley, Melton Valley, Y-12, and ETTP (DOE, 2014).

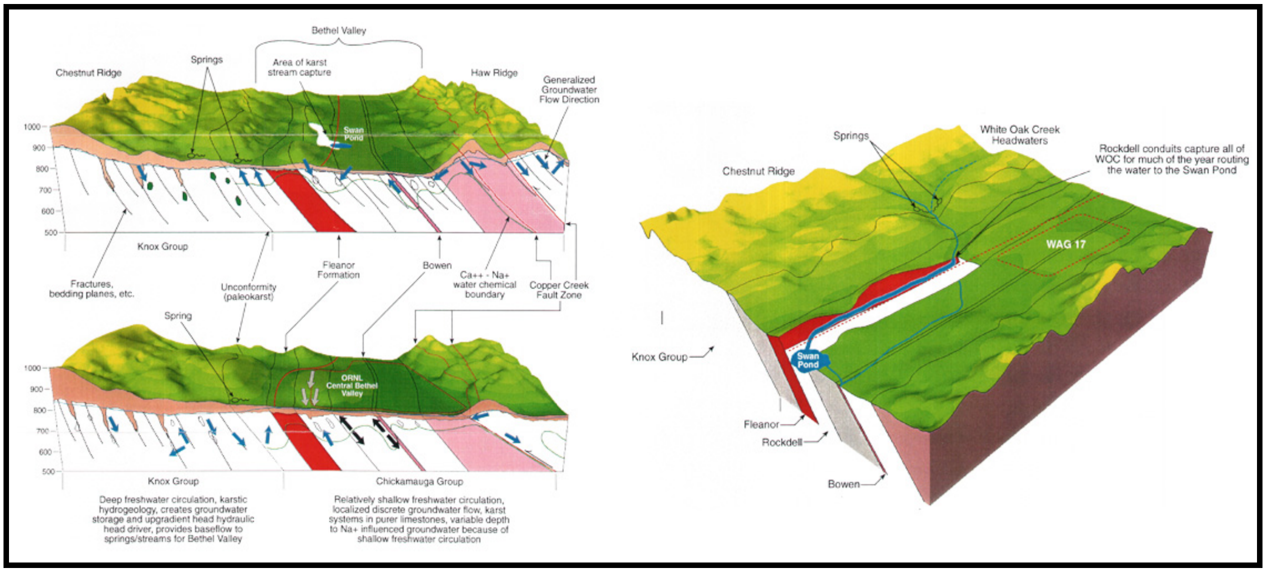

Figure 2: Bethel Valley Conceptual Model (DOE, 2014)

To aid with determining background, the hydrogeologic characteristics of a site determine the number of groundwater monitoring wells required and their locations. The depth of water, flow direction, net recharge rate, aquifer and soil characteristics, topography, thickness and lithology of the vadose zone, and hydraulic conductivity of the aquifer are all important in determining vulnerability of an aquifer and the necessary spacing and depth of monitoring wells.

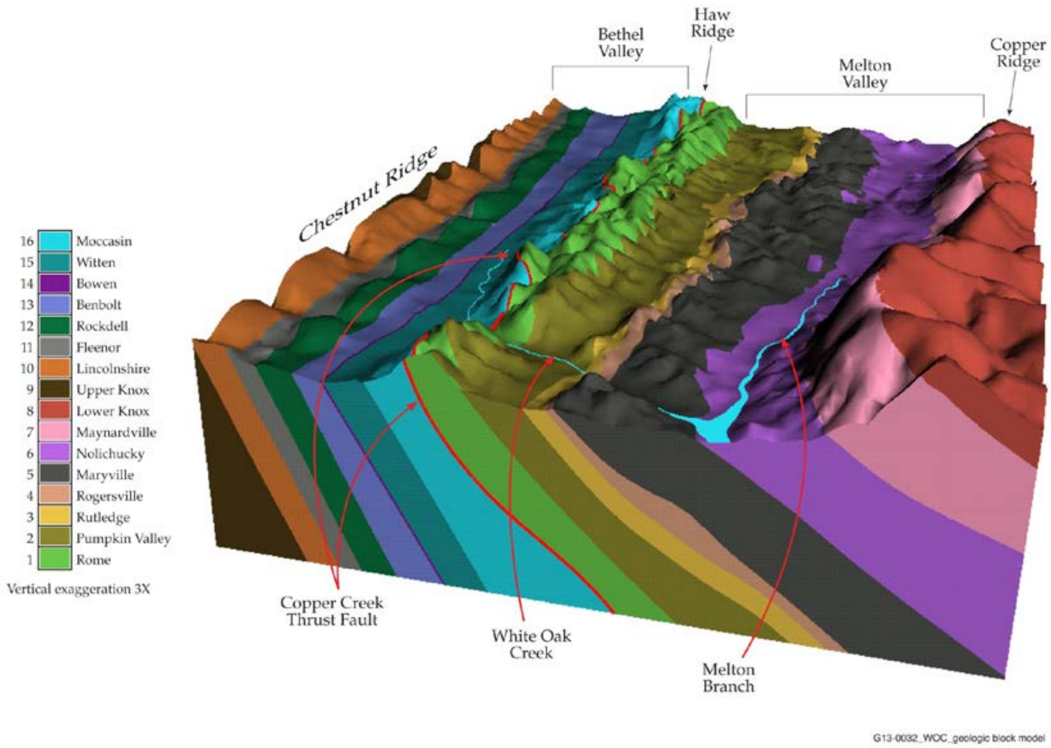

Figure 3: Bethel and Melton Vally Block Model (DOE, 2014)

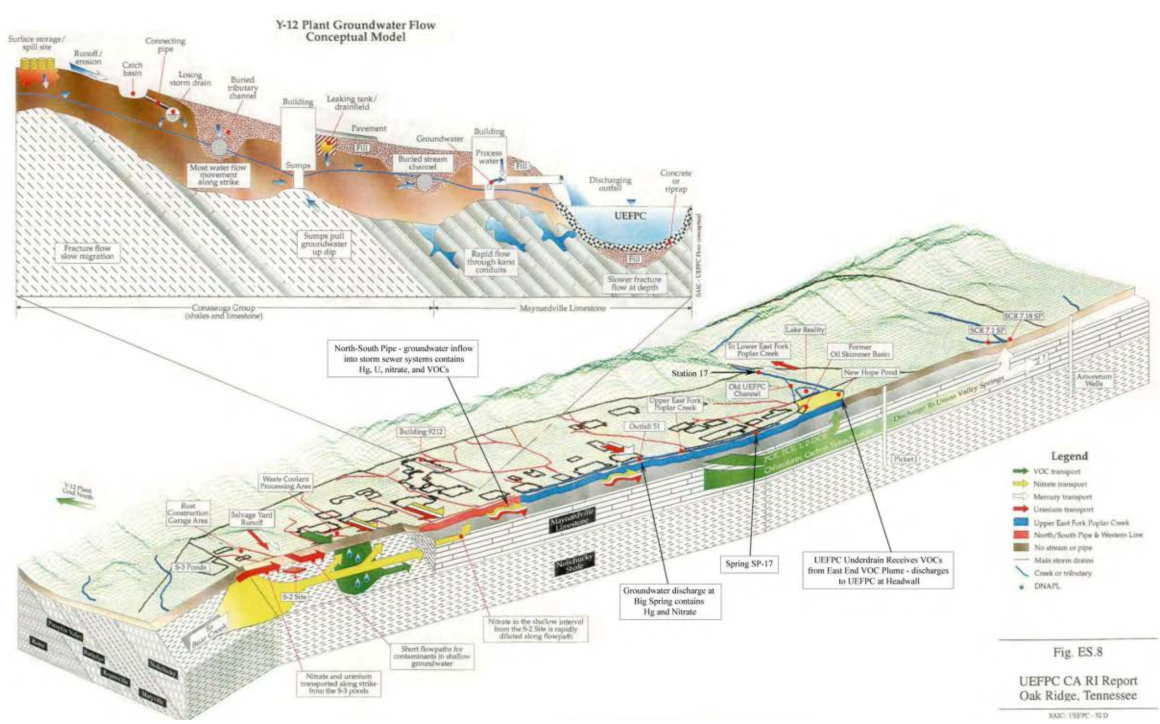

Figure 4: Y-12 Conceptual Model (DOE, 2014)

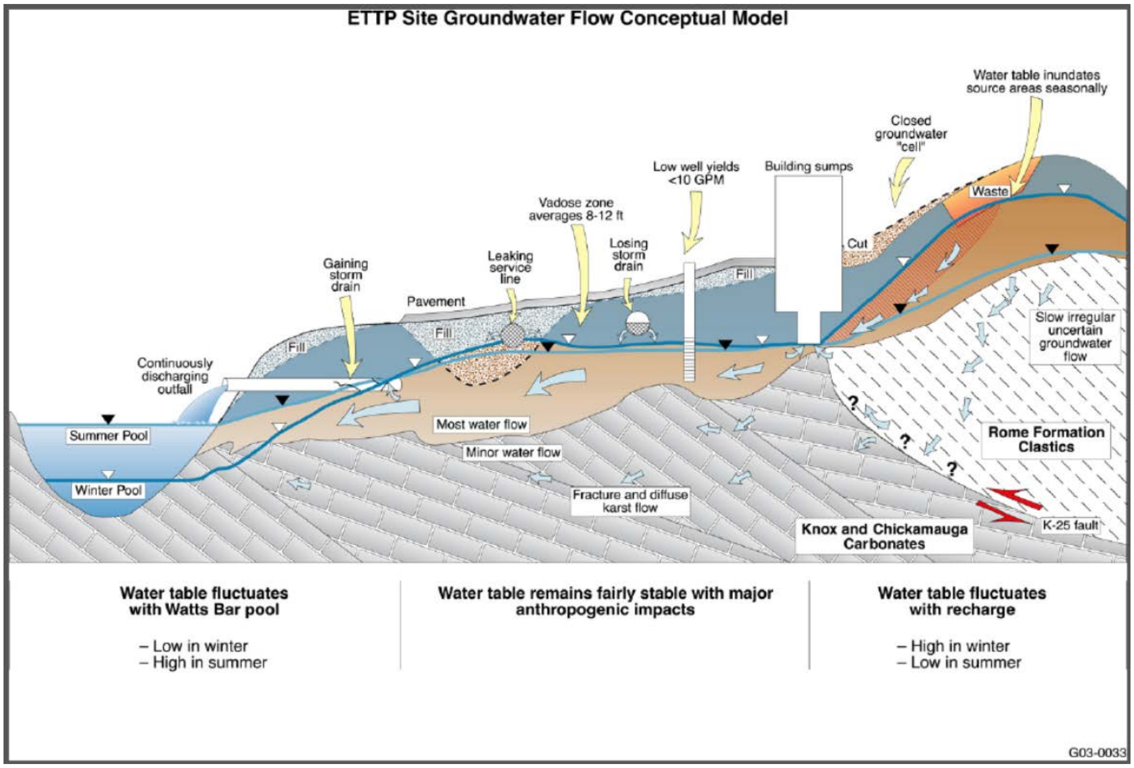

Figure 5: ETTP Conceptual Model (DOE, 2014)

Sample Collection for Background Statistics

Different statistical populations of groundwater quality may occur at different aquifer depths and in different aquifer media. An adequate amount of water quality data is required for each subpopulation so it is statistically representative of the strata, sample depth, or other characteristics that may affect water quality differently. In such cases, background water quality may have to be defined separately for several subpopulations. Future comparisons with background may then have to be conducted with the same consideration in mind so that any statistical conclusions are hydrogeologically defensible in the context of the site conceptual model. In other words, groundwater geochemical conditions at background monitoring well locations must be similar to those in the investigation site area (NAVFAC, 2003).

Data on the groundwater chemistry of each aquifer should be compiled and groundwater quality trends should be identified, if data are sufficient. The sampling locations and frequency should be evaluated to ascertain whether results can be used to represent the groundwater quality within the area of concern. Background groundwater quality should be calculated using upgradient data, samples should be obtained from a sufficient number of wells to account for spatial variability and over a sufficient period of time (for example, two years of quarterly sampling) to consider temporal, or seasonal, variability (ASTM D7045, 2010a). Background data must be statistically characterized to obtain a statistical estimate of an upper bound for the naturally occurring concentration so that it can be confidently determined if onsite and or downgradient concentrations are above background levels (ASTM D7048, 2010b).

Adequate Sample Size

The number of samples needed to conduct a statistical analysis meeting the objectives and goals of a project depends on the site-specific conditions, which in turn controls the data variability. The EPA's Unified Guidance document recommends that a minimum of eight to ten independent samples be available to estimate the standard deviation of a parametrically distributed statistical population. In stark contrast, a tolerance interval estimate for a nonparametric distribution requires a minimum of 59 independent data points to achieve 95% coverage at 95% confidence (EPA, 2009; Conover 1999).

In other situations, such as the presence of a seasonal trend, the seasonal Kendall Test requires a minimum of three years of monthly data, or 36 data points (Gilbert 1987). When quarterly data are sparse, the Kruskal-Wallis test can be used as long as there are at least three years of quarterly data collected in the same months (a minimum of 12 independent data points). To quantify serial correlation effects (temporal dependence), Harris et al (1987) state that at least ten years of quarterly data, or 40 data points, may be necessary.

Adequate sample size varies on a case-by-case basis and is a site-specific decision that must be considered with factors unique to each project and site. The goal of determining sample size is a statistical study to find the number of samples that provides adequate yet practically feasible evidence with which meaningful conclusions can be made relative to the goals of the study.

There is often a need to compare numerous potential constituents of concern to criteria or background at numerous sampling locations. By chance alone there will be exceedences as the number of comparisons become large. The statistical approach to this problem can insure that false positive results are minimized (ASTM D7048, 2010).

