TENNESSEE DEPARTMENT
OF
ENVIRONMENT AND CONSERVATION

DIVISION OF REMEDIATION
OAK RIDGE OFFICE

ENVIRONMENTAL MONITORING PLAN

For Work to be Performed:

July 1, 2023, through June 30, 2024

Nov. 2023

Tennessee Department of
Environment and Conservation,
Authorization No. 327023

To reach your local
ENVIRONMENTAL ASSISTANCE CENTER
Call 1-888-891-8332 or 1-888-891-TDEC

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Acronyms

A	Ac-228	actinium-228
	Am-241	americium-241 (transuranic isotope)
	ANOVA	analysis of variance in statistics
	ARARs	Agency for Toxic Substances and Disease Registry
	As	arsenic (metal)
	ASER	Annual Site Environmental Report (DOE)
	ATSDR	Agency for Toxic Substances and Disease Registry
	AWQC	Ambient Water Quality Criteria
B	Ba	barium (metal)
	Background site	reference site: background site located outside of a 5-mile radius of potential impact from the Oak Ridge Reservation
	BCK	Bear Creek Station or Bear Creek Kilometer
	BC	blue catfish
	BCAP	Bear Creek Assessment Project
	BC/BCK/BCV	Bear Creek/Bear Creek kilometer or station/Bear Creek Valley
	BCBGs	Bear Creek Burial Grounds
	Be-7	beryllium-7 (metal)
	Benthic Life	Organisms that live on or in the streambed (insects, amphibians, spiders, worms, etc.)
	Bi-214	bismuth-214
	Biocides	Any product or substance used in a cooling tower which is intended to destroy, control or prevent the effects of algae, bacteria, sulfate-reducing bacteria, protozoa, and fungi.
	BMP	best management practice
	Bo	boron (metal)
C	CAA	Clean Air Act
	CBSQG	Consensus Based Sediment Quality Guidelines
	CC	channel catfish
	CC/CCK	Clear Creek/Clear Creek kilometer (background stream)
	CCME	Canadian Council of Ministers for the Environment
	Cd	cadmium (metal)
	CEC	Civil and Environmental Consultants
	CERCLA	The Comprehensive Environmental Response, Compensation, and Liability Act (commonly known as Superfund) enacted by Congress on December 11, 1980.

	Cm	curium-242/244
	CMP	Comprehensive Monitoring Plan
	Co-60	cobalt-60
	COC	Chain of Custody
	COCs	Contaminants of Concern
	COND	conductivity
	Cr_6	Hexavalent Chromium (metal)
	CR/CRK	Clinch River/Clinch River kilometer
	Cs-137	cesium-137 (metal)
	CSU	Combined Standard Uncertainty
	Cu	copper (metal)
D	D&D	Decontamination and Decommissioning
	DO	Dissolved oxygen
	DOE	U.S. Department of Energy
	DoR	Division of Remediation
	DOR-OR	Division of Remediation – Oak Ridge
	DWR	Division of Water Resources
E	EFPC/EFK	East Fork Poplar Creek/East Fork Poplar Creek Kilometer
	EMP	Environmental Monitoring Plan
	EMR	Environmental Monitoring Report
	EMWMF	Environmental Management Waste Management Facility
	EPA	U.S. Environmental Protection Agency
	EPT	Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)
	%EPT – Cheum	Percent EPT - Cheumatopsyche (tolerant Trichoptera)
	ESOA	Environmental Surveillance Oversight Agreement
	ETA	Edgewater Technical Associates (DOE subcontractor)
	ETTP	East Tennessee Technology Park (formerly K-25)
F	FDA	Food and Drug Administration (Federal)
	FFA	Federal Facility Agreement
	FHC	flathead catfish
	FRMAC	Federal Radiological Monitoring and Assessment Center
G	GCN	greatest conservation need
	GPS	Global Positioning System
H	HAZWOPER	Hazardous Waste Operations and Emergency Response
	H_2SO_4	sulfuric acid
	H-3	tritium

	HAs	Health Advisory Values
	HCl	hydrochloric acid
	HFIR	High Flux Isotope Reactor
	Hg	mercury (metal)
	HQ	Hazard Quotient (noncarcinogenic risk equations)
	HNO_3	nitric acid
	HRE	Homogeneous Reactor Experiment
I	I-129	iodine-129
	IACUC	Institutional Animal Care and Use Committee
	IC25	Inhibition Concentration 25% reduction in survival, growth and reproduction of test organism
	ISM	Incremental Sampling Methodology
	ITRC	Interstate Technology Regulatory Council
J	J values	Result less than MQL but greater than or equal to MDL
K	K-25	Former site of Gaseous Diffusion Plant closed in 1987, now ETTP
	K-27	Sampling site on ETTP
	K-40	potassium-40
L	LLW	Low-level radioactive waste
	LMB	largemouth bass
	LSC	Liquid Scintillation Counting
M	MB/MBK	Mill Branch/Mill Branch kilometer (background stream)
	MCL	Maximum Contaminant Limit see NPDWR
	MDC	Minimum Detectable Concentration
	MDL	Minimum Detection Limit
	MeHg	methylmercury
	MH	manhole 1 (MH-1), manhole 2 (MH-2) at Y-12
	MIK	Mitchell Branch/Mitchell Branch kilometer
	MQL	Minimum Quantification Limit
	MQL	Method Quantification Limit
	MSRE	Molten Salt Reactor Experiment
N	NaI	sodium iodide (used in gamma scintillator probe)
	Ni	nickel (metal)
	NNSA	National Nuclear Safety Administration
	NAREL	National Air and Radiation Environmental Laboratory (EPA)
	NCBI	North Carolina Biotic Index
	NESHAPS	National Emissions Standards for Hazardous Air Pollutants
	NOAA	National Oceanic and Atmospheric Administration

	NORM	Naturally Occurring Radioactive Materials
	Np-237	neptunium-237 (transuranic isotope)
	NPDES	National Pollution Elimination System permit
	NPDWR	National Primary Drinking Water Regulations
	NPL	National Priority List
	NRC	Nuclear Regulatory Commission
	NSDWR	National Secondary Drinking Water Regulations
	NT-5	Bear Creek Northwest Tributary 5
	NTU	nephelometric turbidity units
	NUREG	NRC Regulation
O	OF-200 MTF	Outfall 200 Mercury Treatment Facility at Y-12
	ORAU	Oak Ridge Associated Universities
	OREIS	Oak Ridge Environmental Information System
	ORNL	Oak Ridge National Laboratory, also known as X-10
	ORP	Oxygen Reduction Potential
	ORR	Oak Ridge Reservation
	OSL	Optically Stimulated Luminescence Dosimeter
	%OC	Percent Oligochaeta and Chironomidae
P	Pb	lead, Pb-212/214
	PC/PCK/PCM	Poplar Creek/Poplar Creek kilometer/Poplar Creek mile
	PCBs	Polychlorinated Biphenyls
	PEC	Probable Effects Concentration
	POP	Persistent Organic Pollutants
	PPE	Personal Protective Equipment
	PRGs	Preliminary Remediation Goals
	Pu	plutonium-238/239/240 (transuranic isotope)
Q	QA/QC	Quality Assurance/Quality Control
	QAPP	Quality Assurance Project Plan
	QEC	Quality Environmental Containers (Beaver, WI)
R	RA	Remedial Activities
	Ra	radium
	RADCON	Radiation Control Program
	RAIS	Risk Assessment Information System
	RBC	Risk-based Assessment
	RCS	Roving Creel Survey
	RER	Remedial Effectiveness Report
	ROD	Record of Decision

	RPM	Radiation Portal Monitor
	RSLs	Regional Screening Levels
	RWP	Radiation Work Permit
S	SAIC	Science Applications International Corporation
	SAP	Sampling and Analysis Plan
	SMB	smallmouth bass
	SOP	Standard Operating Procedure
	Sr-90	strontium-90
	SRS	Southern Research Station
	Station	A specific location where environmental sampling or monitoring takes place.
	SU	standard units
	SD	storm drain
	SMCLs	Secondary Maximum Contaminant Levels same as NSDWRs
	SWPPP	Storm Water Pollution Prevention Plan
	SWSA	Solid Waste Storage Area
T	T&E species	State- or Federal-listed threatened and endangered species as protected under the Endangered Species Act of 1973.
	TECs	Threshold Effects Concentrations
	TENORM	Technically Enhanced Naturally Occurring Radioactive Materials
	TR	Target Risk
	Tc-99	technetium-99
	TDEC	Tennessee Department of Environment and Conservation
	TDEC-DoR	TDEC-Division of Remediation
	TDH	Tennessee Department of Health
	TDH-NEL	Tennessee Dept. of Health-Nashville Environmental Laboratory
	Th	thorium-228/230/232
	THI	Target Hazard Index
	THQ	Target Hazard Quotient
	Tl-208	thallium-208
	TMI	Tennessee Macroinvertebrate Index
	TNUTOL	Total Nutrient Tolerant
	TN AWQC	State of Tennessee Ambient Water Quality Criteria
	TS	tree swallows
	TWQC	Tennessee Water Quality Criteria
	TWRA	Tennessee Wildlife Resources Agency
U	U	Result is less than Method Detection Limit (MDL)

	U-234/235/238	uranium-234/235/238
	UEFPC/UEFK	Upper East Fork Poplar Creek/Upper East Fork Creek Kilometer
	USDI	U.S. Department of the Interior
	UV	ultraviolet
V	VOCs	volatile organic compounds
W	WAC	Waste Acceptance Criteria
	WB	white bass
	WD	wood duck
	WDNR	Wisconsin Department of Natural Resources
	WE	walleye
	WC/WCK	Whiteoak Creek/White Oak Creek/White Oak Creek kilometer
X	X-10	Historical name, renamed Oak Ridge National Lab (ORNL)
Y	Y-12	Y-12 National Security Complex (Building 9213, 9219, 9723-28)

UNITS OF MEASURE AND THEIR ABBREVIATIONS

°C	degrees Celsius/Centigrade
μS/cm	micro-Siemens per centimeter
mV	millivolts
DO	amount of gaseous (O_2) dissolved in water
pH	scale of acidity from 0 to 14
μg/L	micrograms per liter (parts per billion)
mg/L	milligrams per liter (parts per million)
ng/g	nanograms per gram (parts per billion)
μg/g	micrograms per gram (parts per million)
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
millirem	A millirem is one thousandth of a rem
rem	A rem is the unit of effective absorbed dose of ionizing radiation in human tissue, equivalent to one roentgen of X-rays
mrem	Abbreviation for millirem which is a unit of absorbed radiation dose

EXECUTIVE SUMMARY

The Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge Office (TDEC DoR-OR), provides the annual *Environmental Monitoring Plan* (EMP), for fiscal year 2024 (FY24) with a period of performance from July 1, 2023, through June 30, 2024.

Initial publication of this Environmental Monitoring Plan (EMP), intended for July 1, 2023, (at the start of the 2024 state fiscal year), was delayed due to delays in execution of the FY24 Federal Facility Agreement (FFA) grant and the FY24 Environmental Surveillance and Oversight (ESOA) grant. Due to a lack of grant approvals at this time (current date of Nov 21, 2023), this Environmental Monitoring Plan is specifically provided to clearly address for the stakeholders the goals for TDEC DOR-OR's FY24 EMP period of performance. This document will define the oversight and verification work scopes (including independent monitoring and assessment of the U.S. Department of Energy's (DOE's) environmental monitoring and remediation actions across the Oak Ridge Reservation) that TDEC has determined to be necessary to ensure protectiveness of human health and the environment for the period of FY24 for the State of Tennessee.

While inclusion of projects in this EMP does not associate projects with a specific funding source at this time, all projects defined in this EMP are found to be consistent with the National Contingency Plan (NCP) and are intentionally designed to be in compliance with the administrative and operational requirements of the *Environmental Surveillance and Oversight Agreement* (ESOA) and, additionally, in support of the *Federal Facility Agreement (FFA*).

TDEC DoR-OR participates in independent monitoring and verification sampling as well as conducting oversight of current DOE activities across the Oak Ridge Reservation (ORR) to confirm existing DOE project results. TDEC DoR-OR utilizes the data and information derived from these work scopes to support environmental restoration decisions, evaluate performance of existing remedies, and to investigate the extent and movement of legacy contamination.

This independent State of Tennessee sampling and monitoring program is designed to assess and verify current conditions for any ORR related environmental media (i.e., air, surface water, soil, sediment, ground water, drinking water, food crops, fish and wildlife and biological systems), by collecting data to verify, evaluate or supplement DOE's separate environmental monitoring datasets. This State program is intended to provide independent assessment, where necessary, for potential emissions of any materials (i.e., hazardous, toxic, chemical, or radiological) from the ORR to its surrounding environment. Monitoring results from these activities will be used to supplement and verify DOE monitoring data and will support TDEC's data needs to support effective and efficient protectiveness decisions and agreements across the ORR.

Summaries of the FY24 independent monitoring projects, follow:

I. Air Monitoring:

Fugitive Radiological Air Emissions

The project team will independently sample air at a minimum of eight (8) ORR locations. The resulting data will be compared with DOE air monitoring data for compliance verification. Air samples will be screened for radiological emissions, which may have originated from ORR remedial actions and/or waste disposal activities. All data will be evaluated for compliance within Federal Regulatory Standards. The main concern is to identify any air emissions that may have the potential to cause a member of the public to receive an effective dose greater than 10 mrem per year.

RadNet Air

RadNet is a national program funded by the U.S. Environmental Protection Agency (EPA). The program monitors the air, precipitation, and drinking water across the U.S. to track radiation in the environment. RadNet provides independent radiochemical analysis for air samples taken from three (3) air monitoring stations on the ORR, and one (1) background reference station. The air monitoring stations are located within Oak Ridge National Lab's (ORNL's) Bethel Valley, ORNL's Melton Valley, and at the west end of Y-12. Samples collected by TDEC DoR-OR are sent to EPA's National Air and Radiation Environmental Laboratory (EPA NAREL) in Montgomery, Alabama, for analysis.

RadNet Precipitation

RadNet also performs radiochemical analysis of precipitation samples taken from monitoring stations at three Oak Ridge locations that are co-located with the RadNet Air stations. Two (2) stations are located at ORNL: one in Melton Valley and one in Bethel Valley. The third site is located on the east end of Y-12. RadNet precipitation monitoring around both ORNL and Y-12 is valuable as Decontamination and Decommissioning (D&D) activities have begun to focus on these two campuses. Samples will be collected by TDEC DoR-OR, and independent analysis will be performed at the EPA NAREL.

II. Biological Monitoring:

Benthic Macroinvertebrate Health

This project consists of benthic macroinvertebrate monitoring to ascertain the current stream health in the primary ORR exit pathway streams. Two riffles will be sampled on each reach. Animals from both riffles will be combined, randomly sub-sampled, and identified to species level when possible. The overall biodiversity of a sample plus the assemblage of sensitive indicator taxa will help to quantify stream health. These stream statistics will be compared to previous sampling years and to corresponding DOE monitoring data. In addition, during FY24, sampling will help support the holistic *East Fork Poplar Creek Assessment Project* (EFPCAP) with the contribution of benthic macroinvertebrate data obtained from East Fork Poplar Creek.

ORR Roving Creel Survey

This project documents angling efforts at three key areas where impaired ORR watersheds drain into publicly accessible waters. Public outreach surveys will be used to assess risk from exposure of fisherman to ORR contamination through recreational use of the waterways immediately adjacent to the ORR. For FY24, TDEC DoR-OR staff plan to survey fishermen at three stream confluence areas:

1. White Oak Creek Embayment - the Clinch River Confluence (WOCE-CR)
2. Poplar Creek – Clinch River Confluence (PC-CR)
3. East Fork Poplar Creek - Poplar Creek Confluence (EFPC-PC)

To further understand possible human exposure risks, recreators will be surveyed along the North Boundary Greenway. This will assist TDEC in better understanding and evaluating potential for risk associated with recreation on the greenway, which crosses streams that receive ORR discharges upstream of and connect to the three confluence areas described above. Data from this project helps to support discussions on management of risk to the public associated with ongoing remediation efforts on the ORR.

Radiological Uptake in Food Crops

The project assesses possible radiological impacts of DOE ORR activities on food crops grown by local farmers and gardeners. While the project mirrors a similar DOE project, TDEC DoR-OR sampling will be conducted independently to verify and correlate DOE sample results. This food crops project will collect vegetables, hay, and milk samples within a five (5) mile radius of the ORR. For each type of sample, a corresponding background location outside the study area will be analyzed to establish background (i.e., reference) levels.

Ground Beetle Community Health

Mercury is found at elevated levels throughout the ORR and continues to be a contaminant of concern (COC) especially in East Fork Poplar Creek (EFPC). This project will focus on assessing ecological health and the environmental protectiveness of the food chain in this impacted area, by assessing ground beetle community health along EFPC. EFPC is an ORR exit pathway stream, whose headwaters originate within the Y-12 campus and are fed by surface water runoff and groundwater that has been in contact with mercury-contaminated structures.

Ground beetles, or carabids, will be passively collected in pitfall traps from the three main impacted zones and a reference zone. Data results assist in understanding bioaccumulation and contaminant migration in this food web and provide data to support ongoing discussions and evaluations of ecological protectiveness.

III. Groundwater Monitoring:

Offsite Groundwater

Delineation of the nature and extent of groundwater contamination is incomplete in many areas of the ORR (DOE, 2022b). Many contaminant plumes across the ORR are not well defined and require ongoing investigation to delineate their vertical and horizontal extent. Located in an area with geologically complex bedrock containing many faults and carbonates that exhibit a karst terrain with large sinkholes, little is understood about the contaminant flow paths within the bedrock across the ORR, and further investigation is necessary to evaluate these flow pathways.

The goals of this offsite groundwater monitoring project are to make sure contaminants are not present in these selected representative residential drinking water wells located offsite of the ORR, verify that there is no threat to human health based on current results, and provide additional supplemental offsite data to DOE’s datasets. An active focus of the State is ongoing assessment for protectiveness of groundwater for residents around the ORR, while DOE’s plume delineation and contamination delineation activities continue.

IV. Landfill Monitoring:

EMDF Site: Surface Water Monitoring

TDEC is analyzing surface water samples for a range of chemicals, radionuclides, and water quality parameters to characterize baseline conditions prior to construction and operation of the planned Environmental Management Disposal Facility (EMDF) landfill. Establishment of a robust baseline dataset is necessary to support future monitoring programs that will evaluate how well landfill operations protect public health and the environment. This baseline will directly support TDEC's ability to provide comparison with and accurate oversight of those future DOE monitoring programs. Given the presence of other significant sources of contamination upgradient in Bear Creek Valley (e.g., Bear Creek Burial Grounds), a defensible baseline is important for understanding whether contamination detected in the future has been released from EMDF or is attributable to other sources.

For this EMDF Site Surface Water Monitoring Project, one stream, five (5) area flume discharge locations, and one spring, will have surface water quality measurements collected to further delineate the current site conditions within the area of the future EMDF and the associated Bear Creek Valley (BCV) watershed. TDEC sampling is driven by the need for sufficient data to provide a statistically defensible baseline dataset, and this oversight activity is specifically designed to help ensure that TDEC's data needs are met to allow for TDEC's informed support of protectiveness decisions that are intended to be made moving forward. In addition, parameter data will be used with in the baseline for future assessments of stream health and protectiveness after the landfill is in use.

EMWMF Site

Contaminated materials from the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) remediation activities on the ORR are approved for disposal in the Environmental Management Waste Management Facility (EMWMF) at the Oak Ridge Reservation, if waste meets acceptance criteria. There have been concerns identified that landfill associated contaminants could have the potential to migrate from the facility into the environment. (For example, contaminants might leach out via ground and surface waters and travel offsite in concentrations above agreed-upon limits). TDEC DoR-OR independently monitors the environment at the EMWMF (in addition to DOE's sampling activities) to provide independent assurance to the public that DOE operations at the EMWMF are and remain protective of public health and the environment, and that DOE continues to adhere to remedial action objectives within facility surface water discharge limits.

V. Radiological Monitoring:

Haul Road Surveys

TDEC DoR-OR will periodically survey the Haul Road and all associated landfill access roads. Surveys of these ORR routes were initiated following an unintended release of materials on to a publicly accessible roadway and have been continued annually since to provide independent verification of the roads DOE has used for waste hauling. For this period of performance, TDEC independent assessments will correspond with DOE's active waste hauling operations. All surveys will be conducted independently to verify the effectiveness of DOE safety protocols.

Real Time Measurement of Gamma Radiation

Real Time Gamma Measurements is an ongoing TDEC project that measures concentrations of gamma radiation in real time, at five locations across the ORR, allowing for the assessment of conditions at locations where gamma emissions may fluctuate substantially over relatively short periods of time. Specifically, the areas to be assessed during this period of performance include: the EMWMF, ORNL Building 3026 the Radioisotope Development Laboratory, the Molten Salt Reactor Experiment, the Spallation Neutron Source, and the background location, Fort Loudoun Dam.

Previous sampling conducted at these campuses has served to document that the concentration of gamma radiation at these sites can fluctuate unpredictably over time. Monitoring of these five locations is ongoing, provides independent verification of DOE's sampling and risk assessment procedures, and allows TDEC to gather information that supports independent verification of protectiveness to human health and the public.

Surplus Sales Verification

At the request of either Y-12 or ORNL's Excess Properties Sales Group, TDEC DoR-OR provides support with pre-screening or verification of cleanliness of auction items that are set for public access or procurement. These TDEC independent verifications and assessments for radiological contamination help ensure that no contaminated items are sold to the public.

VI. Surface Water Monitoring:

Ambient Surface Water Parameters

To ascertain ongoing water quality and to assess direct impacts to surface water, TDEC DoR-OR conducts monthly sampling to obtain primary water quality parameters (i.e., conductivity, pH, temperature, and dissolved oxygen) for three (3) ORR exit pathway streams. Exit pathway streams are specifically streams that leave (exit) the reservation and have the potential to be accessed by the public. This independently collected data intentionally augments DOE's surface water monitoring program to allow for TDEC to effectively verify protectiveness and current site conditions at these locations. DOE's current sampling focuses samples on the main branch of the Clinch River (CR) and has not collected parameter data on the three TDEC evaluated tributaries which serve as ORR exit pathway streams (DOE, 2021). The streams that TDEC monitors under this project include East Fork Poplar Creek (EFPC), Bear Creek (BC), and Mitchell Branch (MIB), with Mill Branch (MB) serving as an offsite reference (or background) stream location. Part of an ongoing monitoring program which began in 2005, this supplemental TDEC dataset allows for TDEC to better verify and assess the protectiveness of the surface waters leaving the ORR and passing into publicly accessible spaces. This dataset also allows TDEC to evaluate current or active changes that may occur during the demolition activities and other active or remedial actions occurring at the ORR this FY. This data can also provide comparison ambient parameter measurements for use in the event of a future release, if required.

Ambient Surface Water Sampling

The purpose of this sampling project is to evaluate the impact of DOE ORR contamination on the Clinch River, a local source of municipal drinking water. TDEC DoR-OR will focus sampling efforts on the main channel of the CR, at Poplar Creek, and at two primary exit pathway streams that are Poplar Creek tributaries: (1) Bear Creek and (2) East Fork Poplar Creek.

Main channel of the CR sampling sites will be co-sampled with DOE, using TDEC co-sampling to provide independent verification and validation of DOE's samples. The CR provides drinking water to many in the local area, and these independent samples directly support TDEC's independent assessments of DOE's sampling activities, allowing for public reassurance of those sample sets. Co-sampling for FY24 will involve splitting a water sample between the two agencies with independent analysis by both parties.

Quarterly sampling efforts will focus on analysis of metals, including mercury and uranium metals, and radiological analytes, including uranium isotopes. The physical and chemical water quality of these streams will be used to quantify overall stream health, independently verify DOE samples where co-sampling occurred, and will help to evaluate and identify any potential impacts to human health and the environment stemming from exposure to constituents that may be found in these surface waters.

White Oak Creek Radionuclides

White Oak Creek's (WCK) ambient surface water will be monitored quarterly for strontium-90 (Sr-90) and other radiological contaminants of concern (COCs) at eight (8) monitoring locations. This project has been separated from the primary *Ambient Surface Water Sampling Project* to allow for a more in-depth quantification of elevated Sr-90 concentrations that were previously identified throughout the watershed (from WCK 3.9, downstream to the confluence at CRK 33.5) at levels above the EPA derived drinking water limit of 8 pCi/L for Sr90. While DOE has had ongoing projects seeking to define the sources of the strontium releases to White Oak Creek, those sources have not been fully vetted or contained yet. This TDEC sampling is intended to specifically allow for the State to continue to complete independent assessments of the impacts in the creek as they migrate through the ORR, ultimately discharging into the publicly accessible portions of the CR including into the fishing areas at the confluence (addressed in the Roving Creel Survey projects described above), while DOE continues to evaluate sources and historic releases onsite. These assessments will provide data for TDEC to effectively continue to evaluate protectiveness and identify concerns, if appropriate, for the public from these identified ongoing releases.

VII. Sediment Monitoring:

Suspended Sediment (East Fork Poplar Creek – EFPC)

The *East Fork Poplar Creek (EFPC) Suspended Sediment Project* is focused on monitoring stream health in ORR exit-pathway streams. This project will endeavor to fill a sampling gap in DOE monitoring by testing the sediment suspended within the water column of these streams. Suspended sediment is sediment that may be impacted by contaminants. Contaminants may sorb to the sediment grains, but those grains are mobile and entrained in the water column, actively moving through the water column and away from the site. Historically, the mercury and uranium results in EFPC have been identified above its associated residential use soil risk limit. This project provides long term independent monitoring and assessment of this offsite area. This project provides the data necessary to support TDEC's independent assessments related to the mobile contamination entrained in the water column and to assess protectiveness with in these publicly accessible areas.

VIII. Water Resources Monitoring

CERCLA: ORR Water Resources at D&D and Construction Sites

Stormwater has the potential to transport various contaminants offsite; particularly during periods of heavy rainfall and at times when sedimentation basins may become overwhelmed. This project will provide State oversight to potential areas of concern across the ORR and may collect and analyze surface water, stormwater samples and groundwater co-samples at Y-12, ORNL NT-8, and EMDF to identify potential environmental risks resulting from current construction, demolition, and operation activities. Additionally, the project team will evaluate the effectiveness of stormwater best management practices (BMPs) installed at construction sites and provide oversight support for remediation activities across the ORR. Stormwater releases during construction and D&D activities have occurred historically, and this collaborative sampling between the State and DOE highlights the combined focus toward environmental protection, ensuring complete and effective data is collected to ensure protectiveness to the residents of the State of Tennessee for both human health and the environment.

IX. Watershed Assessments (Holistic) Monitoring:

TDEC DoR-OR completes comprehensive watershed assessments to provide the citizens of the State of Tennessee a comprehensive evaluation of the watershed, assessing the interconnectedness of all the environmental media over an entire watershed. The holistic understanding of all possible contaminants and their multiple inputs into one watershed allows for the prioritization of remediation project goals and supports planning to protect human health and the environment. The prior watershed assessment evaluated Bear Creek Valley. This current project is focused on East Fork Poplar Creek (EFPC).

East Fork Poplar Creek Assessment Project (EFPCAP) Phase 2:

EFPC is an ORR exit pathway stream that flows into PC and ultimately empties into the CR. The headwaters of EFPC are located within Y-12 boundaries where the primary COCs are mercury and uranium. Sample analyses will focus on these two contaminants plus a variety of other known contaminants that may be released during remediation activities.

This project will include evaluation and assessment of the following components and data:

- Surface water sampling
- Entrained sediment (sediment traps)
- Soil samples
- Toxicity / biomonitoring
- Fish sampling
- Benthic macroinvertebrates sampling
- Biota sampling

1.0 INTRODUCTION

1.1 PURPOSE OF THE ENVIRONMENTAL MONITORING PLAN (EMP)

The Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge Office (TDEC DoR-OR), provides the annual *Environmental Monitoring Plan* (EMP) for fiscal year 2024 (FY24) with a period of performance from July 1, 2023, through June 30, 2024. Prior to the beginning of each fiscal year, TDEC DoR-OR publishes its upcoming plan for DOE oversight so that this EMP is accessible to the public.

Initial publication of this Environmental Monitoring Plan (EMP), intended for July 1, 2023, at the start of the 2024 state fiscal year, was delayed due to delays in execution of the FY24 Federal Facility Agreement (FFA) grant and the FY24 Environmental Surveillance and Oversight (ESOA) grant. The FFA and ESOA grants were intended to be the funding sources directly supporting these TDEC operations during this period of performance. Due to a lack of grant approvals at this time (effective Nov 2, 2023), this Environmental Monitoring Plan is not tied directly to a funding source grant, but instead is specifically provided to clearly address and define the oversight and verification work scopes (including independent monitoring and assessment of DOE's environmental monitoring and remediation actions across the Oak Ridge Reservation) that TDEC has determined to be necessary to ensure protectiveness of human health and the environment for the period of FY24 for the State of Tennessee.

While inclusion of projects in this EMP does not associate projects with a specific funding source at this time, all projects defined in this EMP are found to be consistent with the NCP and are intentionally designed to be in compliance with the administrative and operational requirements of the *Environmental Surveillance and Oversight Agreement* (ESOA) and, additionally, in support of the *Federal Facility Agreement (FFA*).

TDEC oversight of current and upcoming DOE ORR activities is outlined in the ESOA, while the oversight of DOE's legacy contamination management is addressed in the FFA. TDEC works collaboratively co-sampling and conducting oversight of field actions with the Office of Science, National Nuclear Safety Administration (NNSA), and DOE Environmental Management and their contractors. The State also conducts independent environmental monitoring to ensure protection of human health and the environment and support independent protectiveness assessments if necessary. TDEC collected data is available to the public, including to DOE or EPA for triparty consideration, where appropriate. Independent sampling is conducted by TDEC to support comparison and correlation of results with DOE's monitoring programs. TDEC's monitoring program is intentionally designed and reviewed annually to support active and ongoing environmental restoration decisions, to help evaluate the performance of existing remedies, and to investigate the extent and movement of legacy contamination. With the critical goal to provide verification of DOE's data and to support collection of information needed by the State to support efficient and effective decisions, these monitoring and oversight programs have been key. This allows the State to provide decisions effectively and efficiently for the FFA CERCLA projects as well as to verify protectiveness to the citizens regarding active processes conducted at the ORR under the ESOA work scopes.

With a primary focus on ensuring protectiveness of human health and the environment, all TDEC DOR-OR environmental monitoring is performed to meet TDEC's mission statement. All work outlined in this monitoring plan will be performed in accordance with the *TDEC DoR-OR* technical standard operating procedures.

Under Federal Guidelines and to fulfill TDEC mission goals, stakeholder interests take a priority in project planning (Table 1.1.1). The key Stakeholders for this EMP include:

Table 1.1.1 STAKEHOLDERS

Stakeholders	
Citizens of Tennessee (Tennesseans)	External
Tennessee Department of Environment and Conservation	External and Internal
Local Governments	External
DOE and Contractors	External

1.2 OBJECTIVE

The overarching objective of TDEC DoR-OR's Environmental Monitoring Program is to provide State led independent monitoring and verification sampling as well as State oversight of current DOE activities across the Oak Ridge Reservation to confirm existing DOE project results; support environmental restoration decisions; assess and evaluate performance of existing remedies, and to investigate the extent and movement of legacy contamination to assure protectiveness of human health and the environment for the citizens of the State of Tennessee.

This independent State of Tennessee sampling and monitoring program is designed to assess and verify current conditions by collecting data to verify, evaluate or supplement for

State assessment, if necessary, DOE's separate environmental monitoring datasets. This State led program is intended to provide independent assessment, for potential emissions of any materials (i.e., hazardous, toxic, chemical, or radiological) that may come from the ORR which could impact the surrounding populations or the environment. The environmental media and COCs to be sampled during FY24 are listed below in Table 1.2.1

Tables 1.2.1 Types of Monitoring

Project Areas	Medium/Media	COCs which may be assessed
Air	Particulates (on RadNet and fugitive air filters) Particulates in Precipitation	**Radiological Materials:** Gamma spectrometry Uranium-234/235/238 Strontium (Sr-89/90) Technetium (Tc-99) Transuranic isotopes, Others **Chemical Pollutants:** PCBs and Pesticides VOCs and SVOCs Nitrates/Nitrates Nutrients **Mixed Waste** **Mercury** **Metals:** Chromium Arsenic Cadmium Uranium
Biota	Benthic Macroinvertebrate Taxa Health Fish Surveys, Fish Tissue Sampling [DOE data used] Fathead Minnow and Water Flea - toxicity study Fish Consumption (Creel Surveys) Food Crops/Milk Ground Beetles Bird eggs and ground spiders	
Groundwater	Wells and Springs	
Landfill	Surface water Stormwater Groundwater Soil Sediment	
Radiological	Haul Road – dropped waste Gamma (Air) Surplus Sales	
Surface Water	Surface Water Parameters Stream Water Sampling Shallow Groundwater	
Soil	Landfill surveys	
Sediment	Suspended Sediment Sediment (landfill runoff)	
Water Resources 1. *D&D* 2. *construction*	Stormwater Groundwater Surface Water	
Watershed *Holistic*	All sampling	

1.3 THE OAK RIDGE RESERVATION

The ORR is comprised of three major campuses:

- **ORNL**: Oak Ridge National Lab (Formerly X-10)
- **Y-12**: Y-12 National Security Complex
- **ETTP**: East Tennessee Technology Park (Formerly K-25)

ORNL currently conducts leading-edge research in advanced materials, alternative fuels, climate change, and supercomputing. Previous and ongoing ORNL research has been responsible for producing a fair amount of industrial waste. The following is a list of projects and processes that have been the source of accidental releases of contaminants into the environment:

- fuel reprocessing
- isotopes production
- waste management
- radioisotope applications
- reactor developments
- multi-program laboratory operations

Y-12 continues to be vital to maintaining the safety, security, and effectiveness of the U.S. nuclear weapons stockpile and reducing the global threat posed by nuclear proliferation and terrorism. As with ORNL, Y-12 operational processes have also resulted in the accidental release of radionuclides and hazardous chemicals into the environment. Additionally, as D&D remedial activities move forward, legacy contaminants may be disturbed and migrate into the surrounding environment.

ETTP, in contrast, has undergone a transition from a gaseous diffusion facility into an industrial technology park. Remediation activities continue and have reduced the amounts of legacy contaminants. DOE recently released portions of this area back to the local government and now private businesses operate businesses in this region of the ORR.