Data Below Detection Limits

Data sets that contain nondetect values make it more difficult to determine the type of statistical distribution that characterizes the population from which samples are drawn. These data sets are referred to as censored data. For most nonparametric methods, the presence of censored data is not an issue, but their effect in parametric analysis is very dependent on the statistical form of the data distribution (EPA 2009).

In general, imputation of censored values should be avoided in small data sets and is unnecessary in very large data sets. If censored measurements comprise less than 50% of the measurements of an analyte and the data set appears to be parametrically distributed (either, normal, lognormal, or gamma), then the statistical parameters of the distribution are best inferred using distribution methods such as the maximum likelihood estimator (the utilities available in ProUCL 5.0 [EPA 2013]) are recommended for such situations. If the censored measurements comprise more than 50% of the data set, nonparametric analysis is generally preferred unless special circumstances apply (EPA 2009). In that case, multiple methods for estimating the distribution's parameters should be evaluated, including a sensitivity analysis of the result, before deciding the best outcome.

Plan

The background sampling program will be completed in two phases. The first phase is to do a thorough search of the area northeast of the ORR and collect some initial groundwater samples. Figure 6 shows potential targets from the State of Tennessee well database for Anderson County. The initial task of the first phase will include a search of all residential wells to the north east of the ORR. In addition, the task will seek landowners consent for the State to sample and will seek well completion information to determine what formations the wells may be screened across. The second step of the first phase is to sample a target population of the wells to determine the hydrogeologic characteristics and provide initial sample results from a list of potential contaminants of concerns. For the first year or two, the goal is to sample enough potential targets to identify the four hydrogeologic water quality zones discussed in the conceptual model section. The second step may be a multiyear process, with an estimate of approximately 20 samples. Samples will be analyzed for volatile organic compounds, radionuclides, metals, and inorganics. A complete list of analytes is provided in Table 1.

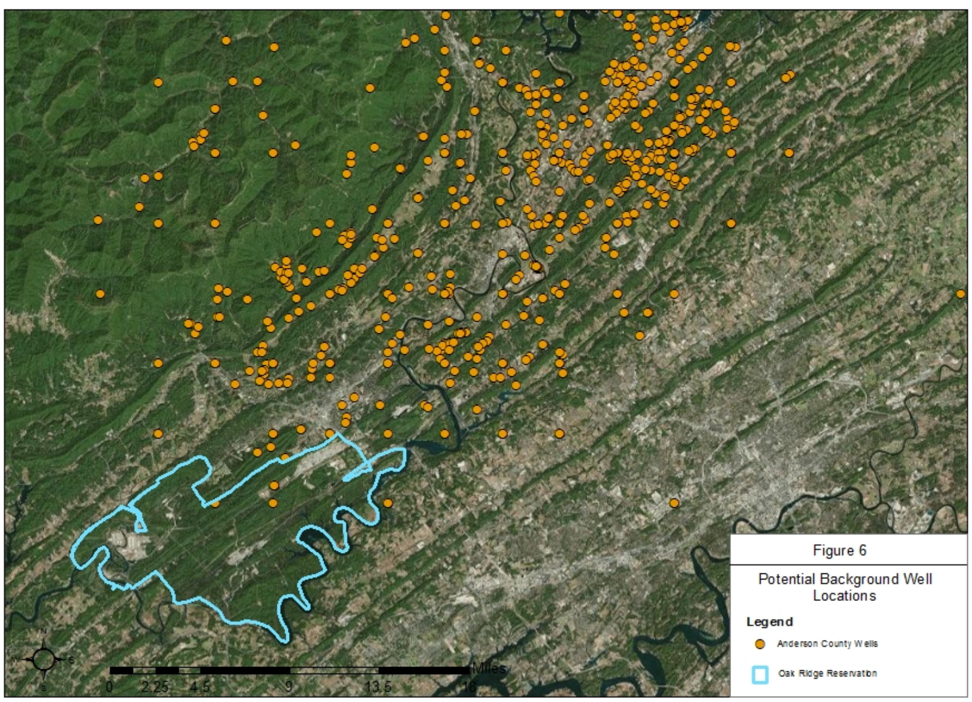

Figure 6: Potential Background Well Locations

Table 1: Phase 1 Sample Analyte List

Analysis	Analytes		
VOCs	Volatile Organic Compounds (8260 list)		
Radionuclides	Gross Alpha/Beta	Technetium 99	
	Gamma Radionuclides	Uranium Isotopic	
	Strontium 89/90		
	Tritium		
Metals	Aluminum	Copper	Silver
	Antimony	Iron	Sodium
	Arsenic	Lead	Strontium
	Boron	Lithium	Thallium
	Barium	Potassium	Uranium
	Beryllium	Magnesium	Vanadium
	Cadmium	Manganese	Zinc
	Calcium	Nickel	Mercury
	Chromium	Selenium	
Inorganics	Alkalinity as CaCO3	Ammonia	
	Chloride	Total Dissolved Solids	
	Fluoride	Sulfate	
	Hardness as total CaCO3	Nitrogen Isotopes	
	Nitrate/Nitrite	Oxygen Isotopes	

VOC - Volatile Organic Compounds

CaCO3 - calcium carbonate

The second phase of the project is a multiyear process. It will be planned as an EMP and will be based on whether or not there are a sufficient number of wells with the correct geochemistry that were identified during the first phase. A quarterly sample program to collect regular samples will be required to determine temporal trends. During the second phase, a review of the groundwater statistics would be required to determine when an adequate sample size is achieved.

Methods and Materials

Sample collection will follow applicable EPA procedures (EPA, 2014). An easy to follow statistical guidance document for determining background water quality was written by the Idaho Department of Environmental Quality and will be followed as it lists all the requirements necessary in performing a good statistical background sampling program (Idaho DEQ, 2014).

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Spring Monitoring Plan for the Oak Ridge Reservation and its Environs

Introduction

The TDEC Division of Remediation, Department of Energy Oversight Office (TDEC/DOE-O) conducts monitoring of the groundwaters of the Oak Ridge Reservation and its environs. In concordance with the mission of the state, as established under the Tennessee Oversight Agreement (TOA) and the Federal Facilities Agreement (FFA), monitoring will facilitate protection of the people as well as protection and improvement of the environment of East Tennessee. This monitoring will encompass wastes and contaminants generated by Oak Ridge Reservation (ORR) Department of Energy (DOE) operations, both legacy and current.

Pursuant to the mission objectives above, the office will sample and analyze groundwater on the ORR and its environs to evaluate the quality of groundwater through the sampling of springs. This project will endeavor to revisit those springs that have provided information on the ambient health of the groundwater on the ORR and along geologic strike to the northeast and southwest. Oversight findings have in the past been used to identify and characterize unplanned releases and to evaluate DOE monitoring and control measures for management of groundwater releases to the environment. This project, as required by the Tennessee Oversight Agreement (TDEC 2011), will build upon those efforts in conjunction with the FFA and other projects in 2015.

Description

Overview of Geology

The Valley and Ridge Physiographic Province is characterized by a sequence of folded and faulted, northeast-trending Paleozoic sedimentary rocks that form a series of alternating valleys and ridges that extend from Alabama and Georgia to New York. The Valley and Ridge Province in the eastern part of Tennessee is underlain by rocks that are primarily Cambrian and Ordovician in age. Minor Silurian, Devonian, and Mississippian rocks also are present in the province. Soluble carbonate rocks and some easily eroded shales underlie the valleys in the province, and more erosion-resistant siltstone, sandstone, and some cherty dolomite underlie ridges. Figure 1 shows the geology of the Oak Ridge Reservation and its environs.

The arrangement of the northeast-trending valleys and ridges and the broad expanse of the Cambrian and the Ordovician rocks in eastern Tennessee is the result of a combination of folding, thrust faulting, and erosion. Compressive forces from the southeast have caused these rocks to yield, first by folding and subsequently by repeatedly breaking along a series of thrust faults as shown in Figure 2. The result of the faulting is that geologic formations can be repeated several times across the faults. For example, the carbonate-rock aquifers in the Chickamauga, the Knox, and the Conasauga Groups are repeated across the thrust faults shown in Figure 2.

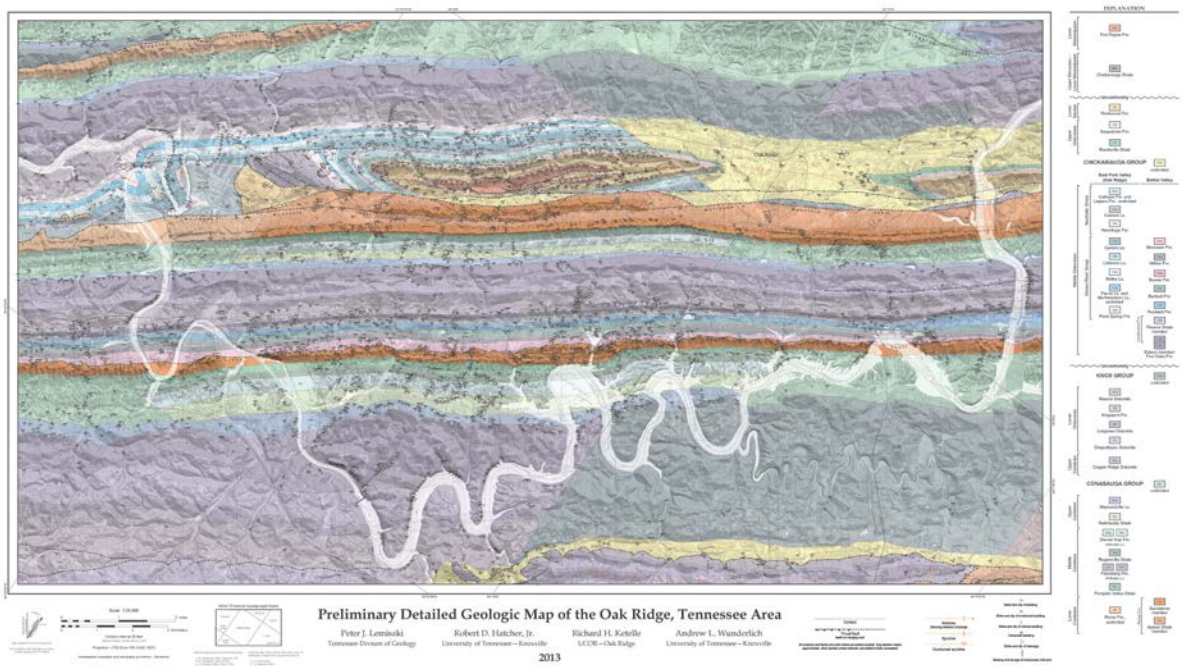

Figure 1: Preliminary Detailed Geologic Map of the Oak Ridge, Tennessee Area (Lemiszki et al, 2013)

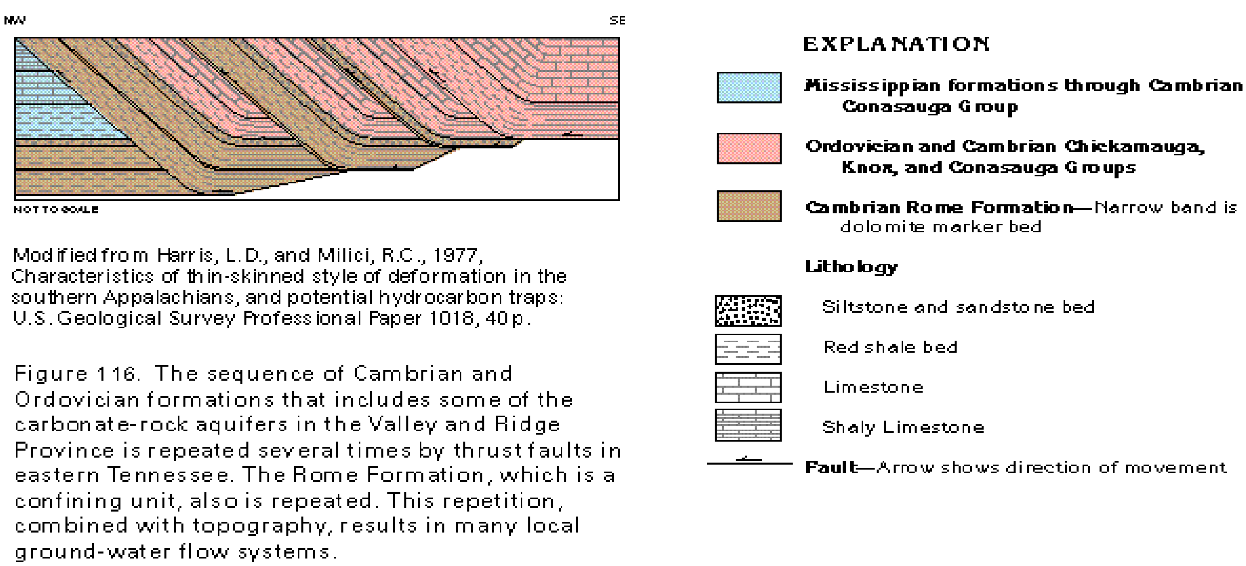

Figure 2: Illustration of thrust faulting and formations involved. (USGS 2014)

In eastern Tennessee, the thrust faults are closely spaced and are more responsible than the folds for the present distribution of the rocks. Following the folding and thrusting, erosion produced the sequence of ridges and valleys on the present land surface.

The general hydrogeologic characteristics of the entire Valley and Ridge Province are fairly consistent. However, unique characteristics can be attributed to local differences in rock type and geologic structure (USGS 2014).

Hydrogeologic Units

The principal aquifers in the Valley and Ridge Province of Segment 10 consist of carbonate rocks that are Cambrian, Ordovician, and Mississippian in age. These aquifers, which are typically present in valleys and on broad, dissected ridges, underlie more than one-half of the Valley and Ridge Province in Tennessee. Most of the carbonate-rock aquifers are directly connected to sources of recharge, such as rivers or lakes, and solution activity has enlarged the original openings in the carbonate rocks. Other types of rocks in the province can yield large quantities of water to wells where they are fractured or contain solution openings or are directly hydraulically connected to sources of recharge (USGS 2014).

Groundwater Movement

Ground water in the Valley and Ridge aquifers primarily is stored in and moves through fractures, bedding planes, and solution openings in the rocks. These types of openings are secondary features that developed after the rocks were deposited and lithified. Little primary porosity and permeability remain in these rocks after the process of lithification. Some ground water moves through primary pore spaces between the particles that constitute the alluvium along streams and the residuum of weathered material that overlies most of the rocks in the area (USGS 2014).

Spring Discharge

The discharges of springs that issue from the principal Valley and Ridge aquifers in eastern Tennessee vary greatly; measured discharges range from about 1 to 5,000 gallons per minute. The largest springs issue from the Newman Limestone and the Lenoir Limestone of the Chickamauga Group. Springs that issue from the Knox Group discharge as much as 4,000 gallons per minute. The median discharges of springs that issue from the principal aquifers range from 20 to 175 gallons per minute. The largest median discharges are from springs that issue from the Shady Dolomite (175 gallons per minute), the Knox Group (50 gallons per minute), and the upper part of the Conasauga Group (40 gallons per minute). Many springs discharge as much as ten times more water during periods of abundant rainfall than during extended periods of little or no rainfall (USGS 2014). Groundwater experts in this office are aware of exceptions to the above. The above however is sufficient to give the current understanding of the importance of the carbonate aquifers.

Groundwater Quality

The chemical quality of water in the freshwater parts of the Valley and Ridge aquifers is similar for shallow wells and springs. The water is hard, is a calcium-magnesium bicarbonate type, and typically has a dissolved-solids concentration of 170 milligrams per liter or less. The ranges of concentrations are thought to be indicators of the depth and rate at which ground water flows through the carbonate-rock aquifers. In general, the smaller values for a constituent represent water that is moving rapidly along shallow, short flow paths from recharge areas to points of discharge. This water has been in the aquifers for a short time and has accordingly dissolved only small quantities of aquifer material. Conversely, the larger values represent water that is moving more slowly along deep, long flow paths. Such water has been in contact with aquifer minerals for a longer time and thus has had greater opportunity to dissolve the minerals. Also, water that moves into deeper parts of the aquifers can mix with saltwater that might be present at depth (USGS 2014). This is a generalization that has exceptions and, where found, a specific description is needed. In an environment of waste disposal the higher dissolved solids will have to be scrutinized and more reasonable statements made for communication of the aquifer properties.

Sample Collection

Collecting samples from springs on the ORR and to the northeast and southwest of the ORR will be the primary focus of this groundwater monitoring project. This office has collected spring samples from the ORR and its environs since 1994. This project will endeavor to revisit those springs that can provide information on the ambient health of the groundwater on the ORR and along geologic strike to the northeast and southwest. Information from the individual springs offsite in the different geologic strike belts may illuminate certain parameters or trends in groundwater that may be helpful in characterization, modeling and remediation on the ORR.

Springs to be sampled are springs that have been sampled previously by this office and four that have yet to be sampled. The spring locations will be divided into three categories; sampled more than ten years ago, sampled five to ten years ago and sampled three to five years ago. See Figure 3 for a map showing the groundwater sampling locations. The red markers indicate locations that have yet to be sampled.

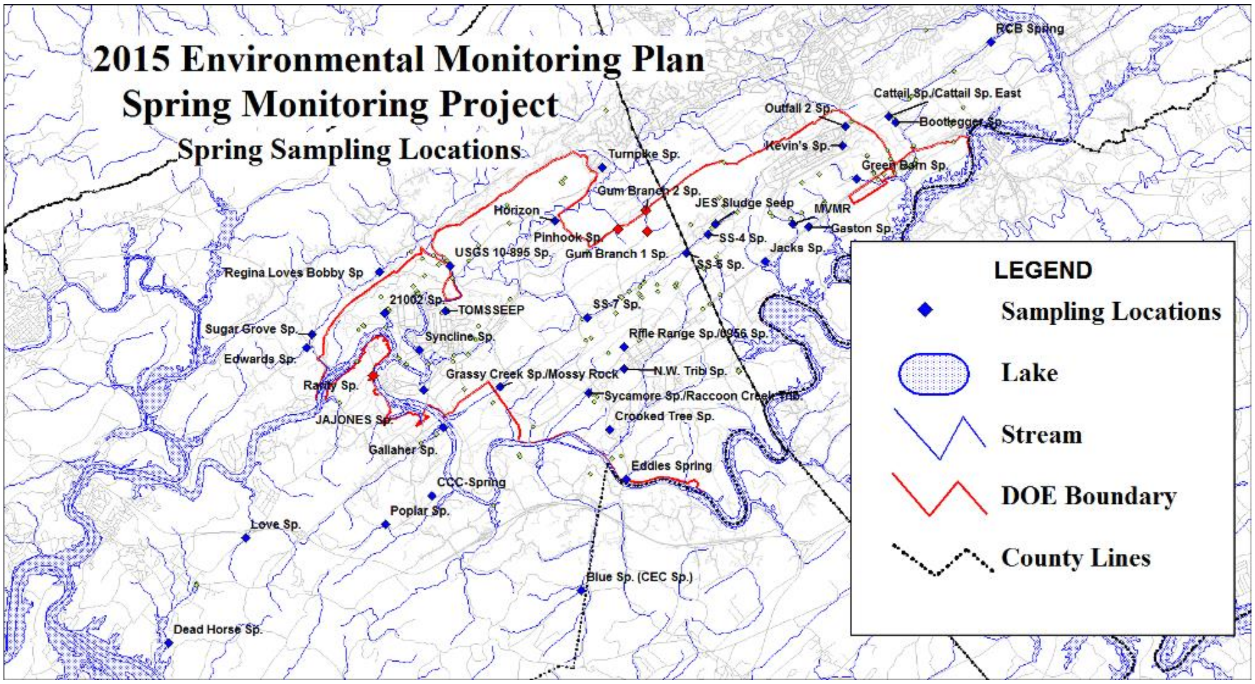

Figure 3: 2015 Groundwater Sampling Locations

Reconnaissance
This office will conduct efforts to locate springs, and seeps offsite or on the periphery of the ORR that are potential discharge locations and/or that may have been impacted by DOE activities. Detailed geologic maps and/or hydrogeological cross sections may be generated with the cooperation of the Division of Geology. Information and updates will be shared with DOE, and other office staff also sampling groundwater.

Methods and Materials
Springs and seeps will be sampled according to standard operating procedures enumerated by the EPA, TDEC (TDEC 2004) and the office. Parameters such as pH, temperature, turbidity, oxidation reduction potential and conductivity will be collected before sampling and recorded in the field notes. Springs will be sampled based on field observation of flow and safety considerations. There will only be a single sampling event for each spring. Time series sampling will be determined for future sampling efforts.

Table 1 contains locations, analyses and rationale as described below. Typically waters *a priori* influenced by ETTP would be analyzed for Tc-99. Also those waters influenced by ORNL would be analyzed for Sr-89/90. If a spring shows a gross alpha activity greater than 5 picocuries/liter then a radionuclide isotope-specific analysis for alpha emitters *may* be performed on the laboratory-archived sample.

Analysis at all sampling locations will include (Table 2) cation/anion parameters to include, calcium, magnesium, sodium, potassium, chloride, sulfate, nitrate, bicarbonate (alkalinity as CaCO3), and carbonate (hardness as CaCO3) in order to calculate ionic charge balances, and to perform groundwater geochemical “fingerprints”. A list of metals is also included in Table 2 for analysis at all locations. Volatile organic compounds (VOCs) will be analyzed from samples collected at all springs. At sampling points where metals, VOCs, or radionuclide results indicate a need to determine variability or to resolve laboratory results, appropriate follow up samples may be collected and analyzed.

The Tennessee Department of Health analytical laboratory in Nashville, Tennessee will furnish sample containers. Samples will be collected using approved TDEC and EPA sampling procedures. Nitrile exam gloves and decontamination equipment and procedures will be necessary to avoid cross contamination. TDEC DOE-O sample coolers will be used to insure that samples are preserved in route to the laboratory.

Appropriate lab, field and trip blanks (QA/QC) will be utilized.

DOE Coordination/Communication
DOE will be notified via this document, meetings, and revisions to this document, of office sampling plans. Should the DOE request the opportunity to observe and/or take split samples, every effort will be made to facilitate DOE participation in the office’s groundwater program. Analytical results will be made available to any and all interested parties upon request.

All results and findings will be reported in the DOE-Oversight Office’s Environmental Monitoring Report.

Table 1: Sampling Locations

LOCATION No.	ANALYTES FROM TABLE 2	LOCATION	SAMPLING RATIONALE	LAST SAMPLED
2015SPGEMP-01	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Grassy Creek Sp./Mossy Rock Spring	Spring that drains Bear Creek Valley and the Firing Range	1995
2015SPGEMP-02	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Turnpike Spring	Regional offsite spring EMDF baseline	1995
2015SPGEMP-03	Metals, Inorganics, Volatile Organic Compounds, Radiologics	CCC-Spring	Regional Base flow spring in the Copper Ridge Formation	1996
2015SPGEMP-04	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Poplar Spring	Base flow spring offsite in Bethel Valley	1996
2015SPGEMP-05	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Jacks Spring	Drains Walker Branch and Chestnut Ridge	1998
2015SPGEMP-06	Metals, Inorganics, Volatile Organic Compounds, Radiologics	N.W. Tributary Spring	Spring drains parts of WAG 3	1998
2015SPGEMP-07	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Gaston Spring	Base flow spring that drains Chestnut Ridge/Landfills	1999
2015SPGEMP-08	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Green Barn Spring	Base flow spring that drains Chestnut Ridge/Landfills	1999
2015SPGEMP-09	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Edwards Spring	Offsite regional base flow spring	2000
2015SPGEMP-10	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Blue Spring (CEC Spring)	Regional base flow spring	2002
2015SPGEMP-11	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Horizon	Spring drains East Ridge area	2002
2015SPGEMP-12	Metals, Inorganics, Volatile Organic Compounds, Radiologics	JES Sludge Seep	Below EMWMF, Oil Landfarm and Bone Yard Burn Yard	2002
2015SPGEMP-13	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Kevin's Spring	Base flow spring for UEFPC and north slope of Chestnut Ridge	2002
2015SPGEMP-14	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Outfall 2 Spring	Drains northeast end of Y-12	2002
2015SPGEMP-15	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Sugar Grove Spring.	Offsite regional base flow spring	2002
2015SPGEMP-16	Metals, Inorganics, Volatile Organic Compounds, Radiologics	JAJONES Spring	Last sampled in 2005 check on remediation	2005
2015SPGEMP-17	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Rifle Range Spring/0956 Spring	Spring drains Chestnut Ridge towards ORNL	2005
2015SPGEMP-18	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Crooked Tree Spring	Spring drains WAG 6	2006
2015SPGEMP-19	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Dead Horse Spring	Regional offsite Spring	2006
2015SPGEMP-20	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Love Spring	Regional offsite spring downgrade from ETTP	2006

LOCATION No.	ANALYTES FROM TABLE 2	LOCATION	SAMPLING RATIONALE	LAST SAMPLED
2015SPGEMP-21	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Syncline Spring	Drains large portion of ETTP	2006
2015SPGEMP-22	Metals, Inorganics, Volatile Organic Compounds, Radiologics	MVMR	Base flow spring that drains Chestnut Ridge/Landfills	2007
2015SPGEMP-23	Metals, Inorganics, Volatile Organic Compounds, Radiologics	RCB Spring	Regional spring downgrade from Y-12	2007
2015SPGEMP-24	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Tom's Seep	Off of Mitchell Branch-Contains VOCs	2007
2015SPGEMP-25	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Eddie's Spring	Copper Ridge Spring	2009
2015SPGEMP-26	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Sycamore Spring/Raccoon Creek Tributary	Spring drains parts of WAG 3	2010
2015SPGEMP-27	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Regina Loves Bobby Spring	Spring offsite near ETTP	2011
2015SPGEMP-28	Metals, Inorganics, Volatile Organic Compounds, Radiologics	SS-5 Spring	Spring drains most of western Y-12/SNS/EMWMF	2012
2015SPGEMP-29	Metals, Inorganics, Volatile Organic Compounds, Radiologics	SS-7 Spring	Spring drains most of western Y-12/EMWMF	2012
2015SPGEMP-30	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Gallaher Spring	Regional offsite spring in Bear Creek Valley	2012
2015SPGEMP-31	Metals, Inorganics, Volatile Organic Compounds, Radiologics	SS-4 Spring	Spring drains most of western Y-12/Bear Creek	2014
2015SPGEMP-32	Metals, Inorganics, Volatile Organic Compounds, Radiologics	21002 Spring	Basin contains K-1070A	2014
2015SPGEMP-33	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Gum Branch 1 Spring	Baseline spring for EMDF	NEW
2015SPGEMP-34	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Gum Branch 2 Spring	Baseline spring for EMDF	NEW
2015SPGEMP-35	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Pinhook Spring	Baseline spring for EMDF	NEW
2015SPGEMP-36	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Rarity Spring	Regional spring downgrade from ETTP	NEW
2015SPGEMP-37	Metals, Inorganics, Volatile Organic Compounds, Radiologics	USGS 10-895 Spring	Drains ETTP North Rail Yard, K-1070A	2012
2015SPGEMP-38	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Bootlegger Spring	Base flow spring that drains Chestnut Ridge/Security Pits	2012
2015SPGEMP-39	Metals, Inorganics, Volatile Organic Compounds, Radiologics	Cattail Spring/Cattail Spring East	Spring drains east end of Y-12 - volatile plume	2012

Table 2: Spring Sampling List of Analytes

METALS		
Aluminum	Iron	Potassium
Arsenic	Lead	Selenium
Barium	Lithium	Sodium
Cadmium	Magnesium	Strontium
Calcium	Manganese	Uranium
Chromium	Mercury	
Chromium, Hexavalent	Nickel	
INORGANICS		
Alkalinity as CaCO3	Nitrogen as Nitrate	
Boron	pH	
Chloride	Residue, Dissolved	
Conductivity	Sulfate	
Hardness as CaCO3		
RADIOLOLOGIC		
Gross Alpha/Beta by LSC*	Strontium 89/90	Technetium-99
Gamma Radionuclides	Tritium	
VOLATILE ORGANIC COMPOUNDS		
SDWA** 524.2		

Notes: * Liquid Scintillation Counting
** Safe Drinking Water Act

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Groundwater Monitoring Special Project Plan

Introduction

The Tennessee Department of Environment and Conservation, Division of Remediation Department of Energy Oversight Office (DOR/DOE-O), will conduct monitoring of the groundwaters southwest of the Oak Ridge Reservation (ORR) by sampling privately-owned water wells. This plan, in conjunction with the Department of Energy's efforts, is a part of an assessment being conducted under the Federal Facilities Agreement and the Oversight Office's Environmental Restoration Program.