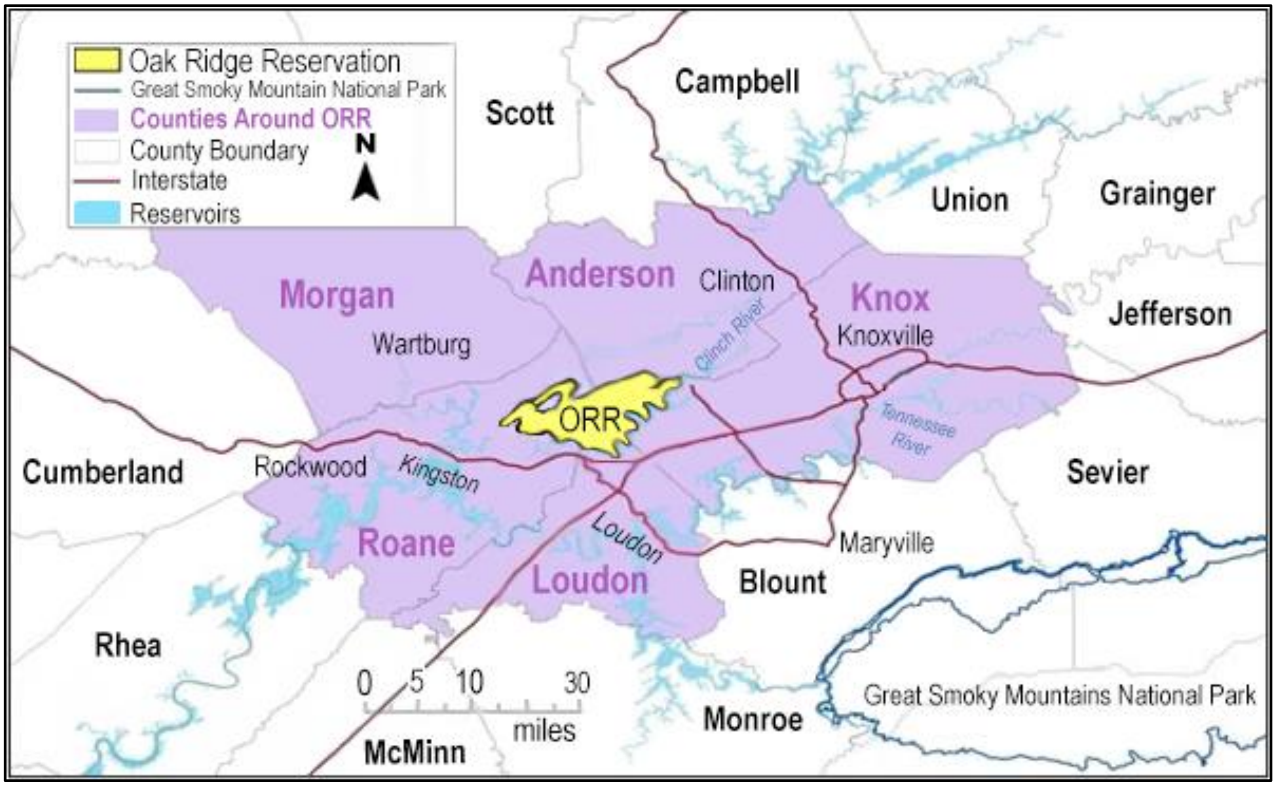

Figure1.3.1 Location of the ORR in Relation to Surrounding Counties

1.3.1 GEOGRAPHY OF THE ORR AREA

Located in the valley of East Tennessee, between the Cumberland Mountains and the Great Smoky Mountains, the ORR is partially bordered to the southeast and southwest by the Clinch River. The ORR is in the southwest corner of Anderson County and the northeast region of Roane County. The ORR is contained within the corporate boundaries of the City of Oak Ridge. Counties adjacent to the reservation include Knox, Loudon, and Morgan Counties. Knox County resides east of Anderson County and is just across the Clinch River from the ORR. Portions of Meigs and Rhea counties reside immediately downstream from the ORR on the Tennessee River. The nearest cities to the ORR include Oak Ridge, Oliver Springs, Clinton, Kingston, Harriman, Farragut, and Lenoir City. The nearest metropolitan area, Knoxville, lies approximately 20 miles to the east.

The ORR encompasses approximately 32,500 acres of mostly contiguous land of alternating ridges and valleys in a southwest-to-northeast orientation. This section of the Valley and Ridge Province is a zone of complex geologic deposits dominated by a series of thrust faults. Sandstone, limestone, and dolomite form the underlying structure of the ridges, which themselves are relatively resistant to erosion. Weaker shales and more soluble carbonate rocks form a less stable basin for the valleys. Also, valley wind currents can differ substantially in speed and direction from the winds at higher elevations along the ridges.

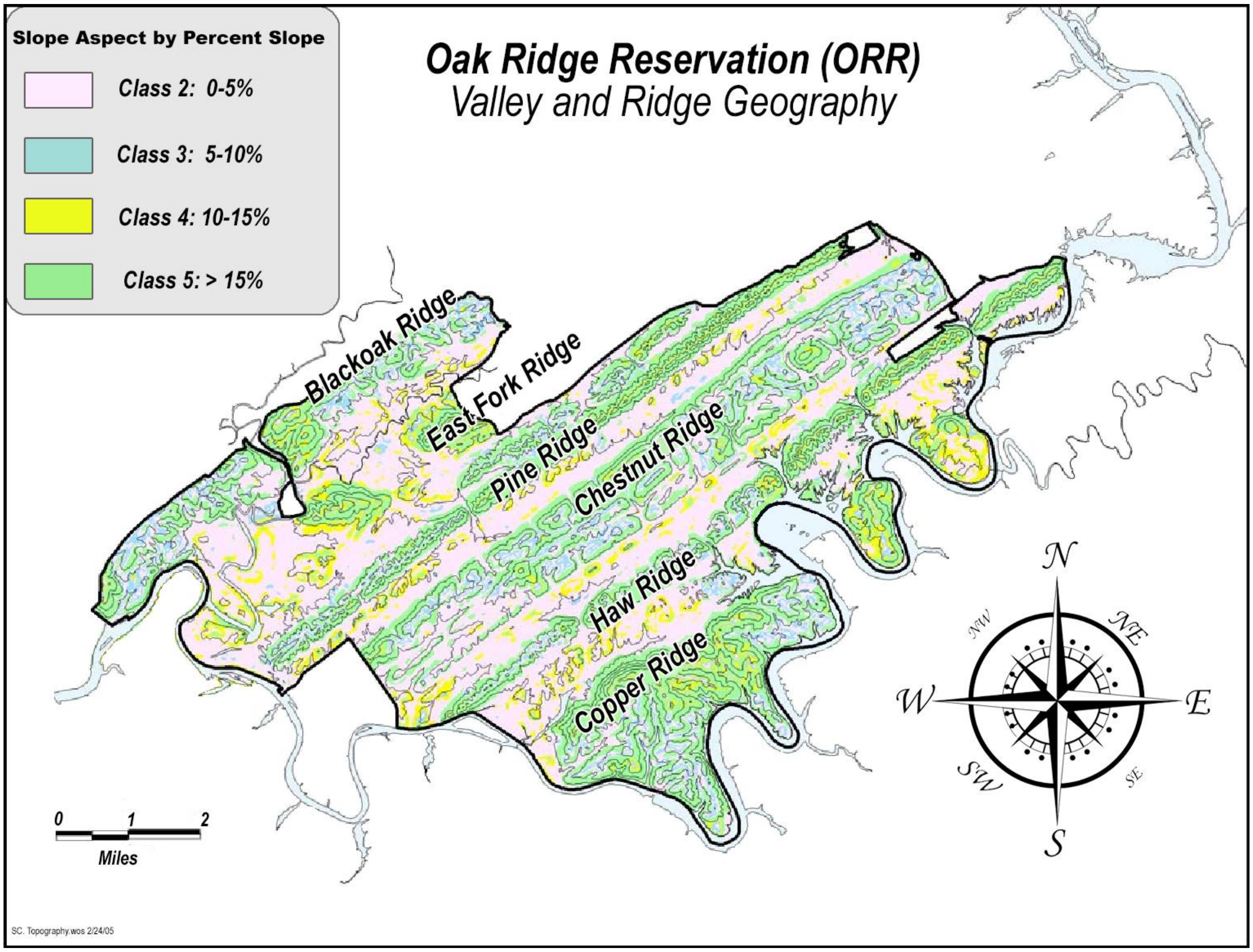

Figure 1.3.1.1 ORR Ridges (southwest-to-northeast orientation)

1.3.2 Climate of the ORR Area

The climate of the ORR region is classified as humid and subtropical. Local climate is characterized by a wide range of seasonal temperature changes between the summer and winter months. According to DOE (DOE, 2023),

> *...the total average rainfall in the ORR area during FY 2022 was 56.4 in. based on a composite of four rain gauge stations located throughout the ORR and at one located in Oak Ridge. The total rainfall during FY 2022 was only 0.1 in. more than the 56.3 in. determined as the 30-year moving average of rainfall measured in the City of Oak Ridge.*

The geography of this region of *The Great Valley of East Tennessee* is shaped by the Ridge-and-Valley physiography, the Cumberland Plateau, and two mountain chains. These major landscape features also affect the wind flow regimes of Eastern Tennessee. Topography and climate are major factors in determining the potential for migration of contaminated media away from the ORR and into the surrounding areas.

1.3.3 Population of the ORR Area

More than one million Tennesseans reside in the counties immediately surrounding the ORR. Knoxville, in Knox County, is the only major metropolitan area near Oak Ridge. Excluding Knoxville, land use is semi-rural and made up of residences, small farms, and pastures. Popular recreation includes fishing, hunting, boating, water skiing, and swimming.

1.4 Tennessee's Commitment to Tennesseans

In accordance with objectives of the ESOA Agreement, the FFA Agreement and in line with TDEC's mission statement, DoR-OR will conduct oversight of DOE ORR activities. Our purpose is to reassure all Tennesseans that activities on and around the ORR are being managed or performed in a manner protective of human health and the environment.

2.0 Air Monitoring

2.1 Fugitive Radiological Air Emissions

2.1.1 Background

Historically, leaks and spills of radionuclide-contaminated materials were not uncommon on the ORR. Radioactive materials were released from operations as gaseous, liquid, and solid effluents with little to no treatment (ORAU, 2003). D&D and related remediation activities across the ORR have the potential to generate fugitive airborne contamination that could pose a risk if transported offsite or may also pose a risk to workers on the ORR.

2.1.2 Related DOE Projects

DOE conducts high-volume air sampling inside and around the perimeter of the ORR. The results from this air sampling are used to calculate the human dose exposure for vulnerable populations offsite. TDEC DoR-OR's Fugitive Air sampling data will also be used to correlate and verify DOE results.

2.1.3 Problem Statements

Fugitive or non-point source dispersal of contaminants can accidentally occur within the ORR. Legacy contaminants could possibly become exposed during remediation activities or a severe weather event. Releases could also be possible under current research and manufacturing projects. This dispersion is geographically promoted by daytime northeasterly winds and nighttime southwesterly winds. For example, Y-12 contains decaying buildings with uranium contamination which must undergo remediation. ORNL structures are contaminated with various fission and activation products in addition to uranium and plutonium isotopes. Some structures at ORNL were identified as the highest risk buildings on the ORR. These building are physically deteriorating and contain lose contamination. The risk is exacerbated by the proximity of these structures to pedestrian and vehicular traffic, to privately funded businesses, and to other active ORNL buildings.

2.1.4 Goals

To verify protectiveness of human health and the environment, TDEC DoR-OR will conduct independent air sampling, compare the results with the air sampling data published by DOE, and confirm that DOE is adequately monitoring airborne emissions of radiological contaminants. This independent monitoring confirms that DOE is compliant with Federal Regulatory Standards and shows that no member of the public receives an effective dose greater than ten (10) mrem per year.

2.1.5 Scope

TDEC DoR-OR will conduct the *Fugitive Radiological Air Emissions Monitoring Project* through continuous air monitoring at each of the three ORR campuses plus a comparable background location. During this next year, up to six (6) additional air monitors will be placed in the ORR. Where possible, these new monitors will be co-located with current RadNet air monitoring stations. They will help to support the transition away from the RadNet air monitoring program, which is slated to be phased out in the next few years. It is the expectation that up to 15 high volume air samplers will be available for monitoring and sampling verification work scopes (see Figure 2.1.5.1) by the completion of FY24.

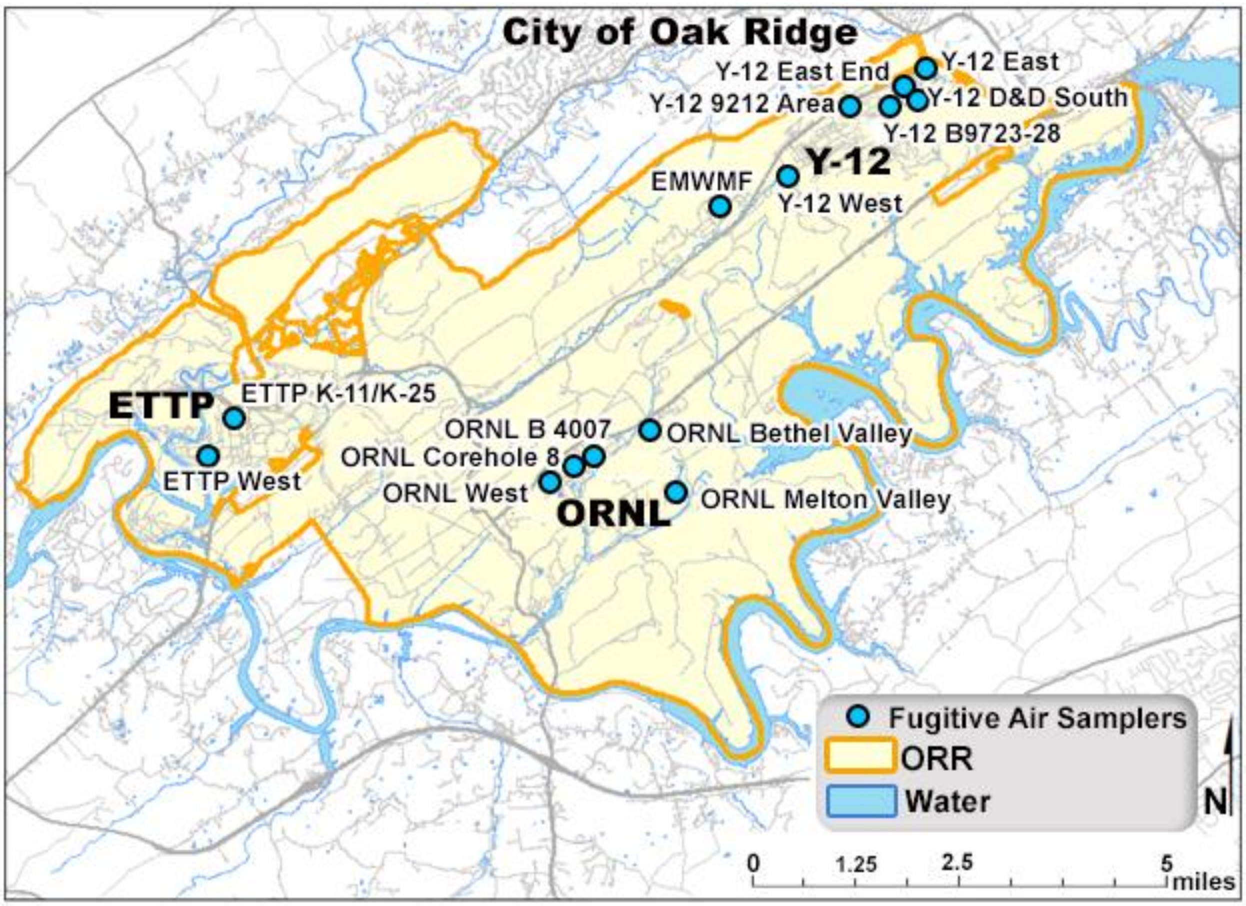

Figure 2.1.5.1 Tentative and Existing ORR Fugitive Air Sampling Locations

2.1.6 Assumptions

1) Adequate budget will exist to support the methods and materials described for this project.

2) Adequate staff will be available to assist with field duties.

3) Air sampler locations will have access to electricity.

4) Access to desirable air sampler locations will not be restricted due to site operations or security.

2.1.7 Constraints

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures.

2) Any interruption to power supply or lack of availability of the 120-volt electrical power source required to operate an air sampler at the preferred locations.

3.) Coordination with DOE staff is key as sampler locations and their access could be restricted due to site operational or security concerns depending on site operations.

2.1.8 Methods, Materials, Metrics

The Fugitive Air Monitoring Project will use up to 15 high volume air samplers to conduct continuous air monitoring on and near the ORR. One sampler will be stationed at Fort Loudoun Dam in Loudon County to collect background data for comparison. The remaining samplers will be placed at ORR locations where the potential for release of fugitive airborne emissions is the greatest. For example, locations where contaminated soils are being excavated, contaminated structures are being demolished, or wastes are being disposed would be areas that may warrant consideration for air monitoring placement.

Each of the high-volume air samplers use the 8 x 10-inch glass-fiber filters to collect particulates from the air. Air is drawn through the unit at a rate of approximately 35 ft^3 per minute. To ensure accuracy, airflow through each air sampler is calibrated quarterly, using a Graseby General Metal Works variable resistance calibration kit, in accordance with the guidelines published for the air samplers.

Samples will be collected from each air sampler weekly, with samples being composited every four (4) weeks and analyzed by the Tennessee Department of Health Nashville Environmental Laboratory (TDEC-NEL) or alternative environmental analytical laboratory contracted with TDEC DoR-OR as available. The analyses performed will be based on the COCs and previous findings for the location being monitored.

To assess contaminant concentrations measured at each location, results will be compared with the background data and the standards provided in the National Emission Standards for Hazardous Air Pollutants (40 CFR 61H, 2017). These standards associate radiological emissions to quantities that would not cause a member of the public to receive an effective dose equivalent greater than 10 millirem (mrem) in a year. Associated findings will be reported to DOE, its contractors, and the public in the annual TDEC DoR-OR EMR.

2.1.9 References

40 CFR 61, Subpart H. 2017. *Title 40 of the Code of Federal Regulations, Chapter 1, Subchapter C, Part 61 National Emission Standards for Hazardous Air Pollutants (NESHAPS)*, Subpart H *National Emission Standards for Emissions of Radionuclides Other than Radon From Department of Energy Facilities*. National Archives. Washington, DC. https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-61/subpart-H

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2.2 RadNet Air

2.2.1 Background

Radiochemical air pollutants resulting from current DOE ORR activities could pose a risk to public health and environmental health. Moreover, the average adult inhales about 16,000 liters of air a day (EPA, 2011), so the importance of identifying airborne radiological contaminants is imperative.

The TDEC DoR-OR RadNet Air Monitoring Project on the ORR began in 1996 and includes the twice weekly collection of air samples taken from four air monitoring stations on the ORR. A total of up to 416 RadNet samples are collected by TDEC DoR-OR each year, and analysis is performed at the EPA National Air and Radiation Environmental Laboratory (NAREL). This monitoring will continue through at least FY24 and allows TDEC DoR-OR to obtain air monitoring data results from an independent, third-party EPA laboratory for comparison and correlation with TDECs fugitive air results as well as DOE's air monitoring results.

2.2.2 Related DOE Projects

TDEC DoR-OR RadNet Air sampling does not directly correlate to DOE's ORR air sampling program.

1) The RadNet Air Monitoring Project uses gross beta analysis as a screening tool. Few isotopes of interest are pure gamma or pure beta emitters. Beta radiation will most

likely be emitted either directly or from daughter products.

1. Gross beta concentrations greater than the 1 pCi/m^3 meet the EPA RadNet Program screening level and will undergo gamma spectroscopy by the EPA. Other additional analyses may be performed at EPA's discretion.

2. If gross beta levels are elevated but less than the 1 pCi/m^3 screening level, the detected level will be reported, and no additional tests will be performed.

2) RadNet Air samples from four locations on the ORR are usually collected and sent for analysis twice a week, which is more frequent than the quarterly composite analysis of weekly samples collected by DOE. However, sampling by DOE varies by ORR site according to the DOE Annual Site Environmental Report (ASER).

2.2.3 Problem Statements

The three (3) ORR campuses could potentially release radioactive contaminants into the air from a disturbance of legacy contaminants or from current operations. Y-12 and ORNL also house deteriorating, contaminated buildings that could potentially release COCs. D&D of these contaminated structures could also lead to releases.

2.2.4 Goals

1. Protect human health and the environment by continuous evaluation of airborne gross beta activity on the ORR, confirming levels do not go above EPA regulatory levels.

2. Complement the TDEC DoR-OR Fugitive Radiological Air Emissions project by providing gross beta analysis and additional analysis if EPA screening levels are triggered.

3. Provide additional air monitoring data to support greater general coverage of the ORR. Support more frequent air monitoring and analysis. Specifically, this project will collect twice weekly sampling and sample analysis, rather than the weekly sampling with four-week composite analysis done for the TDEC Fugitive Air Program, and the quarterly composites of weekly samples that DOE collects. This sampling schedule will allow for closer assessment of general protectiveness overall with data provided across at shorter time intervals.

2.2.5 Scope

The scope of this project includes the continuous monitoring for airborne gross beta contamination on the ORR. The four ORR monitoring station are:

1) East end of Y-12
2) West end of Y-12
3) Bethel Valley
4) Melton Valley

These stations will be sampled twice weekly and compared regularly to background data when possible. The background data will shared with DoR-OR by EPA's RadNet Knoxville station, which is independently monitored.

2.2.6 Assumptions

1) Air from various locations on the ORR can be sufficiently monitored with the particulate air samplers provided by the RadNet program.
2) Beta analysis of air filters will identify most releases of radiological contaminants; these results will trigger further analysis when above EPA screening levels.
3) Natural variations in gross beta levels will be similar at all ORR sampling locations.
4) Small variations due to weather and other environmental factors will be seen at all stations.

2.2.7 Constraints

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures.
2) Four RadNet air samplers cannot physically collect all ORR air emissions.
3) Air sampler power source occasionally loses power.
4) Only one lab, EPA NAREL, processes RadNet samples and only gross beta analysis is guaranteed.

2.2.8 Methods, Materials, Metrics

The locations of the four RadNet Air samplers are provided in Figure 2.2.8.1. The RadNet Air samplers run continuously, and suspended particulates are collected on synthetic fiber filters (10 centimeters in diameter). Air is drawn through the units by a pump at approximately 35 ft^3 per minute (60 m^3/hour). TDEC DoR-OR personnel collect the filters twice weekly from each ORR sampler. Following EPA protocol (EPA, 1988; EPA, 2006) the filters are then shipped to NAREL in Montgomery, Alabama, for analysis.

EPA NAREL performs gross beta analysis on each sample collected. If the gross beta result for a sample exceeds one picocurie per cubic meter (1 pCi/m^3), then gamma spectrometry is performed on the sample. The results of EPA NAREL's analyses of the nationwide RadNet Air data are available at NAREL's website. The Envirofacts RadNet page has a searchable database which allows for simple or advanced searches (EPA, 2022).

The gross beta data from the ORR RadNet Air monitors will be compared to data from the Knoxville RadNet Air monitor, which is used as a background location. The ORR RadNet Air gross beta data will also be compared to the EPA Clean Air Act environmental limit for strontium-90 (a pure beta emitter with a conservative limit) (EPA, 2023).

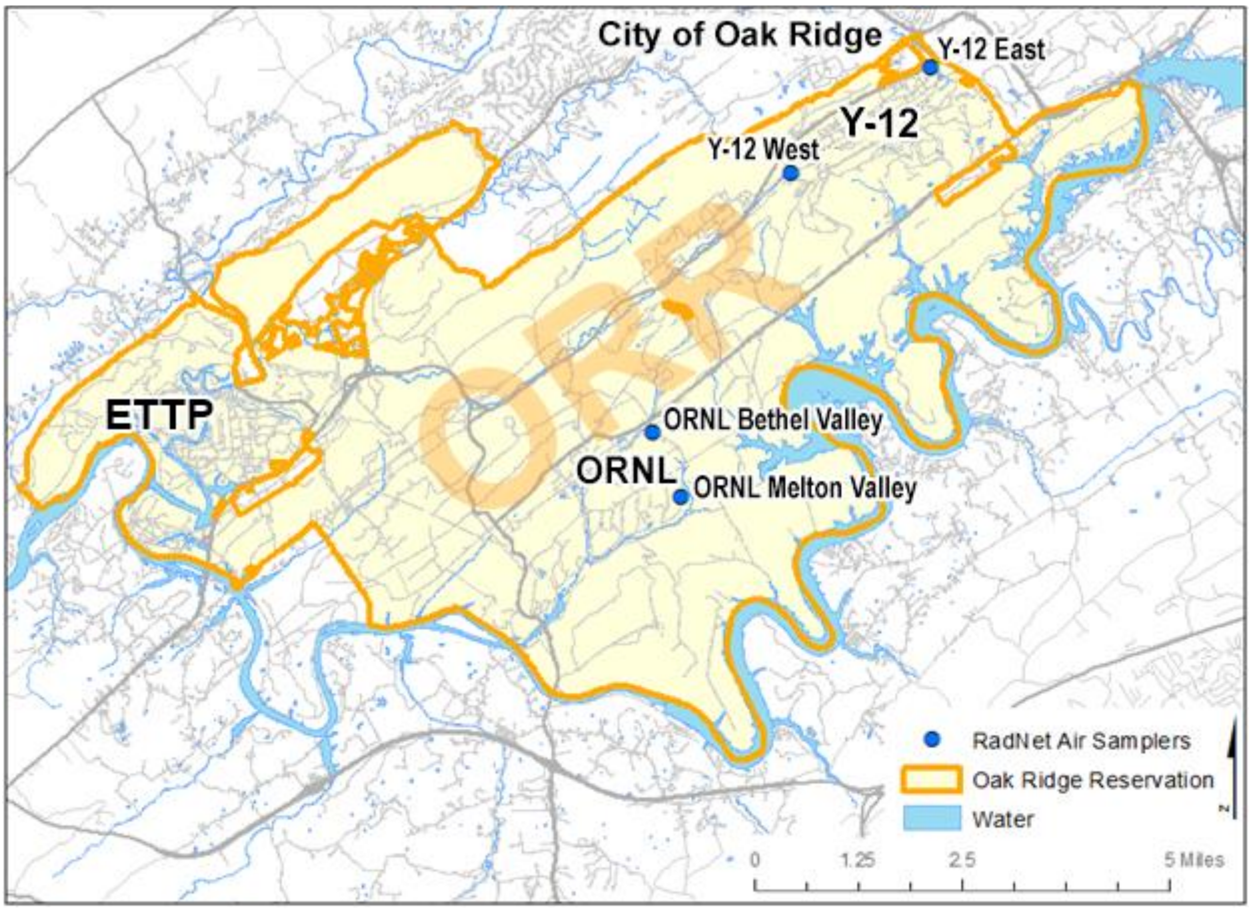

Figure 2.2.8.1 Locations of RadNet Air monitoring stations on the Oak Ridge Reservation

2.2.9 References

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40 CFR 61, Appx E. 2017. *Title 40 of the Code of Federal Regulations, Chapter 1, Subchapter C, Part 61; National Emission Standards for Hazardous Air Pollutants (NESHAPS)*, Appendix E *Compliance Procedures Methods for Determining Compliance With Subpart I*. https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-61/appendix-Appendix%20E%20to%20Part%2061

40 CFR 61, Subpart H. 2017. Title 40 of the Code of Federal Regulations, Chapter 1, Subchapter C, Part 61 *National Emission Standards for Hazardous Air Pollutants (NESHAPS)*, Subpart H *National Emission Standards for Emissions of Radionuclides Other than Radon From Department of Energy Facilities* (40CFR61). 2017. https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-61/subpart-H

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2.3 RadNet Precipitation

2.3.1 Background

The nationwide EPA RadNet Precipitation Monitoring Program measures radioactive contaminants that are removed from the atmosphere and transported to the Earth's surface by precipitation. On the ORR, the RadNet Precipitation Monitoring Project provides radiochemical analysis on precipitation samples taken from monitoring stations at two ORNL sites and one Y-12 site. Samples are collected by TDEC DoR-OR personnel, and gamma analysis is performed on monthly composite samples by EPA NAREL. Gamma analysis functions as a screening tool because few isotopes of interest are pure beta or pure gamma emitters; therefore, if a radiological release occurred on the ORR, some gamma radiation would likely be emitted either directly or from daughter products. Additional analysis may be conducted if a radiological release is known or is indicated by monthly gamma analysis results.

While there are no regulatory standards that apply directly to contaminants in precipitation, this project will provide data that could potentially indicate the presence of radioactive materials.

2.3.2 Related DOE Projects

Precipitation sampling techniques for this project do not directly correlate to any of DOE's air sampling programs per DOE's *EMP* for 2023 (2022). This project seeks to fill a gap in DOE monitoring data by sampling a different medium that might capture COCs that are not collected by other methods.

2.3.3 Problem Statements

The three ORR campuses (ORNL, Y-12, and ETTP) could potentially release legacy radioactive contaminants into the air. Y-12 and ORNL may also have releases due to current operations, the deterioration of contaminated buildings, D&D remedial efforts, and from construction of new buildings.

This project will attempt to measure radioactive contaminants that are captured by precipitation and then fall into a sampler. The analytical results will serve as an additional indicator to show when radioactive materials are present. Also, this new medium may yield results that may not be evident in the particulate samples collected by air monitors.

2.3.4 Goals

The goal of the EPA RadNet Precipitation Monitoring Project is to measure radioactive contaminants that are washed out of the atmosphere and reach the Earth's surface through precipitation. TDEC uses this EPA program to provide precipitation sampling data that may be used as an indicator for the presence or absence of radiological contaminants affecting the ORR and nearby environments.

2.3.5 Scope

There are three (3) precipitation samplers that will be used to monitor precipitation for radiological contamination. Each sampler is strategically co-located with an ORR RadNet Air station. The first sampler is located at the east end of Y-12. At this location, the sampler could potentially indicate if any gamma radioisotopes have been moving offsite and towards the City of Oak Ridge. The other two samplers are at ORNL, with one in Bethel Valley and the other in Melton Valley. The latter sampler is near the High Flux Isotope Reactor (HFIR) and the Solid Waste Storage Area (SWSA) five burial grounds. All three samples will be collected on a twice weekly basis.

2.3.6 Assumptions

1) Gamma analysis of monthly composite precipitation samples will indicate most releases of radiological contaminants.
2) Anomalies in radiological contaminant levels can be detected.
3) Natural variations in gamma levels will be similar at all ORR sites.

2.3.7 Constraints

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures.
2) The plume must pass through the precipitation for radiological emissions to transfer from air to water and be collected.
3) Monitoring is limited to three locations.
4) A small, undocumented release could potentially be missed due to consolidation into a monthly composite for analysis.
    - *Note: Samples from a known release will be tested individually.*
5) The EPA RadNet Precipitation Program requires that all samples are analyzed by NAREL. Only gamma radiation testing is guaranteed.

2.3.8 Methods, Materials, Metrics

The three (3) RadNet Precipitation samplers are mapped in Figure 2.3.8.1. All the samplers were provided by the EPA RadNet Program. Each sampler collects precipitation that falls on a 0.5 m^2 fiberglass collector and drains into a five-gallon plastic collection bucket. The sample will be measured and then collected using a four-liter sample container. After two (2) or more liters of precipitation accumulate, then each sample is processed as specified by EPA protocol (EPA, 1988; EPA, 2013). Samples will be shipped to EPA NAREL in Montgomery, Alabama, for analysis. Once at NAREL, each station has its weekly samples combined into one composite monthly sample. Analysis for gamma emitting radionuclides will then be performed on all three composite samples.

Since there are no regulatory limits for radiological contaminants in precipitation, the results of the gamma analysis will be compared to EPA drinking water limits, which are considered conservative reference values. EPA's *Radionuclides Rule* (EPA, 2000) outlines water quality parameters for drinking water. Gross alpha radioactivity levels are limited to at or below 15 pCi/L (picocuries per liter). Beta and gamma emitters are limited to 4 millirem (mrem) per year and are radionuclide specific (EPA, 2015). Results will also be compared to data from other sites nationwide.

In some cases, the EPA has not yet specified limits for a particular gamma radionuclide. For this reason, only those radionuclides previously found in precipitation samples are used for year-to-year comparisons. While the ORR stations are near major sources of radiological contaminants, other stations nationwide tend to be near metropolitan areas. The EPA's maximum contaminant levels (MCLs) for beta and gamma emitters are listed in Table 2.3.8.1.

Table 2.3.8.1: EPA Drinking Water Limits (MCLs) for select isotopes

Isotope	EPA limit (pCi/L)
Beryllium-7 (Be-7)	6,000
Cobalt-60 (Co-60)	100
Cesium-137 (Cs-137)	200
Iodine-131 (I-131)	3

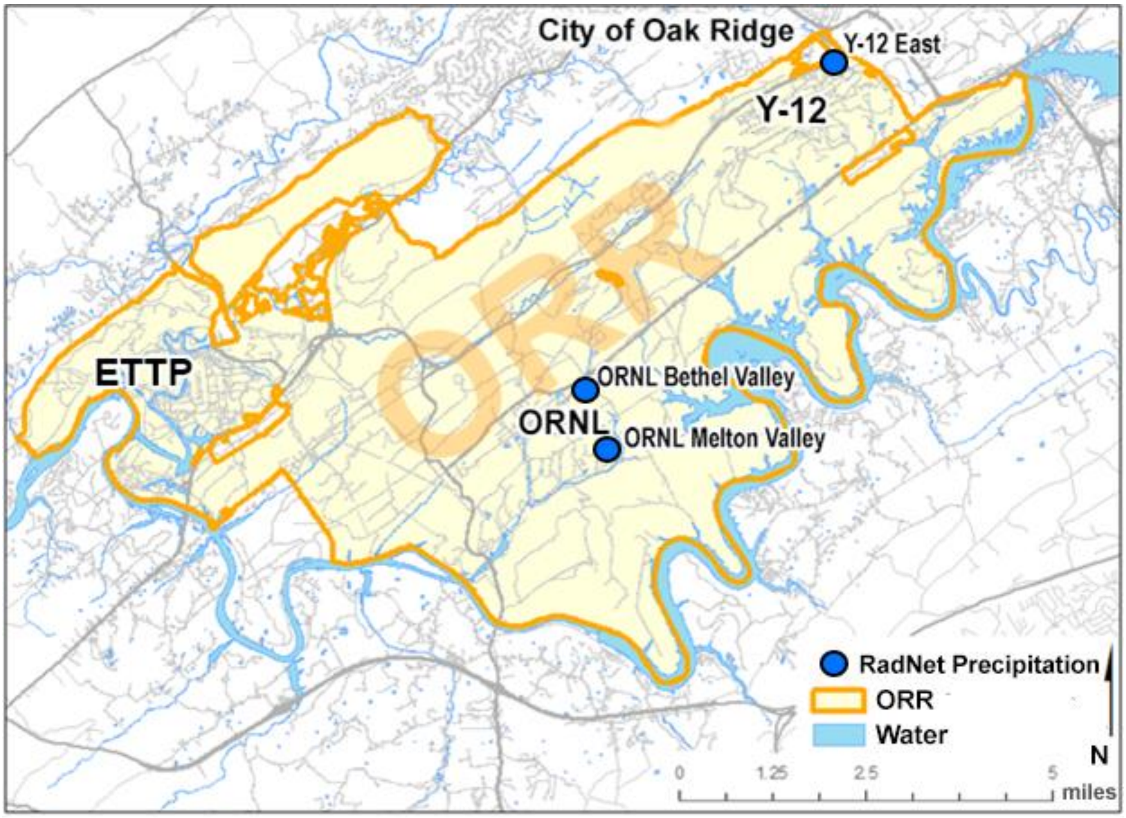

Figure 2.3.8.1 Locations of RadNet Precipitation Monitoring ORR Stations

The results of NAREL's analyses are available in the EPA Envirofacts RadNet searchable database, by either a simple or an advanced search (EPA, 2022). The data can be used to identify anomalies in radiological contaminant levels, to appraise conditions on the ORR as compared to other locations in the RadNet database, and to determine levels of local contamination.

2.3.9 References

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3.0 Biological Monitoring

3.1 Benthic Community Health

3.1.1 Background

One extremely good indicator of stream health is the biodiversity of macroinvertebrate species on and associated with the bottom of the stream, or the benthic zone. The purpose of the Benthic Community Health Monitoring Project is to conduct macroinvertebrate sampling on the ORR to quantify the health of each stream reach sampled. This project aims to record the macroinvertebrate taxa present, note any changes from previous sampling years, and identify possible reasons for any disparities in species counts or densities. Any changes that coincide with ongoing CERCLA remedial activities will be documented.

The biodiversity of macroinvertebrates will be evaluated within the four main watersheds on the ORR. This sampling data will aid in the evaluation of the real effects from known contamination on the benthic assemblages. Unimpacted reference streams will be used to determine the composition of a healthy benthic community. The benthic taxa from each impacted stream will be compared with those found in the associated reference stream.

Four main watersheds are studied at the three (3) ORR campuses:

1) ORNL: White Oak Creek Watershed
2) ETTP: Mitchell Branch Watershed
3) Y-12: East Fork Poplar Creek Watershed and Bear Creek Watershed

Aquatic macroinvertebrate species serve as both quantitative and qualitative indicators to assess biotic responses to environmental stressors (Holt, 2010). Macroinvertebrates are tied to the stream bottom and generally do not move or migrate very far. These animals are continuously exposed to any adverse conditions caused by direct or indirect discharges to these waters. In addition, the longest life stage for macroinvertebrate species is usually aquatic or semi-aquatic. Being sedentary during a long life-stage allows these animals to be a good index of environmental changes over time.

Overall, determining impacts on benthic assemblages is an arduous task. One must also consider that the results can be interpreted in different ways depending on one's knowledge and experience. Thus, input from different experts can help delineate the most accurate interpretations of actual conditions in ORR streams.

3.1.2 Related DOE Projects

ORNL conducts benthic macroinvertebrate sampling for DOE throughout the ORR. After completion of the taxonomy and relevant calculations, ORNL reports their findings in both the *Remediation Effectiveness Report (RER)* and the *Annual Site Environmental Report (ASER)* each year.