In 2015, the Environmental Restoration Program will concentrate in the areas beyond the Department of Energy's boundary southwest of the ORR and, to a lesser extent, northeast of Melton Valley (Figure 1). Previous groundwater sampling results have reported constituents that are present in DOE's legacy waste. Where related, hydrogeologically, to those wastes, especially by pumping wells, the potential vulnerability of the region's aquifers will be evaluated.

The goal of these efforts are to better understand the distribution of potential contaminant pathways to assist in the decision making processes under the Federal Facilities Agreement in order to protect human health and safety.

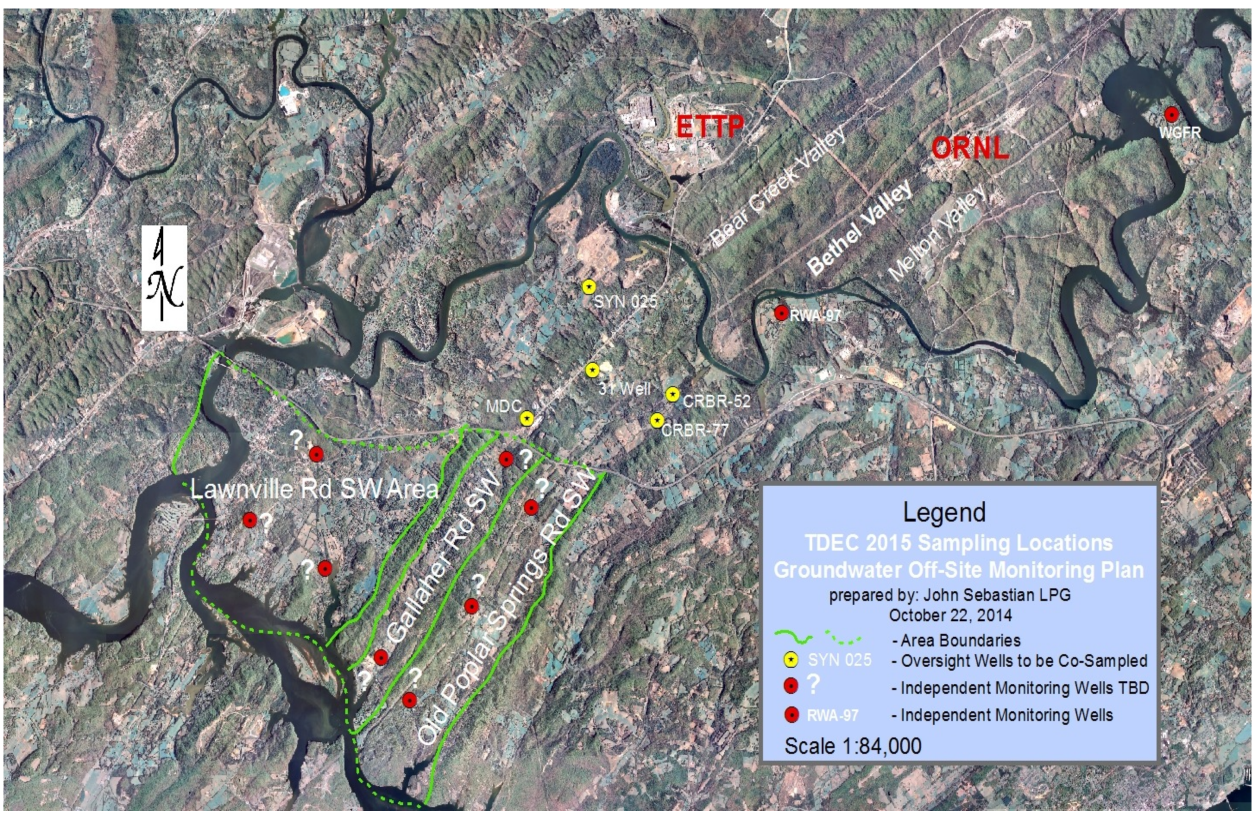

Figure 1: 2015 Sampling Locations

Monitoring will be divided as co-sampling with DOE and sampling to assess the regional groundwater flow regimes. Co-sampling will consist of five sites and five samples to be obtained in cooperation with DOE contractors as part of DOE's offsite monitoring program. Independent sampling will consist of ten sites chosen that are not a part of DOE's offsite monitoring program or within the boundaries of that program. A contingency for an additional ten samples is included to follow leads gained early in the sampling and resampling process as warranted.

The locations for the ten contingency samples will be chosen from sites that are either in the DOE or the TDEC program or from new sites of interest that are recognized during execution of the sampling programs and which are deemed to require further or initial investigation by the office Environmental Restoration Program groundwater staff.

Methods and Materials

Sampling

The DOE-O standard operating procedures will be used for the collection and handling of samples. Private or public water supply sources will be sampled by collecting raw water as close to the wellhead as possible. In general, the residential or water-supply wells will be sampled after being purged for at least 20 minutes or after field parameters stabilize. Any monitoring wells will be co-sampled by facility personnel making use of contractor sampling equipment or by division personnel using either disposable bailers or a portable pump. Additionally, new or properly decontaminated tubing and standard or plan-specific purging methods will be used. Field parameters, such as, pH, temperature, dissolved oxygen, oxidation-reduction potential, turbidity, and conductivity will be collected prior to sampling and recorded in the field notebook.

Springs will be sampled based on nature of measured field-parameters and nature of discharge (and, where possible, measurement of discharge) using obvious safety considerations. 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 in order to determine optimum sample-collection frequency and timing of sampling events. This will help to better understand the response time and variability of the system.

Containers for sample collection will be obtained from the office's supply on the day that samples are taken. After samples are obtained, they will be shipped to the Nashville Central Laboratory for analysis.

Samples will be analyzed based on DOE site-related contamination, and for the acquisition and compilation of fundamental hydrogeological and hydrogeochemical data. The analyses listed in Table 1 are planned to be requested of the state laboratory but are subject to changes as the results are evaluated against the nature of the groundwater system.

Table 1 shows locations, number of samples, and analyses to be undertaken. Specific radiochemical analyses will be selected prior to sampling. If the results of domestic private water supply sampling show an alpha activity greater than 5 picoCuries/liter or beta activity greater than 15 picoCuries/liter, radionuclide isotope-specific analysis for potential alpha or beta emitters may be performed on the laboratory-archived samples.

As contaminants may be transported in rapid turbulent groundwater on sediment (ASTM 1995), occasionally sediment samples may be collected and analyzed for inorganic and radiological parameters.

As new contaminants of concern are identified by the regulatory and monitoring community, new parameters may be added to the analysis of ground and surface waters sampled by the program.

Appropriate QA/QC samples will be utilized.

Reconnaissance

Reconnaissance will be an integral part of the 2015 groundwater monitoring program. Significant portions of the study area have not been sampled as part of the offsite monitoring efforts. Thus it will be necessary to locate springs and wells that are potential discharge locations and/or that could be affected by DOE's legacy activities. This will be accomplished by reference to the State's data base of wells in the area, neighborhood surveys, and interviews with well owners whose wells have previously been sampled by this office.

If feasible, detailed geologic maps and/or hydrogeological cross sections may be generated with the cooperation of the Division of Geology.

DOE Coordination/Communication

DOE will be notified of the office's groundwater sampling plans by sharing this document and any revisions to it. Should the DOE request the opportunity to observe and/or take split samples, every effort will be made to facilitate DOE participation in the program. Analytical results will be made available to any and all interested parties upon request.

All results and findings will be published in the TDEC Division of Remediation DOE-Oversight Environmental Monitoring Report.

Table 1: Groundwater Sampling Locations - 2015

Area	Name	Number of samples	List of analytes
Offsite of Bear Creek Valley - southwest		**Minimum of one sample for each location**	**VOCs, Rad, Metals, Inorganics, stable isotopes**
	31 Well*		
	Michael Dunn Center*		
	Gallaher Road SW #1		
	Gallaher Road SW #2		
Offsite Bethel Valley – southwest	**RWA-97 Well**	**Minimum of one sample for each location**	**VOCs, Rad, Metals, Inorganics, stable isotopes**
	CRBR-77 (645msl, 255tD)*		
	CRBR-52 (740msl, 200tD)*		
	Old Poplar Springs Rd SW#1		
	Old Poplar Springs Rd SW#2		
	Old Poplar Springs Rd SW#3		
Melton Valley Offsite- northeast	**1004' Well West Gallaher Ferry Rd Well**	**Minimum of one sample for each location**	**VOCs, Rad, Metals, Inorganics, stable isotopes**
ETTP Offsite- southwest	**SYN025***	**Minimum of one sample for each location**	**VOCs, Rad, Metals, Inorganics, stable isotopes**
	Lawnville Road Area #1*		
	Lawnville Road Area #2		
	Lawnville Road Area #3		

"*" - denotes oversight well

VOCs - Volatile Organic Compounds

Rad - Radionuclides. Includes alpha/beta by liquid scintillation, gamma radionuclides, strontium 89/90, tritium, technetium 99, carbon-14 and uranium isotopes

Metals - 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, vandium, zinc, mercury and/or hexavalent chromium depending on site.

Inorganics - alkalinity as CaCO3, chloride, fluoride, hardness as total as CaCO3, nitrate/nitrite, ammonia, pH, total dissolved solids, and sulfate

Stable Isotopes – nitrogen, oxygen, possibly chlorine, and boron

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RADIOLOGICAL MONITORING

Haul Road Surveys

Introduction

The Tennessee Department of Environment and Conservation (TDEC), with the cooperation of the U.S. Department of Energy (DOE) and its contractors, will continue to perform weekly surveys of the Haul Road and Haul Road extension to Y-12 in 2015. For safety reasons, the Haul Road monitoring schedule may vary due to adverse weather conditions. 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, TDEC personnel perform walk over inspections of the road and associated access roads weekly. Anomalous items noted are surveyed, logged, and their description and location submitted to DOE for disposition. DOE and its contractor have continued to demonstrate improvement in the number of items found over previous years.

Methods and Materials

For safety and by agreement with DOE and its contractors, staff members performing the weekly inspections will log onto the road at the East Tennessee Technology Park (ETTP) transportation hub where site personnel shall be advised staff will be entering 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 maintain communication should unforeseen conditions arise that could present a safety hazard while on the road. Where excessive traffic presents 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 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. Due to the association with CERCLA activities and potential contamination each anomalous item will be surveyed for radiological contamination. Findings will be included in the above report. Any radiological contamination will be documented in disintegrations per minute per 100 cm2 (dpms/100cm2) 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 inspection, they will perform a follow-up inspection of the flagged anomalous items found in previous weeks. If the anomalous items have been removed, the flagging will be pulled. If any anomalous items remain, they will be included in subsequent reports, until removed by staff, or until they have been determined to be free of radioactive and hazardous constituents.

Table 1: Office of DOE Oversight Portable Radiation Detection Equipment

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

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Yard, C.R., Health and Safety Plan. Tennessee Department of Environment and Conservation, Division of Remediation, DOE Oversight Office. Oak Ridge, Tennessee. 2014.