As a DOE subcontractor, ORNL's Aquatic Ecology Group conducts benthic macroinvertebrate monitoring on some of the same streams as TDEC DoR-OR. The number of specific stream sites differs between the two agencies, but some sampling sites are shared. At these sites, TDEC sampling serves as an independent check on ORNL's monitoring results.

3.1.3 Problem Statements

1) Past studies indicate that most of the benthic community sampling sites located in ORR streams have been negatively impacted when compared to healthy communities in unimpacted reference streams (TDEC, 2021; DOE, 2021). Many of the impacts affecting these streams result from both historical Manhattan Project activities on the ORR as well as current operational activities.

2) In areas where stream sections have been heavily channelized, part of the problem may be due to a sparsity or lack of preferred habitats for the establishment of healthy stream bottom communities.

3) Sampling of benthic communities contains inherent variability. There are natural, seasonal changes, and year-to-year fluctuations in benthic communities. The knowledge and experience of the sampler is an additional variable. Both issues are remediated with long term sampling.

4) Sampling sites may need to be moved due to changes in habitat. Severe weather events exacerbated by climate change can lead to flash flooding. Human and animal activities can also cause habitat change or habitat loss in streams. On the ORR, beaver activity may also lead to changes in sample sites. One TDEC DoR-OR sampling site on Bear Creek, km 9.9, was washed out by flash flooding and is currently a large pool due to a beaver dam. The once fast-moving shallow section of the stream is now a deep, slow-moving pool. The collection protocol calls for taking samples in riffles where possible, so a new location may be necessary.

5) TDEC DoR-OR stream sampling is conducted in spring when stream diversity is at its highest. Any comparisons of ORNL's fall sampling results with TDEC's spring sampling results must factor in any seasonal differences.

3.1.4 Goals

1) Assess the overall stream health of the four main ORR watersheds.

2) Maintain continuous sampling to compare current stream health with previous sample years and find any changes in biodiversity due to contaminant migration and/or potential releases.

3) Maintain continuous sampling on the reference streams for yearly comparisons to the ORR stream samples.

4) Provide a yearly quality check (QC) on DOE's ORR macroinvertebrate data.

5) Draft remediation recommendations, based on the analysis of macroinvertebrate assemblages, on methods to improve the overall health of each watershed.

3.1.5 Scope

The four watersheds of the ORR will be sampled. Eleven (11) benthic macroinvertebrate samples will be collected at these impacted sites during spring 2023. An additional four reference stream sites will also be sampled. (Figure 3.1.8.1). TDEC DoR-OR staff will also aim to provide oversight for at least 15% of DOE's macroinvertebrate collections in FY 2024.

3.1.6 Assumptions

1) Benthic macroinvertebrates are a good indicator of stream health.

2) Any changes in stream health will be identified by this sampling method.

3.1.7 Constraints

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures.

2) Sampling is seasonal and can only be completed between May – June.

3) Sufficiently trained staff that can obtain a Radiation Worker Permit (RWP) if needed.
    1. DOE site badging, HAZWOPER, Radiological Worker II, assigned dosimeter, TDEC DWR approval.

3.1.8 Methods, Materials, Metrics

Benthic macroinvertebrates will be collected at 11 sites on the ORR and at four corresponding reference locations (Table 3.1.8.1). Duplicate samples will be collected at two of the sites to ensure consistent laboratory analysis. Macroinvertebrate sampling will follow the guidance outlined in the *SOP for Benthic Macroinvertebrate Sampling* (TDEC, 2021).

Then, macroinvertebrates will be processed by trained staff.

As part of DOE oversight, TDEC DoR-OR staff will review at least 15% of DOE's macroinvertebrate collection in FY24. The collection protocol is the same for both agencies and results are directly comparable at shared sites.

Table 3.1.8.1 Benthic Community Health Sampling Locations

Site Description	Name	DWR ID	Latitude	Longitude
Bear Creek Kilometer 3.3	BCK 3.3	BEAR002.0RO	35.94341	-84.3493
EMDF Construction Site	BCK 7.2	BEAR004.6RO	35.950318	-84.313321
Bear Creek Kilometer 12.3	BCK 12.3	BEAR007.6AN	35.974597	-84.276216
East Fork Poplar Creek Kilometer 2.2	EFK 2.2	EFPOP001.4RO	35.95169	-84.371606
East Fork Poplar Creek Kilometer 6.3	EFK 6.3	EFPOP003.9RO	35.9663	-84.3515
East Fork Poplar Creek Kilometer 13.8	EFK 13.8	EFPOP008.6AN	35.99283	-84.31371
East Fork Poplar Creek Kilometer 23.4	EFK 23.4	EFPOP014.5AN	35.995919	-84.240296
Clear Creek Kilometer 1.6	CCK 1.6	ECO67F06	36.21361	-84.05972
Mitchell Branch Kilometer 0.45	MIK 0.45	MITCH000.3RO	35.938469	-84.390027
Mitchell Branch Kilometer 1.43	MIK 1.43	MITCH000.9RO	35.9384	-84.3762
White Oak Creek Kilometer 2.3	WCK 2.3	WHITE001.4RO	35.9092	-84.3191
White Oak Creek Kilometer 3.9	WCK 3.9	WHITE002.6RO	35.924232	-84.3160935
First Creek Kilometer 0.1	FCK 0.1	WHITE002.3T0.1RO	35.921836	-84.3191796
White Oak Creek Kilometer 6.8	WCK 6.8	WHITE004.2RO	35.939928	-84.300034
Mill Branch Kilometer 1.6	MBK 1.6	FECO67I12	35.98833	-84.28888

Impacted Stream Site	(orange)
Reference Stream Site	(green)

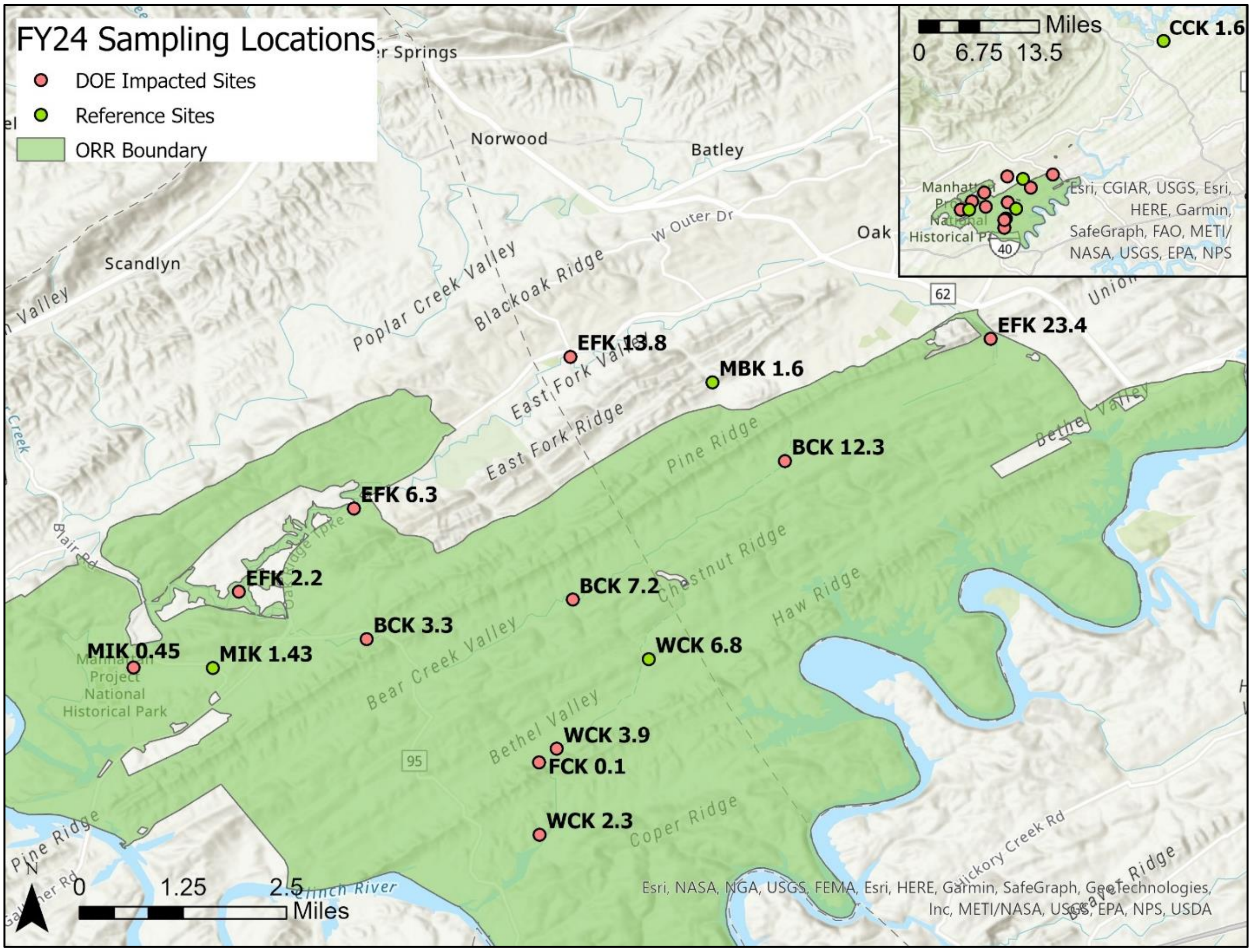

Figure 3.1.8.1 Benthic Community Health Sampling Locations

3.1.9 References

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3.2 Lower East Fork Poplar Creek – Mercury Uptake in Biota

3.2.1 Background

Mercury is found in elevated levels throughout the ORR resulting from processes and spills dating back to Manhattan Project and Cold War era activities. Mercury in streams and wetlands often undergoes methylation and is transformed into toxic methylmercury (MeHg) in conjunction with the activity of microorganisms (Kalisinska et al, 2013). Methylmercury is particularly bioavailable to wildlife (and humans) and, if ingested, may cause serious neurological, reproductive, and other physiological damage (Standish, 2016). Decreases in reproductive success of 35–50% have been observed in birds with high dietary methylmercury uptake including reduced hatching and fledging success (USDI, 1998; Hallinger and Cristol, 2011).

Methylmercury biomagnifies through food webs. Higher-level organisms, such as songbirds and ducks, accumulate increasingly larger body burdens of MeHg through consumption of lower trophic-level prey items. Small invertebrates, salamanders, benthic larval-stage biota, terrestrial spiders, and emergent flying insects are examples of some possible prey items. (Scheuhammer et al, 2007). Adults of some aquatic macroinvertebrates that emerge from these contaminated streams are often eaten by terrestrial insectivores, creating a key link of accumulation between aquatic environments to terrestrial ones (Henderson et al, 2012).

Based on these bioaccumulation studies, key species from multiple trophic strata should be monitored to document any movement of these contaminants through the food web. By sampling songbirds, adult flying insects, spiders, and snakes, the pathways of the bioaccumulative transfer of mercury will become clearer. There are also concerns that contaminants migrate away from the known point sources via movement of organisms that make up the associated food web. Evidence of bioaccumulation will provide a key link between aquatic and terrestrial systems. One could also hypothesize that some migratory birds and snakes may spread these contaminants over a larger area.

3.2.2 Related DOE Projects

During the CERCLA-driven Five Year Review, biota such as turtles, spiders, earthworms, and adult insects are sampled by DOE and analyzed for mercury and other contaminants.

3.2.3 Problem Statements

1) Migratory birds are highly mobile and therefore have the capability to travel great distances and potentially disperse contaminants.

2) Terrestrial macroinvertebrate adults that emerge from larval stages in contaminated

aquatic environments are often eaten by terrestrial insectivores such as songbirds, waterfowl, bats, and spiders. This link in the food web creates a key transfer point of Hg and MeHg. In effect, contaminants are transferred from aquatic biota and accumulate in terrestrial biota.

3) Little to no data has been collected in the last 10–15 years on the role of snakes in mercury bioaccumulation. As an intermediate and top-level consumer, snakes have the potential to accumulate higher levels of mercury and methylmercury through the consumption of birds, bird eggs, small mammals, and other small herpetofauna. Additionally, with their larger home ranges, snakes have the capability to disperse contaminants over larger distances. Studies have demonstrated a correlation between contaminants levels in herpetological species and humans (Pelallo-Martinez et al, 2011), supporting the use of snakes to assess potential exposure risks to humans within those areas.

4) TDEC-DoR-OR staff observed people in homeless camps established along the banks of the upper reaches of EFPC (i.e., NOAA site), and at a new public greenway along the Bruner site, downstream of the NOAA site. These sightings suggest that the human exposure risk to Hg and MeHg along EFPC may be higher than previously thought. Investigation of how much Hg and MeHg is travelling through trophic levels is relevant to assess protectiveness in these areas for both human health and the environment.

3.2.4 Goals

1) Determine the concentrations of mercury and methylmercury in biota samples collected from impacted ecological zones along EFPC and compare them to unimpacted reference zones.

2) Document the bioaccumulation of mercury and methylmercury through the trophic levels in biota species living along EFPC and thereby note possible human health risks.

3) Support the EFPC Holistic Assessment Project by providing data to supplement the findings of the watershed assessment.

3.2.5 Scope

This project consists of laboratory analysis of mercury and methylmercury in songbird eggs, adult flying insects, wolf spiders, and adult snakes. Specimen(s) will be captured on the ORR by DoR-OR personnel from three main study areas and one reference area (Figure 3.2.5.1) over a one-year period or until enough biomass has been collected for laboratory analysis. Results from the three monitoring zones will be compared with results from the reference zone.

3.2.6 Assumptions

1) Terrestrial biota can transfer mercury/methylmercury from EFPC to the land via predation and bioaccumulation.

2) Songbirds, adult flying insects, spiders, and snakes on EFPC are exposed to higher levels of mercury and methylmercury than the corresponding reference area.

3.2.7 Constraints

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures.

2) Obtaining adequate biomass samples for laboratory analysis.

3) Theft or vandalism of songbird nest boxes and other deployed sampling equipment left in the field.

4) Obtaining approval and appropriate permit(s) from the Institutional Animal Care and Use Committee (IACUC) to evaluate the mercury and methylmercury contamination in snake species.

3.2.8 Methods, Materials, Metrics

Terrestrial biota collected to obtain biomass for mercury and methylmercury testing are listed below.

Songbird Eggs:

Songbird nest boxes have been installed along EFPC and at reference locations. Songbird nest boxes will be checked routinely in the spring to determine occupancy. Once a nest box is confirmed to have an occupant, the box will be checked twice per week to collect the first clutch of eggs for analysis. The breeding season for songbirds runs from March through June, and this protocol will allow songbirds time to produce a second brood. All eggs collected from the same zone will be composited into one sample. There will be four total composite songbird egg samples sent for analysis.

Spiders:

Wolf Spiders will be sampled by staff at EFPC and reference sites. Sampling activities will occur between May and October 2023. After dark, samplers will hold flashlights at eye level to locate the reflective spider eyes near the stream shoreline or adjacent floodplain area. The spiders will be retrieved using either an aquarium net or forceps. During collection, spider specimens will be placed into plastic cups with lids.

ADULT INSECTS:

Adult insects will be collected from EFPC and reference sites between May and October 2023. Nocturnal insects will be trapped in an adult insect trap comprised of a white mesh globe (*no-see-um* material) containing a black light inside. Insects will be attracted to this special black light which provides maximum insect response from as far away as 500 meters. After numerous insects have landed on the globe, they are hand collected using an aspirator-vacuum tool which sucks the insects off the mesh globe and secures them inside sample vials.

SNAKES:

Snakes will be sampled along EFPC and at reference sites. Snake boards will be used to attract snakes. Snakes resting under boards will then be captured by hand. Trained staff will record morphological measurements to assess snake body condition and collect blood samples from captured snakes. Snakes will be released unharmed at the site of capture. Due to safety concerns, venomous snakes will not be sampled.

BIOTA SAMPLING AND HANDLING PROTOCOL FOR TDEC DOR-OR LAB:

1) Biota samples will be weighed to the nearest 0.01 gram and recorded on the laboratory sample log.
2) Bird egg, flying insect, and wolf spider biota samples will be placed into Level 2 pre-cleaned glass jars with labels and screw-top plastic lids. These sample jars will be stored at -18ºC in the TDEC DoR-OR lab freezer until shipped to an external lab for analysis.
3) Upon assessment of total biomass per zone, snake blood samples will either remain in original collection tubes or be composited into Level 2 pre-cleaned glass vials with labels and screw-top plastic lids. These samples will be stored at -18ºC in the TDEC DoR-OR lab freezer until shipment to an external laboratory for processing.

DATA ANALYSIS:

1) Biota data results will be compared to available DOE biota datasets in OREIS.
2) The Hg, MeHg, and radiological analytical data results will be normalized to account for differences in body mass, where applicable, among and between species.
3) Total Hg vs. MeHg graphs and figures will be generated to compare among sites on the ORR and reference sites.
4) Total Hg and MeHg concentrations and radiological contaminants will be compared among feeding guilds: insectivores, omnivores, herbivores, carnivores.

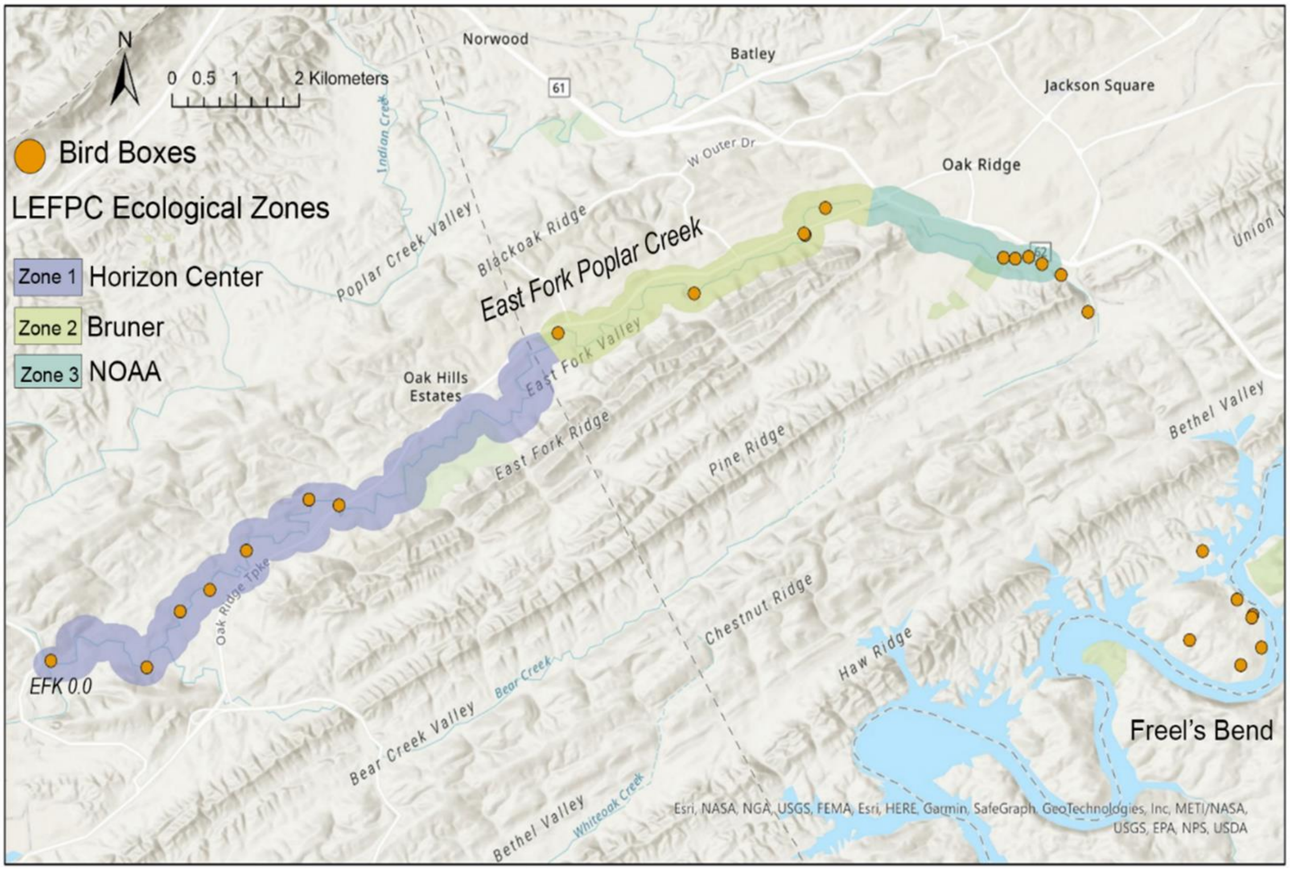

Figure 3.2.5.1 Biota sampling locations along EFPC within impacted areas and in Freels Bend reference area

Species that are State or federally listed as greatest conservation need (GCN), threatened, endangered, or deemed in need of management will not be sampled. State or federally listed species (if encountered) will be reported to TWRA and USFWS within 5 working days.

1) **Zone 1**: *Horizon Center reach* is the most downstream reach of EFPC. TDEC-DoR-OR personnel will collect specimens at seven (7) sites on EFPC from EFPC kilometer EFK 0.0 to EFK 13.8.

2) **Zone 2**: *Bruner Site reach* flows through the City of Oak Ridge, following closely to the Oak Ridge Turnpike. TDEC-DoR-OR personnel will collect specimens at five sites on EFPC from EFK 13.8 to EFK 19.2.

3) **Zone 3**: *NOAA site reach* is the most upstream reach of EFPC, in closest proximity to Y-12, and flows through the City of Oak Ridge. TDEC-DoR-OR personnel will collect specimen at six (6) sites on EFPC from EFK 19.2 to EFK 23.4.

4) **References Locations**: are comprised of seven sites within Freels Bend, a peninsular area along the Clinch River upstream of Melton Hill Lake. These sites are not within the floodplain of EFPC and have not been affected by mercury or methylmercury contamination.

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3.3 ORR Roving Creel Survey

3.3.1 Background

The Roving Creel Survey is an ongoing project that measures angling effort just outside the ORR boundaries. There are three key confluence sites where impaired ORR watersheds drain into publicly accessible waters. Angler interviews will be conducted at these confluences; East Fork Poplar Creek-Poplar Creek (EFPC-PC), Poplar Creek-Clinch River (PC-CR), White Oak Lake-Clinch River (WOL-CR). Both catch-and-release fishing and fishing for consumption will be documented. Since all these waterways have been impacted by both historical ongoing operational activities, fish consumption is a likely pathway for human exposure and risk evaluations need to consider site specific finds for these locations.

Fishing, and recreational activities will be actively and passively surveyed in the lower reaches of BC and EFPC. These lower stream reaches are located within the North Boundary Greenway (NBG) and feed into Poplar Creek. This greenway is a popular recreation attraction for Oak Ridge citizens and people have been observed there year-round.

BCK and EFPC originate within the confines of the Y-12 and are fed by springs and numerous outfalls from various plant facilities. During weapons production at Y-12 in the 1950s and 1960s, large amounts of mercury, chemical contaminants, and radiological materials like uranium were released in a wide range of concentrations to surface waters, sediments, and floodplain soils (Brooks et all, 2017; Pant et al, 2010).

White Oak Creek (WOC) originates just north of ORNL. Radionuclides released from ORNL to WOC are a result of leaks from ponds and waste disposal areas and include contaminants such as Sr-90 and Cs-137, as well as other byproducts from nuclear and industrial activities (DOE, 1988). These contaminants are significant because of their radiotoxicity, mobility in the environment, and quantities released. Other radionuclides of significance include tritium and transuranics (DOE, 1988). The availability of Cs-137 for biological uptake is a major public health concern as it can be transferred to humans through food webs. Even in the most mobile aquatic habitats (i.e., flowing rivers), Cs-137 may persist in a biologically available form for several years after release (Rowan DJ, 1994; Sakai MT et al, 2016).

Mercury in streams and wetlands often undergoes methylation and is transformed into toxic methylmercury (MeHg) in conjunction with the activity of microorganisms (Kalisinska et al, 2013). Methylmercury is particularly bioavailable to wildlife and humans and, if ingested, may cause serious neurological, reproductive, and other physical damage (Standish, 2016). Fish are especially vulnerable to Hg bioaccumulation due to their habitat and diet (Murphy, 2004).

3.3.2 Related DOE Projects

No DOE investigations have taken place for over 20 years on or near the ORR to ascertain the level of human exposure risk through angling efforts and/or recreational activities. This DoR-OR public outreach project seeks to fill a gap in the environmental monitoring of DOE.

3.3.3 Problem Statements

1) Fish have been shown to bioaccumulate mercury and other contaminants (Murphy, 2004). If contaminated, ingestion of these fish could harm people and other piscivores.

2) Fish consumption warning signs and postings are either not visible or they are missing. In addition, residents who have fished these waters for many years may disregard warnings.

3) Little is known about the extent of human engagement with natural areas on and near the ORR.

3.3.4 Goals

1) Quantify the angling effort in the 5 key locations just outside ORR boundaries (EFPC and BC along the NBG, confluence points of EFPC-PC, PC-CR, and WOL-CR).

2) Determine if recreational fishing is a significant pathway for human exposure to contaminants.

3) Provide data that is pertinent to CERCLA requirements and future ORR decisions regarding human health and environmental protection.

4) Document the amount of human recreational activity in the lower reaches of BCK and EFPC within the North Boundary Greenway.

3.3.5 Scope

Roving angler interviews will be limited to three stream confluences of concern: EFPC-PC, PC-CR, and WOL-CR (Figure 3.3.8.1). There will be 20 survey events throughout the year (i.e., 5 per quarter). Specific survey event dates will be selected using non-uniform probability based on the guidelines from TWRA (1992).

Recreational activities along the public North Boundary Greenway, which crosses Bear Creek and East Fork Poplar Creek multiple times, will also be monitored to better understand public interactions with natural resources that may be impacted by DOE activities and contaminants.

3.3.6 Assumptions

1) When exposed, fish can bioaccumulate contaminants discharged from the ORR into public waters.

2) Migration of contaminants outside the ORR boundary could pose a risk to human health.

3.3.7 Constraints

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures.

2) The number of people available and willing to answer the surveys cannot be predicted.

3.3.8 Methods, Materials, Metrics

TDEC personnel will conduct angler surveys at three locations with active, on-site methods whereby anglers are interviewed before, during, or immediately after fishing. Survey information that will be collected is listed below.

Observable data collected from anglers includes:

1. Date/Time
2. Type – boat/bank fishing, private/commercial

3. Location – Lat/Long
4. Number of people in party

Angler reported data includes:

1. County and state residence
2. Total amount of time spent fishing for that trip
3. An estimate of days spent fishing per month
4. Target species of fish
5. Consumption of fish harvested from the areas of concern
6. Provision of fish to sensitive populations (i.e., pregnant women, nursing mothers, or children) for consumption
7. Knowledge of posted signage in these areas of concern

Additionally, voluntary surveys will be available year-round to visitors via paper and online survey methods posted at the Clinch River Boat Launch (Figure 3.1.8.3, Table 1).

Recreational activities along the NBG will be monitored for one year using active and passive monitoring techniques. TDEC-DoR-OR will observe activity on the NBG during four survey events scheduled once per quarter. Additionally, voluntary surveys will be available year-round to recreators via paper and online survey methods posted at three locations (Figure 3.1.8.2, Table 1).

Recreator reported data includes:

1. Date/Time
2. Recreation activity – hiking, biking, fishing, kayaking…etc.
3. Number of people in party
4. County and State residence
5. Total amount of time spent recreating for that trip
6. Estimate of time spent fishing per month along the NBG (days/month)
7. Target species of fish
8. Consumption of fish harvested from the areas of concern
9. Provision of fish to sensitive populations (i.e., pregnant women, nursing mothers, or children) for consumption
10. Knowledge of posted signage in these areas of concern

In addition, visitors can also complete surveys year-round via paper and online survey options. Drop-boxes containing paper surveys are set-up at four locations: three on the North Boundary Greenway and one at the Clinch River Boat Launch. Each drop-box also has a QR code for accessing the online survey.

The survey stations are temporary structures that consist of a wooden frame, a weatherproof overhang, and a locking drop-box. TDEC-DOR-OR personnel will collect surveys once monthly and perform equipment maintenance.

Figure 3.3.8.1 Map of Clinch River Boat Dock

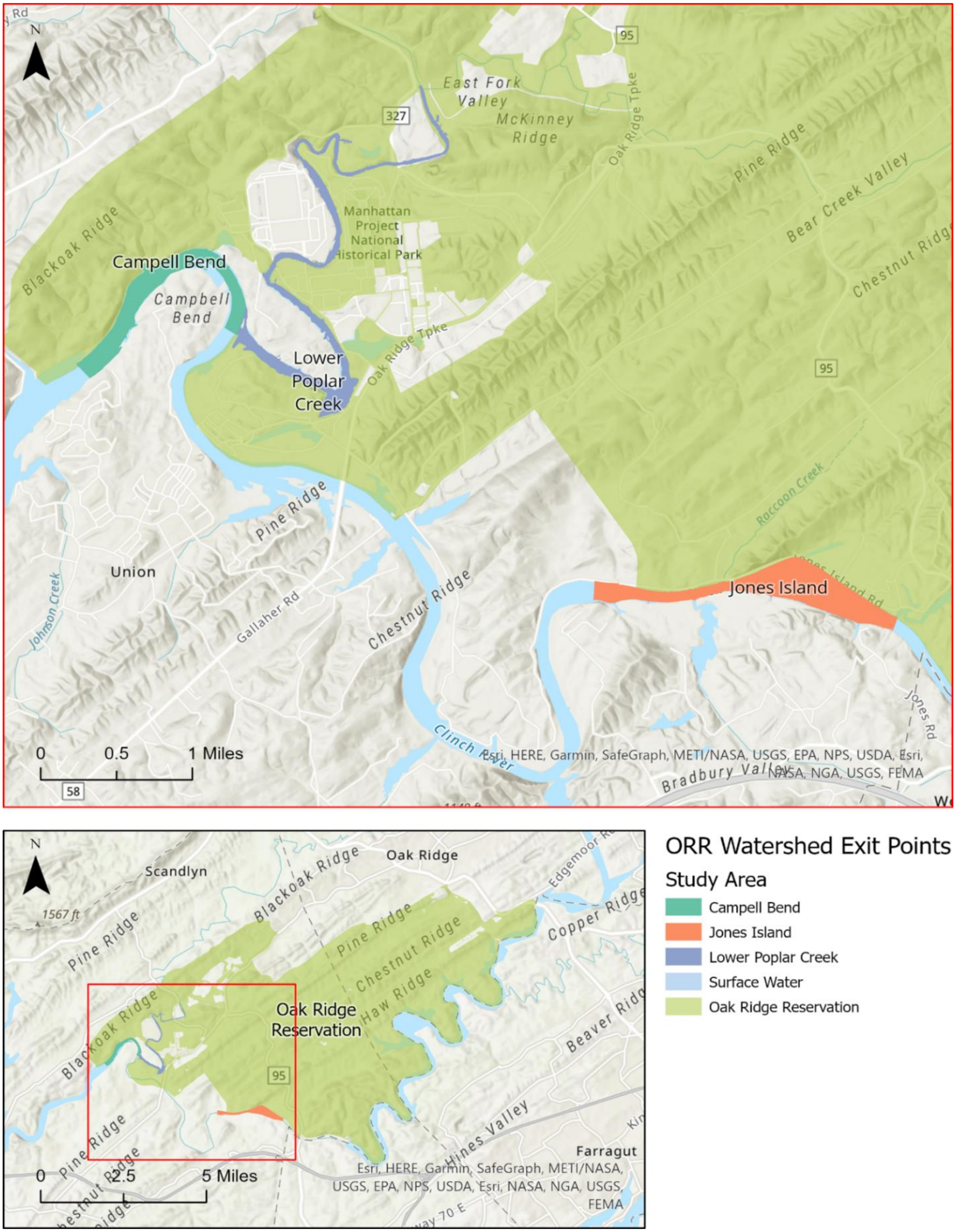

Figure 3.3.8.2 Map of ORR Stream Exit Points

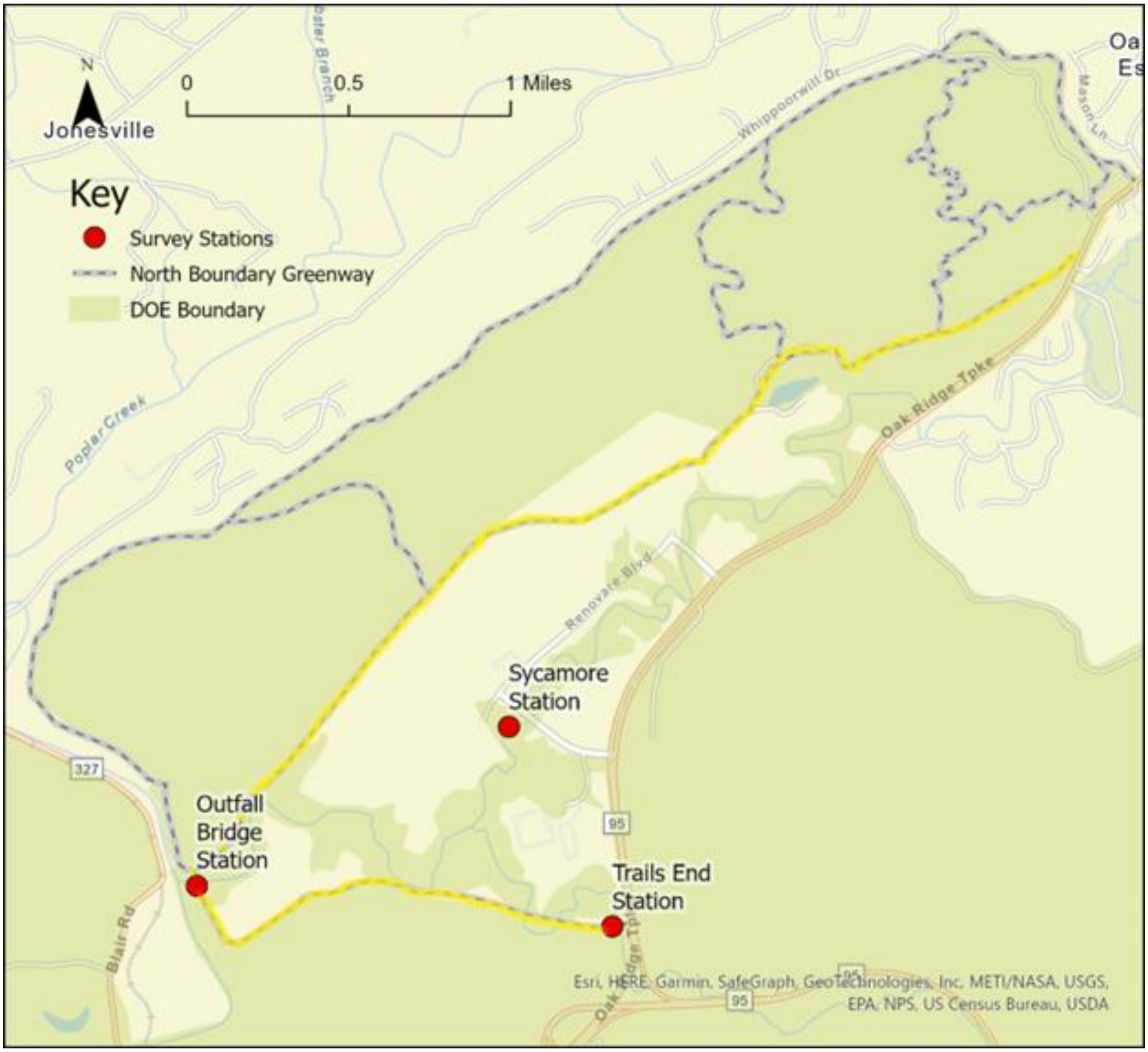

Figure 3.3.8.3 Northern Boundary Greenway

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3.4 Radiological Uptake in Food Crops

3.4.1 Background

The Radiological Uptake in Food Crops Project was requested by DOE. TDEC DoR-OR's data will serve to supplement and independently verify DOE sampling data. Each agency will conduct a separate radiological analysis on locally grown and harvested food crops, hay, and milk (as available) to look at any possible uptake of radiation.

Project staff will sample food crops, hay, and milk harvested from multiple locations on or near the ORR. Corresponding samples will also be collected from reference locations that are not impacted by ORR activities. Samples will be analyzed for radiological contaminants to monitor for potential impacts from the ORR. Results will be documented as well as compared to DOE sampling results.