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 uses 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 Landauer, Inc. 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, to 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
2) Y-12 National Security Complex
3) Spallation Neutron Source Site
4) Environmental Management Waste Management Facility
5) Off site areas of interest
6) Tower Shielding Facility
7) East Tennessee Technology Park
8) ORAU/ORISE Neutron Source

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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 office) 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. The results are compared to background levels and dose limits provided in state regulations. Findings are used to identify unplanned releases of radioactivity, to assess compliance with state regulations and DOE Orders and to evaluate DOE control measures (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®. 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 μrem/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 individually 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) where there is a potential for an unplanned release of gamma emitting radionuclides to the environment, and / or 3) where 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 data to background concentrations, to the state limit for the maximum dose to an unrestricted area (2 mrem in any one hour period), and to 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 (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

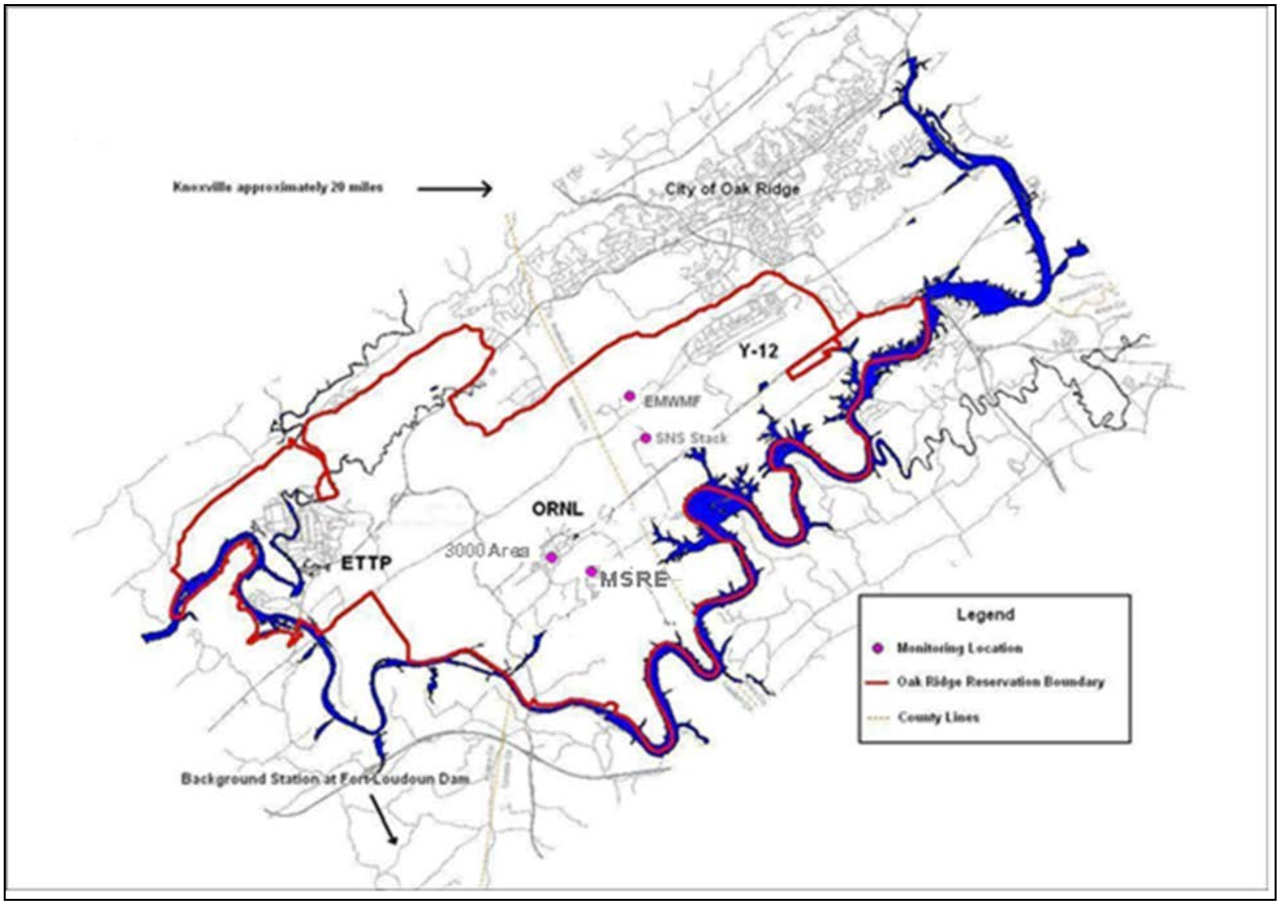

Figure 1: Gamma exposure rate monitoring locations in 2015

Monitoring stations can be expected to vary as the sites subject to remediation change and findings warrant.

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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 is following proper radiological control procedures. 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

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

Introduction

The Environmental Management Waste Management Facility (EMWMF) was constructed for, and is dedicated to, the disposal of low level radioactive waste (LLW) and hazardous waste generated by remedial activities on the 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 by FFA parties is approved for disposal in the EMWMF. 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 EMWMF (DOE, 2001). The state and EPA oversee and audit associated activities, including decisions authorizing waste lots for disposal.

To help ensure compliance with the WAC, 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 EMWMF 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. Basic information as to the nature and source of the waste passing through the portal at the time of the measurements is obtained from EMWMF personnel. If preliminary information indicates the facility's WAC may have been violated, the information is submitted to DOE Oversight's Audit Team for review and disposition.

Methods and Materials

A Canberra RadSenrty 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 is 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 EMWMF personnel will be contacted and the source of the waste passing through the portal monitor at the time of the measurements will be 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

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SURFACE WATER MONITORING

Surface Water Monitoring 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 2015, the Tennessee Department of Environment and Conservation's Division of Remediation will monitor surface waters, storm water, groundwater, effluents, and sediments at DOE's Environmental Management Waste Management Facility (EMWMF), located in eastern Bear Creek Valley. 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 this project to assess the performance of the facility, 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.

The EMWMF 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 loosing 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 EMWMF 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 EMWMF, 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. The drainage provided by the NT-4 channel was 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 remain near a ten-foot geologic buffer required between the water table and the facility's liner.

Currently, the only authorized discharges from the EMWMF are contaminated storm water (contact water) which 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. The EMWMF 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 limit on releases from the holding ponds/tanks to the sedimentation basin is based on requirements contained in DOE Order 5400.5 that restrict 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 1200-2-11-.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 settling solids in liquid effluents to 5.0 pCi/g and 50 pCi/g respectively.

Plan

To ensure that EMWMF is meeting its operational requirements, several parameters and analytes are being monitored:

(1) To monitor water parameters leaving the EMWMF, continuous water quality parameters will be taken at two locations: EMWMF-2 (underdrain) and EMWMF-3 (Sediment Basin v-weir discharge). In addition, staff will perform basic monitoring of these sites at least twice weekly with the use of a YSI-Professional Plus water quality instrument.

(2) To insure that contaminants from the cell are not adversely affecting the surrounding environment, water samples will be collected on a routine basis from select sites. Sediment samples will be collected from the sediment basin as available.

(3) To determine the changes in groundwater due to seasonal and precipitation fluxes, data loggers will be placed in seven wells and downloaded on a monthly basis.

(4) To insure best practices are utilized to limit contaminant migration, site visits will be made at least twice weekly to monitor ongoing activities at the EMWMF.

(5) To verify compliance that the water table is below the geologic buffer, a review of groundwater level measurements will be conducted annually from data received on the wells listed in Table 1.

Table 1: Continuous Water Quality Parameter and YSI-Professional Plus Monitoring Locations

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

EMWMF - Environmental Management Waste Management Facility

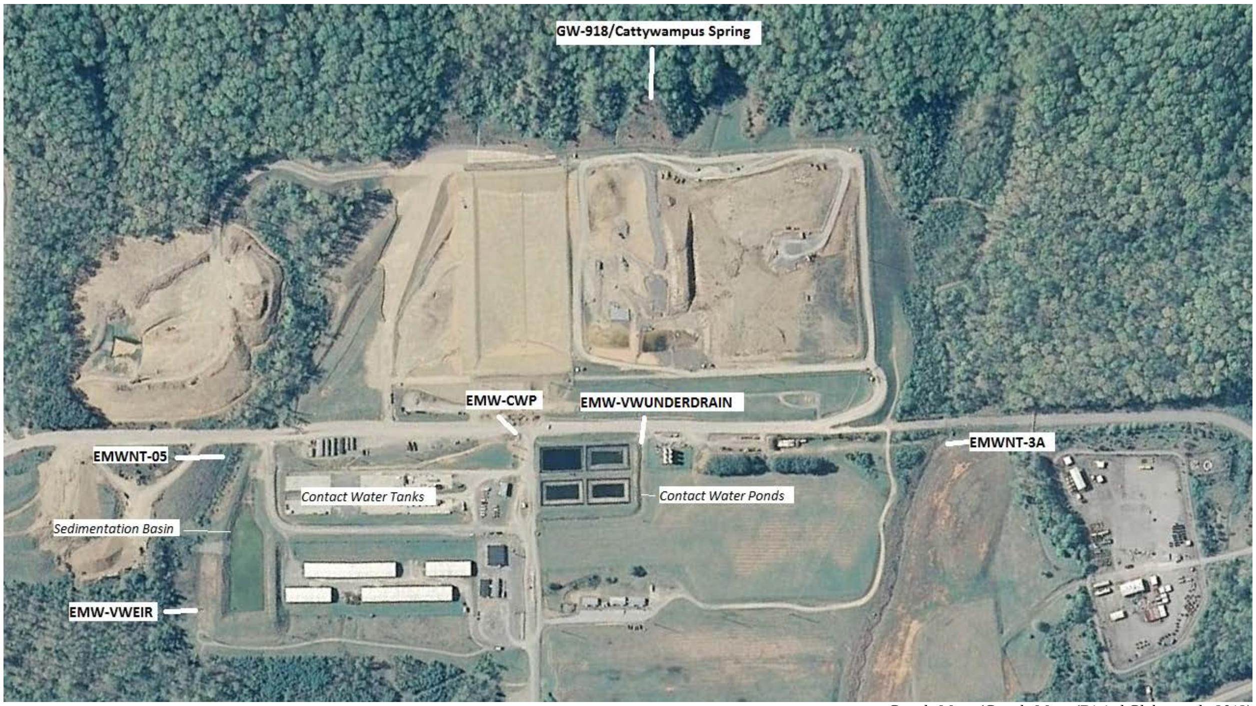
TDEC -DOE-O - Tennessee Department of Environment and Conservation Department of Energy Oversight Office

Methods

Task 1 - The continuous water quality parameters of temperature, pH, conductivity, dissolved oxygen, turbidity, and water level (converted to discharge) will be measured with an In-Situ® Troll 9500. Precipitation data will be collected from the closest ORR meteorological tower. The continuous water quality monitoring will follow the 2011 TDEC Water Pollution Control Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water. The continuous water quality data loggers will be visited once per week to aid in determining calibration drift, to check on any sedimentation and/or biological problems at the locations, and to make sure the instruments are functioning properly. In addition, staff will perform basic monitoring of these locations for temperature, pH, conductivity, DO, and ORP at least twice weekly utilizing a YSI-Professional Plus water quality meter. Calibration or confidence check of this instrument is performed prior to field use. Locations and rationale are listed in Table 1.

Task 2 – Water samples will be collected on a routine basis or as opportunity arises and/or conditions merit the monitoring of water discharges. Table 2 and Figure 1 depict locations of interest at the EMWMF, analytes and rationale for sampling. To assess compliance with the DOE limit placed on radionuclides released from the contact water ponds and tanks (100 mrem/yr), samples will be collected of the discharge of contact water as it is pumped to the drainage ditch at EMW-CWP. To assess compliance with the TDEC limit placed out 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. To evaluate the performance of the liner and associated EMWMF monitoring, samples will be collected from the underdrain (EMW-VWUNDERDRAIN). To capture contaminants that could be migrating from the cells laterally in shallow groundwater, the

NT-3 and NT-5 tributaries 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. GW-918 will be co-sampled with DOE as a background well.



Google Maps (Google Maps (Digital Globe, et al., 2012)

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

Table 2: Surface Water / Groundwater / Contact Water Samples

DOE-O Sample Location	Alias	Schedule	List of Analytes	Rationale
EMWMF-1 or GW-918	GW-918	Quarterly	alpha & beta, gamma, total uranium, strontium-90, technetium-99, tritium	Upgradient spring/well location (headwaters for NT-5 and background)
EMWMF-2	EMW-VWUNDERDRAIN	Monthly	Isotopic Uranium, Strontium-90, technetium-99, tritium,	A French drain that collects groundwater under the waste cells (Headwaters for NT-4)
EMWMF-3	EMW-VWEIR	Monthly	alpha & beta, gamma, total uranium, strontium-90, technetium-99, tritium	Sediment pond discharge location to NT-5, which leads to Bear Creek (EMWMF Discharge)
EMWMF-4	Surface Drainage	As needed	alpha & beta, gamma, total uranium, strontium-90, technetium-99, tritium	Discharge location from waste cells that are designated as inactive, but contain stored materials (EMWMF discharge after rain events)
EMWMF-05	Discharge from Contact Water Ponds	As needed	alpha & beta, gamma, total uranium, strontium-90, technetium-99, tritium	Discharge location for the CWP (sampled only if CWPs not sampled)

DOE-O Sample Location	Alias	Schedule	List of Analytes	Rationale
EMWMF-6	NT-4	Bi-annually / as needed	alpha & beta, gamma, total uranium, strontium-90, technetium-99, tritium	Downgradient of the underdrain. (Samples collected bi-annually or based on elevated underdrain results)
EMWMF-7	NT-5	As needed	alpha & beta, total uranium, strontium-90, technetium-99, tritium	At NT-5 surface water structure (Samples are based on elevated EMWMF-3 results)
EMWNT-05	EMWNT-5	Bi-annually/as needed	alpha & beta, gamma, total uranium, strontium-90, technetium-99, tritium	Upgradient from the sediment pond V-weir but downgradient from the western end of the waste cells (Potential Surface Flow)
EMWNT-3a	EMWNT-3A	Bi-annually/as needed	alpha & beta, gamma, total uranium, strontium-90, technetium-99, tritium	Downgradient from the eastern end of the waste cells, upgradient from other known sites. (Potential Surface Flow)
CWP/CWT	Contact Water Ponds/Contact water tanks	As needed	alpha & beta, gamma, total uranium, strontium-90, teccnetium-99, tritium	Effluent holding pond (prior to discharge to sediment pond or leachate tanks)

Task 3 – The oversight office will instrument up to seven monitoring wells or piezometers with HOBO® U20 water level and U24 conductivity loggers. The Oversight Office will monitor GW-918, GW-947, GW-916, GW-952, GW-927, GW-917, and GW-922 with an option to move the data logger at GW-922 during the monitoring period to GW-925. The locations of the monitoring wells or piezometers for continuous monitoring are provided in Table 3 and Figure 2. The data loggers record temperature, conductivity, and pressure (water level). The duration of this plan may cover up to a year and a half in data collection to ensure an overlap with the screening level investigation of the EMDF and to observe the yearly hydrogeologic variations at the site.

Table 3: Continuous Monitoring Locations

Table 3. Continuous Monitoring Locations		
Well/Piezometer	Total Depth from Ground Surface (feet)	Rationale
GW-918	33.00	Will help understand fluctuations and hydrogeologic conditions along Pine Ridge.
GW-947	47.68	The fluctuating seasonal groundwater levelshave been near, at, or above the ground surface.
GW-952	45.00	Seasonal fluctuation in groundwater levels have been observed.
GW-916	36.00	Is close to a seep elevation and is by an existing wetland near EMDF.
GW-917	51.00	Wells GW-917 and GW-927 have shown an upward gradient.
GW-927	92.00	Wells GW-917 and GW-927 have shown an upward gradient.
GW-922	46.00	Very little water groundwater fluctuations have been previously observed, near NT-4 - see how lower NT-4 responds seasonally and to rain events.
GW-925	148.00	This well is hydraulically connected to NT-4 (water levels decreased when underdrain was installed) - see how NT-4 responds to rain events and other variations.

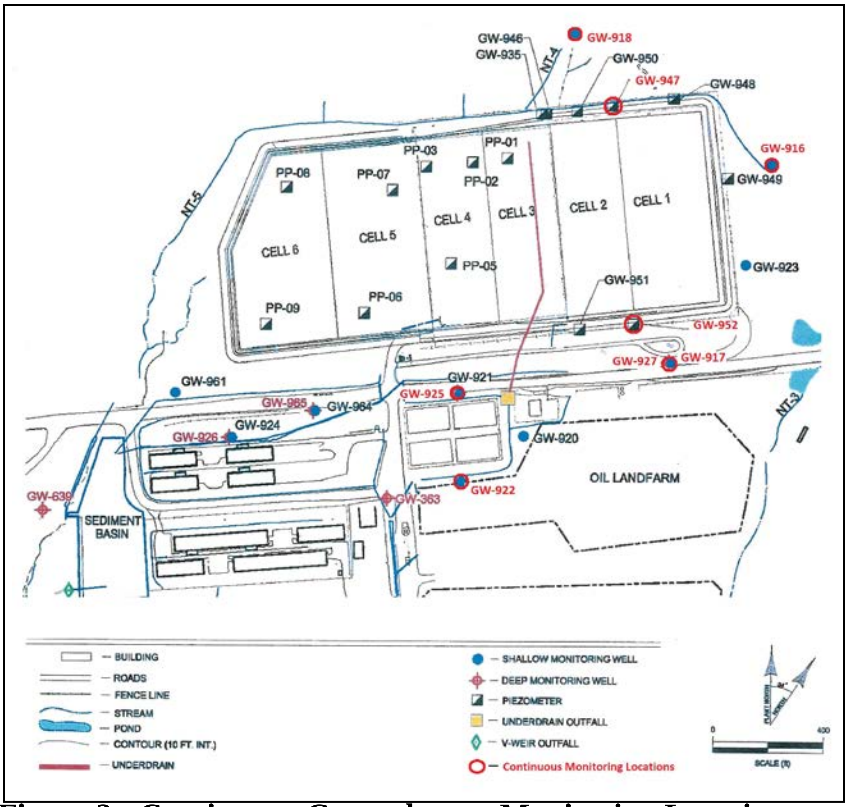


Figure 2: Continuous Groundwater Monitoring Locations

The loggers will be deployed, downloaded, and set up per their instrument manuals. Each water level data logger records absolute pressure (atmospheric pressure and water head), which is later converted to water level readings by software with initial deployment water level and the final water level upon removal or download and by processing a barometric pressure reference. To compensate for barometric pressure changes, one HOBO® water level logger will be deployed as a barometric reference.

In order to account for instrument drift with the conductivity data loggers, the units will be placed in tap water or conductivity standard for 15 minutes to ensure at least two conductivity readings. The conductivity parameters will be simultaneously recorded with a YSI© Professional Plus water quality meter at the same time. The instrument will be downloaded to a Waterproof HOBO® data shuttle. Before redeployment, the instrument will again be placed in the water or conductivity standard for another 15 minutes to gain reference data prior to placement back in the well. The data loggers will be downloaded monthly.

Task 4 – On a bi-weekly basis, staff will visit the EMWMF to perform general monitoring of the site. In addition to measuring water parameters, collecting water and sediment samples and data logger acquisition, staff will monitor the water levels in the contact water ponds and tanks, note discharges and water condition, observe condition of the sediment basin and note daily activity of the cell. Any concerns will be brought to the attention to EMWMF staff. Field notes are recorded and events reported in the annual EMR.

Task 5 - 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 reestablishing drainage previously provided by the filled NT-4 channel. Currently, the contractors take quarterly water level measurements at thirty-two wells and piezometers at the site, to assess the height of the water table. To evaluate EMWMF monitoring, this data will be reviewed as it becomes available and used to model the potentiometric surface of the water table beneath the facility relative to the bottom of the geologic buffer. Historical data collected by DOE does indicate a potential incursion for groundwater in the geologic buffer.

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Yard, C.R., Health, Safety, and Security Plan, Tennessee Department of Environment and Conservation, Division of Remediation, DOE Oversight Office. Oak Ridge, Tennessee. 2014.

Ambient Sediment Monitoring

Introduction

Contaminated sediments can directly impact benthic life as well as pose detrimental indirect effects on other organisms, including humans, through bioaccumulation and subsequent transfer through the food web. Sediment-associated contaminants are accepted as an important ongoing environmental problem that impacts the uses of many water bodies. 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 of its tributaries. Sediment samples are to be collected at five locations on the Clinch River and at four area streams. The sediment samples will be analyzed for certain metals and radiological contamination in order to assess the sediment quality for public health and ecological considerations.

Table 1: Sediment Sampling Locations

Monitoring Location	ID	Alternate ID	Monitoring Rationale
Clinch River Mile 48.7	CLINC048.7AN	CRK 78.4	Reference site upstream of DOE facilities.
Clinch River Mile 23.2	CLINC023.2RO	CRK 37.3	Sediment depositional area upstream of White Oak Creek outfall.
Clinch River Mile 14.5	CLINC014.5RO	CRK 23.3	Sediment depositional area downstream of White Oak Creek outfall.
Clinch River Mile 10.0	CLINC010.0RO	CRK 16.1	Sediment depositional area downstream of White Oak Creek and Poplar Creek outfalls.
Clinch River Mile 0.0	CLINC000.0RO	CRK 0.0	Sediment depositional area downstream of all DOE inputs.
Poplar Creek Mile 3.5	POPLA003.5RO	PCK 5.6	Sediment depositional area downstream of Mitchell Branch and East Fork Poplar Creek outfalls.
East Fork Poplar Creek Mile 3.1	EFPOP003.1RO	EFK 5.0	Sediment depositional area downstream of Y-12 influence.
Bear Creek Mile 2.8	BEAR002.8RO	BCK 4.5	Sediment depositional area downstream of Y-12 influence.
Mitchell Branch Mile 0.1	MITCH000.1RO	MIK 0.1	Sediment depositional area downstream of some ETTP influences.

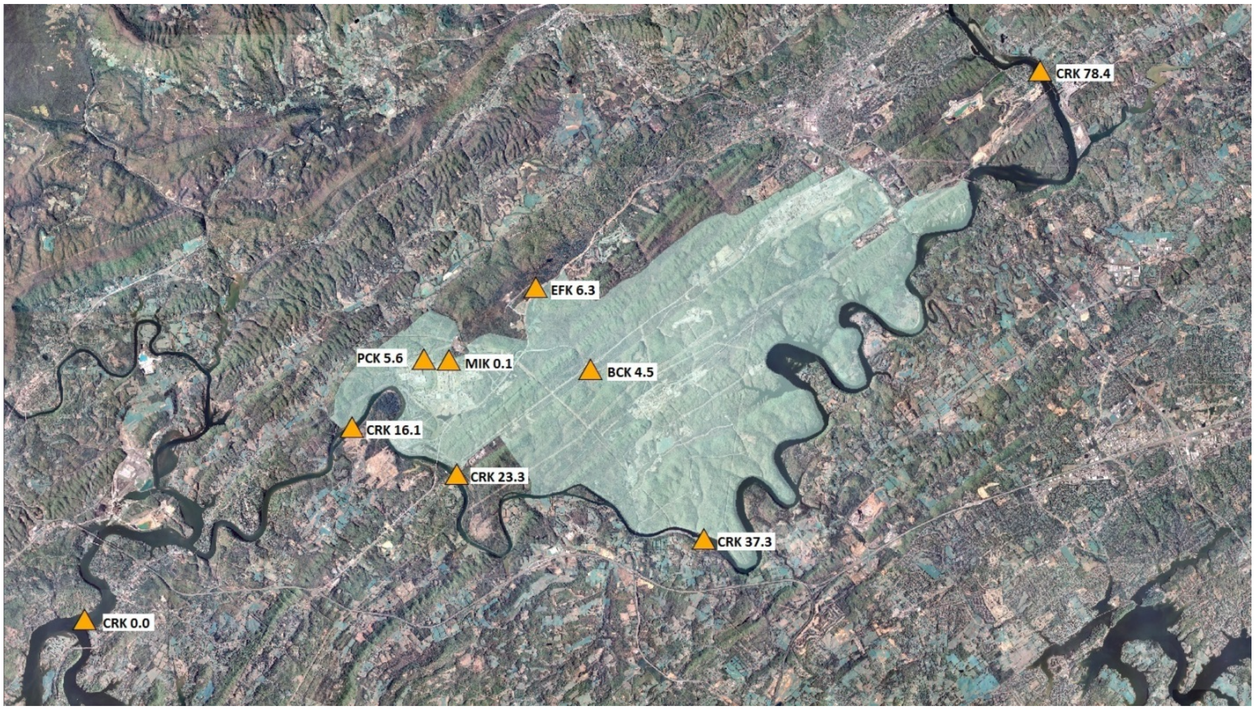

Figure 1: Sediment sampling locations

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
Parameters to be analyzed:
Inorganics: arsenic, barium, beryllium, boron, chromium, mercury, nickel, uranium.

Radiological: gross alpha (total), gross beta (total), gross gamma (total), and gamma radionuclides. At Bear Creek km 4.5 and Mitchell Branch km 0.1, radiological uranium analysis will be conducted.

Schedule
The ambient sediment monitoring will be conducted in the second or third quarter of 2015.

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
- Trash bags

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 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 to 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.

Wet chemistry and metals samples as well as organics samples will be sent 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

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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 2015, 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 (specific conductivity, pH, temperature, and dissolved oxygen). It will be monitored continuously to determine temporal trends with specific conductivity, pH, temperature, dissolved oxygen, and oxidation reduction potential.

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. This program will provide supplementary water quality data for office and Department of Energy (DOE) programs, and organizations outside of Tennessee Department of Environment and Conservation (TDEC). Figure 1 is a map of the monitoring locations. Table 1 provides the discrete locations that have been selected for monthly monitoring. Table 2 provides the locations of the three continuous monitoring locations with an option for placing a fourth continuous monitoring station at one of several potential locations.

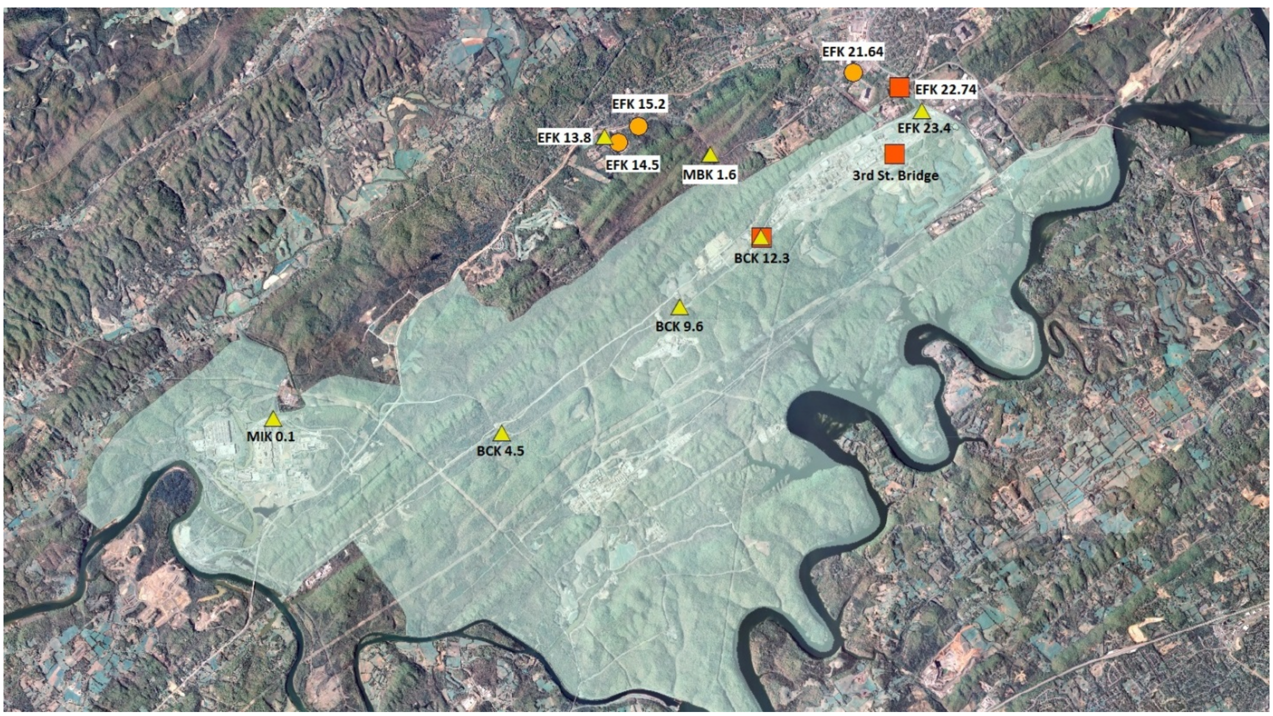

Figure 1: 2015 Surface Water Physical Parameters Monitoring Program

△ Discrete Monitoring Locations
■ Current Continuous Monitoring Locations
● Potential Continuous Monitoring Locations

Table 1:Discrete Stream Monitoring Locations

Stream Location	TDEC-DOE-O Project Site	DWR Site	Monitoring Rationale
East Fork Poplar Crk	EFK 23.4	EFPO014.5AN	Monitor water quality trends from the compliance point for water exiting Y-12.
East Fork Poplar Crk	EFK 13.8	EFPO008.6AN	Evaluate stream recovery.
Bear Creek	BCK 12.3	BEAR007.6AN	Monitor water quality trends of the water exiting Y-12 along Bear Creek.
Bear Creek	BCK 9.6	BEAR006.0AN	Monitor water quality trends from water exiting BCBG area and EMWMF and evaluate for unexpected impacts from DOE activities.
Bear Creek	BCK 4.5	BEAR002.8RO	Evaluate for unexpected impacts from DOE activities.
Mitchell Branch	MIK 0.1	MITCH000.1RO	Monitoring water exiting ETTP (K-25 area).
Mill Branch	MBK 1.6	FECO67I12	Background or Baseline Location.