3.4.2 Related DOE Projects

DOE conducts sampling of locally grown food crops, hay, and milk to look for the uptake of contaminants in these products due to ORR activities. This is done to ensure that the health of residents is not being negatively impacted by consuming such products directly (vegetables, milk) or indirectly (hay). According to the *2023 DOE Environmental Monitoring Plan for the Oak Ridge Reservation*, DOE intends to sample crops from broad-leaf systems (lettuce, turnip greens, etc.), root-plant-vegetable systems (tomatoes), and root-system vegetables (turnips, potatoes, etc.). They intend to perform this sampling at three locations potentially impacted by ORR activities: north of Y-12 (Scarboro community), southeast of ORNL (Gallaher Bend area), southeast of ETTP/southwest of ORNL (Jones Island area), and at a reference location not impacted by the ORR. Hay will be sampled annually from the southeastern edge of the ORR if harvested and made available to offsite operations. Vegetation samples are analyzed for gross alpha, gross beta, gamma emitting radionuclides, and isotopic uranium. If available, DOE collects milk samples bi-monthly from areas that could be potentially impacted by ORR activities and analyzes the samples for gamma emitting radionuclides, strontium, and tritium.

3.4.3 Problem Statements

1) ORR radiological contaminants have been released into the atmosphere, groundwater, surface water, soils, and sediment.

2) Airborne releases from DOE ORR activities can be disturbed and transported beyond the boundaries of the ORR.

3) Members of the public have the potential to be exposed to doses of ORR radiological

contaminants through the consumption of locally grown food crops or milk.

3.4.4 Goals

1) To collect and analyze samples to determine if there is radiological contamination in food crops, hay, and milk on or near the ORR.

2) To compare TDEC DOR-OR results to the results of the corresponding DOE ORR project.

3.4.5 Scope

This project will collect and analyze samples of hay, milk, and food crops (root vegetables, fruiting vegetables, leafy vegetables) from within a five-mile radius of the ORR. These samples will be compared to samples taken from reference locations. The reference locations will be greater than five miles from the ORR boundary and, therefore, considered unimpacted by ORR operations. Vegetable and hay samples will be analyzed for gross alpha, gross beta, and gamma emitting radionuclides. If levels are elevated in any sample, additional strontium-90, technetium-99, and/or isotopic uranium analysis may be requested. Milk samples will be analyzed for tritium, gamma emitting radionuclides, strontium-90, and isotopic uranium.

3.4.6 Assumptions

1) Vegetables and hay may uptake radiological constituents from contaminated soil, water, and/or air. People who consume herbivores or consume milk from livestock on or near the ORR may be exposed to radiological contamination.

2) Any radiological contamination originated from DOE ORR activities.

3) DOE's data will be comparable to TDEC DoR-OR's data.

3.4.7 Constraints

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures.

2) Farming on or near the ORR cannot be predicted or guaranteed.

3.4.8 Methods, Materials, Metrics

Project staff will collect yearly samples of hay, milk, and food crops (root vegetables, fruiting vegetables, leafy vegetables), preferably from within five miles of the ORR. Ideally, up to five samples will be collected from each food crop type, including a sample from a corresponding reference location. The reference locations are over five miles from the ORR boundary and considered unimpacted. Ideally, at least six (6) hay or grass samples and up to six milk samples will be collected including one corresponding sample of each from a reference location. Vegetable and hay samples will be analyzed for gross alpha, gross beta, and gamma emitting radionuclides. If the initial radiological results are elevated, additional analysis may be requested [strontium-90 (Sr-90), technetium-99 (Tc-99), and/or isotopic uranium]. Milk samples will be analyzed for tritium, gamma emitting radionuclides, strontium-90, and isotopic uranium.

Providing that the project budget limit is not exceeded, additional analyses may be requested if the sample results meet any of the following criteria:

- If sample site results are above radiological detection limits, then:
    1) Gross alpha results must be over 1.5 pCi/g and more than twice the levels at the corresponding reference site for *isotopic uranium analysis*.
    2) Gross beta results must be over 5.0 pCi/g and more than twice the levels at the corresponding reference site for *Sr-90 analysis*.
        1. If analysis of Sr-90 shows levels are not elevated, then Tc-99 must be documented as a COC at the closest ORR site. The potential must exist for contamination at the sampling location (due to proximity) for *Tc-99 analysis*.

The Radiological Uptake in Food Crops Project analytical results will be reviewed and compared to DOE's most recent food crop data as published in the annual ORR ASER.

Figure 3.4.8.1 shows the proposed sample area for vegetables, hay, and milk sampling.

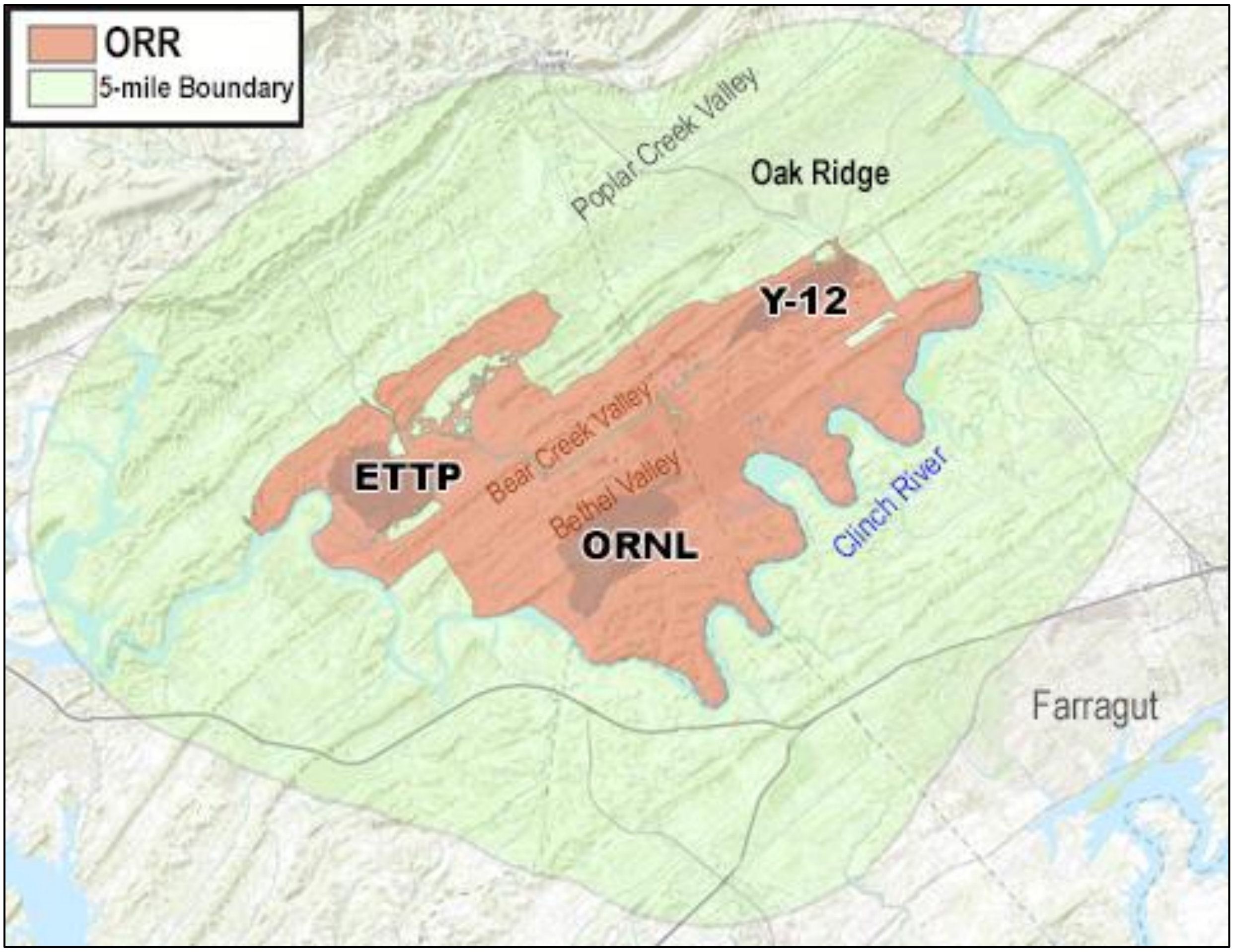

Figure 3.4.8.1 Proposed Food Crop Sampling Area

3.4.9 References

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3.5 Ground Beetle Community Health

3.5.1 Background

Mercury is found in elevated levels throughout the ORR. Due to historical releases from the Y-12 Complex (Brooks et al, 2017), mercury continues to be a contaminant of concern. East

Fork Poplar Creek (EFPC) originates within the northeast footprint of Y-12. This stream's headwaters are fed by surface water runoff and groundwater that has been in contact with mercury-contaminated structures. Historically, mercury (Hg) was released in a wide range of concentrations to EFPC surface waters, sediments, and floodplain soils (Brooks et al, 2017; Pant et al, 2010). Legacy mercury contamination and its migration to ORR exit-pathway streams continues to create potential exposure risks to humans and other biota living in and around EFPC.

Mercury in streams and wetlands around Y-12 undergoes methylation and is transformed into toxic methylmercury (MeHg) through microbial activity (Kalisinska et al, 2013). Methylmercury is particularly bioavailable to local biota (e.g., wildlife and humans). If ingested, MeHg may cause serious neurological, reproductive, and other physiological damage (Standish, 2016).

In general, to better understand the comprehensive movement of contaminants like Hg and MeHg through the food web, key bioindicator species from multiple trophic strata should be assessed. A critical first step to this process is understanding impacts of contaminants on habitat quality and organismal community health. For example, in another TDEC DoR-OR project, benthic macroinvertebrate species are bioindicators used to monitor stream health and assess impacts of human disturbance to aquatic environments. However, in addition to aquatic indicators, the analysis of multiple key species will lead to a better understanding of contaminant pathways and additional environmental impacts. In this way, bioindicator species can provide information on the transition of contaminants from aquatic to terrestrial environments. This project addresses a terrestrial biota sampling gap and will focus on a group of generalist consumers that occupy multiple trophic levels. Terrestrial invertebrates like ground beetles are ideal bioindicators for this project given their close contact with contaminants present within soils and leaf litter (Hunter et al, 1987; Pizzolotto et al, 2013; Ghannem et al, 2018) that link aquatic and terrestrial habitats.

Ground beetles (carabids) are excellent bioindicators because they are ground-dwelling arthropods in both their larval and adult stages; therefore, carabids have a stronger potential to uptake heavy metals through the soils and leaf litter in their immediate environment (Ghannem et al, 2016). They are also ideal bioindicators due to their sensitivity to environmental change. Ground beetles will exhibit relatively rapid and measurable changes within species and community composition (Pearce and Venier, 2006; Avgin and Luff, 2010; Ghannem et al, 2018). Ground beetle community assemblages are directly tied to environmental structure and can thus be used to monitor changes due to anthropogenic impacts on local environments. To date, heavy metals and other contaminant concentrations have been analyzed in some terrestrial invertebrate communities along EFPC at sites downstream of the ORR. However, no ORR studies have evaluated the impacts of contaminants on invertebrate community composition. More specifically, no study has looked at ground beetle communities to evaluate heavy metal impacts on community composition.

While other terrestrial invertebrates have been utilized in previous studies, ground beetles are unique in that they represent multiple inputs into the food web as both consumers and prey items. The diet of a ground beetle is species dependent. A carabid species can be carnivorous, herbivorous, or both (omnivorous). In addition, carabids are also a common prey item of various insectivores (e.g., birds, small mammals, herptiles, other insects). Sampling ground beetle communities provides a means to assess terrestrial ecological connectivity. Changes to ground beetle community composition can be used as an indicator of overall environmental health. Ground beetles have been shown to uptake heavy metals from their environment at concentrations that reflect current contamination levels (Jelaska et al, 2007; Pizzolotto et al, 2013). Thus, sampling carabids offers an excellent opportunity to quantify the contamination uptake levels in these beetles and compare with environmental contamination levels. This project can provide a clearer picture of the bioaccumulative transfer of mercury and methylmercury within this trophic level and beyond. There are concerns that contaminants migrate away from the known point sources through bioaccumulation up the food web. This biological process allows contaminant migration from aquatic and terrestrial systems. More mobile invertebrates may even spread these contaminants over a larger area, perhaps exposing otherwise unimpacted species to sources of contamination.

Mercury and other metallurgic contaminants can negatively impact reproduction, overall size, and mobility of ground beetles (Coleoptera: *Carabidae*) (Ghannem et al, 2018). Due to this susceptibility, mercury uptake could have long term adverse impacts on their community structure and ecological function (Michelangeli et al, 2022). Furthermore, ground beetles are more likely to transfer heavy metals to insectivorous species such as songbirds, which commonly prey on ground beetles (Pizzolotto et al, 2013; Larochelle et al, 2003). This bioaccumulation of methylmercury subsequently has adverse effects in songbird communities. Decreases in avian reproductive success of 35–50% have been observed in conjunction with high dietary methylmercury uptake. More specifically, studies have observed reduced hatchling and fledging success (USDI, 1998; Hallinger and Cristol, 2011). This will be addressed in-depth under another trophic strata study.

In addition to filling a data gap in terrestrial systems, this project will contribute to a separate, larger EFPC Holistic Watershed Assessment. The EFPC Holistic Watershed Assessment aims to complete a comprehensive evaluation of the ecological health of the entire watershed. As a valuable data gap project, ground beetle community assessments will establish a more complete analysis on watershed ecological health. To further aid in the success of this project, open-sourced data from the National Ecological Observatory Network (NEON) will be leveraged. NEON has collected data on carabids from multiple unimpacted sites around the ORR for 8 years, serving as a robust reference data source.

3.5.2 Related DOE Projects

During the CERCLA Five Year Review, biota such as turtles, spiders, earthworms, and adult insects will be sampled by DOE and analyzed for mercury and other contaminants. However, there has been no project completed using ground beetle community assemblages to evaluate environmental health.

3.5.3 Problem Statements

1) Mercury inputs into EFPC from Y-12 continue to be a concern, especially as it becomes bioavailable through methylation.
2) Mercury and methylmercury concentrations have been quantified for some biotic groups but have not been evaluated for impacts on terrestrial biotic community assemblages.
3) DOE does not directly monitor the migration of mercury and methylmercury via bioaccumulation from aquatic to terrestrial habitats
4) While benthic macroinvertebrates are used as bioindicators of stream health, there is no established, analogous terrestrial equivalent that can connect watershed health directly to terrestrial environmental health. The ground beetle is a good terrestrial equivalent.

3.5.4 Goals

1) Determine if ground beetles are a good terrestrial bioindicator to research mercury migration through the food web.
2) Support the EFPC Holistic Assessment Project by providing data to supplement the ongoing biotic sampling under the watershed assessment.

3.5.5 Scope

Specimen(s) will be collected from the three main impacted study zones and from one reference zone. Sampling takes place from May – August. Each zone will consist of two sample sites with at least two invertebrate traps per site. Results from the three impacted zones will be compared with results from the reference zone. We will also use carabid community data collected by NEON Domain 07 to strengthen carabid community data collected from the reference zone.

3.5.6 Assumptions

1) Adult carabid beetles will emerge during the scheduled field event and an active representative sample of the community will be captured using pitfall traps.

2) TDEC-DoR-OR personnel will capture adequate invertebrate biomass to conduct accurate laboratory analysis.

3) Carabids on EFPC are exposed to higher levels of mercury, methylmercury, and other contaminants than the corresponding reference area.

4) Carabid data can be directly compared to other reference datasets for comprehensive community analysis.

3.5.7 Constraints

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures.

2) Adequate biomass must be collected for laboratory analysis to be accurate.

3) Pitfall traps are left unattended.
    1. Ground dwelling wildlife might disturb or destroy traps.
    2. Traps may be damaged or vandalized.

3.5.8 Methods, Materials, Metrics

Terrestrial Invertebrate Field Sampling:

Insect pitfall traps will be installed along EFPC and at corresponding reference zones. Two different types of sites will be established within each zone: diversity sites (DS) and analyte sites (AS). The first project goal is to collect samples from DS pitfall traps to document carabid community taxa diversity. These traps will contain a preservative that is non-toxic to wildlife and people, and samples will be collected every two weeks. To complete the second project goal, AS pitfall traps will passively collect samples that will be used for contaminant analysis (Hg, MeHg). These traps will contain no preservative and will be collected twice a week. Sampling will continue until sufficient biomass is collected. All samples present in the traps will be collected. The pitfall traps from all sites will be left open from May through August 2023. State or Federal listed species (if encountered) will be reported to TWRA within 5 working days.

TDEC DoR-OR LABORATORY PROCESSING:

DS samples will be rinsed and stored in 70% ethanol at the DoR-OR Lab until sorting is complete. Sorting will involve separating carabid beetles for taxonomic identification to species where possible. Additionally, separating the invertebrate bycatch into coarse taxonomic groups will be achieved. Once identified, samples will be composited by taxonomic groups by site and stored at the DoR-OR Lab.

AS samples will be collected and stored at the TDEC DoR Lab at -18ºC to euthanize any live invertebrates in the sample. Samples will subsequently be sorted to identify any carabids in the sample while invertebrate bycatch will be separated into coarse taxonomic groups. Carabids and invertebrate bycatch will remain separated or be composited, depending on collected biomass, into Level-2 pre-cleaned glass vials (with labels and screw-top lids) if needed to achieve necessary biomass. These samples will again be stored in the -18ºC freezer until shipment for mercury and methylmercury analysis.

DATA ANALYSIS:

1) Carabid communities will be assessed by various diversity metrics along with comparisons between impacted sites and reference zones.
2) Hg and MeHg analytical data will be normalized to account for differences in body mass, where applicable, among and between species.
3) Graphs will be used to compare ORR sites to references sites. Carabid diversity will be plotted against the Total Hg vs. MeHg values.
4) Total Hg and MeHg concentrations will be compared among feeding guilds (e.g., insectivores, omnivores, herbivores, carnivores, detritivores) and among invertebrate groups, where possible.
5) Mercury and methlymercury results for **non-carabid taxa** will be compared to DOE biota datasets in OREIS if available.

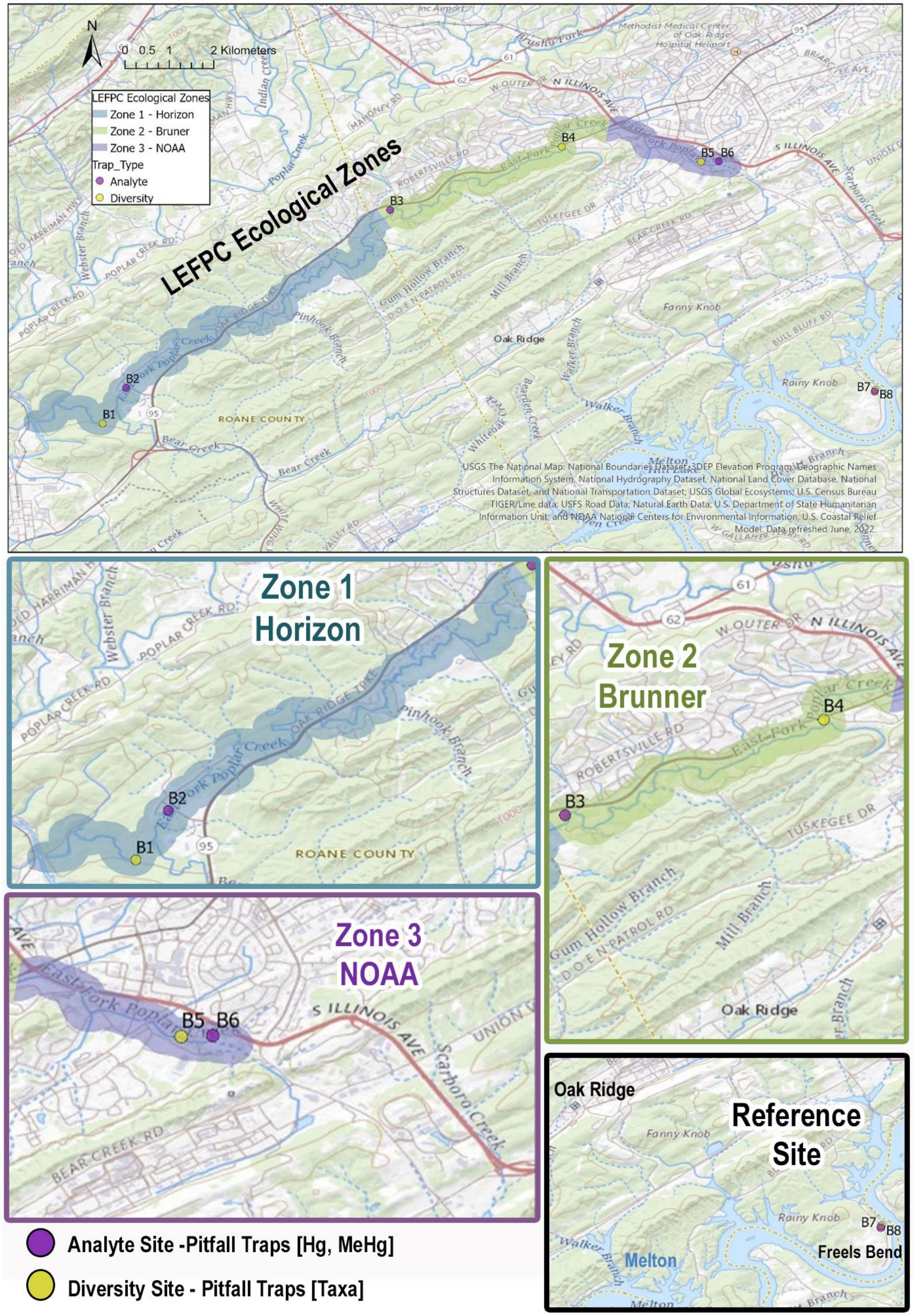

Figure 3.5.8.1: **East Fork Poplar Creek Ground Beetle Sampling Sites**

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4.0 GROUNDWATER MONITORING

4.1 OFFSITE GROUNDWATER

4.1.1 Background

Historically, offsite groundwater downgradient of the DOE ORR has been monitored by both the TDEC DoR-OR and the DOE. The purpose of TDEC's DoR-OR offsite groundwater monitoring program is to monitor groundwater quality at offsite locations for possible DOE legacy contamination that may have migrated off the ORR into the adjacent surrounding area. The location of sampling efforts for the FY24 Offsite Groundwater Project (Project) will be private resident water wells and springs located downgradient, to the southwest and along strike, of Y-12. This general area will be referred to herein as the Bear Creek Valley Offsite Subarea whose boundary is defined by DOE (DOE, 2017) and is illustrated on Figure 4.1.1 and Figure 4.1.2. A topographic and hydrologic divide has been identified in the general vicinity of the former S-3 ponds. As such, the headwaters of Bear Creek and Upper East Fork Poplar Creek are on the west and east side of this divide, respectively (Elvado, 2020). This Project will include sampling private water wells and springs located east of Y-12.

4.1.2 Related DOE Projects

In prior years, DOE has collected groundwater samples from numerous offsite private water well locations. Often, DOE staff are accompanied by DoR-OR staff, and co-samples may be collected. Within the last five years, DOE has completed the following offsite groundwater activities:

1) 2017 – DOE submitted the *Offsite Groundwater Assessment Remedial Site Evaluation* (DOE, 2017) which documents the collection of water samples between FY14 and FY16 at 34 private water wells and 15 springs located outside the ORR boundary.

2) 2022: DOE completed field activities as outlined in the *Remedial Site Evaluation Phase 2 Offsite Detection Monitoring Report* (DOE, 2018). These field activities included three years of annual sampling conducted during the wet season at 14 offsite private water wells/springs within all four subareas (Figure 4.1.1). Of these 14 sample locations, five of these sample locations fell within the BCV-OS: specifically, sites *RWA-035, RWA-118, RWA-132, RWA-143,* and *SYN-120*. In addition to measuring water quality parameters (temperature, pH, specific conductivity [SpC], dissolved oxygen [DO], oxidation-reduction potential [ORP], and turbidity) in the field, the water samples were also analyzed for volatile organic compounds (VOCs), radioactive materials (gross alpha,

gross beta, uranium-233/234, uranium-235/236, uranium-238, and select fission products/transuranic elements. DOE documented the results of this monitoring effort in the *Phase 2 Offsite Detection Monitoring Remedial Site Evaluation* (DOE, 2022a).

3) DOE collected groundwater samples from exit pathway wells and springs, specifically those within Bear Creek Valley and Melton Valley. The purpose was to monitor groundwater water quality within the western boundary of the ORR. These exit pathways wells and/or springs contain concentrations of VOCs and manmade radionuclides which suggests westward contaminant migration (DOE, 2022b).

4) Offsite migration of VOCs is occurring on the east end of Y-12. DOE operates a groundwater extraction system to control offsite migration of the East End Volatile Organic Compound (EEVOC) Plume (DOE, 2022b).

4.1.3 Problem Statements

Delineation of the nature and extent of groundwater contamination is incomplete in many areas of the ORR (DOE, 2022b). Figure 4.1.1 shows the reservation boundary and the three primary DOE campuses. Each campus has numerous associated groundwater contaminant plumes which have been documented by DOE mission activities. Many contaminant plumes are not well defined and require ongoing investigation to delineate their vertical and horizontal extent as required. Without plume extent defined, it is unclear the distances that onsite contamination may have traveled.

The ORR is an area with geologically complex bedrock containing many faults and carbonates that exhibit a karst terrain with large sinkholes. Little is understood about the contaminant flow paths within the bedrock and further investigation is necessary to evaluate these flow pathways. Research has established that groundwater can move long distances rapidly in all fractured-rock settings (Worthington, 2004) and in channels and conduits. This geologic complexity may enable enhanced offsite movement of impacted groundwater. Accordingly, it is important to monitor groundwater/spring water quality offsite the ORR until delineation of the site characteristics and the plume delineation is completed.

This Project will continue TDEC DoR-OR's efforts towards monitoring water quality of private water wells and springs in the area surrounding the ORR to ensure there is no threat to human health and the environment from potential offsite migration of DOE ORR legacy contamination.

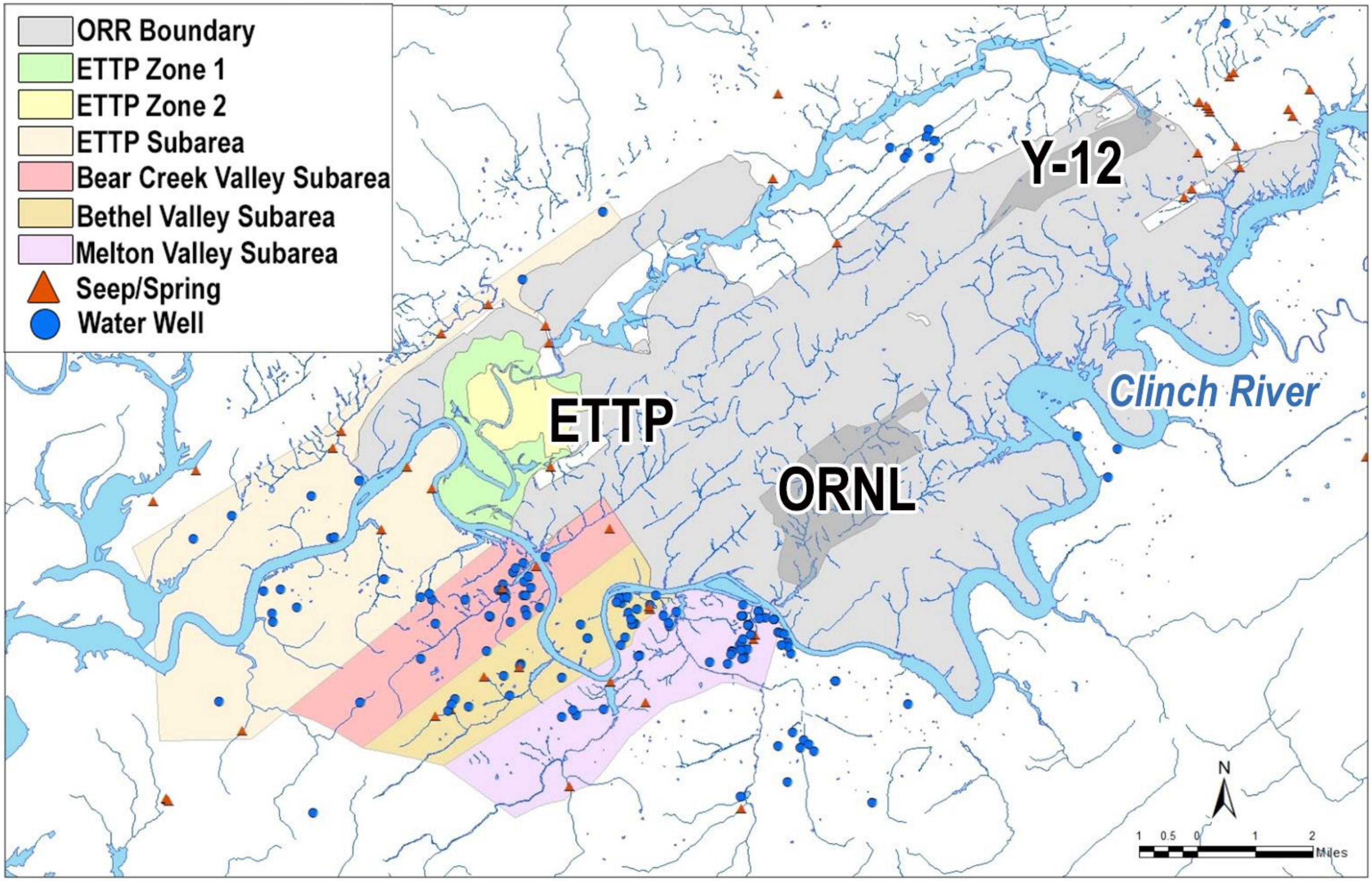

Figure 4.1.1: Oak Ridge Reservation Offsite Groundwater Subareas Map

4.1.4 Goals

The primary goal of this Project is to evaluate protectiveness of human health and the environment though monitoring groundwater offsite the ORR that citizens may utilize for drinking water sources. This Project involves collecting groundwater samples at private water wells and at springs within the BCV Offsite Subarea at the locations illustrated on Figures 4.1.2 and 4.1.3.

The objectives of this Project include the following:

- Monitor water quality of private water wells and springs in the area surrounding the ORR tosspot check water quality intermittently and to use that data to assess protectiveness to human health at that time.
- Provide additional offsite data.
- To allow for comparison with DOE collected data including co-sampling events.
- Assist with FFA Y-12 site-wide groundwater decisions by evaluating potential exit pathway impacts as early as possible.

The collection of these data will help guide future groundwater cleanup decisions that support TDEC DoR-OR's mission of protecting human health and the environment.

4.1.5 Scope

The scope of this Project is to collect groundwater samples from 24 private water wells and 11 springs within the BCV-OS (Figures 4.1.2 and 4.1.3). At each location, field water quality parameter measurements will be documented, and groundwater samples will be collected and submitted for laboratory analysis.

4.1.6 Assumptions

The scope of this Project is based on the following assumptions:

- Private well owners provide consent to collect groundwater samples.
- Groundwater samples will arrive intact and will be analyzed within their respective analytical method holding times.
- A maximum of 10 groundwater samples will be submitted for isotopic uranium analysis.
- Analytical laboratory costs do not increase during FY24.
- Equipment, vehicles, and trained personnel are available to complete field work events.

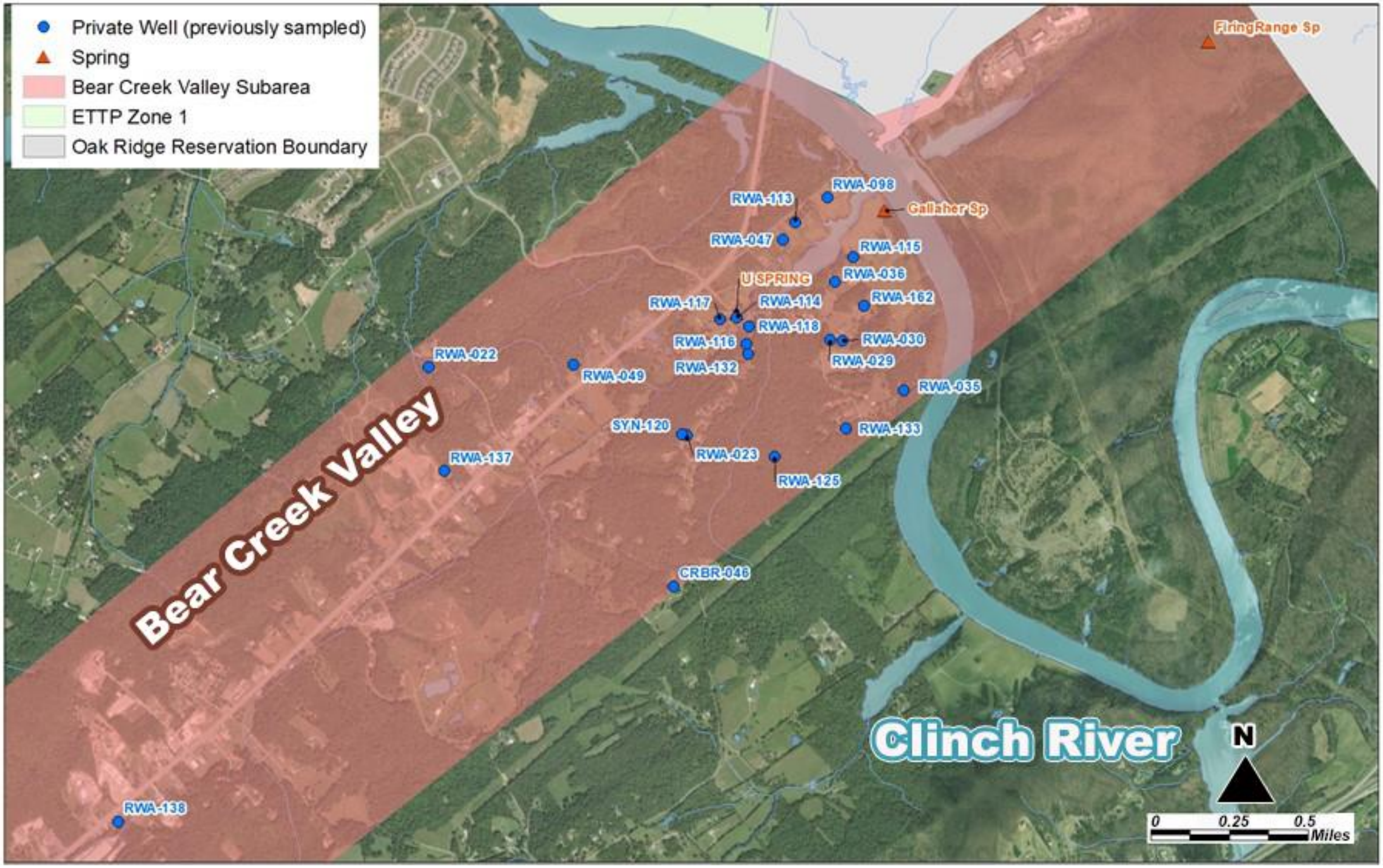

Figure 4.1.2: Proposed Southwestern BCV Offsite Subarea (OS) Sample Locations

Figure 4.1.3 Proposed Eastern Sample Sites

4.1.7 Constraints

Constraints that may impact this project include:

1) Contacted residents may not want to participate in the groundwater sampling project.
2) It may be difficult or impossible to bypass filtration systems, water softeners, etc., which affect the quality and usefulness of the data or ability to collect a viable sample.
3) The infrequent sampling of the private water wells and springs will not capture the potential temporal variability of water quality.
4) Lack of information on well construction, such as depth, may complicate data interpretation and analysis.

4.1.8 Methods, Materials, Metrics

Sample Collection

The project will include the collection of groundwater samples from 24 private water wells and 11 springs within the BCV-SO and to the east of Y-12 (Figure 4.1.2 and Figure 4.1.3; Table 4.1.1). Private water wells will be sampled, and springs will be located to document field water quality parameters and flow conditions during the dry season (June, July, August). An additional event to collect analytical samples at the spring locations will be conducted during the wet season (January, February, March). The private water well samples will be collected using each well's dedicated submersible pump from an outside tap located as close to the well as possible. Ideally these samples will be taken before water passes through any filtration and/or water softener systems. If that is impossible, a field determination will be made regarding sampling. At minimum, field notes will record any systems in use at the time of sampling if sample is collected for analytical data validation. The volume of water that will be purged prior to sample collection will depend on frequency of use for each well. Once the appropriate volume of water has been purged, and water quality parameters have stabilized for three consecutive readings, a groundwater sample will be collected. Field parameter stabilization is specified in Table 4.1.2.

Table 4.1.1. Groundwater Sampling Plan

Station Name	# of Sample1 Events Historical	FY24 Analytical Parameters2			
		VOCs	Inorganics	Metals	Radionuclide[3]
Wells					
CRBR-046	2	1	1	1	1
RWA-022	5	1	1	1	1
RWA-023	3	1	1	1	1
RWA-029	14	1	1	1	1
RWA-030	3	1	1	1	1
RWA-035	7	1	1	1	1
RWA-036	3	1	1	1	1
RWA-047	12	1	1	1	1
RWA-049	1	1	1	1	1
RWA-098	2	1	1	1	1
RWA-110	2	1	1	1	1
RWA-113	1	1	1	1	1
RWA-114	4	1	1	1	1
RWA-115	1	1	1	1	1
RWA-116	7	1	1	1	1
RWA-117	5	1	1	1	1
RWA-118	11	1	1	1	1
RWA-125	2	1	1	1	1
RWA-132	7	1	1	1	1
RWA-133	6	1	1	1	1
RWA-137	1	1	1	1	1
RWA-138	1	1	1	1	1
RWA-162	2	1	1	1	1
SYN-120	5	1	1	1	1
Springs					
Cattail Sp.	40+	1	1	1	1
Bootlegger Sp.	40+	1	1	1	1
Fallen Tree Sp.	2	1	1	1	1
Fiddle Head Sp.	1	1	1	1	1
Firing Range Sp.	1	1	1	1	1
Gallaher Sp.	2	1	1	1	1
Scarboro Sp.	1	1	1	1	1
Soil Cave Sp.	3	1	1	1	1
Triangle Sp.	2	1	1	1	1
U Spring	3	1	1	1	1
Yellowjacket Sp.	2	1	1	1	1

Table 4.1.1 (continued) Groundwater Sampling Plan

Sample Quantities Total incl. QA/QC	VOCs	Inorganics	Metals	Radionuclide[3]
Total Primary Samples	35	35	35	35
Field Blank	2	2	2	2
Field Duplicate	4	4	4	4
Total Samples (FY 24)	**41**	**41**	**41**	**41**

<u>*Notes:*</u>

All private water well samples will be collected during the FY24 dry season (June, July, August).
Spring samples will be collected during the FY24 wet season (January, February, March).
[1] – Total number of sampled events either conducted by TDEC and/or DOE. The number of historic spring sample events is estimated.
[2] – The list of analytes and their analytical methods are defined in Table 2.1.2.
[3] – Isotopic uranium analysis will be run on samples with a gross alpha activity concentration greater than or equal to 5 picocuries per liter (pCi/L).

Field water quality parameter measurements and laboratory samples will be collected from the springs using a peristaltic pump.

The water samples collected from the private water wells and springs will be analyzed for VOCs, gross alpha/beta, inorganics, and metals using the analytical methods specified in Table 4.1.2 or equivalent analytical methods. If gross alpha activity is detected in any of the groundwater samples at a concentration greater than or equal to five picocuries per liter (pCi/L), then those groundwater sample(s) will be analyzed for isotopic uranium.

Two monitoring events will be performed at the 11 spring locations. The first event will be conducted during the dry season and will only consist of measuring field water quality parameters and documenting flow conditions. The second event will occur during the wet season and includes collecting samples for laboratory analysis.

Quality assurance/quality control (QA/QC) samples will be collected at a frequency of every 10%. Trip blanks will be included in coolers and two field blanks will be submitted for analysis (Table 4.1.1). All water samples will be collected in accordance with internal standard operating procedures (SOPs).

Table 4.1.2. Analytical Test Suite

Parameter Type	Analytes	Analytical Method/Stabilization Criteria
Inorganics	alkalinity	SM 2320-B
	ammonia as N	EPA Method 350.1
	nitrate/nitrite as N	EPA Method 353.2
	chloride	EPA Method 300.0
	fluoride	EPA Method 300.0
	sulfate	EPA Method 300.0
	total dissolved solids (TDS)	SM 2540-C
Metals	calcium, iron, magnesium, potassium, sodium, total hardness	EPA Method 200.7
	aluminum, **antimony**, **arsenic**, **barium**, **beryllium**, boron, **cadmium**, **chromium**, **copper**, **lead**, lithium, manganese, **nickel**, **selenium**, silver, strontium, **thallium**, **uranium**, vanadium, zinc	EPA Method 200.8
	low level mercury	EPA Method 1631
Volatile Organic Compounds	**numerous**	EPA Method 8260B Low Level
Radionuclides	**gross alpha**/gross beta	D7283-17
	isotopic uranium	HSL-300
Field Water Quality Parameters	pH	±0.1
	temperature (°C)	±10%
	specific conductivity (µS/cm)	±5%
	dissolved oxygen (mg/L)	NA
	oxidation-reduction potential (mV)	±10 mV
	turbidity (NTU)	±10%

Notes:
***Bolded** values have a numerical standard.*

°C – degrees Celsius
NA – not applicable
NTU – nephelometric turbidity unit
µS/cm – microSiemens per centimeter
mg/L – milligram per liter
mV - millivolt

Data Evaluation

The resulting analytical data will be evaluated and compared against numerical standards set forth in TDEC's *General Water Quality Criteria Chapter 0400-40-03-.03* (TDEC, 2019) and the EPA's *National Priority Drinking Water Regulations* (EPA, 2009) to evaluate risk to human health and to confirm the private water wells and springs have not been impacted from DOE ORR legacy contamination. Additional analysis will be conducted and may include using graphing, mapping, and geochemical tools to display data and compare the major ion chemistry between the groundwater samples (e.g., Stiff Plots). The results of the groundwater sampling will be incorporated into the TDEC's FY24 *EMR*.

4.1.9 References

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5.0 LANDFILL MONITORING

5.1 BASELINE SURFACE WATER MONITORING AT THE EMDF SITE

5.1.1 BACKGROUND

The EMDF is a new landfill that will begin construction in 2024. This landfill will be used for the disposal of low-level radioactive waste, hazardous waste, and toxic waste generated by remediation activities on the ORR. The landfill will be operated under the authority of CERCLA and DOE directives. While the EMDF will not be required to hold a State of Tennessee permit, the landfill will be required to comply with DOE orders and substantive portions of *Applicable or Relevant and Appropriate Requirements* (ARARs). These regulations are listed in the CERCLA EMDF *Record of Decision (ROD)* signed in September 2022. The EMDF will be located within the Central Bear Creek Valley (CBCV) area; more specifically, located to the west of the current landfill under use, the EMWMF (Figure 5.1.1).

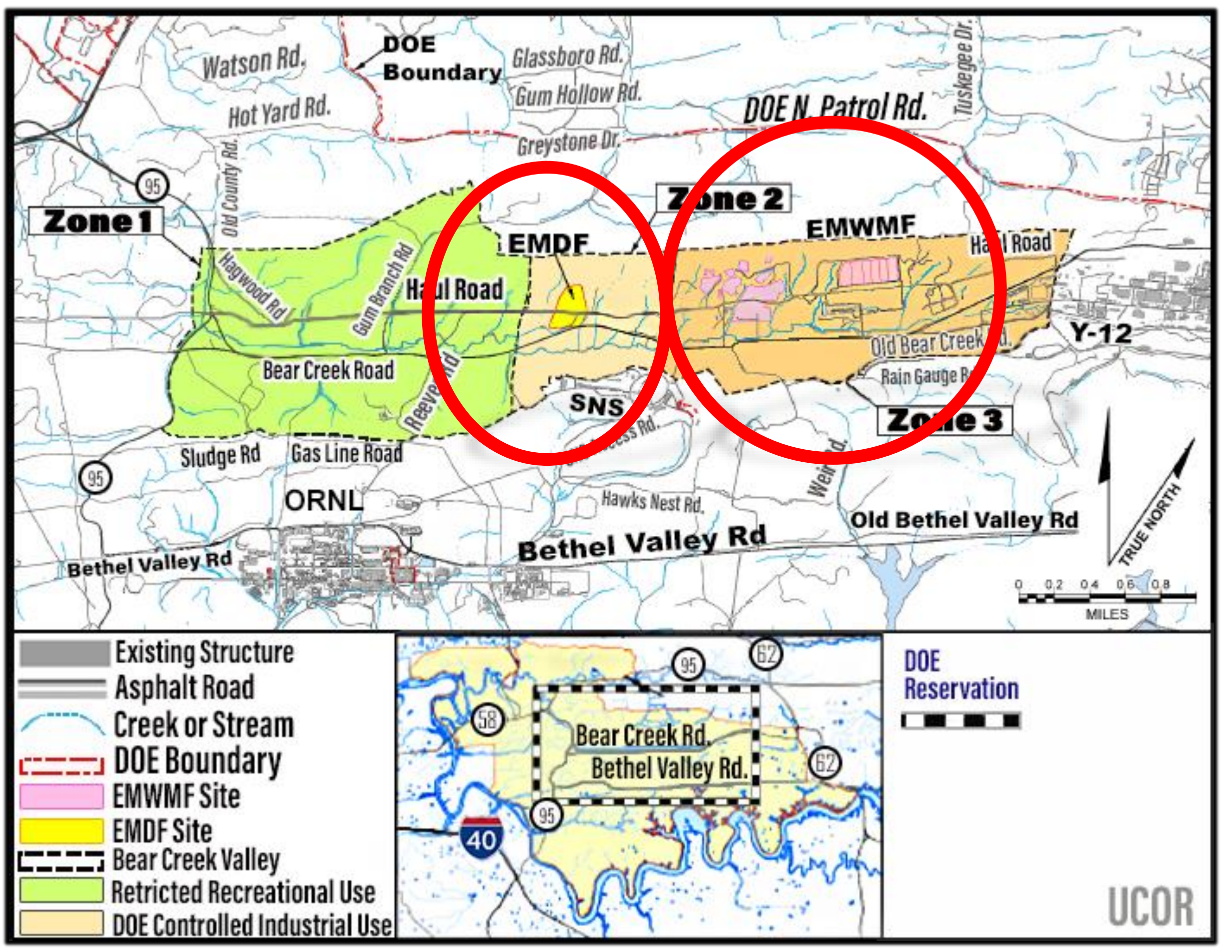

Figure 5.1.1 EMDF and EMWMF Landfill Locations

DoR-OR staff will monitor during this FY24 period of performance, surface water along the reach of Bear Creek where the proposed EMDF landfill will be constructed. Furthermore, surface water plus one spring will be sampled to support efforts to get baseline data prior to construction.

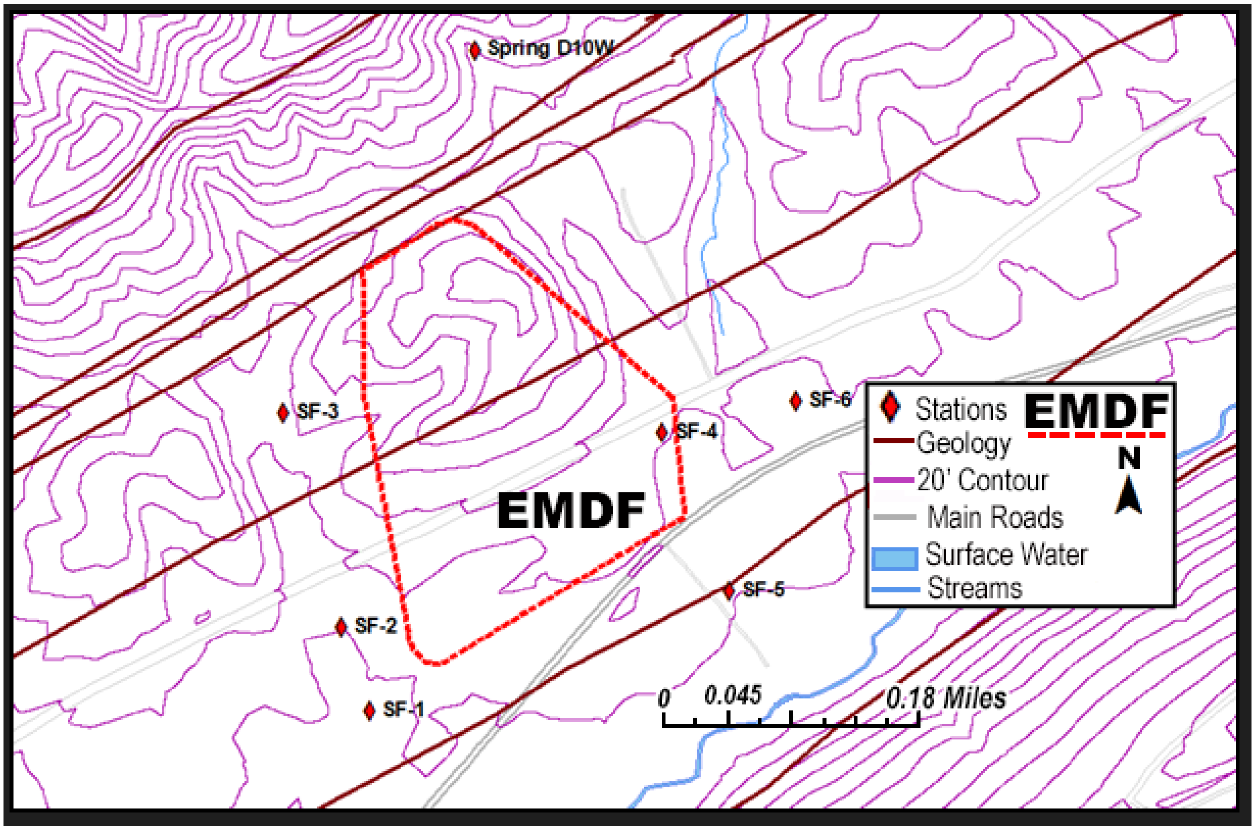

Figure 5.1.1.1 EMDF Site

5.1.2 Related DOE Projects

DOE will continue to monitor the existing landfill, the EMWMF. Currently, under the EMWMF program, DOE monitors Bear Creek and some of its northern tributaries (NT-3, NT-4, NT-5) for potential releases. The wastewater released from the EMWMF sediment basin is collected by an automatic sampler using a weekly flow-weighted composite sample. Annually, the results from these sampling efforts are published in the *EMWMF Phased Construction Completion Report (PCCR).*

DOE's conducts (or will conduct) surface water sampling with in the CBCV Watershed. DOE currently plans to begin EMDF baseline sampling in 2028, or one year prior to the planned start of EMDF operations.

5.1.3 Problem Statements

1) Contaminants in the waste materials from CERCLA remediation activities will be buried in the EMDF once construction is completed. Once placed in the landfill, contaminants may leach out into the environment.

2) If EMDF landfill runoff is contaminated and spreads into the surrounding area, TDEC and DOE will need baseline water quality parameters to plan and assess remediation efforts.

5.1.4 Goals

1) Obtain baseline surface water monitoring data before EMDF Landfill construction begins in the CBCV.

2) Verify / compare baseline surface water parameter data with DOE collected surface water data.

5.1.5 Scope

1) Within the proposed EMDF footprint, staff will measure water quality parameters in streams at six flume discharge locations and at one spring: SF-1, SF-2, SF-3, SF-4, SF-5, and SF-6 and spring D10W (Figure 5.1.1).

2) Observations of site conditions and surface water parameter measurements will be made once a month or as conditions warrant.

3) Staff will collect surface water samples at a subset of the standard sampling locations to complement DOE's efforts to characterize baseline conditions (Table 5.1.8.1).

5.1.6 Assumptions

1) Currently, mercury, radionuclides, and volatile organics are the COCs.

2) There is the possibility that additional COCs will be found during sampling.

5.1.7 Constraints

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures.

2) Monitoring may be contingent upon the availability of a DOE escort / site accessibility.

5.1.8 Methods, Materials, Metrics

Tasks for this program include water quality monitoring and analytical sampling. DoR-OR will monitor quality parameters at seven locations, including one stream, five stream discharge flumes, and one spring (i.e., *D10W*) (Figure 5.1.8.1). Staff will utilize a *YSI Professional Plus* water quality meter to measure water quality parameters at least once a month at all locations. Parameters will include temperature, pH, conductivity, dissolved oxygen, and oxidation-reduction potential. Calibration and/or a confidence check of this instrument will be performed prior to field use. Multi-parameter logging probes will be used at two locations to collect continuous samples (hourly or other schedule as deemed appropriate) at locations *SF-1* and *SF-5R. A*t least twice a month, a visual inspection will be conducted on equipment. These locations were selected for continuous monitoring because, *SF-1* receives *NT-11* water from up-stream and *SF-5R* receives *NT-10* water from up-stream.

Analytical Sampling will be conducted on a semi-annual basis at four locations (including the background location). The schedule for this analytical sampling will correspond to wet and dry seasons. Table 5.1.8.1 presents the four locations where surface water samples will be collected for analytical analysis. In addition, the sampling frequency and rationale for

STATION	Sample ID	Rationale for Frequent Sampling	Sampling Frequency
Flume 1	SF-1	Farthest point downstream from NT-11	Semi-Annually
SF-5R	SF-5R	In-Stream location captures water from NT-10	
Flume 6	SF-6	Captures water from NT-10 upstream	
Spring 10W	SP10W	Background Spring	
SF: Surface Water Flume *Note: SF5R is an instream location downstream from SF5 former location* *NT: North Tributary*			

each station are listed. The analytical test suite is presented in Table 5.1.8.2. Any pertinent water quality regulatory criteria from the EPA and TDEC will be included in the graphs.

Table 5.1.8.1 EMDF Analytical Sampling

DoR-OR will monitor the streams and document discharges, water conditions, stream bank conditions, and note any concerns. All concerns will be brought to the attention of DOE. Field notes will be recorded in a dedicated field book and events will be reported internally in a monthly TDEC DoR-OR project report.

Data collected from these key locations by TDEC DoR-OR and DOE will be entered into an Excel database for evaluation. Evaluation will include the construction of tables and graphs illustrating ranges, limits of constituents and parameters, and identifying potential trends throughout the project.

Table 5.1.8.2: TDEC DoR-OR EMDF Monitoring Analyte List

EMDF ANALYTE LIST	
Radionuclides	
Gamma Activity	Plutonium-238
Gross Alpha Beta Activity	Plutonium-239/240
Americium-241	Radium-226
Carbon-14	Radium-228
Chlorine-36	Strontium-90
Cobalt-60	Technetium-99
Cesium-137	Thorium-228
Europium-154	Thorium-230
Tritium	Thorium-232
Iodine-129	Uranium-233/234
Lead-210	Uranium-235/236
Neptunium-237	Uranium-238
Metals	
Arsenic	Lead
Barium	Mercury
Cadmium	Nickel
Chromium	Uranium
Cobalt	Vanadium
Copper	Zinc
Inorganics	
Nitrite and Nitrate	
Organics	
Volatile Organics	PCBs

5.1.9 References

TDEC. 2019. *Rules of the Tennessee Department of Environment and Conservation, General Water Quality Criteria*. Chap. 0400-40-03. Tennessee Department of Environment and

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5.2 Water Monitoring at EMWMF

5.2.1 Background

EMWMF is operated under the authority of CERCLA (EPA) and DOE. This landfill was constructed for the disposal of low-level radioactive waste and hazardous waste generated by remedial activities on the ORR. The EMWMF Landfill is required to comply with DOE orders and ARARs listed in the CERCLA EMWMF *Record of Decision (ROD) (*DOE, 1999). Due to oversight by these regulatory entities, the EMWMF is not required to hold a permit from the State of Tennessee.

Currently, potentially contaminated contact water (i.e., stormwater), is the only authorized discharge from EMWMF. Contact water collects in the disposal cells above the leachate collection system. This water is routinely pumped from the disposal cells to holding ponds and tanks (Figure 5.2.8.1), and then it is sampled and analyzed for the COCs listed in Table 5.2.8.1. Previously, the contaminant that has exceeded its release criteria and required some remediation is chromium VI (Cr_6). Depending on Cr_6 concentrations, water is either treated onsite, or if that is not possible, the water is treated offsite at the Liquid Gaseous Waste Operation (LGWO). If Cr_6 levels are below criteria limits, (2017 EMWMF SAP/QAPP) the water is released to the storm water sedimentation basin which discharges into NT-5.

The limits on radioactive waste discharge releases from the holding ponds to the sedimentation basin are published in DOE Order 435.1 (formerly DOE Order 5400.5) which restricts the release of liquid wastes containing radionuclides to an average concentration equivalent of 100 mrem/year. The limit for radioactive discharges from the sedimentation basin to NT-5 are based on State of Tennessee regulations (TDEC 0400-20-11-.16{2}) which 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 to the whole body, 75 millirems to the thyroid and 25 millirems to any other organ of any member of the public. Reasonable effort shall be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.” (TDEC, 2012). In addition, DOE Order 458.1 limits gross alpha and gross beta activity of settleable solids in liquid effluents to 5.0 pCi/g and 50 pCi/g, respectively.

DoR-OR water monitoring at the EMWMF began in 2006 and is ongoing. Each year since 2006, samples of surface water, contact water, and sediment have been collected and analyzed. The results are published in the annual *EMR*. All monitoring of contact water and surface water will assist DOE in their efforts to comply with the EMWMF *ROD* (DOE, 1999) and the Tennessee *General Water Quality Criteria* (TDEC, 2019).

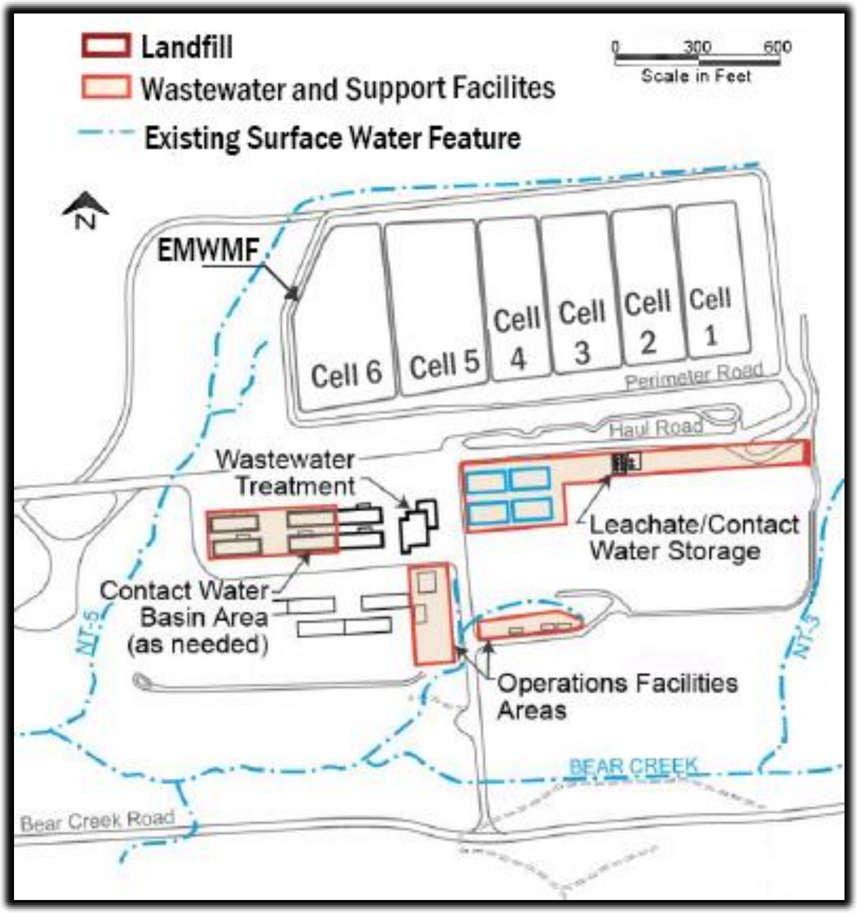

Figure 5.2.1.1 EMWMF Diagram

5.2.2 Related DOE Projects

DOE currently monitors surface water quarterly at *NT-5* and *NT-3* (Bear Creek Tributaries) for potential releases from the landfill. Monthly samples from the Underdrain and the V-weir are also collected. DOE collects the water released from the Sediment Basin at the V-weir (*EMWMF-3*) using an automatic sampler. Sampling consists of a weekly flow-rated composite sample as it is discharged (named *VCOMP*). This is used to calculate the volume weighted sum of fractions for discharge. Additional DOE sampling of surface water takes place at *EMWNT-03B*, *EMWNT-05*, *NT-4* (Bear Creek Tributary) and the V-weir semi-annually after a qualifying precipitation event (> 0.1 inches). In addition, DOE collects a suspended solids sample at the V-weir after a qualifying precipitation event (> 0.5 inches).

Annually, DOE's results from this sampling are published in the *Phased Construction Completion Report* (PCCR) (DOE, 2020). These data are entered into the DOE Oak Ridge Environmental Information System (OREIS).

5.2.3 Problem Statements

Only low-level radioactive solid waste, as defined in TDEC 0400-02-11.03(21) with radiological concentrations below limits imposed by Waste Acceptance Criteria (WAC) and agreed to by the FFA tri-parties (DOE, EPA and TDEC), is approved for disposal in the EMWMF. DOE is accountable for compliance with the WAC and has delegated responsibility of WAC attainment decisions to its prime contractor. DoR-OR will independently monitor and verify that DOE and UCOR are operating the EMWMF within regulations (e.g., TDEC-DRH, FFA, WAC). Contaminants in the waste materials from CERCLA remediation activities are buried in the EMWMF and may leach out and enter the surrounding environment and potentially go offsite via surface water and/or groundwater.

Water discharges from the contact water ponds/tanks are logged and contaminant loading is estimated. This tracking of discharges will help TDEC to verify and assess reported releases, should they occur, to ensure volumes of contaminants during any discharge cycle are compared adequately to agreed limits (100 mrem/yr) (10 CFR 20, 1991).

5.2.4 Goals

Provide assurance through independent monitoring and evaluation that DOE operations at the EMWMF are protective of public health and the environment.

1) Verify DOE's remedial effectiveness objectives for the EMWMF are being met.
2) Provide independent data on discharges from the Underdrain.
3) Track releases of contact water from ponds and tanks.
4) Collect independent surface water monitoring data for comparison to DOE data to validate and verify DOE datasets.
    - Surface water monitoring is intended to verify that DOE is adhering to published (DOE 2017, DOE/OR/01-2734&D1/R1) agreed-to-limits. This includes ARARS listed in the EMWMF SAP/QAPP, DOE 2017.

5.2.5 Scope

This project will monitor environmental media (primarily surface water) at the EMWMF and will collect samples including discharge samples, sediment from the sedimentation basin, and contact water samples. Contact water at EMWMF is defined as stormwater that has been in a cell but has not gone through the waste. These samples will be analyzed for radionuclides, metals, mercury, organics, and potentially PFAS where appropriate or requested. Additionally, staff will monitor the landfill and maintain a contact water discharge log. These data will be used to assess DOE's calculated volume weighted sum of fractions from discharge.

For FY24, monitoring and sampling will be conducted at the following intervals listed in Table 5.2.5.1 below.

Table 5.2.5.1 EMWMF Sites Sampling Frequency and Rationale for Inclusion

Station	Medium	Freq.	Rationale
EMWMF-2 *Underdrain*	GW and SW	SA (**WK–WQ**)	NT-4 discharge below EMWMF Landfill
EMWMF-3 *VWEIR*	Water	SA (**WK-WQ**)	Monitor discharges from sediment basin
EMWMF-5	Water	SA	Discharging pond effluent point
EMWMF-7 or -8	Pond or Tank	SA	Tank effluent locations and a ditch
EMWMFSB-1	Sediment	A	Sediment basin 1 composite sample if dry
EMWNT-3B/ EMWMF3B	Surface Water	A	Baseline – upstream site, **WQ** as requested
NT-5@BCK	Surface Water	A (**WK-WQ**)	Baseline - downstream bioaccumulation
SW-003 (BCK 11.54A)	Water	A **(WK–WQ)**	Below discharge
SA: semi-annually,	*A: annually,*	***WK-WQ:** weekly water quality parameters*	

Surface water monitoring and sampling is intended to provide independent State led verification of DOE's datasets that will support protectiveness determinations and assurances that DOE is adhering to published (DOE 2017, interim SAP/QAPP DOE/OR/01-2734&D1/R1) agreed-to-limits with EMWMF discharges. Protectiveness assessments include evaluation of compliance with ARARS listed in the EMWMF interim SAP/QAPP, DOE 2017 and in the EMWMF ROD (1999). EMWMFs Site Specific ARARs that are relevant to this project are identified in Table 5.2.5.2 below.

Table 5.2.5.2 ARARs for Contact Water/Surface Water – (EMWMF SAP/QAPP)

EMWMF Regulations for Contact Water (CW) and Surface Water (SW)			
Action		**Objective**	**ARARs**
CW	Monitor discharges	TDEC 0400-40-03-.03(3) TDEC 0400-20-11-.16*	EMW-VWEIR, CW ponds and tanks: compare analytical results to AWQC
SW	Check RAD	10 *CFR* 20.1301 (a) TDEC 0400-20-11-.16*	SW samples from EMW-VWEIR: analyzed RAD COCs Use for sum of fractions required for dose calculations
* (10CFR20, 1991). Formerly TDEC 1200- 04-03-.3(3) and TDEC 1200-2-11-.16(2) *RAD: radioactive activity or radioactive materials*			

5.2.6 Assumptions

1) Any releases from EMWMF that could potentially impact residents, or the environment, will be identified by this sampling method.
2) Mercury, radionuclides, and volatile organics are the main COCs potentially migrating from the landfill.

5.2.7 Constraints

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures.
2) Availability of DOE escort where required.

5.2.8 Methods, Materials, metrics

Surface Water: Contact Water and Associated Stormwater

DoR-OR will collect surface water grab samples on a regular basis for laboratory analysis. The sampling and monitoring locations are shown on Figure 5.2.8.1. Collected samples will be analyzed for radionuclides, metals, mercury, and organics (Table 5.2.8.1).

Samples collected at *EMWMF-5* and *EMWMF-7 (*or *EMWMF-8)* will be comprised of either contact water contained inside or discharged from a pond or tank. Any water samples collected directly from a pond or tank can be directly compared with DOE surface water sampling.

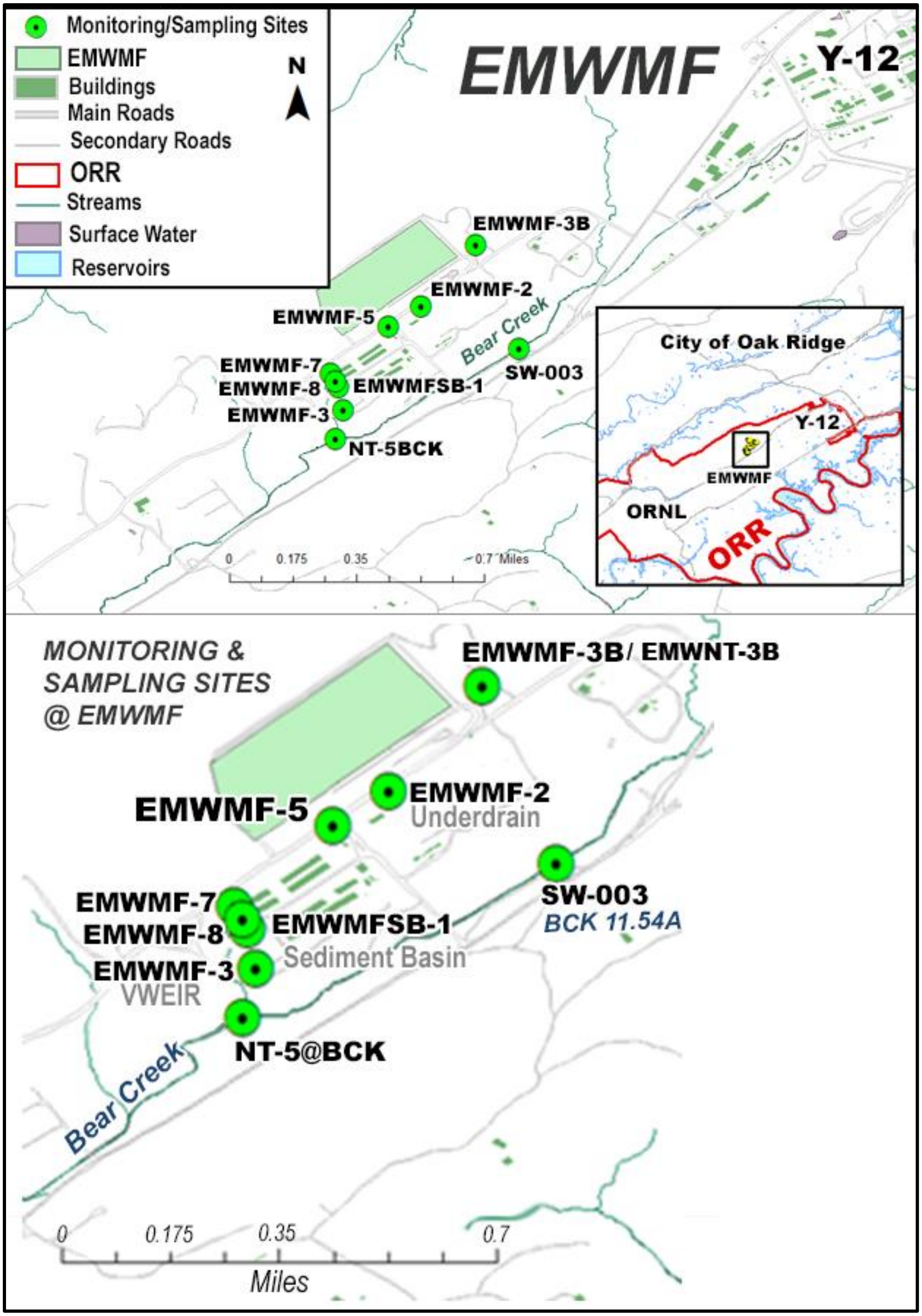

Figure 5.2.8.1 EMWMF Sampling and Monitoring Sites

Table 5.2.8.1 EMWMF Analytes and Contaminants of Concern

EMWMF ANALYTE LIST and COCs		
Water & Sediment	***Water ONLY***	***Additional Sediment ONLY analysis***
Gamma Activity	**Dissolved Solids**	Iron
Sr-89/90	**Suspended Solids**	Magnesium
Tc-99		Manganese
Tritium		**Isotopic Uranium** *233-234/ 235-236 /238*
Transuranics/Isotopic U		Aluminum
Arsenic		Antimony
Chromium		Barium
Cobalt		Beryllium
Copper		**Cadmium**
Lead		Calcium
Mercury		Potassium
Nickel		*Selenium*
Uranium		*Silver*
Vanadium		*Sodium*
Zinc		*Thallium*
PFAs		**Cyanide**
		Total Organic Carbon
Analytes *dissolved* in water / *solids* in sediment: COCs in **BOLD**		

The EPA's human and aquatic life criteria and the State of Tennessee aquatic life criteria will be used as comparison values for the water samples collected during this project.

SEDIMENTS: SEDIMENTATION BASIN

Sediment sampling is conducted annually when the EMWMF sediment pond is dry. One large composite sample will be sent to a contracted lab for analysis. Analytes and contaminant levels used in this project for screening sediment samples are listed below in Table 5.2.8.2. The criteria for sediment comparisons shown in Table 5.2.8.2. include:

1.) EPA's Regional Screening Levels for the Soil to Groundwater pathway using the Soil Screening Level (SSL) tool.
2.) The Consensus-Based Sediment Quality Criteria from the Wisconsin Department of

Natural Resources which provides a threshold effects concentration (TEC) and a probable effect concentration (PEC) (MacDonald et al 2000).