Stream Location = Oak Ridge Reservation Stream/Watershed

TDEC-DOE-O Project Site = Tennessee Department of Environment and Conservation Department of Energy Oversight Office site designation

DWR Site = Division of Water Resources site designation

BCBG - Bear Creek Burial Grounds

EMWMF - Environmental Management Waste Management Facility

Table 2: Current and Potential Continuous Monitoring Locations

Stream Location	TDEC-DOE-O Project Site	DWR Site	Monitoring Rationale
		Current Locations	
East Fork Poplar Crk	3rd Street Bridge	EFPOP015.5AN	Observe and note the changes in water quality parameters just downgradient from Big Springs and OutFall 200.
East Fork Poplar Crk	EFK 22.74	EFPOP014.1AN	Observe and note the changes in water quality parameters of surface water exiting Y-12
Bear Creek	BCK 12.3	BEAR007.6AN	Observe the higher than normal conductivity values and any changes in water quality parameters.
		Potential Sites	
East Fork Poplar Crk	EFK 21.64	EFPOP013.4AN	Observe and note the changes in water quality parameters of surface water a little further from Y-12
East Fork Poplar Crk	EFK 15.2	EFPOP009.4AN	Determine the downgradient water quality parameters before the sewage treatment plant.
East Fork Poplar Crk	EFK 14.5	EFPOP009.0AN	Determine the downgradient water quality parameters before the sewage treatment plant.

Stream Location = Oak Ridge Reservation Stream/Watershed

TDEC-DOE-O Project Site = Tennessee Department of Environment and Conservation Department of Energy Oversight Office site designation

DWR Site = Division of Water Resources site designation

Methods and Materials

The discrete surface water physical parameters of temperature, pH, conductivity, and dissolved oxygen will be measured with a YSI© 556 multiprobe system and/or a YSI© professional plus multiparameter instrument. The continuous water quality parameters of temperature, pH, conductivity, dissolved oxygen and oxidation reduction potential will be measured with an In-Situ® Troll 9500. Precipitation data will be collected from the closest meteorological tower on the ORR. Water quality monitoring will follow the 2011 TDEC Water Pollution Control Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water.

Schedule

The discrete surface water monitoring will be conducted once per month. The continuous water quality data loggers will be visited once per week to aid in determining calibration drift, check on any sedimentation issues at the locations, and make sure the instruments are functioning properly.

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.

Yard, C.R. Health, Safety, and Security Plan. Tennessee Department of Environment and Conservation, Division of Remediation, DOE Oversight Office. Oak Ridge, Tennessee. 2014.

Ambient Trapped Sediment Monitoring

Introduction

Contaminated sediments can directly impact benthic life as well as pose detrimental indirect effects on other organisms, including humans, through bioaccumulation and subsequent transfer through the food web. Sediment-associated contaminants are accepted as an important ongoing environmental problem that impacts the uses of many water bodies. 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 East Fork Poplar Creek, Bear Creek, and at North Tributary 5 of Bear Creek (NT5). Sediment traps will be deployed at the following approximate stream locations: East Fork Poplar Creek km 6.3, 13.8, 23.4, Bear Creek km 4.5, 7.6 and at NT5.

Methods and Materials

Sediment Sampler Design

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

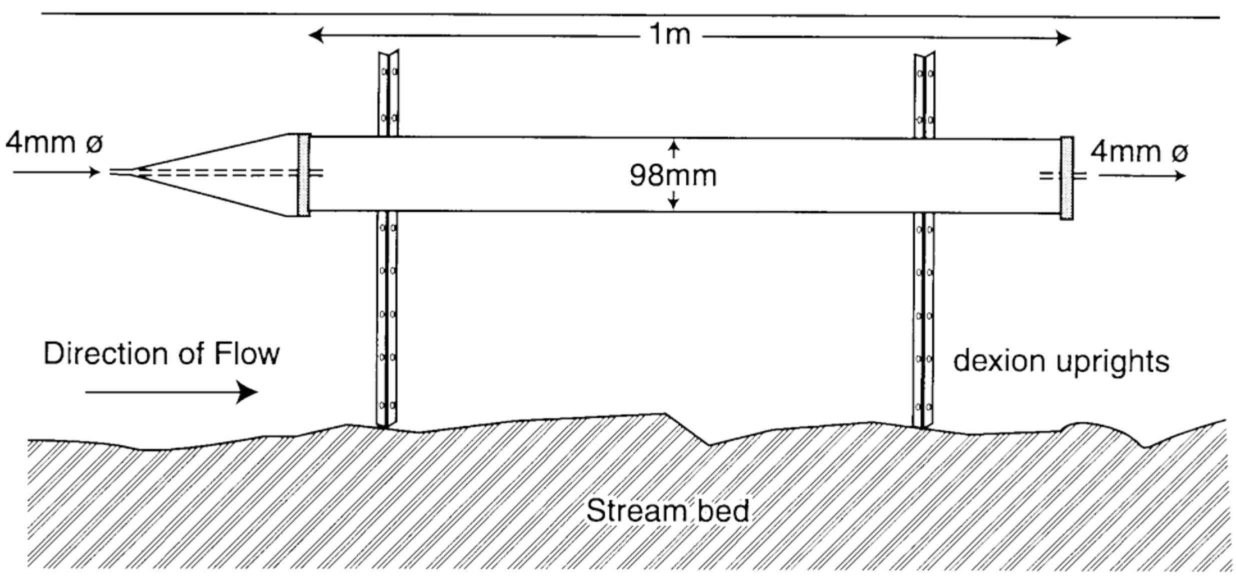

Figure 1: Design by Phillips *et al.* (2000)

The following parameters will be analyzed utilizing Tennessee Department of Health (DRH) Laboratory services:

Inorganics: arsenic, barium, beryllium, boron, chromium, mercury, methyl mercury, nickel, uranium.

Radiological: gross alpha (total), gross beta (total), isotopic uranium, gross gamma (total), *gamma radionuclides.*

Schedule
Passive sediment samplers will be deployed in the first quarter of 2015. Sediment samplers will be checked weekly in order to clear the inlet and outlet tubes. They will be opened and checked after approximately six months and the contents removed for analysis if the yield is sufficient.

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.

<u>Required Equipment</u>

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

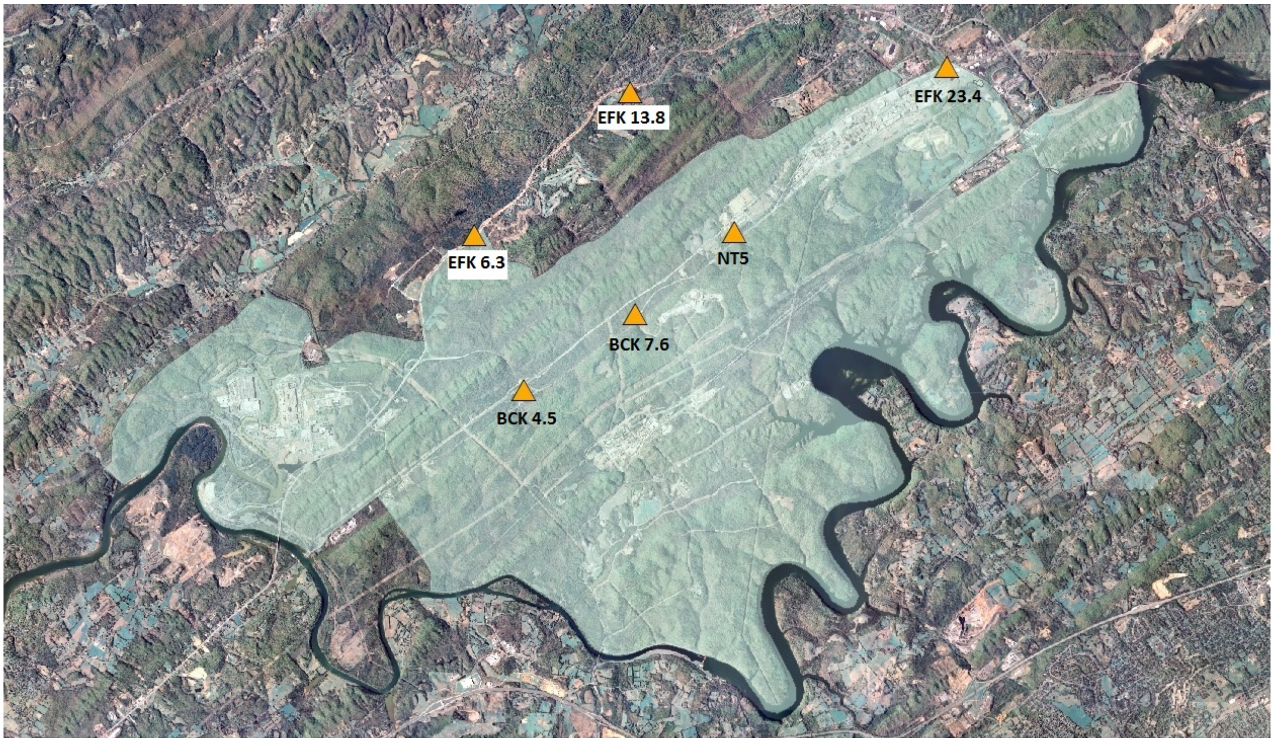

Figure 2: Trapped Sediment Site Locations

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 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 six 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 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. Certain analyses and quality control 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.

Wet chemistry and metals samples will be analyzed at the state lab in Nashville. All laboratory analysis will follow appropriate methods as documented in the Laboratory Services Inorganic Chemistry Standard Operating Procedure (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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Yard, C.R. Health and Safety Plan. Tennessee Department of Environment and Conservation, Division of Remediation, Department of Energy Oversight Office. Oak Ridge, Tennessee. 2014.

Ambient Surface Water Monitoring

Project Description

The objective of this monitoring program is to monitor radiological, chemical and physical characteristics of the Clinch River and several area streams to enable an assessment of the impacts of past and current Department of Energy (DOE) operations on the quality of local surface water. The sampling locations chosen are either exit pathways or reference sites (Table 1). Some of the sampling sites were chosen to provide data for evaluation of stream health at the sites where benthic macroinvertebrate monitoring is conducted. This surface water data is necessary in order to determine trends in macroinvertebrate communities in relation to changes in water quality and quantity. Clinch River sites were chosen for surveillance of water quality for public drinking water supplies and recreational purposes in relation to activities of the DOE.

Introduction

Surface water sampling is to be conducted annually at the sites listed in Table 1. The samples will be analyzed for radiological activity, nutrients, metals, and physical parameters in order to assess the water quality for public health and ecological considerations. Reference sites are located upstream of or outside of the influence of the Oak Ridge Reservation (ORR). The other sites were chosen to detect contaminants being transported by surface water coming from the ORR or areas affected by DOE related activities.

Methods and Materials

In addition to conducting surface water chemical sampling, physical parameters of the stream will be measured and recorded. Utilizing YSI® Professional Plus or YSI® 556 MPS multi-parameter field instruments, the parameters of pH, temperature, dissolved oxygen, and conductivity will be measured at each stream. Flow at streams will be measured with a Sontek Flowtracker® or by the flow estimation float method.

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 Health, Safety, and Security Plan (Yard 2014). Field sampling will be completed within the spring of 2015. Table 1 specifies the sampling sites; Figures 1 and 2 provide maps of the sampling sites.

The surface water samples will be transported to the Tennessee Department of Health (TDH) Laboratory Services in Nashville and analyzed for the following parameters:

Inorganics: hardness (total as $CaCO_3$), nitrogen (ammonia), nitrogen (NO_3 & NO_2), nitrogen (total Kjeldahl), phosphorus (total), residue (dissolved), and residue (suspended).

Metals: arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, and zinc.

Radionuclides: gamma radionuclides, gross alpha, and gross beta. Raccoon Creek samples will be analyzed for strontium-90 and technetium-99.