Table 5.2.8.2 EMWMF Sediment Criteria

Sediment Levels for Risk Comparisons			
	EPA RSL Soil to Goundwater SSL mg/kg	TEC* mg/kg	PEC** mg/kg
Aluminum	30000	n.a	n.a
Arsenic	0.0015	9.8	33
Antimony	0.35	2	33
Barium	160	n.a	n.a
Beryllium	20	n.a	n.a
Cadmium	0.69	0.99	5
Calcium	n.a	n.a	n.a
Chromium	4.00E+07	43	110
Cobalt	0.27	n.a	n.a
Copper	28	32	150
Iron	350	20000	40000
Lead	14 MCL based	36	130
Magnesium	n.a	n.a	n.a
Manganese	28	460	1100
Mercury	14	0.18	1.1
Nickel	26	23	49
Potassium	n.a	n.a	n.a
Selenium	0.52	n.a	n.a
Silver	0.8	1.6	2.2
Sodium	n.a	n.a	n.a
Thallium	0.014	n.a	n.a
Uranium	1.8	n.a	n.a
Vanadium	86	n.a	n.a
Zinc	370	120	460
Gamma, Sediments	Use EPA PRGs for comparison	n.a	n.a
Sr-89, 90 in solids	Use EPA PRGs for comparison	n.a	n.a
Technetium 99	Use EPA PRGs for comparison	n.a	n.a
Tritium in solids	Use EPA PRGs for comparison	n.a	n.a
Istopic Uranium in solids	Use EPA PRGs for comparison	n.a	n.a

*Consensus Based Sediment Quality Criteria, Threshold Effects Concentration (McDonald et al. 2000)

**Consensus Based Sediment Quality Criteria, Probable Effects Concentration (McDonald et al. 2000)

n.a. - criteria not established for that characteristic

SAMPLE SHIPPING

All Samples will be obtained via standard protocols and shipped for lab analysis. Sampling will follow criteria specified in the TDEC chemical and bacteriological sampling procedure (TDEC, 2022) and the EPA guide to *Surface Water Sampling* (EPA, 2021). Samples will be shipped to the TDEC Nashville State Laboratory (NSL), or another contracted environmental laboratory.

5.2.9 References

10 CFR 20. 1991. *Title 10 of the Code of Federal Regulations, Chapter 1, Subpart D, § 20.1301 Dose limits for individual members of the public.* National Archives. Washington, DC. https://www.ecfr.gov/current/title-10/chapter-I/part-20/subpart-D/section-20.1301

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MacDonald DD, Ingersoll CG, & Berger TA. 2000. Development and Evaluation of Consensus-based Sediment Quality Guidelines for Freshwater Ecosystems. *Arch Environ Contam Toxicol* 39:20–31.

TDEC. 2015. *Environmental Sampling of the ORR and Environs Quality Assurance Project Plan*. Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge Office (TDEC DoR-OR). Oak Ridge, TN.

TDEC. 2012. *Rules of the Tennessee Department of Environment and Conservation, Licensing Requirements for Land Disposal of Radioactive Waste.* Chap. 0400-20-11. Tennessee Department of Environment and Conservation, Division of Radiological Health

(TDEC-DRH). Nashville, TN. https://publications.tnsosfiles.com/rules/0400/0400-20/0400-20-11.20120522.pdf

TDEC. 2019. *Rules of the Tennessee Department of Environment and Conservation, General Water Quality Criteria*. Chap. 0400-40-03. Tennessee Department of Environment and Conservation (TDEC). Nashville, TN. https://www.epa.gov/sites/default/files/2014-12/documents/tn-chapter1200-4-3.pdf

TDEC. 2016. *Sampling and Analysis Plan for General Environmental Monitoring of the Oak Ridge Reservation and its Environs.* Division of Remediation, Oak Ridge Office, Oak Ridge, TN.

TDEC. 2022. *Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water.* Tennessee Department of Environment and Conservation, Division of Water Resources (TDEC-DWR). Knoxville, TN. DWR-WQP-P-01-QSSOP-Chem-Bact-082918. https://www.tn.gov/content/dam/tn/environment/water/policy-and-guidance/dwr-wqp-p-01-qssop-chem-bac-082918-update-2022-jan.pdf

TDEC. 2019. *Procedures for Shipping Samples to Laboratories for Analysis*. Tennessee Department of Environment and Conservation, Division of Remediation Oak Ridge (TDEC DoR-OR). Oak Ridge, TN. Draft SOP No. 101.

EPA. 2021. *Surface Water Sampling*. U.S. Environmental Protection Agency, Region 4, Lab Services and Applied Science Division (LSASD). Athens, Georgia. SESDPROC-201-R5.

EPA: Risk Assessment, Regional Screens Levels (RSLs), "Regional Screening levels for Chemical Contaminants at Superfund Sites". 2020. Washington (DC): U.S. Environmental Protection Agency; [assessed 2022 Feb]. https://www.epa.gov/risk/regional-screening-levels-rsls

6.0 Radiological Monitoring

6.1 Haul Road Surveys

6.1.1 Background

TDEC DoR-OR staff perform bimonthly surveys of the Haul Road and other waste transportation routes on the ORR. The Haul Road was constructed and reserved for trucks transporting *CERCLA* radioactive and hazardous waste from remedial activities on the ORR to the EMWMF for disposal.

To check for wastes that may have fallen from the trucks in transit, DoR-OR personnel perform walk over inspections of different segments of the nine-mile-long Haul Road and associated access roads, such as Reeves Road, on a bimonthly basis. Anomalous items noted along the roads are scanned for radiation, logged, marked with contractor's ribbon, and their descriptions and locations submitted to the DOE for disposition.

6.1.2 Related DOE Projects

DOE conducts radiological surveys of the Haul Road using a tractor with radiological detection instrumentation attached. There is some concern that the distance from the road surface to the radiation detectors on the tractor is too far for effective detection of beta radiation. The tractor does not stop to survey anomalous objects found on or beside the road. As a check of this monitoring project, TDEC DoR-OR performs independent walking surveys.

6.1.3 Problem Statements

Throughout the history of the Haul Road survey project, numbers of anomalous items have been identified such as waste debris, personal protection equipment, tarp patches, waste stickers, steel pipe, etc.

6.1.4 Goals

The primary goal is to prevent the spread of contamination resulting from the transportation of radioactive and hazardous waste being transported from the originating clean up locations on the ORR to the waste disposal location. More specifically, the objectives include the following:

1) To assess the radiological conditions of the Haul Road and objects that may have fallen from trucks.

2) To ensure DOE and their contractors continue their waste transportation in a manner that limits potential environmental concerns for the Haul Road and the surrounding areas.

6.1.5 Scope

The scope of this project is limited to locating, surveying, and reporting to DOE any ORR derived waste materials that may have been blown or dropped from waste-hauling trucks on the EMWMF's Haul Road.

6.1.6 Assumptions

1) DOE will continue to allow DoR-OR to conduct radiological surveys along the Haul Road and Reeves Road, especially as D&D operations proceed on Y-12 and ORNL.
2) Radiation detector meters are sufficient to find any dropped radioactive materials that have fallen from these dump trucks.

6.1.7 Constraints

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures.

6.1.8 Methods, Materials, Metrics

As previously noted, the nine-mile-long Haul Road and Reeves Road will be surveyed in segments, typically consisting of one to two miles. For safety and by agreement with DOE and its contractors, DoR-OR staff will coordinate with Haul Road site personnel to schedule a time to perform this survey. The DOE contractor is responsible for providing briefings on road conditions and any known situation that could present a safety hazard while on the road. When the DOE contractor is not working, staff members call into the designated DOE site safety office for the segment being surveyed. Should excessive traffic present a safety concern, the survey is postponed to a later date. Alternate entrances are sometimes used to access and egress the road with DOE approval, but the basic requirements remain the same.

DoR-OR staff will arrive at the road section to be surveyed. The vehicle is parked completely off the road, as far away from vehicular traffic as possible. No fewer than two people perform the surveys, each walking in a serpentine pattern along opposite sides of the road to be surveyed or one person walking in a serpentine pattern across the entire road accompanied by an approved safety buddy. Typically, a Ludlum Model 2221 Scaler Ratemeter with a Model 44-10 2"X2" NaI Gamma Scintillator probe, held approximately six inches above ground surface, is used to scan for radioactive contaminants as the walkover proceeds. A Ludlum 2224 Scaler with a Model 43-93 Alpha/Beta dual detector is used to investigate potential surface contamination on the road surfaces or anomalous items found along the road that may be associated with waste shipments. Any areas or items with contamination levels exceeding 200 dpm/100 cm2 removable beta, 1000 dpm/100 cm2 total beta, 20 dpm/100 cm2 removable alpha, and/or 100 dpm/100 cm2 total alpha that require further investigation are noted.

Anomalous items, found during the survey, are marked with contractor's ribbon at the side of the road. A description of each item and its location are logged and reported to DOE and its contractors for disposition. When staff members return to the road for the subsequent inspection, staff members perform a follow-up inspection of items found and reported during previous weeks. If any items remain, they are included in subsequent reports until removed or staff members are advised the item(s) to have been determined to be free of radioactive and hazardous constituents. The planned Haul Road Survey schedule is:

1. Six surveys will be completed over a 12-month period.
2. Conduct a minimum of two surveys on the Y-12 segment of the Haul Road.
3. Conduct a minimum of two surveys on Reeves Road.

6.1.9 References

DOE. 2005. *Remedial Action Work Plan for the Operation of the East Tennessee Technology Park to Environmental Management Waste Management Facility (ETTP-EMWMF) Haul Road on the Oak Ridge Reservation.* U.S. Department of Energy. Oak Ridge, Tennessee. DOE/OR/01-2220&D1.

TDEC. 2019*. Standard Operating Procedure T-532 Operation and Use of a Ludlum Model 2224 (-1) and 43-93 Probe (Dual Phosphorous Meter).* Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge Office (TDEC DoR-OR). Oak Ridge, Tennessee.

TDEC. 2019. *Standard Operating Procedure T-540 Operation and Use of a Ludlum Model 2221 and 44-10 Probe (NaI Meter)*. Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge Office. Oak Ridge, Tennessee.

6.2 Real Time Measurement of Gamma Radiation

6.2.1 Background

During early operations, leaks and spills were common within these campuses and resulting radioactive materials were released from operations as gaseous, liquid, and solid effluents, with little or no treatment (ORAU, 2003). Currently, D&D activities may also re-release these contaminants into the environment. The DoR-OR *Real Time Monitoring of Gamma Radiation Project* focuses on measuring and determining radioactive exposure rates at some of these locations. One main concern of these selected locations is that gamma emissions can potentially be expected to fluctuate. Therefore, consistent gamma air monitoring within proximity to these structures is a valuable assessment tool for evaluation of potential impacts of remaining historical contaminants and to help assess and insure protection of human health and the environment during present day operations.

6.2.2 Related DOE Projects

The DOE conducts ambient gamma sampling along the ORR perimeter to ensure that the primary dose limit for protecting members of the public (100 mrem/year) is not exceeded. The TDEC DoR-OR *Real Time Measurement of Gamma Radiation Project* is conducted closer to potential sources and would be an indication of potential onsite influences. Sampling closer to the sources would more likely give an indication of the effect to onsite members of the public.

6.2.3 Problem Statements

ORR campuses have the potential to release variable amounts of gamma radiation and these emissions can be expected to fluctuate substantially over relatively short periods of time.

6.2.4 Goals

Results from monitored sites will be compared to the TN-NRC dose limit of 2 mrem/hr to determine the maximum dose exposure from each unrestricted area. The results will also be compared to TN-DOE primary dose limits for protecting members of the public (i.e. 100 mrem/year).

6.2.5 Scope

This project measures ambient gamma radiation dose/exposure rates at areas on the ORR that are more likely to vary over time. Candidates for monitoring locations include sites on the ORR with remedial activities, waste disposal operations, pre- and post-operational investigations, and/or environmental response activities. Data recorded by the monitors will be evaluated by comparing it to background and the TN-NRC maximum dose limit (MDL) for members of the public.

6.2.6 ASSUMPTIONS

There are enough stations to identify any contaminant releases at ORR campuses nearby.

6.2.7 CONSTRAINTS

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures.

2) Stations may not be located in the most ideal places due to the placement of other equipment.

3) Sampling locations may not always be accessible due to operational or security concerns.

6.2.8 METHODS, MATERIALS, METRICS

The gamma exposure rate monitors deployed for this project are manufactured by Genitron Instruments and are marketed under the trade name, GammaTRACER®. Each monitor contains two Geiger Mueller tubes, a microprocessor-controlled data logger, and lithium batteries sealed in a weather resistant case to protect internal components. Each monitor can be programmed to measure gamma exposure rates ranging from 1 μrem/hour to 1 rem/hour over predetermined intervals ranging from one minute to two hours.

The project's results are derived from averaging the values of the data recorded by both Geiger Mueller detectors. Data for any interval from either detector can be independently accessed and used. The results recorded by the data loggers are downloaded monthly on the ORR and semiannually from the background location at Fort Loudoun Dam. These data are transmitted via an infrared transceiver to a DoR-OR computer housing the associated software. Results from monitored sites will be compared to background data and the TN-NRC limit (2 mrem/hr) to determine the maximum dose exposure.

The following locations (Figure 6.2.8.1) have been selected for monitoring to be co-located at or near waste management areas or active plant facilities with the potential for gamma radiation exposure above background levels.

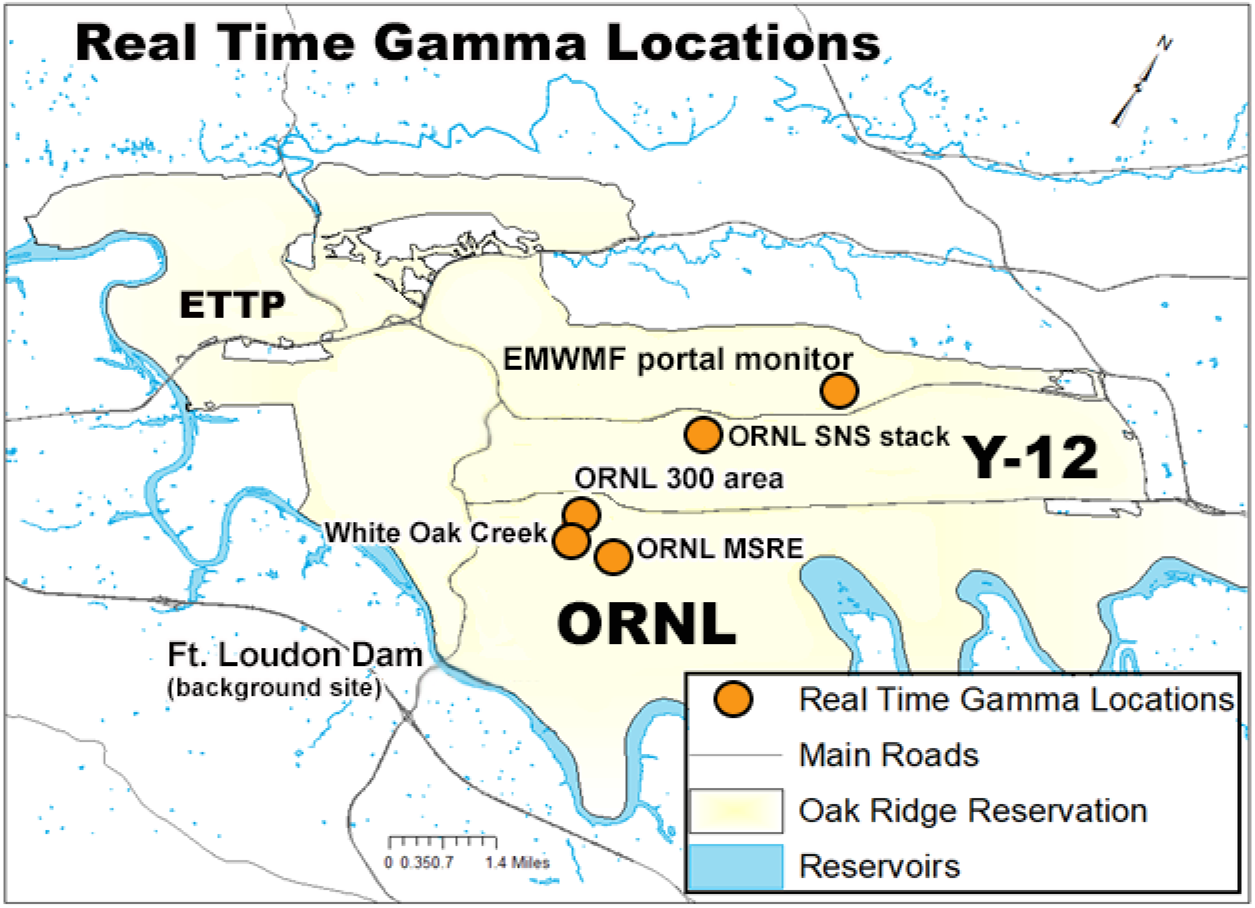

Figure 6.2.8.1 Current sampling Locations

6.2.9 References

10 CFR 20. *Title 10 of the Code of Federal Regulations, Chapter 1, Subpart D, § 20.1301 Dose limits for individual members of the public.* National Archives. Washington, DC. https://www.ecfr.gov/current/title-10/chapter-I/part-20/subpart-D/section-20.1301

ORAU. 2003. *NIOSH Dose Reconstruction Project*. Oak Ridge National Laboratory (ORNL). Oak Ridge, TN. ORAUT-TKBS-0012-2. https://www.cdc.gov/niosh/ocas/pdfs/arch/ornl2.pdf

6.3 Surplus Sales Verification

6.3.1 Background

To verify DOE ORR surplus materials are safe to be sold to the public, our staff will conduct radiological surveys of these items. In addition to performing these surveys, TDEC DoR-OR reviews DOE procedures used for the release of materials in accordance with DOE radiological regulations (DOE, 2013). The project will utilize the guidance set forth in the *Multi-Agency Radiation Survey and Assessment of Materials and* Equipment (MARSAME) manual (DOE, 2013). 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 auction.

Y-12 uses an out-of-state contractor to direct their auction sales. ORNL has a list of organizations approved to buy materials by the truckload. TDEC DoR-OR, upon request by ORNL or Y-12, will conduct radiological verification screening surveys to help ensure that no potentially contaminated materials reach the public. If radiological activity is detected above the NRC contamination limits (NRC, 2006), a quality control check is made with measurements from a second meter. If both meters show elevated activity, TDEC DoR-OR immediately reports the finding(s) to the surplus sales program supervisor. A removable contamination assessment may be performed on the item. Radiological activity is recorded in dpm/100 and then reported. TDEC DoR-OR confirms that the appropriate steps are taken to protect the public.

6.3.2 Related DOE Projects

DOE Radiation Control personnel scan most materials before they are submitted for auction at ORNL or Y-12 surplus sales. Process knowledge may also be a factor used for judging the appropriateness of release of certain equipment or materials to the public.

6.3.3 Problem Statements

1) When incidental radiological contamination is present, the source is most likely related to activities in the area where the material was being used. Any material or equipment from that same area should be scanned to ensure that no contaminated equipment is accidentally sold. DOE and its contractors follow procedures for unrestricted release of material and equipment and have process knowledge. TDEC DoR-OR has an open invitation to perform an additional scan before each auction and routinely performs these scans as circumstances allow.

2) Items with surface activity may not ultimately prove to be of concern. Sometimes elevated levels are attributed to naturally occurring radon (Rn) and its daughter isotopes, Naturally Occurring Radioactive Material (NORM), or Technically Enhanced Naturally Occurring Radioactive Materials (TENORM).

6.3.4 Goals

Although DOE made great strides in its reduction of contaminated Surplus Sales material from 2021 through 2022, TDEC DoR-OR staff continued to find material with elevated radiological activity. Due to these rare but concerning finds, TDEC DoR-OR's goal is to verify that all materials staged to be sold at auction are free of radiological surface contamination. The project attempts to locate any contaminated items that may have evaded detection prior to being staged for sale. In rare instances where items of concern are found, the release of potentially contaminated materials to the public is prevented.

6.3.5 Scope

TDEC DoR-OR staff conduct pre-auction verification surveys on items being auctioned by Y-12 or ORNL's Excess Properties Sales. These surveys are performed upon request of Y-12 and/or ORNL's Excess Properties staff. Every attempt is made to fulfill that request. Typically, no more than eight (8) events occur during a calendar year. Since the inception of the project, TDEC DoR-OR has responded to all requests.

6.3.6 Assumptions

1) This scanning of surplus materials prevents any contaminants from going off site.

6.3.7 Constraints

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, and ORR closures.

2) There can be little notice of these sales and the need for surveys until right before the auction. Since auctions cannot be predicted, there is a chance that no one will be available to do survey screenings.

6.3.8 Methods, Materials, Metrics

Prior to sales of surplus items from ORNL or Y-12 to the public, TDEC DoR-OR conducts a pre-auction survey. Depending on the availability of staff, typically one to three staff members perform a verification survey. The intent of a survey is to spot check items that are for sale with appropriate radiation survey instruments Accordingly, not all items or surfaces of a specific item are surveyed for potential radioactive contamination. Biased measurements are often used where specific attention is paid to well-used items where material damage, uncleanliness, or staining is present. Well-maintained items may also be checked based on previous usage and location. When radiological activity (alpha or beta/gamma) above the contamination limits is detected, the item is brought to the attention of Property Excessing staff.

Based on survey results, the Property Excessing staff will decide whether to have the item rechecked by ORNL RADCON. While DoR-OR does not attempt to determine if an item meets DOE release criteria, project staff will actively try to locate such items.

6.3.9 References

DOE. 2013. *Multi-Agency Radiation Survey and Assessment of Materials and Equipment (MARSAME).* U.S. Department of Energy and Oak Ridge Associated Universities (ORAU). Oak Ridge, TN.

NRC. 2006*. Consolidated Decommissioning Guidance: Characterization, survey, and determination of radiological criteria, final report.* U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Material Safety and Safeguards, Division of Waste Management and Environmental Protection. Washington, DC. Vol 2, Rev 1. NUREG-1757. https://www.nrc.gov/docs/ML0630/ML063000252.pdf

TDEC. 2018. *Standard Operating Procedure: T-525 Radiation Instrument Correction Factors, Pre-checks, and Survey Documentation (Draft)*. Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge Office (TDEC DoR-OR). Oak Ridge, Tennessee.

TDEC. 2019*. Standard Operating Procedure T-532 Operation and Use of a Ludlum Model 2224 - 1 and 43-93 Probe (Dual Phosphorous Meter).* Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge Office (TDEC DoR-OR). Oak Ridge, Tennessee.

7.0 Surface Water Monitoring

7.1 Ambient Surface Water Parameters

7.1.1 Background

Legacy waste across the ORR is responsible for a large portion of the contamination to surface water via the accidental releases of hazardous wastes (e.g., metals, organics, and radioactive materials). Additionally, current projects and processes at these sites also have the potential to significantly contribute to surface water contamination (DOE 1992, DOE 2021, Pickering et al. 1970, Turner et al. 1999).

The DoR-OR *Ambient Surface Water Parameter Project* both complements and verifies the DOE environmental monitoring program. This project has been implemented each year since 2005. The main project goal aims to identify surface water that may be impacted relative to potential contamination displacement. To accomplish this goal, DoR-OR proposes to collect stream monitoring data monthly to establish and build upon a database of physical stream parameters (i.e., specific conductivity, pH, temperature, and dissolved oxygen). Seven stream locations (EFK 23.4, EFK 13.8, MBK 1.6, BCK 12.3, BCK 9.6, BCK 4.5, and MIK 0.1) have been monitored each year since 2005. An additional three monitoring locations (EFK 24.4, BCK 9.2, and BCK 7.6) will be added for the July 2023 – June 2024 sampling period.

7.1.2 Related DOE Projects

DOE conducts surface water monitoring yearly with sample collection and analysis from various locations on the Clinch River. As part of this program, stream water quality parameters are measured at the time of sampling (DOE, 2022). However, while this DOE program focuses on the Clinch River, many ORR surface water exit-pathway streams that flow into the Clinch River remain infrequently monitored. This complementary TDEC-DoR-OR project seeks to fill part of this surface water quality monitoring data gap.

7.1.3 Problem Statements

ORR exit-pathway streams and the Clinch River are subject to contaminant releases from previous and current activities at ETTP, ORNL, and Y-12. These releases can be detrimental to the environment and to human health.

Identified concerns include, but are not limited to, the following:

1) Mercury (Hg), approximately 100 metric tons, was released from Y-12 into East Fork

Poplar Creek (EFPC) from 1950 to 1963. Mercury exited Y-12 via spills, leakage from subsurface drains, purposed discharge of wastewater, and leaching from contaminated building foundations and soils (Turner and Southworth, 1999).

2) Other metals (e.g., cadmium, chromium, lead, nickel, silver, and zirconium) are present in elevated concentrations in exit pathway streams (DOE, 1992).

3) Uranium contaminated nitric acid wastes and other liquid wastes (roughly 7.5 million L/yr) were disposed of in the S3 ponds from 1951 to 1984 near the headwaters of Bear Creek (Moss et al. 1999).

4) Solid and liquid wastes, including approximately 18 million kg of uranium metal and 1 million L of waste oils and chlorinated solvents, were disposed of in the unlined Bear Creek Burial Grounds (BCBG) between 1955 and 1989. BCBG is adjacent to Bear Creek (Moss et al. 1999).

DOE's surface water monitoring program focuses solely on the Clinch River (DOE, 2022); therefore, the TDEC DoR-OR's *Ambient Surface Water Parameters* project plans to focus on three ORR exit-pathway streams that flow into the Clinch River. Data from these streams will help identify any shifts or changes in water quality that might indicate potential migration of contaminants. An additional stream, a background stream, will also be measured for comparison to the selected ORR streams.

7.1.4 Goals

The goal of TDEC DoR-OR's *Ambient Surface Water Parameters Project* is to measure surface water parameters in EFPC, Bear Creek, and Mitchell Branch within the ORR. These data will supplement DOE's surface water monitoring program data. TDEC DoR-OR will collect and provide data that can assist in the evaluation of site activities. In addition, a record of ambient conditions will also be compiled for future use as a baseline in the event of unexpected releases that may impact surface water. Mill Branch will also be measured to serve as an offsite background stream. See Figure 7.1.4.1and Table 7.1.4.1 below for sample locations.

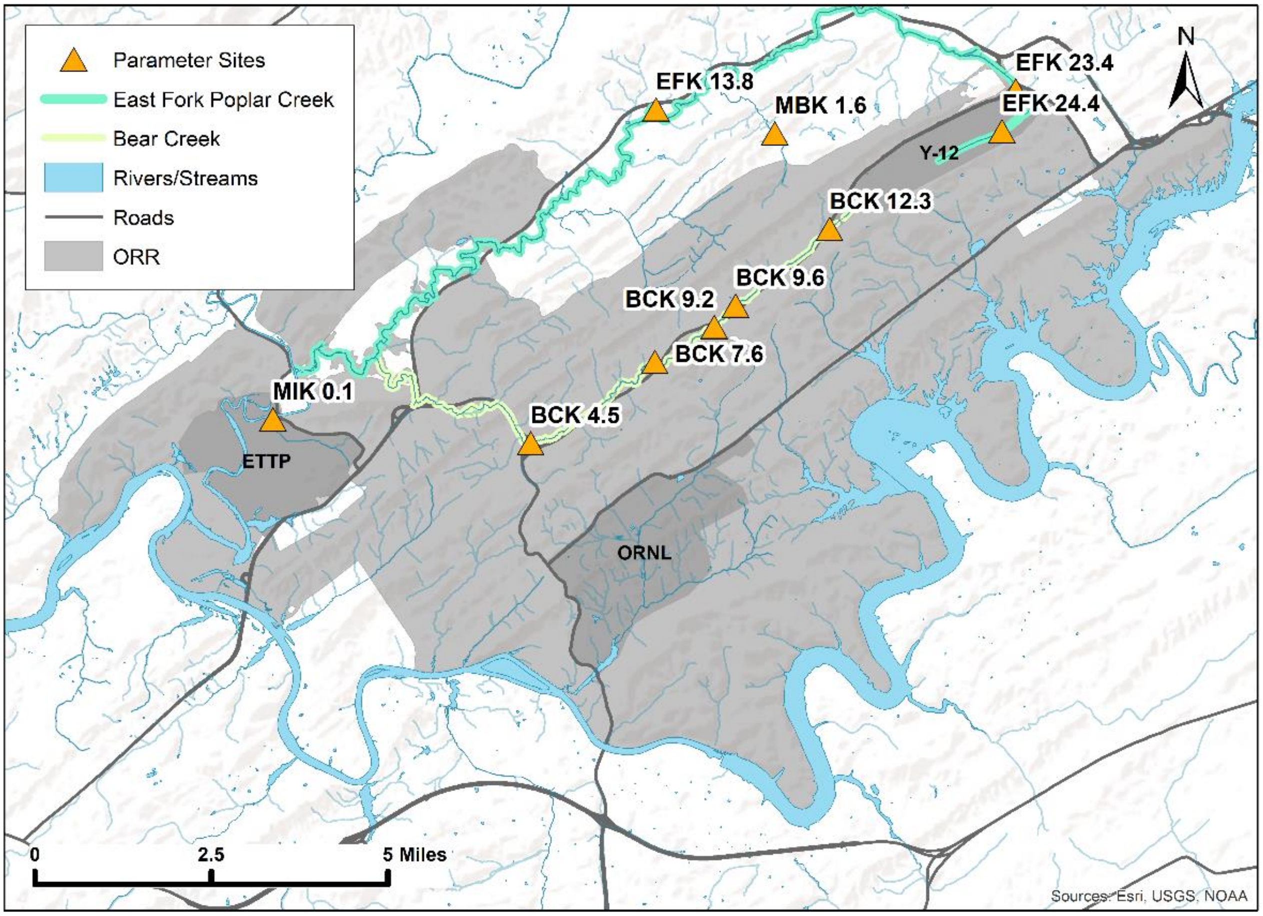

Figure 7.1.4.1 Map showing TDEC DoR-OR proposed surface water parameter sites

Table 7.1.4.1 Proposed site locations

Description	Site	Latitude	Longitude
East Fork Poplar Creek Mile 15.2	EFK 24.4	35.98922	-84.24282
East Fork Poplar Creek Mile 14.5	EFK 23.4	35.99596	-84.24004
East Fork Poplar Creek Mile 8.6	EFK 13.8	35.99283	-84.31371
Bear Creek Mile 7.6	BCK 12.3	35.973	-84.27814
Bear Creek Mile 6.0	BCK 9.6	35.96032	-84.29741
Bear Creek Mile 5.7	BCK 9.2	35.95677	-84.3018
Bear Creek Mile 4.7	BCK 7.6	35.95096	-84.31395
Bear Creek Mile 2.8	BCK 4.5	35.9375	-84.33938
Mitchell Branch Mile 0.1	MIK 0.1	35.94146	-84.3922
Mill Branch Mile 1.0	MBK 1.6	35.98886	-84.28935

Each month, physical water parameters (i.e., conductivity, dissolved oxygen, pH, and temperature) will be measured at each site. Results will be analyzed using statistical programming software to identify trends as well as any anomalous data.

7.1.5 Scope

This project involves the characterization of physical stream parameters of three ORR exit-pathway streams (EFPC, BC, and MI) and one offsite background stream (MB).

7.1.6 Assumptions

1) Ambient physical parameters at the Mill Branch background station are indicative of a geographically similar stream without contamination.

2) Baselines or trends are stable for the physical parameters at the sampling stations.

7.1.7 Constraints

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures.

2) This project is contingent on funding, manpower, and access to ORR controlled areas.

7.1.8 Methods, Materials, Metrics

Field Parameter Measurements

At each site, physical water parameters will be measured and recorded. Physical parameters will be measured using a multiple parameter water quality meter. Conductivity (μS/cm), dissolved oxygen (mg/L), pH, and temperature (°C) will be recorded along with the time of measurement. Measurements will be taken in accordance with the TDEC DWR chemical and bacteriological surface water sampling standard operating procedure (TDEC, 2022).

Data Evaluation

Recorded measurements will be stored in a database. Using R programming language, several statistical analyses will be performed to better understand the results. Trend analysis will be performed using linear regression to identify any increasing or decreasing trends in data. Anomalous data will also be identified. Basic descriptive statistics (mean, median, minimum, maximum, etc.) will also be assessed.

The selected ORR streams will be compared to the Mill Branch background stream. Project staff will use statistical approaches, such as an analysis of variance, to determine if corresponding water quality measurements are significantly similar.

7.1.9 References

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7.2 Ambient Surface Water and Shallow Groundwater Sampling

7.2.1 Background

Activities at the three ORR campuses have resulted in the discharge of hazardous substances (e.g., metals, organics, and radioactive materials) causing contamination of waterbodies on the ORR and in the surrounding areas (DOE, 1992; DOE, 2022a; Pickering, 1970; Turner & Southworth, 1999).

While legacy waste across the ORR may be responsible for a large portion of contamination to surface water, current projects and processes at these sites also have the potential to significantly contribute to and exacerbate surface water contamination. To monitor potential contamination in waterways that have been impacted by past and present activities on the ORR, DoR-OR *Ambient Surface Water Sampling Project* has been implemented each year since 1993. This monitoring project began by investigating the water quality of the Clinch River at five locations near the ORR. The sampling locations for this project have been modified throughout the years, sometimes adding or discontinuing sampling at a particular location. Most recently, monitoring has focused on BC, EFPC, and the CR.

As in previous years, the *Ambient Surface Water Project* for FY24 will focus on monitoring surface water in the CR. Additionally, to support TDEC's *Holistic East Fork Poplar Creek Assessment Project*, this project will also include monitoring surface water and shallow floodplain groundwater in EFPC to evaluate potential impacts to the public from these releases. Lastly, surface water in Upper East Fork Poplar Creek (UEFPC) within the Y-12 boundary will be monitored to evaluate potential impacts from a proposed D&D project.

7.2.2 Related DOE Projects

DOE has implemented a surface water monitoring program for several years that consists of sample collection and analysis from a few locations along the Clinch River (e.g., DOE 2018, DOE 2020a, DOE 2021, DOE 2022). Currently, DOE collects samples quarterly at four sites along the Clinch River at river kilometers 16, 32, 58, and 66 as shown by red triangles in Figure 7.2.2.1 (DOE, 2022). Of these sites, CRK 58 is near the water supply intake for Knox County, and CRK 66 is upstream of the Oak Ridge City water supply intake. Grab samples are collected at these four sites and field water quality parameters such as dissolved oxygen, pH, and water temperature are measured. Samples are also screened for radioactivity by investigating gross alpha, gross beta, tritium, and gamma disintegrations. At three of the four sites (i.e., CRK 16, CRK 32, and CRK 66), analyses are performed to investigate activities of radioactive strontium as well as concentrations of mercury.

However, radioactive strontium and mercury samples are not collected by DOE from the Knox County water supply site (CRK 58). The purpose of the current DOE Surface Water Monitoring Project is to assess the impacts from both past and present site operations to surface water bodies as well as to assess the impact of radioactivity to human health. Respective analyte maximum contaminant levels (MCLs) as defined by the EPA are used to determine these potential impacts (EPA, 2009). Other surface water sampling by DOE and its subcontractors occurs as needed or desired at other locations but is not routinely reported.

Between 2013 to 2016, ORNL performed a three-year research project for DOE. The main objective was to better understand mercury fluxes in EFPC (Watson, et al., 2016). The groundwater portion of the project targeted one location, EFK 15.7, and investigated shallow floodplain groundwater contribution in mercury cycling and dynamics in EFPC. Shallow piezometers were installed in the floodplain near EFK 15.7 (Figure 7.2.2.1), adjacent to the entry point for the Mill Branch, an EFPC tributary. Numerous groundwater samples were collected. The three-year project concluded the following:

1) the chemical composition of groundwater was distinct from surface water,
2) groundwater quality parameters are consistent with anaerobic activity (e.g., low/absent DO and nitrate, elevated dissolved iron and manganese),
3) dissolved mercury concentrations were lower in groundwater compared to surface water,
4) dissolved methylmercury concentrations were comparable or higher in groundwater compared to surface water, and
5) water level measurements support the potential for water exchange between EFPC and shallow floodplain groundwater but were not conclusive.

Because this ORNL groundwater investigation was limited to the one location along EFPC, data should be interpreted conservatively.

DOE is planning on conducting additional surface water monitoring for mercury as part of the removal action for demolition of the mercury-contaminated Alpha-2 Complex (Building 9201-2). DOE plans to cease operation of the basement sump pump, which has been operating for many years. Operation of this sump pump has likely resulted in a cone of depression beneath the Alpha-2 Complex, thus minimizing mercury-contaminated groundwater from migrating to EFPC. It is unknown what impact turning off the sump will have on groundwater and surface water resources in the vicinity of the Alpha-2 Complex. Preliminary modeling by DOE was presented during the September 21, 2022, meeting with the Y-12 Project Team. Modeling suggests that concentrations of mercury in groundwater will increase to levels greater than the MCL while impacts to surface water will be minimal. As part of this removal action, DOE has proposed collecting weekly grab samples from two UEFPC locations to monitor mercury concentrations in surface water. One surface water location is upstream of the Alpha-2 Complex near Outfall 62, and the second surface water location is downstream of the complex near Outfall 44 (Figure 7.2.1.1). Samples will be taken before, during, and after demolition, which is slated to begin in early 2024 (DOE/OR/01-2479&D1/A13/R2).

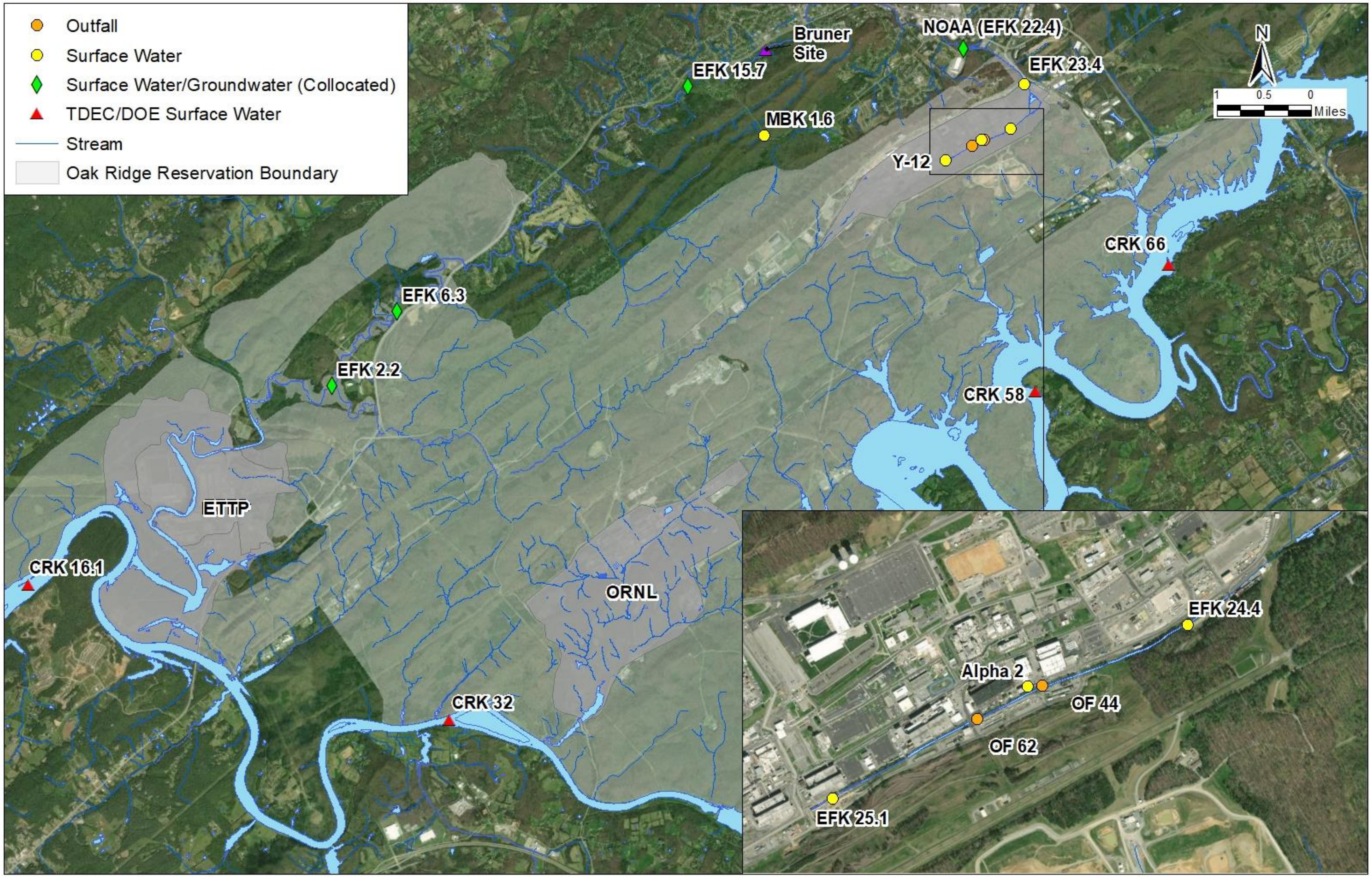

Figure 7.2.2.1 Map showing proposed sampling locations

7.2.3 Problem Statements

This DoR-OR Project supplements DOE's study of the Clinch River to better understand impacts of exit-pathway streams to human health and the environment. It is estimated, based on 2020 US census data, that nearly 1.1 million people live in the counties surrounding the ORR (DOE, 2020). A large portion of these people are direct downstream receptors of streams that drain from the ORR. All exit-pathway streams on the ORR eventually flow into the Clinch River which is an important drinking water source for the surrounding communities. The Clinch River surface waters are also used by facilities at Y-12, ORNL, and ETTP. It is important to monitor these exit-pathway streams, as well as the Clinch River, to better understand the ORR's impact on the region's widely used water resources.

Mercury is and has been a major contaminant of EFPC. It is estimated that over 20 million pounds of mercury were used at the Y-12 in the 1950s and 1960s for lithium processing. Of that 20 million pounds, 700,000 pounds were suspected to be released into buildings, such as the Alpha-2 Complex, and the surrounding environment (DOE, 2020a). Discharges of mercury through spills and leaks, or even intentional discharges of mercury bearing wastewater added nearly 100 metric tons of mercury directly to EFPC (Southworth et al, 2010). Several remedial actions have helped address mercury in soils and sediments, yet mercury is still present at elevated concentrations. The most recent treatment planned is the Outfall-200 Mercury Treatment Facility, which is slated to be operational in 2025. The goal of this facility will be to help reduce mercury releases from the West End Mercury Area storm sewer into EFPC. The system is anticipated to reduce mercury concentrations in Y-12's wastewater by 84 percent (DOE, 2020).

Over the past 10 years, mercury in surface water has exceeded all TN 0400-40-03 surface water criteria (TDEC, 2019), and even EPA's drinking water MCL (conservative reference level) (EPA, 2009). In the most recent DOE Remediation Effectiveness Report, DOE determined that the mercury flux at EFK 23.4 ranged from 5.3 kg/yr to 21.5 kg/yr over the past decade, with an average of 11.75 kg/yr (Figure 7.2.3.2) (DOE, 2022b).

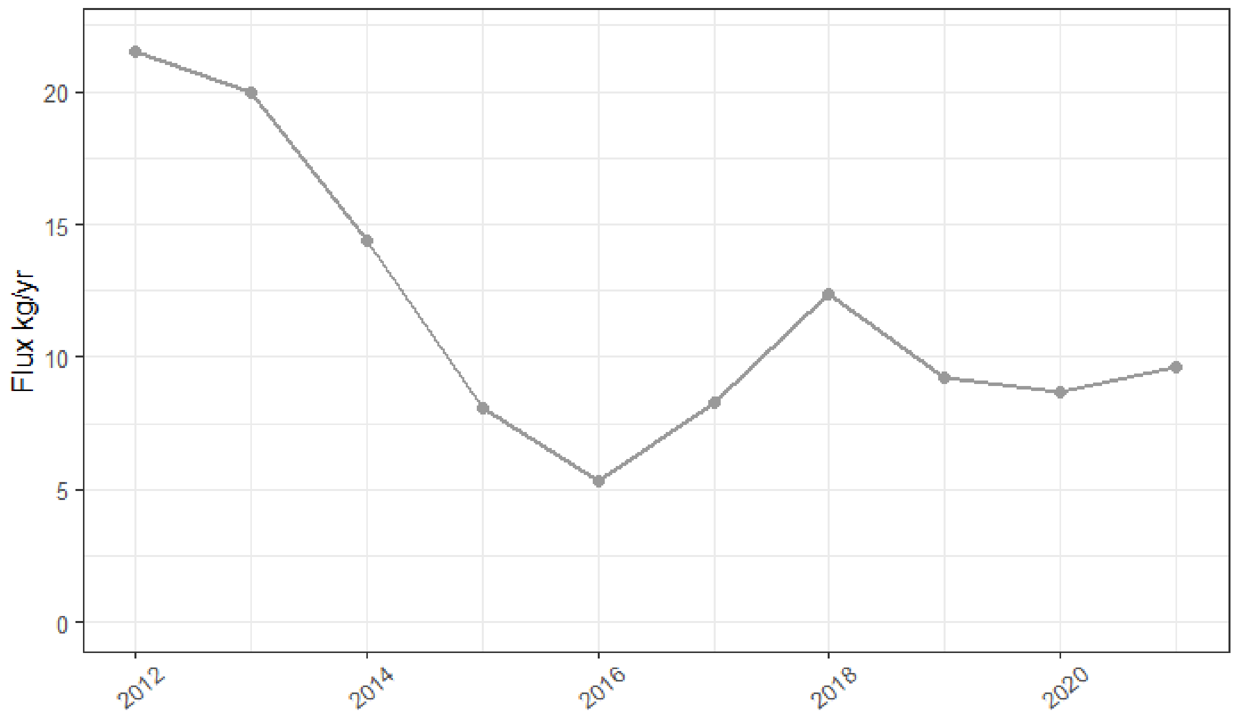

Figure 7.2.3.2 Mercury flux at EFK 23.4 in kg/year from 2012 to 2022

The loading of mercury in EFPC has occurred for many years and has affected downstream biota, floodplain soils, sediments, and surface water. In 1996 and 1997, remedial actions (RAs) were performed by DOE to clean up mercury contaminated sediments at the NOAA and Bruner sites which are located downstream of Y-12 (Figure 7.2.2.1). The objective was to excavate mercury contaminated soil from the EFPC floodplain. The RAs removed a combined total of approximately 35,000 cubic yards (CY) (in-situ) of mercury contaminated sediments from both sites (DOE, 2000). While this excavation was performed at a large scale, mercury was left in sediments at or below 400 mg/kg. An evaluation of the shallow groundwater and surface water near these remaining sediments is warranted.

7.2.4 Goals

The main goal of this monitoring project is to evaluate Clinch River surface water conditions, to assess surface water and shallow floodplain groundwater on East Fork Poplar Creek, and to monitor surface water conditions in Upper East Fork Poplar Creek immediately adjacent to proposed D&D activities at the mercury-contaminated Alpha-2 Complex. The Clinch River will be monitored in conjunction with DOE sampling to provide an external quality control for the DOE required quarterly sampling (Figure 7.2.2.1).

Due to the current understanding of the distribution of contaminants in East Fork Poplar

Creek, sampling will target distinct sections of the stream (e.g., upper, middle, and lower) (Figure 7.2.2.1) to achieve the overarching goal. While these sampling efforts will support the main goal, several sub-goals also exist for each stream section as discussed below.

1. *Upper EFPC (i.e., from EFK 25.1 to EFK 23.4):* Surface water within this section will be monitored to understand potential impacts from the proposed D&D, including cessation of the basement sump, of the Alpha-2 Complex. Surface water sampling will provide a baseline (pre-demolition) dataset as well as provide insights to runoff and surface water/groundwater interactions during demolition.

2. *Middle EFPC (i.e., from the NOAA site [EFK 22.4] to EFK 15.7):* Collocated surface water and shallow floodplain groundwater samples will be collected to not only complement historic surface water monitoring efforts within this zone, but also to evaluate surface water/groundwater interaction and potential impacts to shallow floodplain groundwater due to transport of contaminated sediments from Y-12. The NOAA and Bruner sites were remediated up to 400 mg/kg, but some mercury remains in soils at or below this level which may influence water concentrations.

3. *Lower EFPC (i.e., from EFK 6.3 to EFK 2.2):* This section will be evaluated to help understand what contaminants are leaving EFPC before entering Poplar Creek and to identify any impact to shallow floodplain groundwater. Collocated surface water and shallow floodplain groundwater samples will be collected in this section.

Aside from investigations of EFPC, Mill Branch will be used as a background comparison site. An assessment of EFPC and the Clinch River will be performed by comparing sampling results to general water quality criteria for organisms (TDEC, 2019) and the EPA defined MCLs (EPA, 2009). This project will help to identify areas of concern that may significantly impact the surface water resources of Tennessee's citizens.

7.2.5 Scope

The scope of this project entails sampling surface water in reaches of the Clinch River, EFPC, and Mill Branch. Water quality measurements and analytical samples will be collected to identify the presence or absence of contamination. In addition to surface water samples, shallow groundwater will be sampled for contaminants at several locations along EFPC.

7.2.6 Assumptions

1) Mercury contamination of East Fork Poplar Creek is attributable to activities at Y-12.
2) Potential stream contamination is attributable to DOE activities on the ORR.
3) Temporary piezometers will operate as expected:
    1. Installation will be successful.
    2. Representative groundwater sample collection will be obtained.
    3. Recharge of temporary piezometers will be sufficient to provide the volume of water required for analytical suite.

7.2.7 Constraints

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures:
    1. demolition and construction activities at Y-12 may inhibit EFPC access near the Alpha-2 and Outfall 200 areas.
    2. Scheduling will allow for co-sampling with DOE.
    3. Streams have adequate flow for sampling.

7.2.8 Methods, Materials, Metrics

Sample Collection

Ambient Surface Water

Surface water samples will be collected quarterly (Table 7.2.8.1) at the Clinch River, East Fork Poplar Creek, and Mill Branch (Figure 7.2.2.1).

1) *Clinch River (CRK):* co-sample with UT-Battelle quarterly at one of the four sites CRK 66, CRK 58, CRK 32, and CRK 16.1 with each site sampled at least once throughout the

project. These sites will be analyzed for gross alpha/beta and mercury. Radioactive strontium will be analyzed at CRK 32.

2) *East Fork Poplar Creek (EFPC):* collect samples from eight locations at (EFK 25.1, a location near Alpha-2 which is TBD, EFK 24.4, EFK 23.4, EFK 22.4, EFK 15.7, EFK 6.3, and EFK 2.2) for analysis of major cations and anions, metals, and gross alpha/beta quarterly. All locations downstream of EFK 22.4, including EFK 22.4, will be analyzed for both dissolved and total metal concentrations.

3) *Mill Branch (MB):* sample one (1) location at MBK 1.6 for major cations and anions, metals, and gross alpha/beta.

SHALLOW GROUNDWATER-HYPORHEIC ZONE SAMPLING

Shallow temporary groundwater piezometers will be installed at EFK 22.4 (NOAA site), EFK 15.7 (ORNL study location), EFK 6.3, and EFK 2.2 using a hand-driven piezometer groundwater sampling kit. Shallow groundwater samples will be collected quarterly at these four collocated locations and submitted for analysis of major cations and anions, total and dissolved metals, and gross alpha/beta (Table 7.2.8.2).

STANDARD OPERATING PROCEDURES (SOPS)

Quality assurance/quality control (QA/QC) samples will be collected for every 10th sample of any given analyte (Table 7.2.8.1). Surface water sampling protocols will follow the TDEC-DWR SOPs for *Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2022). All groundwater samples will be collected in accordance with internal SOPs. Analytical methods for sample analysis are shown in Table 7.2.8.2.

Table 7.2.8.1 Planned samples and site information

Description	Site	Type	Planned FY 24						
			Sr-90	Gross α/ß	LL Hg	MeHg	Anions*	Cations*	Metals*
Clinch River Mile 10.0	CRK 16.1	SW		1	1				
Clinch River Mile 19.7	CRK 32	SW	1	1	1				
Clinch River Mile 36.0	CRK 58	SW		1	1				
Clinch River Mile 41.0	CRK 66	SW		1	1				
East Fork Poplar Creek Mile 15.6	EFK 25.1	SW		4	4		4	4	4
Adjacent Alpha-2 (Location TBD)	TBD	SW		4	4		4	4	4
East Fork Poplar Creek Mile 15.2	EFK 24.4	SW		4	4		4	4	4
East Fork Poplar Creek Mile 14.5	EFK 23.4	SW		4	4		4	4	4
East Fork Poplar Creek Mile 13.9	EFK 22.4	GW		4	8	4	4	4	8
East Fork Poplar Creek Mile 13.9	EFK 22.4	SW		4	8		4	4	8
East Fork Poplar Creek Mile 9.8	EFK 15.7	GW		4	8	4	4	4	8
East Fork Poplar Creek Mile 9.8	EFK 15.7	SW		4	8		4	4	8
East Fork Poplar Creek Mile 3.9	EFK 6.3	GW		4	8	4	4	4	8
East Fork Poplar Creek Mile 3.9	EFK 6.3	SW		4	8		4	4	8
East Fork Poplar Creek Mile 1.4	EFK 2.2	GW		4	8	4	4	4	8
East Fork Poplar Creek Mile 1.4	EFK 2.2	SW		4	8		4	4	8
Mill Branch Mile 1.0	MBK 1.6	SW		4	4		4	4	4
Field Duplicate	FD			5	8	1	5	5	8
DOE Co-Sample	*Note:								
Ambient	Anions: Nitrate/Nitrite, Total Phosphorus, Sulfate, Alkalinity (Total), Chloride, Fluoride								
QA/QC	Cations: Sodium, Potassium, Calcium, Magnesium								
SW = Surface Water; GW = Groundwater	Metals (Total and Dissolved): Metals digestion, Uranium, Cadmium								

Table 7.2.8.2 Planned Methods and Detection levels

Metals					
Parameter	**Description**	**Method**	**MDL**	**MQL**	**Unit**
Methylmercury	Methyl Mercury in Water by Distillation	EPA 1630	0.0002		ug/L
Mercury, Low Level	Mercury in Water CVAF Spectrometry	EPA 1631	0.00185	0.005	ug/L
Metals digestion	ICP Digestion (water)	EPA 200.2	-	-	-
Calcium	ICP-OES	EPA 200.7	0.0897	0.1	mg/L
Magnesium	ICP-OES	EPA 200.7	0.029	0.1	mg/L
Potassium	ICP-OES	EPA 200.7	0.051	0.1	mg/L
Sodium	ICP-OES	EPA 200.7	0.025	0.1	mg/L
Cadmium	ICP-MS	EPA 200.8	0.219	1	ug/L
Uranium	ICP-MS	EPA 200.8	0.143	1	ug/L
General Inorganics					
Parameter	**Description**	**Method**	**MDL**	**MQL**	**Unit**
Alkalinity (Total)	Alkalinity By Titration	2320-B	10	10	mg/L
Chloride	Inorganic Anions by Ion Chromatography	EPA 300M	1.11	2.5	mg/L
Fluoride	Inorganic Anions by Ion Chromatography	EPA 300M	0.0224	0.1	mg/L
Sulfate	Inorganic Anions by Ion Chromatography	EPA 300M	1.35	2.5	mg/L
Nitrate/Nitrite	Nitrate-Nitrite Nitrogen by Automated Colorimetry	EPA 353.2	0.0241	0.1	mg/L
Total Phosphorus	Phosphorus by Semi-Automated Colorimetry	EPA 365.1	0.00829	0.01	mg/L
Radionuclides					
Parameter	**Description**	**Method**	**MDL**	**MQL**	**Unit**
Gross Alpha/Beta	Liquid Scintillation Counting	ASTM D7283-17 LSC	-	-	pCi/L
Strontium-89,90	Radioactive Strontium in Drinking Water	EPA 905	-	-	pCi/L

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Field Parameter Measurements

At each site, during the time of sampling, physical water quality parameters will be measured using a properly calibrated multiple parameter water quality meter. Parameters of conductivity (µS/cm), dissolved oxygen (mg/L), pH, temperature (°C), ORP (mV), and turbidity (NTU) will be recorded along with the time of measurement.

Data Evaluation

Several statistical analyses will be performed to better understand the results. Results will be compared with any available DOE available data from co-sampling or historical DoR-OR data. Applicable methods such as analysis of variance (ANOVA) or the Kruskal-Wallis test may be used to see if project results are statistically significantly different from available datasets. Basic descriptive statistics (e.g., mean, median, minimum, maximum, etc.) and any increasing or decreasing trends in data will also be analyzed. Data will be assessed using TDEC and EPA defined MCLs to determine if there is a potential impact to human health and the environment (EPA, 2009, TDEC, 2019). Any exceedances may invoke further investigation.

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7.3 White Oak Creek Radionuclides Surface water sampling project

7.3.1 Background

The *Ambient Surface Water Sampling Project (ASWSP)* has been implemented each year since 1993 to help monitor potential ORR stream contamination. ASWSP originally began with the investigation of water quality along the Clinch River at locations near the ORR. The sampling locations for the ASWSP have been modified as needed throughout the years, sometimes adding, and sometimes discontinuing sampling at specific locations. White Oak Creek was initially monitored under the *ASWS Project*, but since 2020, DoR-OR has focused on this stream under a separate project. WOC became a focal exit-pathway stream due to specific concerns regarding the elevated radionuclide strontium-90 (Sr-90). Sr-90 was first detected at a CR sampling station (CRK 33.5) in 2017. CRK 33.5 is located at the WOC-CR confluence, immediately downstream of the WOC Embayment (WOCE) sediment retention structure (Figure 7.3.1.1). The White Oak Creek Radionuclide Surface Water Sampling Project (Project) was developed to focus on monitoring surface water quality along White Oak Creek and at its confluence with the Clinch River which is a publicly accessible.

The ORR exit-pathway streams, such as WOC, and the CR have historically, and are currently, being subject to contaminant releases from activities at Y-12, ORNL, and ETTP. Monitoring WOC will provide a better understanding of its contributions to surface water contamination and may provide insights into helping protect human health and the environment, especially for the important resource of the CR. These independent monitoring data results will also be available to supplement DOE's ongoing investigations.

7.3.2 Related DOE Projects

DOE has implemented a surface water monitoring program for several years that consists of monitoring surface water at a few locations along the Clinch River (DOE, 2022a). The purpose of DOE's surface water monitoring project is to assess impacts of site operations, both past and present, on surface water bodies. Other DOE projects specific to WOC include the following:

1) Sampling WOC at the 7500 Bridge (Bethel Valley Watershed Integration Point) as part the *Record of Decision (ROD) for Interim Actions in Bethel Valley Watershed, Oak Ridge, Tennessee*, DOE/OR/01-1862&D4. (DOE, 2020).

2) Investigating source(s) of ungauged Sr-90 contributions to WOC (flow/flux study) to evaluate potential remedial actions to offset ungauged Sr-90 discharges (DOE, 2022b).

3) Evaluating potential Sr-90 surface water impacts to 5th Creek if the sump pump at Building 3042 is turned off. Sampling along 5th Creek (DOE station name = "*5TH CR*" aka "*FFK 0.2*") has been conducted since at least 1987, with semi-annual sampling currently being conducted (DOE, 2022c).

While the current DOE projects only sample the CR and one location along WOC, this DoR-OR Project will complement DOE's sampling by monitoring specific points along WOC and its tributaries. The intent is to provide a more representative evaluation of the contaminants entering WOC, and ultimately the CR.

7.3.3 Problem Statements

It is estimated, based on 2020 U.S. census data, that nearly 1.1 million people live in the counties surrounding the ORR (DOE, 2020). A large portion of these people have the potential of being affected by streams that flow through the ORR and eventually flow into the Clinch River, which is an important drinking water source for the surrounding communities. Furthermore, TDEC's roving creel study has determined that the Clinch River near the White Oak Creek and Clinch River confluence is used for recreational fishing. As such, it is important for monitoring of White Oak Creek occur to better understand the ORR's impact on this widely used resource.

Legacy contaminant migration along with continued industrial releases from the ORR into WOC can also be detrimental to the environment and to human health. Identified concerns for WOC include, but are not limited to the following:

1) ORNL has been releasing low-level radioactive liquid wastes to the Clinch River via White Oak Creek since 1943. (Pickering, 1970).

2) The Clinch River received approximately 665 curies of cesium-137 from White Oak Creek between 1954 and 1959. (DOE, 1992).

3) Groundwater containing elevated levels of strontium-90 is collected from the solid waste storge areas in Melton Valley and transferred to the Process Waste Treatment Complex (PWTC) in Bethel Valley for treatment. The PWTC does not entirely remove strontium-90 from the waste stream and ultimately discharges treated wastewater containing elevated levels of strontium-90 into White Oak Creek at Outfall X12 (Figure 7.3.3.1) (DOE, 2022c).

4) Historic and ongoing discharges of strontium-90 and cesium-137 into White Oak Creek is impacting surface water quality. Known sources include, but are not limited to, impacted floodplain soils from the former Surface Impoundment Operable Unit (SIOU)

area (Figure 7.3.3.1) and baseflow groundwater seepage into White Oak Creek (DOE, 2022).

7.3.4 Goals

The goal of the *White Oak Creek Radionuclides Monitoring Project* is to evaluate the impacts of DOE ORR contamination to WOC, its tributaries, and the CR at the WOC confluence. This Project involves collecting surface water samples at the locations illustrated on Figure 7.3.7.1.

7.3.5 Scope

The scope of this Project is to collect surface water samples quarterly at eight monitoring locations. Four monitoring locations (WCK 6.8, WCK 3.9, WCK 3.4, WCK 2.3) are along WOC, one monitoring location (CRK 33.5) is at the confluence of WOC and the CR, and the remaining three monitoring locations (FFK 0.2, HRT-3, MEK 0.3) are on tributaries of WOC (Figure 7.3.7.1).

7.3.6 Assumptions

1) Potential contamination is attributable to activities on the ORR.

2) WOC is the main source of Sr-90 entering CR.

7.3.7 Constraints

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures.

2) Scheduling escort for sampling on WOC.

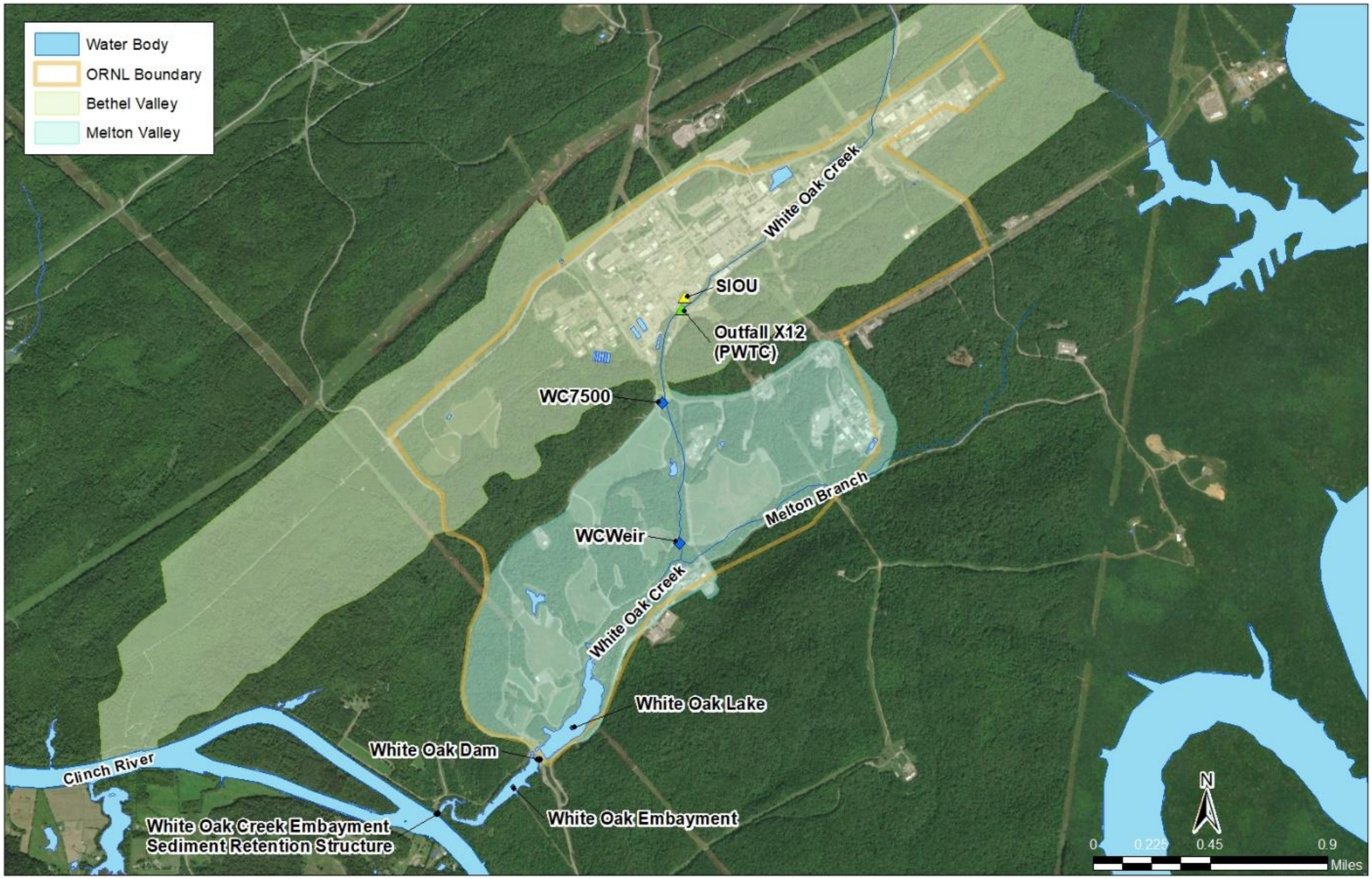

Figure 7.3.3.1 Map illustrating location of White Oak Creek and pertinent features.

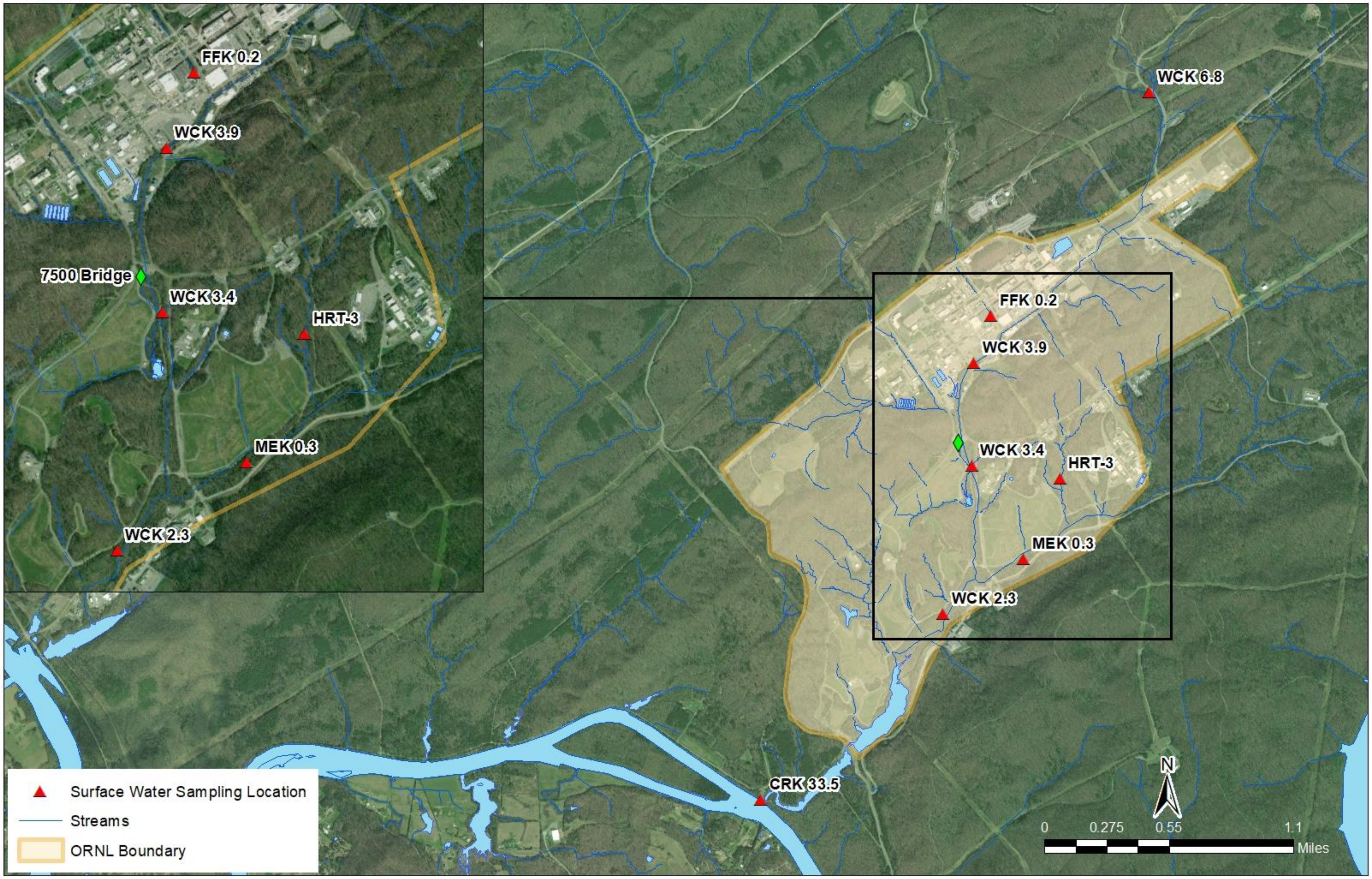

Figure 7.3.7.1 Map showing TDEC DoR-OR White Oak Creek Surface Water Sampling Locations

7.3.8 METHODS, MATERIALS, METRICS

Sample Collection

The Project includes collecting surface water samples at eight monitoring sites (WCK 6.8, WCK 3.9, WCK 3.4, WCK 2.3, CRK 33.5, FFK 0.2, HRT-3, MEK 0.3) whose locations are illustrated on Figure 7.3.7.1. Surface water samples will be collected quarterly (Table 7.3.8.1) and in accordance with TDEC-DWR *Quality System SOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2022).

Table 7.3.8.1 Surface Water Sampling Plan

Station Name	Stream Name	Analytical Parameters[1]			
		Sr-90	**Gamma Radionuclides**	**Isotopic Uranium**	**Isotopic Plutonium**
WCK 6.8	White Oak Creek	4	4	4	4
WCK 3.9	White Oak Creek	4	4	4	4
WCK 3.4	White Oak Creek	4	4	4	4
WCK 2.3	White Oak Creek	4	4	4	4
CRK 33.5	Clinch River	4	4	4	4
FFK 0.2	5th Creek	4	4	4	4
HRT-3	Homogeneous Reactor Test Tributary	4	4	4	4
MEK 0.3	Melton Branch	4	4	4	4
	Total Primary Samples	32	32	32	32
	Field Duplicate	3	3	3	3
	Total Samples (FY 24)	**35**	**35**	**35**	**35**

Notes:
All water samples will be collected quarterly.
[1] – The list of analytes and their analytical methods are defined in Table 7.3.8.2.

Samples will be submitted for analysis of strontium-90, gamma radionuclides, isotopic uranium, and isotopic plutonium using the analytical methods specified in Table 7.3.8.2 or equivalent analytical methods. At each site, water quality parameters will be measured in the field at the time of sampling using a properly calibrated multi-parameter water quality meter. The following water quality parameters will be measured and recorded: pH, temperature, specific conductivity, dissolved oxygen, and oxidation-reduction potential. Quality assurance/quality control (QA/QC) samples will be collected at a frequency of every 10%.

Table 7.3.8.2. Analytical Laboratory and Field Methods

Parameter Type	Analytes	Analytical Method / Equivalent
Radionuclides	**strontium-89/90**	EPA Method 905.0
	gamma radionuclides	EPA Method 901.1
	isotopic uranium	EPA Method 908.0 Modified
	isotopic plutonium	Method EML Pu-02 Modified
Field Water Quality Parameters	pH	Field measurement
	temperature (º C)	
	specific conductivity (µS/cm)	
	dissolved oxygen (mg/L)	
	oxidation-reduction potential (mV)	

Measurements:
ºC – degrees Celsius; mg/L – milligram per liter; MV – millivolt
µS/cm – microSiemens per centimeter; NTU – nephelometric turbidity unit; NA – not applicable

Notes: **Bolded** values have a numerical standard

DATA

The resulting analytical data will be evaluated and compared against numerical standards set forth by the EPA's *National Priority Drinking Water Regulations* (EPA, 2009). EPA has established a maximum contaminant level (MCL) of 4 millirems per year for beta particle and photon radioactivity from manmade radionuclides in drinking water. For strontium-90, a derived concentration of 8 picocuries per liter (pCi/L) is assumed to yield 4 millirems per year. If other radionuclides that emit beta particles and photon radioactivity are present, the resulting concentration will be compared to the corresponding derived concentrations of the detected radionuclide. The results of the surface water sampling will be incorporated into the TDEC's FY24 Environmental Monitoring Report (EMR).