Table 1: Stream Locations

Monitoring Location	DWR ID	Alt. ID	Monitoring Rationale
Clinch River Mile 78.7	CLINC078.7AN	CRK 126.7*	Reference site upstream of DOE facilities.
Clinch River Mile 52.6	CLINC052.6AN	CRK 84.7*	Reference Site & Surveillance of water quality near Anderson County Water Filtration Plant.
Clinch River Mile 41.2	CLINC041.2AN	CRK 66.3	Surveillance of water quality near Oak Ridge "Y-12" Water Filtration Plant.
Clinch River Mile 35.5	CLINC035.5AN	CRK 57.1	Surveillance of water quality near Knox County Water Filtration Plant.
Clinch River Mile 17.9	CLINC017.9RO	CRK 28.8	Surveillance of water quality downstream of White Oak Creek outfall.
Clinch River Mile 14.3	CLINC014.3RO	CRK 23	Surveillance of water quality near Oak Ridge "K-25" Water Filtration Plant.
Clinch River Mile 10.0	CLINC010.0RO	CRK 16.1	Surveillance of water quality downstream of all DOE ORR facilities.
Raccoon Creek Mile 1.6	RACCO001.6RO	RCK 2.6	Surveillance of water quality possibly influenced by contaminated groundwater from SWSA 3.
East Fork Poplar Creek Mile 15.6	EFPOP015.6AN	EFK 25.1	Surveillance of water quality at East Fork Poplar Creek (EFPC) headwaters.
East Fork Poplar Creek Mile 15.2	EFPOP015.2AN	EFK 24.4	Surveillance of water quality at EFPC intermediate to EFK 25.1 and EFK 23.4.
East Fork Poplar Creek Mile 14.5	EFPOP014.5AN	EFK 23.4	Surveillance of water quality at point where EFPC leaves leaves DOE property and enters Oak Ridge.
East Fork Poplar Creek Mile 8.6	EFPOP008.6AN	EFK 13.8	Surveillance of EFPC water quality just upstream of Oak Ridge sewage treatment outfall.
East Fork Poplar Creek Mile 3.9	EFPOP003.9RO	EFK 6.3	Surveillance of EFPC water quality downstream of Oak Ridge.
Bear Creek Mile 7.6	BEAR007.6AN	BCK 12.3	Surveillance of Bear Creek water quality near headwaters.
Bear Creek Mile 6.0	BEAR006.0AN	BCK 9.6	Surveillance of Bear Creek water quality downstream of Environmental Management Waste Management Facility (EMWMF).
Mitchell Branch Mile 0.9	MITCH000.9RO	MIK 1.43 *	Surveillance of Mitchell Branch (MIK) water quality upstream of ETTP.
Mitchell Branch Mile 0.4	MITCH000.4RO	MIK 0.71	Surveillance of MIK water quality at a point influenced by ETTP activities.
Mitchell Branch Mile 0.3	MITCH000.3RO	MIK 0.45	Surveillance of MIK water quality at a point influenced by ETTP activities.
White Oak Creek Mile 4.2	WHITE004.2RO	WCK 6.8 *	Reference site upstream of ORNL.
White Oak Creek Mile 2.4	WHITE002.4RO	WCK 3.9	Surveillance of White Oak Creek (WCK) at a point influenced by ORNL.
White Oak Creek Mile 2.1	WHITE002.1RO	WCK 3.4	Surveillance of White Oak Creek (WCK) at a point downstream of ORNL.
White Oak Creek Mile 1.4	WHITE001.4RO	WCK 2.3	Surveillance of White Oak Creek (WCK) at a point downstream of Melton Valley Burial Grounds.
Melton Branch Mile 0.2	MELTO000.2RO	MEK 0.3	Surveillance of Melton Branch (MEK) at a point influenced by Melton Valley Burial Grounds.
Clear Creek Mile 1.0	ECO67F06	CCK 1.6 *	Reference site upstream of DOE facilities.
Gum Hollow Branch Mile 1.8	GHOLL001.8RO	GHK 2.9 *	Reference site on Oak Ridge Reservation.
Hinds Creek Mile 12.8	HINDS012.8AN	HCK 20.6 *	Reference site north of Oak Ridge.
Mill Branch Mile 1.0	FECO67I12	MBK 1.6 *	Reference site in Oak Ridge.

DWR ID = Division of Water Resources site designation

ID is an abbreviation of the stream name with the distance from mouth in km; * = Reference Stream

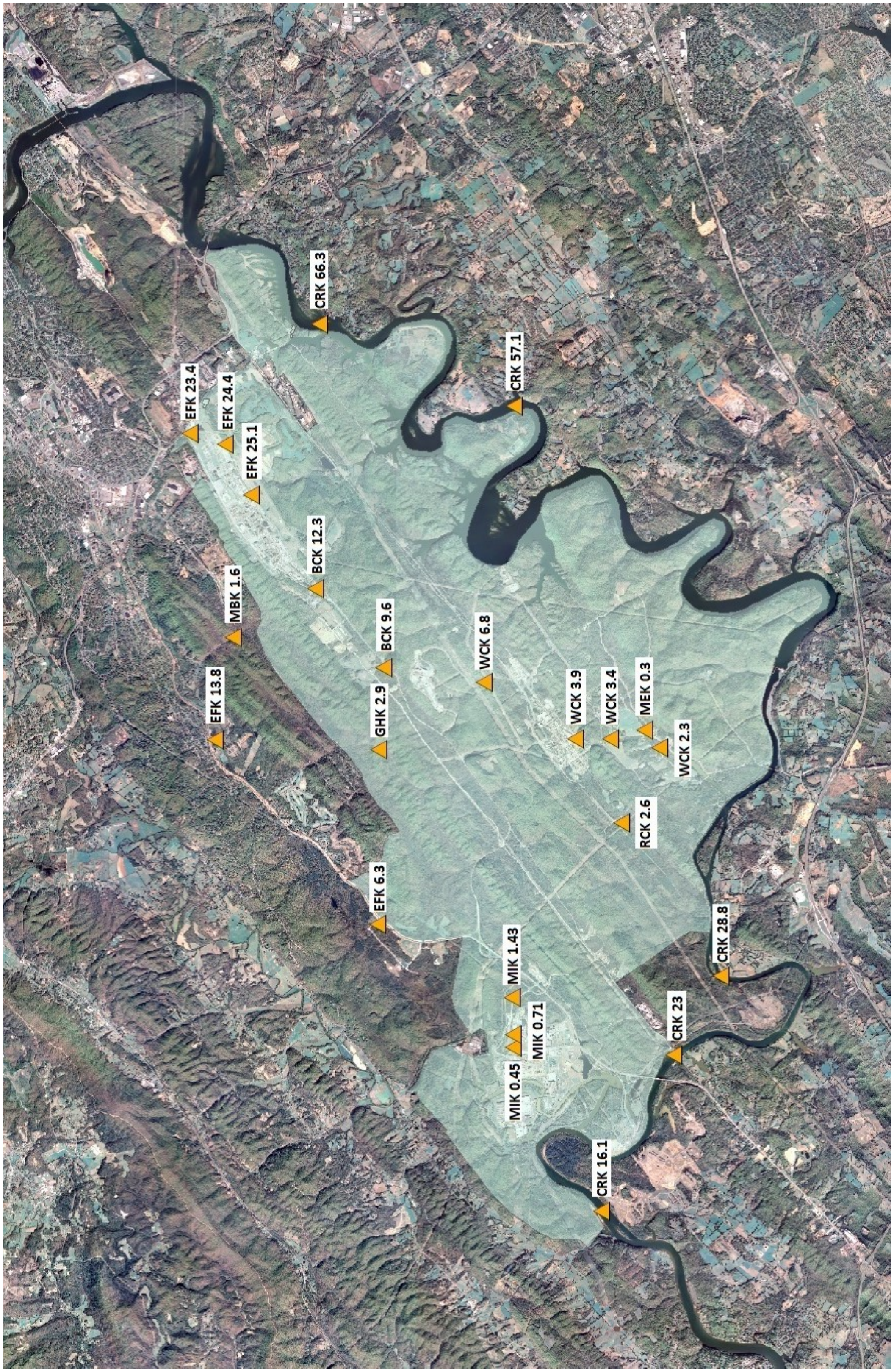

Figure 1: Surface Water Sampling Sites in and around the ORR

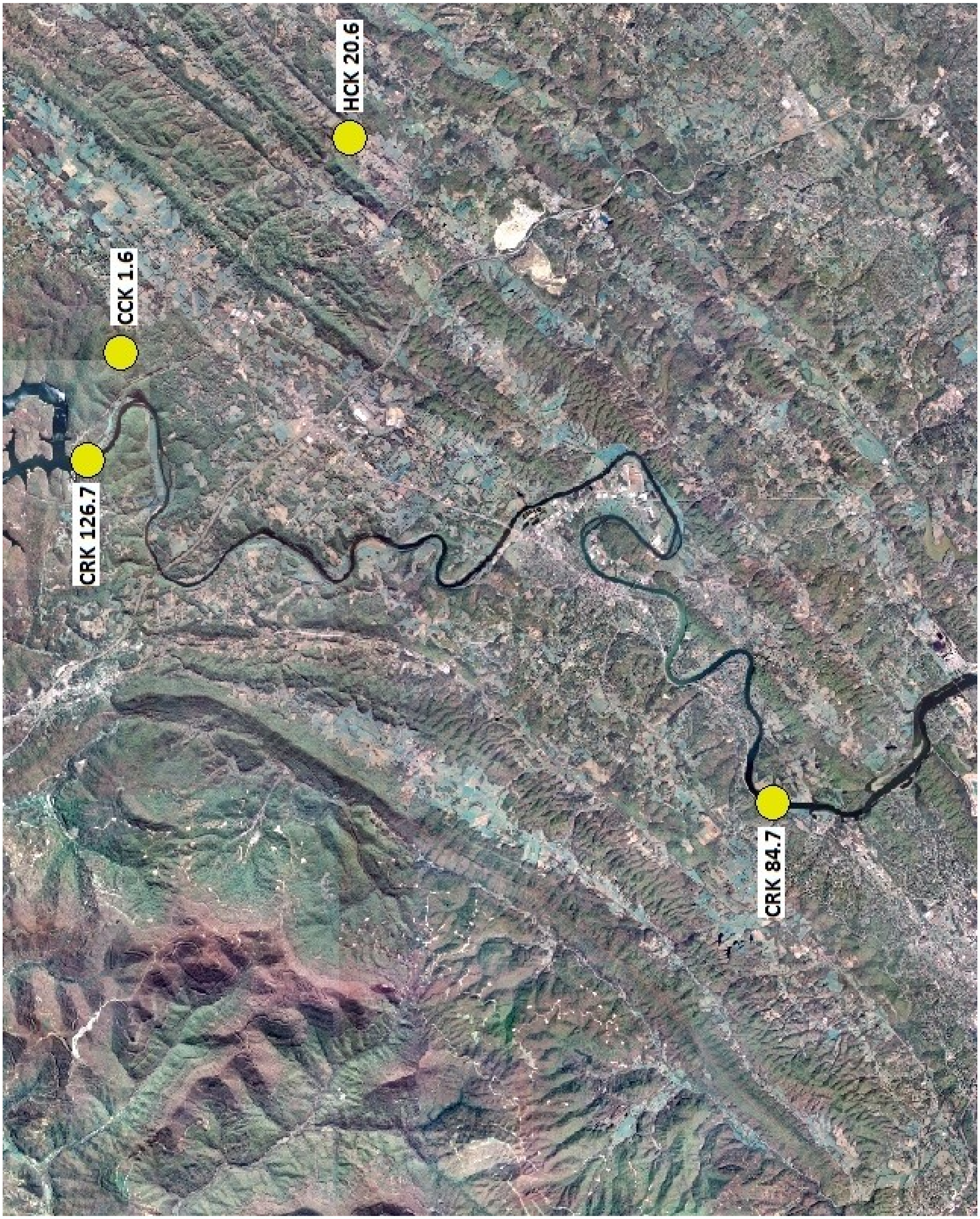

Figure 2: Kentucky-located Surface Water Sampling Sites

The TDH Laboratory Services has expertise in a broad scope of services and analyses. This expertise is available to the Tennessee Department of Environment and Conservation (TDEC), 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

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.

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, Division of Remediation, DOE Oversight Office. Oak Ridge, Tennessee. 2014.

Rain Event Surface Water Monitoring

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 rain events. These events could cause the displacement of contamination that would not normally impact streams around the ORR.

During 2015, to assess the degree of surface water impact caused by these rain events, a sampling of streams will be conducted following heavy rain events to determine the presence or absence of contaminants of concern. Table 1 shows locations that are being considered for sampling.

Table 1: Sample locations:

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 ETTP)
SD 490	Storm Drain located at ETTP
P1 Pond Weir	Weir located at ETTP
MBK 1.6 (1.0)	Mill Branch (Reference)
SD 510	K-31 ETTP

Methods and Materials

The physical parameters of temperature, pH, conductivity and dissolved oxygen will be measured at all sites in the field. Based on past sampling results, the following locations will have the listed analysts analyzed utilizing Tennessee Department of Health Laboratory services:

EFK 23.4 (14.5):	Metals:	Mercury
	Radionuclides:	Gross alpha, Gross beta, Gamma
WCK 0.0 (0.0):	Metals:	Mercury
	Radionuclides:	Gross alpha, Gross beta, Gamma, Strontium 90
BCK 4.5 (2.8):	Metals:	Mercury
	Radionuclides:	Gross alpha, Gross beta, Gamma
*MIK 0.1 (*0.06):	Metals:	Mercury
	Radionuclides:	Gross alpha, Gross beta, Gamma
SD 490:	Metals:	Mercury, Hexavalent Chromium, Uranium
	Radionuclides:	Gross alpha, Gross beta, Gamma,

		Technetium-99, Isotopic Uranium, Tritium
P1 POND WEIR:	Metals:	Mercury, Hexavalent Chromium,
	Radionuclides:	Gross alpha, Gross beta, Gamma, Technetium-99, Tritium, Isotopic Uranium, Tritium
MBK 1.6 (1.0)	Metals:	Mercury, Uranium
	Radionuclides:	Gross alpha, Gross beta, Gamma, Isotopic Uranium
SD 510:	Metals:	Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Hexavalent Chromium, Uranium, Zinc
	Radionuclides:	Gross alpha, Gross beta, Gamma, Isotopic Uranium, Strontium-90 and Technetium-99, Tritium PCB's

Schedule
Sampling and monitoring will be conducted no more than once a 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
Laboratory Services has expertise in a broad scope of services and analysis. This expertise is available to the Tennessee Department of Environment and Conservation, Division of Remediation (the division) 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 Nashville branch of Laboratory Services. Metal and radiological samples will be sent to Laboratory Service in Nashville. Hexavalent Chromium and PCB samples will be contracted out to Microbac Laboratories in Maryville, Tn. All Laboratory Services will follow appropriate methods as documented in the Laboratory Services Inorganic Chemistry Standard Operating Procedures (SOP) and Organic Chemistry SOP. Specific analytical methods are covered in the standard operating procedures manuals for Laboratory Services. The SOPs direct analysts to the proper EPA or other methodology.

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.

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, 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.

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