7.3.9 REFERENCES

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8.0 Sediment Sampling

8.1 Suspended Sediment Sampling

8.1.1 Background

Contaminated sediments can directly impact benthic life and can also indirectly impact terrestrial biota, including humans. These detrimental indirect effects stem from bioaccumulation and subsequent transfer of contaminants through the food web. These sediment-associated contaminants are attributable to DOE activities and are accepted as an important ongoing environmental problem that impacts the uses of many ORR water bodies. In order to assess the degree of contamination at the benthic level, TDEC DoR-OR collects sediment samples for chemical analysis from tributaries that drain the ORR to the Clinch River.

This program monitors for suspended sediment contaminants transported in impacted waterways. Surface waters have been adversely affected by past and present activities on the ORR. The sediment traps used for this project collect suspended sediment particles from the stream. The information gathered from the chemical analysis (metals, organics, and radiological) of these suspended sediments reveals any contaminants being transported downstream in the water column. The sediment traps are a means for detecting any changes in sediment-associated contamination. This method of sampling is used due to a lack of fine sediment deposition areas used in traditional sampling.

The EFPC data from this project will be used in the *East Fork Poplar Creek Assessment Project* (EFPCAP) report. For more information about the EFPCAP, refer to the separate EMP in this document in Section 8.1.0. Sites for sediment traps are located in areas where they can best evaluate EFPC to track any migration of contaminants.

During the previous holistic watershed project, sediment traps were placed at three major locations in Bear Creek Valley: two on Bear Creek (BCK) and one on the North Tributary (NT). These locations include NT-5, BCK 7.6, and BCK 3.3. The continuation of sampling at these sites in FY24 will be used for additional analyses. The sediment trap at NT-5 is used to detect contaminant releases from EMWMF. The sediment traps at BCK 7.6 and BCK 3.3 will provide important baseline data for assessing the condition of sediments leaving the Bear Creek watershed and emptying into the Clinch River. The Clinch River and the lower segments of Bear Creek are publicly accessible and there may be exposure to sediments for users of these waterways.

The *Suspended Sediment Sampling Project* plans to include new sites on EFPC. On EFPC, sediment traps are deployed at EFK 23.4 and EFK 2.2. The first site, EFK 23.4, will provide information about suspended contaminants leaving Y-12. The second sediment trap, EFK 2.2, just downstream of the Bear Creek embayment, will provide data about the confluence of suspended sediments from EFPC and BC. Mill Branch will provide background reference data.

8.1.2 Related DOE Projects

DOE does not currently sample suspended sediments. This project was devised to cover this DOE sampling gap.

8.1.3 Problem Statements

Sediment is an integral component of stream ecosystems but often serves as a sink for many contaminants. Sediment traps collect suspended sediment particles that are migrating in streams whereas grab sampling collects stationary sediment deposits. At the present time, DOE only conducts grab sampling of sediments, so there is not a sufficient program in place to monitor sediment transport through a watershed.

The information gathered from the laboratory analysis of these suspended sediments will reveal what contaminants are being transported downstream within the water column. Data will also be used to detect changes in sediment contaminants that may not be discernable through grab sediment sampling techniques alone.

8.1.4 Goals

The goal of the project is to detect contaminants in suspended sediments due to releases from the DOE facilities at Y-12. The data obtained from the sediment traps will be used to assess the extent of sediment transported contamination in Bear Creek and East Fork Poplar Creek to provide a baseline of data to compare to future data.

8.1.5 Scope

This project will continue to monitor sample sites on EFPC, BC, and NT-5 and add sites on EFPC for the holistic watershed project.

8.1.6 Assumptions

1) Suspended sediment is a medium in which ORR contaminants can migrate in streams and potential travel offsite.

2) The correct number of sediment traps have been placed to monitor for contaminants.

8.1.7 Constraints

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR

closures.

2) Sediment Traps must be left unattended.
   1. Wildlife
   2. Vandalism / theft

8.1.8 METHODS, MATERIALS, METRICS

To monitor for changes in contaminant flow through sediment transport, passive sediment samplers (sediment traps) are deployed in focal ORR streams. Samples will be retrieved from all sediment trap locations twice during the fiscal year. The first set of samples will be collected in November 2023, while the second set of samples will be collected in May 2024.

Sediment samples will be analyzed for metals (cadmium, lead, mercury, uranium) and radiological activity (gross alpha/beta, isotopic uranium). The metals data will be compared to the *Consensus-Based Sediment Quality Guidelines (CBSQGs)* (MacDonald et al, 2000). Radiological data will be compared to data from background locations and risk-based screening levels. In addition to these contaminants, PFAS/PFOA and PCB analysis will also be conducted on the sediment samples.

DOE does not currently conduct this type of suspended sediment sampling, therefore,no other relevant dataset is available for comparison. At the present time, DOE only conducts grab sampling of sediments, so there is not a sufficient program in place to monitor sediment transport through a watershed. The data from the background stream will serve as the main reference.

METHOD SUMMARY

The procedure used for this project is the TDEC DoR-OR *Standard Operating Procedure for Sediment Sampling* (TDEC DoR-OR, 2022). Suspended sediment samples will be collected using fixed sediment collection devices are sediment traps. These traps are installed in a stream bed and oriented so that considerable water flows through the body of the trap. Suitable sites are limited in a stream and careful consideration must be given to selecting installation locations for these devices. The sediment traps must be placed in stream locations with sufficient flow and adequate depth to completely immerse the sediment traps. These passive sediment samplers are modeled after a design described in Phillips *et al* (2000).

Figure 8.1.8.1 Tandem sediment trap installation in East Fork Poplar Creek (EFPC)

Following a collection period of a minimum of four months, the sediment is emptied from a sediment trap and is transferred to a clean bucket where the sediment is allowed to settle on ice for 48 to 72 hours. After the sediment settles, the supernatant water is carefully drawn off the sample with a peristaltic pump. Sediment samples are spooned from the bucket into sample containers and sent to a laboratory for analysis.

Table 8.1.8.1 Sediment Sampling Stations

Site Description	Name	Latitude	Longitude
East Fork Poplar Creek km 23.4	EFK 23.4	35.99596	-84.24004
East Fork Poplar Creek km 2.2	EFK 2.2	35.95169	-84.3716
Bear Creek kilometer 3.3	BCK 3.3	35.94354	-84.34911
Bear Creek kilometer 7.6	BCK 7.6	35.95094	-84.31455
North Tributary 5 of Bear Ck.	NT-5	35.96633	-84.29031
Mill Branch kilometer 1.6	MBK 1.6	35.98560	-84.28722

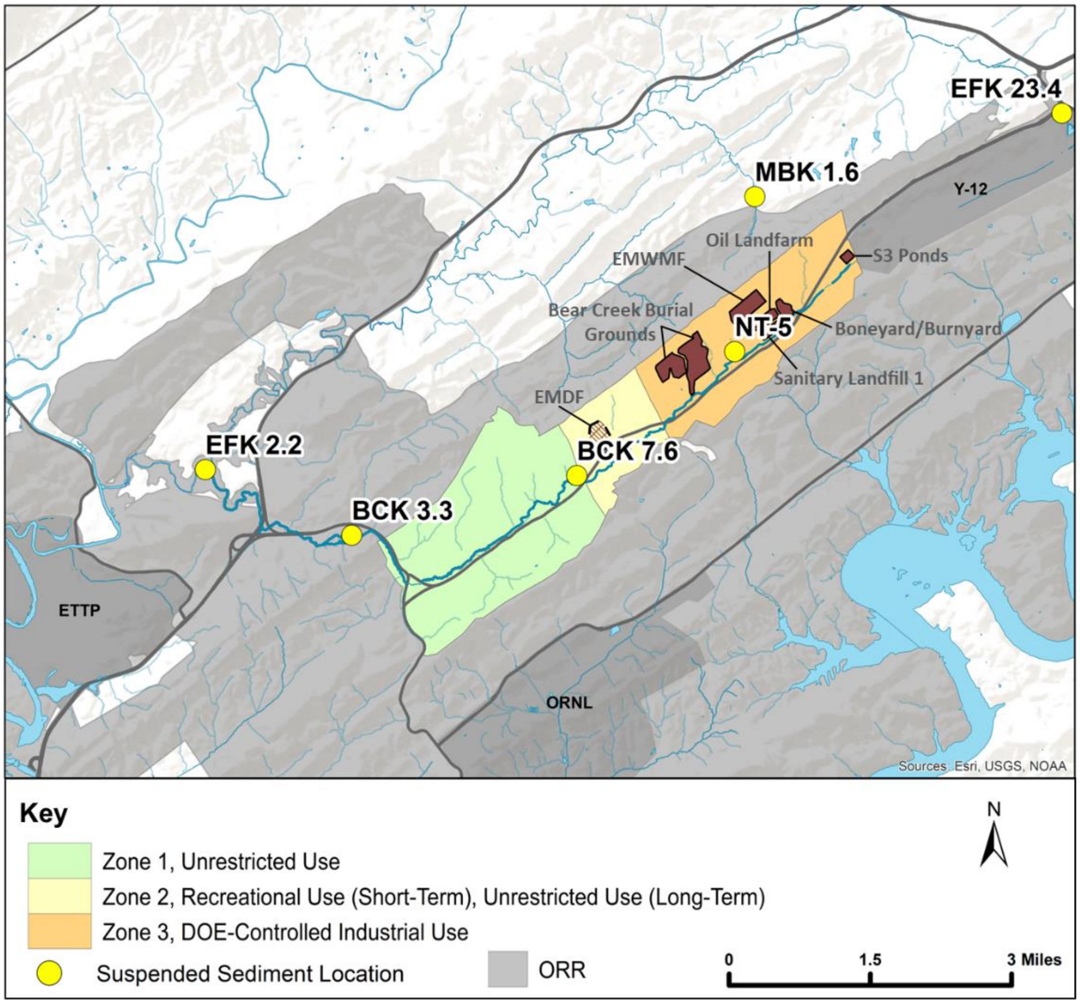

Figure 8.1.8.2 Map of Sediment Trap Sampling Stations

8.1.9 References

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9.0 Water Resources Monitoring: Storm, Ground, Surface Water

9.1 CERCLA; ORR Water Resources at D&D and Construction Sites

9.1.1 Background

Stormwater runoff has the potential to transport various contaminants, including sediments, nutrients, organic and inorganic chemicals, metals, and bacteria, into waterways. This results in water quality issues and environmental function degradation (Marsalek, 2002). To verify DOE sampling and to independently evaluate the quality of stormwater runoff and identify potential sources of pollution, stormwater assessments will be conducted at the sites of ORNL D&D of reactors, Y-12 D&D of mercury-contaminated facilities, and EMDF Construction from July 2023 to June 2024.In addition, there will be co-sampling with DOE to satisfy oversight activities.

Sampling sites and COC selections are shown in Table 9.1.8.1. These COCs will be identified based on DOE and UCOR documents (DOE 2022a, DOE 2022b, DOE 2021, UCOR 2020b).

9.1.2 Related DOE Projects

To determine whether ongoing site operations, construction, and/or demolition activities pose a risk to Y-12 stormwater, which could potentially impact East Fork Poplar Creek (EFPC), DOE has implemented stormwater monitoring programs. This program includes the collection of samples and water quality analysis from stormwater outfall and in-stream sites under the NPDES Permit. DOE generated an Annual Stormwater Report for the Y-12 National Security Complex to identify stormwater pollutant content and sources, as well as to evaluate the efficacy of stormwater protections implemented during construction and demolition activities at Y-12. Stormwater monitoring is conducted on both stormwater outfalls and in-stream locations.

Moreover, internal management assessments were conducted at ORR to ensure environmental monitoring procedural compliance, work planning, and control as expressed in DOE ORR's *Environmental Monitoring Plan* (EMP) for CY24 (DOE, 2023).

DOE has developed a remediation plan for the NT-8 site to reduce uranium discharge to Bear Creek near NT-8, which addresses the issue identified in the 2016 Remediation Effectiveness Report (*RER*) where the ROD goals for uranium in Bear Creek, set in the Bear Creek Valley Phase I ROD (DOE/OR/01-1750&D1) are not being met (DOE, 2016). In the coming year, DOE will prepare an engineering evaluation/cost analysis for NT-8 to meet the FFA milestone.

9.1.3 Problem Statements

ORNL

Currently, ORNL D&D projects include Building 3005 and Building 3010. The primary COCs at Bldg. 3005 and the nearby North Auxiliary Building are uranium, transuranic isotopes, fissile materials, and beryllium (UCOR, 2023). For Building 3010, the primary COCs are the uranium isotopes and their daughter products. Fission products and activation products are also present, while transuranic isotopes (e.g. Am-241, Np-237, Pu-238, and Pu-239/240) have been detected less frequently.

Y-12

According to the *Annual Stormwater Report for Y-12* (DOE, 2023), an area of concern for stormwater is the construction work on the new Outfall 200 Mercury Treatment Facility (MTF). Discharge of mercury-contaminated sediments in water to Upper East Fork Poplar Creek (UEFPC) has been noted in the DOE monthly discharge monitoring reports (DOE, 2023) and RER (DOE, 2022a). Also, the impact to EFPC from stormwater runoff from the Uranium Processing Facility (UPF) site will be a concern. While several sedimentation basins are in this area, they may become overwhelmed, and the water quality in EFPC can be negatively impacted during periods of heavy rainfall.

For the demolition projects at the Alpha2 and Beta-1 Complexes, baseline stormwater monitoring from these sites has suggested that U-isotopes, mercury, beryllium and PCBs may pose potential environmental concern. Therefore, it is necessary to monitor the water and continue DOE data oversight when demolition work is initiated.

EMDF

Construction activities in EMDF may cause environmental issues. Stormwater runoff from the construction site can transport various pollutants such as sediments, debris, oil, metals, and other harmful materials into nearby streams. These contaminants have negative impacts on aquatic ecosystems and environmental function degradation.

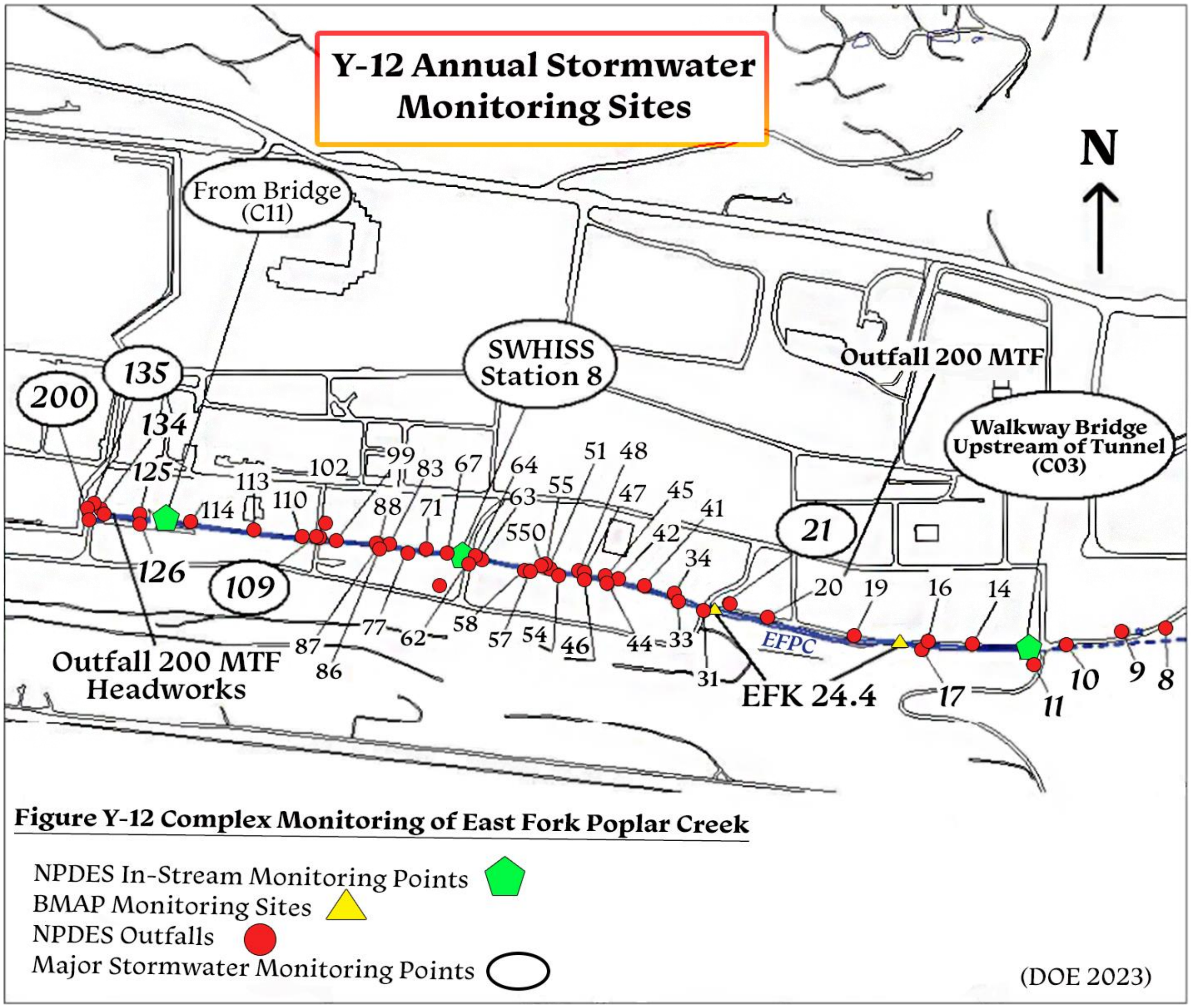

Figure 9.1.3.1 Sampling Sites of Y-12 Annual Stormwater Monitoring

NORTH TRIBUTARY-8 (NT-8)

According to the previous NT-8 transect study by DOE (DOE, 2022b), surface water samples were collected along a transect from the NT-8 flume upstream to the Bear Creek Burial Ground's (BCBG's) fence line. The purpose of this study was to identify COC inputs, including, uranium, VOCs, and PCBs into NT-8. Initial results suggest that uranium is the primary COC in surface water, with the highest levels occurring in the eastern branch of NT-8 that drains BCBG Unit C (BCBG-C) West, BCBG-C East, and BCBG Unit D East (DOE, 2022b). Also, PCBs show high concentrations in the East Tributary, West Tributary, and Main Stem in NT-8. The BCBG, via NT-8, is thought to be the main source of uranium entering Bear Creek.

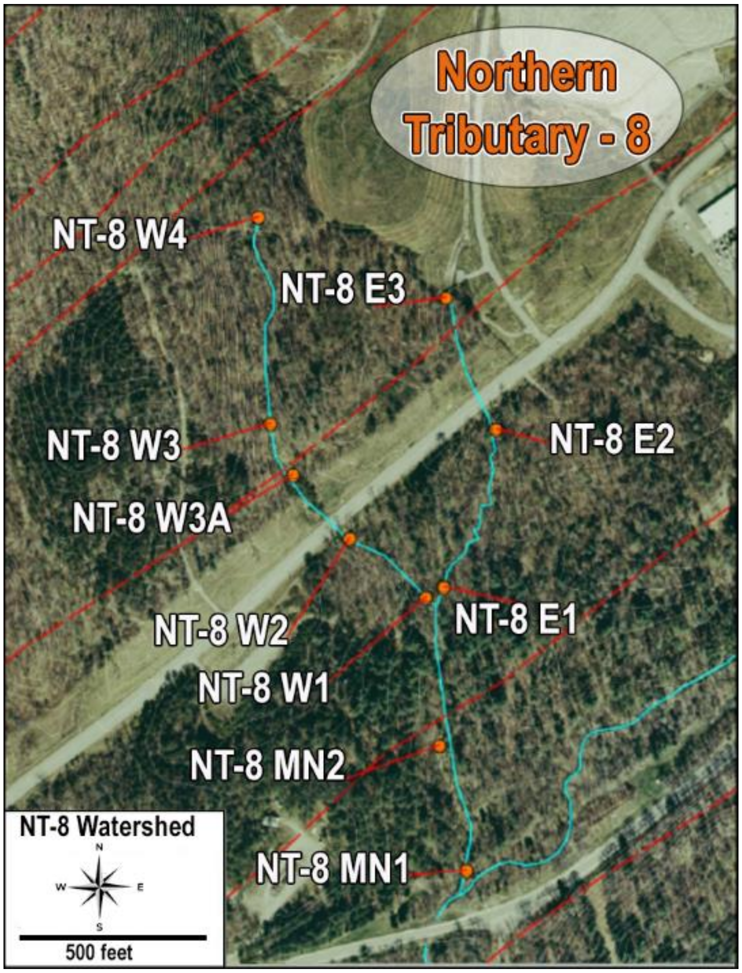

Figure 9.1.3.2 Sampling Sites for NT-8 Surface Water Monitoring

9.1.4 Goals

1) Perform stormwater assessment on D&D project in ORNL (Bldg. 3005) and Y-12 (Alpha-2) to identify COCs carried out from the demolition sites.

2) Conduct surface water investigations on Fifth Creek and EFPC to assess potential environmental impacts caused by D&D activities in ORNL and Y-12, respectively.

3) Conduct groundwater co-sampling at ORNL, Y-12, NT-8 to evaluate impacts of remedial activities, as needed.

4) Perform oversight/assessments on various projects throughout the reservation, including but not limited to accumulated water management, stormwater runoff sampling, surface stream sampling, well sampling/monitoring.

5) Conduct oversight actions to include Review/QC of sampling procedures outlined in DOE/Contractor documentation to determine sampling and monitoring requirements and verify DOE sampling results adhere to negotiated and agreed-upon release criteria.

9.1.5 Scope

This project will collect and analyze surface water and stormwater samples and groundwater co-samples at Y-12, ORNL, NT-8, and EMDF, to identify potential environmental risks resulting from current construction, demolition, and operation activities. The data collected will also be used to evaluate the performance of remediation practices implemented by DOE.

Additionally, the project team will evaluate the effectiveness of stormwater BMPs installed in construction sites and provide oversight support for remediation activities on the ORR.

9.1.6 Assumptions

1) Radiological content detected in stormwater outfalls at ORNL may be linked to specific demolition or operational activities at the site.

2) DOE Radiation Control Technicians (RCTs) will be available to support sampling in areas with potential radiological contamination.

9.1.7 Constraints

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures.

2) The seasonal stormwater data provided by DOE for oversight in ORNL and Y-12 may be insufficient for comprehensive analysis.

9.1.8 Methods, Materials, Metrics

Sampling procedures are outlined in the site-specific monitoring report (DOE 2021, UCOR 2020b, TDEC 2022). This project aims to conduct comprehensive sampling and independent data analysis to identify the COCs in stormwater runoff that drain into nearby water sources, including sampling sites at Y-12, ORNL, NT-8, and EMDF. Additionally, it will evaluate the effectiveness of stormwater BMPs installed in construction sites and provide oversight support for remediation activities on the ORR. The Stormwater BMPs in both ORNL and Y-12 D&D sites includes: 1. Install lined berm or gravel berm around the perimeter of the demolition area; 2. Plug storm catch basin; 3. Absorbent pads will be used if oily sheen is present on the accumulated water.

TDEC DoR-OR will independently collect stormwater, surface water, and groundwater samples, with oversight activities primarily focused on DOE data. The TDEC-collected samples will serve as a QA/QC check to verify the accuracy of DOE data.

The sampling protocols, site selection, sampling intervals, sample sizes, QA/QC measures, safety protocols, and data analysis will follow the procedures outlined in the site-specific monitoring report (DOE 2021, UCOR 2020b, TDEC 2022). The data collection and analysis will establish a baseline prior to planned D&D activities and ensure compliance with work plans, SOPs, stormwater BMPs installation and performance.

Groundwater co-sampling activities may also be conducted by TDEC DoR-OR. The specific sampling locations and site access will be determined through discussions with TDEC staff and co-sampling with DOE staff. These assessment activities will also be coordinated with the *Baseline Monitoring at the EMDF Site Project*, which is conducted by TDEC DoR-OR staff.

Sampling sites and COCs selection in Table 9.1.8.1 are identified based on DOE and UCOR documents (DOE 2022a, DOE 2022b, DOE 2021, UCOR 2020a).

Table 9.1.8.1 ORR Sampling Frequency, Sites Selection, and COCs

ORNL D&D *COCs: U-isotopes, Metals (+lead), Beryllium, Gross Alpha & Beta, Gamma*					
Medium	**Sampling Frequency**			**Site 1**	**Site 2**
	Pre-Demo	**Initial Work**	**Post-Demo**		
Stormwater	SA	QE	SA	Field Outfall	BDS
Surface Water	SA	SA	SA	Fifth Creek	BDS
Ground Water	SA	SA	SA	GW Flow Path Site 1	BDS
Y-12 D&D *COCs: U-isotopes, Mercury, Beryllium, PCBs*					
Stormwater	SA	QE	SA	Field Outfall	BDS
Surface Water	SA	SA	SA	EFPC	BDS
Groundwater	SA	SA	SA	GW Flow Pate Site 1	BDS
NT-8 Remediation Site *COCs: U-isotopes, Thorium, Radium, PCBS, Metals*					
Surface Water	SA			NT-8E	NT-8W
Groundwater	SA			DPT-01	DPT-02
EMDF Construction *Parameters: DO, Conductivity, pH, Temperature, Turbidity*					
Stormwater	EQ			Field Outfall	BDS
Surface Water	SA			Downstream of NT-11	BDS
Sampling Frequency: SA: Semi-Annual; QE: Each Qualifying Rain Event				*Sampling Site: BDS: Baseline Data Site; GW: Groundwater*	

9.1.9 References

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10.0 WATERSHED ASSESSMENTS (HOLISTIC) MONITORING

10.1 EAST FORK POPLAR CREEK ASSESSMENT PROJECT PHASE 2

10.1.1 BACKGROUND

The ORR resides in the Valley and Ridge physiographic province. This province is distinguished by series of northeast-southwest trending ridges and interceding valleys (Figure 1.3.1.1) (Miller, 1974).

The headwaters of EFPC are located within the Y-12 NSC where the primary COCs are mercury and uranium. The EFPCAP involves a comprehensive evaluation of the ecological health of this entire watershed and will focus on mercury and uranium monitoring. To accomplish this holistic assessment, the EFPCAP has been organized into several progressive phases.

1) **Phase 1** involves researching and compiling existing data.
    1. Data acquisition, review, summarization, and interpretation of historical data for upper and lower EFPC.

    2. Examine and compile available types of environmental data including: (1) surface water, (2) groundwater, (3) sediment, (4) soils, (5) toxicity/ biomonitoring, (6) fish tissue, (7) benthic macroinvertebrates, (8) terrestrial biota [bird eggs, spiders, flying insects, ground beetles].

2) **Phase 2** will include new sampling and subsequent analysis of monitoring data collected in Phase 1. In Phase 2, the above-mentioned projects (1.b.) will focus on the EFPC. In addition, mercury uptake sampling will also include ground beetle monitoring. Shallow ground water sampling results will also be incorporated.

3) **Phase 3** will use the analytical data obtained from Phases 1 and 2 to produce a comprehensive report. If data gaps are present after Phase 2, there will be further sampling and analysis.

4) **Phase 4** will address any areas requiring additional field sampling for a more comprehensive analysis and interpretation of all watershed data.

As stated above, in FY 24 DoR-OR will continue collecting these data for the EFPCAP Phase 2. New sampling projects, along with the continuation of ongoing projects, will add to the body of environmental knowledge regarding EFPC.

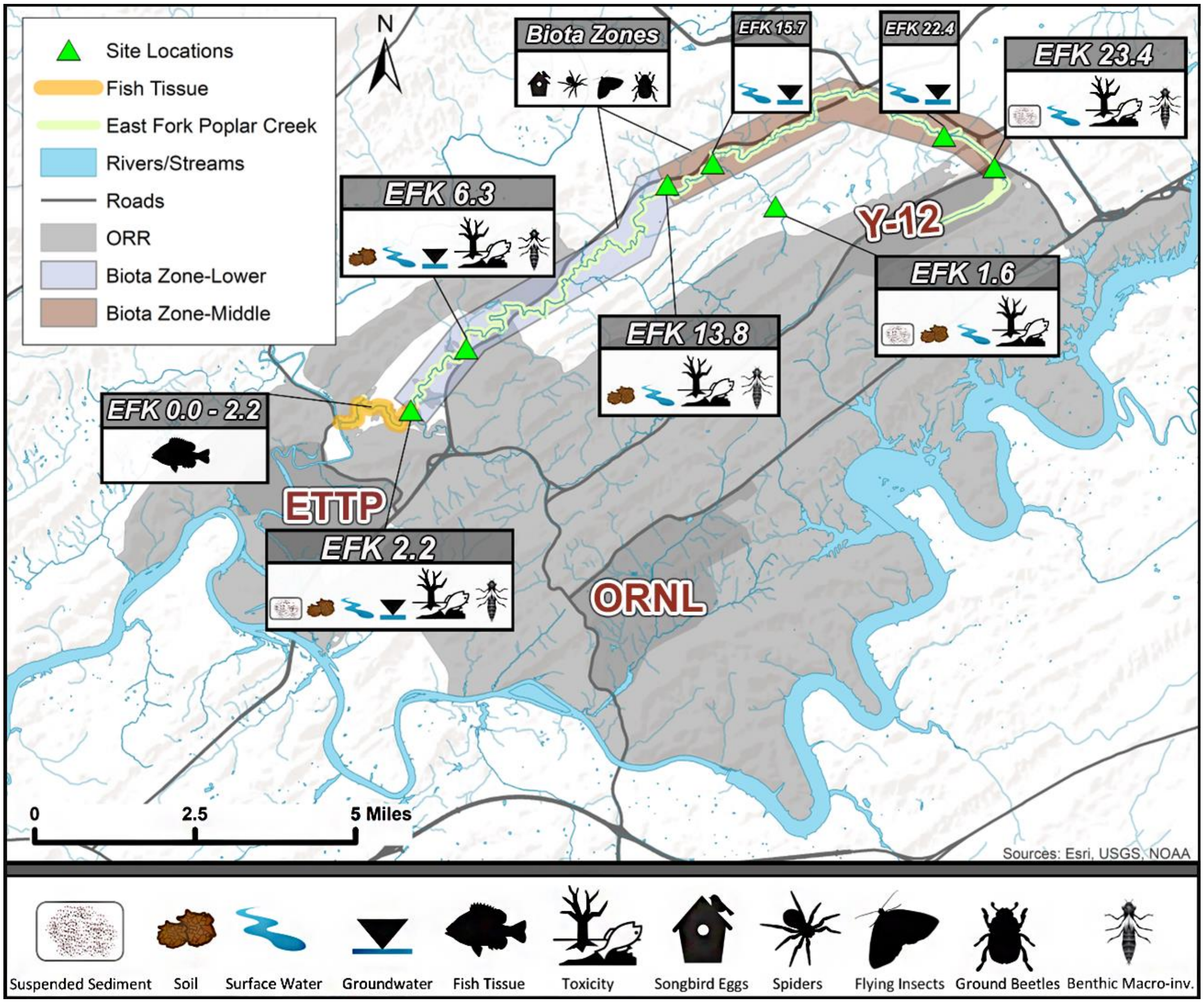

Figure 10.1.1.1: Map of Phase 2 Sampling Sites

10.1.2 Related DOE Projects

DOE has a few projects that can be incorporated into the EFPCAP Phase 2 assessment. For example, ORNL's Environmental Sciences Division (ESD) samples fish and benthic macroinvertebrates in EFPC. Furthermore, the DOE Y-12 Environmental Division monitors mercury and surface water flow at a co-located site (EFK 23.4) (Figure 10.1.1.1) and at other locations along the EFPC. This DOE EFPC data can also serve as additional data.

10.1.3 Problem Statements

Mercury continues to migrate into EFPC from Y-12 subsurface drains, contaminated building foundations, and soils. It is estimated that EFPC discharges approximately 0.2 metric tons of mercury to the Clinch River every year (DOE, 1992). This mercury has migrated into soils in the floodplain and into the food web. Although mercury concentrations in EFPC water have decreased 85% from the 1980's, methylmercury concentrations in water and in fish tissue have not declined, even with efforts to improve water quality (Brooks and Southworth, 2011). The second COC, uranium, was released into the air by Y-12 vents and stacks. Eventually contaminants dropped into surface water and migrated via EFPC.

10.1.4 Goals

1) Holistic assessment of ORR contaminants and the quantification of the risk to wildlife in the EFPC watershed.

2) Provide an environmental assessment benchmark to gauge the effects of future DOE remediation activities in the EFPC watershed, including the Y-12 Mercury Treatment Facility and changes to the nearby Outfall 200 area.

10.1.5 Scope

The EFPCAP Phase 2 scope is to obtain all the monitoring data to sufficiently provide a holistic view of the EFPC watershed. This assessment will require the assistance of other TDEC DoR-OR projects to collect and share data. For this data sharing to be applicable, each individual program will need to shift their focus to include, as needed, sampling locations in the EFPC watershed.

10.1.6 Assumptions

1) Phase 2 sampling and analysis activities will provide a thorough and useful holistic model of the EFPC Watershed that will aid in making future remediation decisions.

10.1.7 Constraints

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures.

2) Biomass of sample may be insufficient for analysis.

10.1.8 Methods, Materials, Metrics

Surface water samples will be collected quarterly at eight sites on EFPC and at one site on MB, the background stream. Surface water samples from EFPC will be analyzed for major cations and anions, total metals, dissolved metals, and gross alpha/beta. For information about the EFPC surface water sampling project, refer to the *Ambient Surface Water and Shallow Groundwater-Hyporheic Zone Sampling* EMP in this document.

Sediment traps will be deployed in streams at EFK 23.4, EFK 2.2, and MBK 1.6 (Figure 10.1.1.1) for approximately five months. The analyses will include metals (arsenic, cadmium, mercury, uranium), polychlorinated biphenyls (PCBs), and radiochemistry (gross alpha/beta, gamma radionuclides) parameters. Sampling will be conducted in November/December 2023 and in May/June 2024. For information about the EFPC sediment sampling project, refer to the *Suspended Sediment Sampling* EMP in this document.

Soil samples were collected on 2/22/2023 at three locations on EFPC (Figure 10.1.1.1) and at Clear Creek in Anderson County (reference site). The samples were collected by Civil & Environmental Consultants, Inc. (CEC) using Incremental Sampling Methodology (ISM). The samples were analyzed for arsenic, cadmium, mercury, uranium, gross alpha, gross beta, gamma radionuclides, and PCBs. The results are currently being reviewed and will be reported in the 2023 EMR. Soil sampling at EFPC is not planned for FY 2024.

Toxicity/biomonitoring was conducted by CEC during the weeks of 9/12/2022, 10/17/2022, and 2/27/2023 at four locations on EFPC and at MB. The test organisms were fathead minnow (survival and growth) and water flea (survival and reproduction). In addition, water samples collected each day of sampling were analyzed for nitrate, cadmium, mercury, uranium, PCBs, and gross beta. One more round of toxicity/biomonitoring will be conducted in June 2023. The results will be reported in the 2023 EMR. Toxicity/biomonitoring at EFPC is not planned for FY 2024.

Fish sampling was conducted on 4/27/2023 by CEC at EFK 2.2. The fishes collected included golden redhorse, striped shiners, bigeye chub, and stoneroller. The fish samples will be analyzed for Hg, MeHg, As, Cd, U, PCBs, Dioxins/Furans, gross alpha/beta, gamma radionuclides, Sr-89,90, U isotopic, Pu isotopic, C-14, Po-210, and Tc-99. The results will be reported in the 2023 EMR. Fish sampling at EFPC is not planned for FY 2024.

Benthic macroinvertebrates will be sampled in May of 2023 at several locations on EFPC (Figure 10.1.1.1). Macroinvertebrate sampling will follow the guidance outlined in the *SOP for Benthic Macroinvertebrate Sampling (TDEC 2021).* For information about the EFPC benthic macroinvertebrate sampling project, refer to the separate *Benthic Macroinvertebrate Community Health* EMP in this document.

Biota samples will be collected within specified biota zones in the EFPC Valley (Figure 10.1.1.1). As the upper EFPC stream reach is within the Y-12 plant, this portion of the stream is not in the scope of the EFPCAP. Songbird eggs, spiders, adult insects, ground beetles, and non-venomous snakes (blood samples only) will be sampled and analyzed for Hg, MeHg, and radiological parameters. For information about the EFPC biota sampling projects, refer to their separate EMPs in this document.

10.1.9 References

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